



**US Army Corps
of Engineers®**
Engineer Research and
Development Center

Science and Adaptive Management Plan

Missouri River Recovery Program

August 2018



The U.S. Army Engineer Research and Development Center (ERDC) solves the nation's toughest engineering and environmental challenges. ERDC develops innovative solutions in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, the Department of Defense, civilian agencies, and our nation's public good. Find out more at www.erdcl.usace.army.mil.

To search for other technical reports published by ERDC, visit the ERDC online library at <http://acwc.sdp.sirsi.net/client/default>.

ERDC/EL TR-18-XX
August 2018

Science and Adaptive Management Plan

Missouri River Recovery Program

J. Craig Fischenich

*Environmental Laboratory
U.S. Army Engineer Research and Development
Center
3909 Halls Ferry Rd
Vicksburg, MS 39180*

Kate E. Buenau

*Marine Science Laboratory
Pacific Northwest National Laboratory
U.S. Department of Energy
1529 W. Sequim Bay Rd
Sequim, WA 98382*

Joseph L. Bonneau and Craig A. Fleming

*U.S. Army Corps of Engineers
Omaha District
Gavins Point Project Office
Yankton, SD 57078*

David R. Marmorek, Marc A. Nelitz,
Carol L. Murray and Brian O. Ma

*ESSA
600 – 2695 Granville Street
Vancouver, BC Canada V6H 3H4*

Graham Long

*Compass Resource Management Ltd
210 - 111 Water Street
Vancouver, BC Canada V6B 1A7*

Carl J. Schwarz

*Department of Statistics and Actuarial Science,
Simon Fraser University
8888 University Drive
Burnaby, BC Canada V5A 1S6*

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Missouri River Recovery Program

Abstract: The Missouri River Recovery Program (MRRP) is undergoing a transformation resulting from recommendations on emerging science by an Independent Science Advisory Panel and the Missouri River Recovery Implementation Committee (MRRIC). An Effects Analysis study established the best available scientific information and provided the foundation for a Science and Adaptive Management Plan (SAMP) that addresses lingering uncertainties and improves management decisions while implementing actions that avoid jeopardizing three federally listed species (piping plover, least tern and pallid sturgeon). This draft SAMP includes a process for resolving critical uncertainties using a framework consisting of four implementation levels: 1) research, 2) in-river testing of hypotheses, 3) scaled implementation of select management actions, and 4) full implementation. The decision criteria for moving to higher levels of implementation are included. A NEPA evaluation of alternative management actions identified an initial suite of actions that will be implemented to meet the objectives of the MRRP. This SAMP accompanies the Missouri River Recovery Management Plan-Environmental Impact Statement and provides the roadmap for the implementation of the selected alternative and for the identification of subsequent management needs should the initial suite of actions fail to meet objectives. The SAMP will be implemented collaboratively by the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and MRRIC following the governance process outlined in this plan. Addendums and updates to this plan are anticipated as the program evolves and will be noted on the “Addendum and Version Log” on page xxi.

DISCLAIMER: The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. All product names and trademarks cited are the property of their respective owners. The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

DESTROY THIS REPORT WHEN NO LONGER NEEDED. DO NOT RETURN IT TO THE ORIGINATOR.

Table of Contents

List of Figures and Tables	x
Preface.....	xviii
Addendum and Version Log.....	xix
Unit Conversion Factors	xx
1 Introduction.....	1
1.1 Overview, background and context	1
1.1.1 Overview	1
1.1.2 Missouri River Recovery Program (MRRP)	1
1.1.3 Purpose and scope of the MRRP	7
1.1.4 Effects Analysis (EA) and modeling framework for the MRRP	8
1.1.5 AM and decision-making concepts	11
1.1.6 Relationship between MRRMP-EIS alternatives and actions in the SAMP	12
1.2 AM governance.....	15
1.2.1 AM decision needs.....	15
1.2.2 Program composition, roles, and responsibilities	16
1.2.3 AM decision process.....	19
1.2.4 Protocols and procedures	22
1.2.5 Other key points and issues	22
1.3 AM for plovers and terns.....	22
1.3.1 Bird objectives, uncertainties, and targets.....	23
1.3.2 Implementing, monitoring, and evaluating bird actions	26
1.3.3 Decisions and planning contingencies.....	29
1.3.4 Other key points or issues	32
1.4 AM for pallid sturgeon.....	32
1.4.1 Overview of Chapter 4	32
1.4.2 Pallid sturgeon objectives and key uncertainties.....	33
1.4.3 Pallid sturgeon framework	36
1.4.4 Pallid sturgeon in the Upper Missouri River.....	37
1.4.5 Pallid sturgeon in the Lower Missouri River.....	40
1.5 Human Considerations (HC)	44
1.5.1 How HCs are considered	44
1.5.2 Monitoring and assessment of HCs.....	45
1.5.3 HCs and Adaptive Management	45
1.6 Data acquisition, management, reporting and communications.....	46
1.6.1 Monitoring and other data acquisition issues.....	46
1.6.2 Data management.....	47
1.6.3 Reporting and communications.....	48
1.6.4 Quality assurance (QA) and quality control (QC)	48
1.7 Summary	49
2 Governance of the AM Program	53

2.1	Definition, principles and key attributes for effective governance	53
2.1.1	Governance defined	53
2.1.2	Attributes of governance that enable AM.....	53
2.1.3	Ensuring objective and reliable science in the Missouri River Recovery Program ..	56
2.2	Decision needs for adaptively managing the MRRP	58
2.2.1	Scope of decisions in the MRRP	59
2.2.2	Balancing needs	60
2.2.3	Timing of AM decisions.....	62
2.2.4	Role of decision criteria in the MRRP	63
2.2.5	NEPA, the Master Manual, and decisions regarding management actions.....	63
2.3	AM program composition, roles, and responsibilities.....	65
2.3.1	Oversight level.....	69
2.3.2	Management Team.....	72
2.3.3	Implementation-Level Teams (Bird, Fish and HC).....	74
2.3.4	Technical Team.....	81
2.3.5	Integrated Science Program (ISP).....	84
2.3.6	Other MRRP entities and position descriptions	85
2.3.7	Overview of MRRIC roles and responsibilities.....	88
2.3.8	Basin states, other Federal agencies, and tribal roles outside the MRRIC collaborative process 100	
2.4	AM Decision process, critical engagements, and workflows	103
2.4.1	Overview of the MRRP AM decision process.....	103
2.4.2	Basic Annual AM engagement process.....	105
2.4.3	Science Update process.....	109
2.4.4	Strategic Plan development and approval	119
2.4.5	Consideration of new management actions	125
2.4.6	Workflows for specific scenarios.....	130
2.5	Important protocols and procedures	131
2.5.1	Procedures for dispute resolution.....	131
2.5.2	Procedures for adjustments to significant components of the SAMP	132
2.5.3	Procedure for addressing significant new information.....	135
2.5.4	Independent external review.....	137
2.5.5	Requirements for research and focused study efforts.....	139
2.5.6	Agendas for the Fall Science Meeting and for the Annual AM Workshop.....	140
2.5.7	Guidelines for technical publications	140
2.5.8	Example Fact Sheet.....	140
2.5.9	Program priorities development process.....	140
2.5.10	Cost management.....	141
2.5.11	Program safety and health requirements.....	144
3	Adaptive Management for Plovers and Terns	145
3.1	Assess.....	145
3.1.1	Management objectives and scope for least terns and piping plovers	145
3.1.2	Key findings from Effects Analysis (EA)	150
3.2	Plan and Design	160
3.2.1	Bird Framework.....	160

3.2.2	<i>Metrics and management conditions</i>	164
3.2.3	<i>Targets</i>	169
3.2.4	<i>Management Actions</i>	175
3.2.5	<i>Effects of Pallid Sturgeon Actions on Terns and Plovers</i>	202
3.3	<i>Monitoring</i>	205
3.3.1	<i>Status of revised monitoring programs</i>	207
3.3.2	<i>Monitoring of hydrology and habitat metrics</i>	208
3.3.3	<i>Existing program for monitoring of population metrics and associated challenges</i>	209
3.3.4	<i>Options for changing the population monitoring program</i>	212
3.3.5	<i>Additional species monitoring</i>	213
3.3.6	<i>Action effectiveness monitoring and research</i>	214
3.4	<i>Implementation</i>	216
3.5	<i>Evaluation</i>	216
3.5.1	<i>Evaluation of habitat status relative to targets</i>	216
3.5.2	<i>Evaluation of population status relative to targets and objectives</i>	220
3.5.3	<i>Overall Evaluation of Status and Management Needs</i>	224
3.5.4	<i>Evaluation of management conditions</i>	228
3.5.5	<i>Incorporation of new information</i>	230
3.5.6	<i>Evaluation of key relationships and science questions</i>	230
3.5.7	<i>Evaluation of action effectiveness</i>	232
3.5.8	<i>Evaluation of cross-program effects</i>	233
3.5.9	<i>Model updates and validation</i>	233
3.5.10	<i>Ancillary information</i>	236
3.5.11	<i>Unexpected outcomes</i>	236
3.6	<i>Decisions and planning contingencies</i>	238
3.6.1	<i>Decision making process</i>	238
3.6.2	<i>Information for making decisions</i>	239
3.6.3	<i>Management action decisions</i>	241
3.6.4	<i>Decisions related to experiments and research activities</i>	244
3.6.5	<i>Decision criteria for when targets are not met</i>	245
3.6.6	<i>Decisions to add, change, or remove management actions</i>	250
3.6.7	<i>Decisions to change metrics and targets</i>	251
4	<i>Adaptive Management of Pallid Sturgeon in the Missouri River</i>	254
4.1	<i>Assess</i>	255
4.1.1	<i>Goals and management objectives for pallid sturgeon</i>	255
4.1.2	<i>Key findings from Effects Analysis and more recent work</i>	264
4.2	<i>Plan and Design</i>	285
4.2.1	<i>Pallid sturgeon framework</i>	285
4.2.2	<i>Tradeoffs between different learning strategies</i>	295
4.2.3	<i>Recommended learning strategy for AM Plan</i>	295
4.2.4	<i>Overview of Level 1 and 2 Components and Decision Criteria</i>	296
4.2.5	<i>Details on Level 2 and Level 3 Actions for Upper Missouri River</i>	310
4.2.6	<i>Details on Level 2 and Level 3 Actions for Lower Missouri River</i>	336
4.2.7	<i>Potential Effects of bird actions on pallid sturgeon</i>	385
4.3	<i>Implement</i>	388

4.3.1	Implementation Plan	388
4.4	Monitor	391
4.5	Evaluate.....	392
4.5.1	Evaluation Methods.....	392
4.6	Decide.....	401
5	Human Considerations	405
5.1	Introduction to HCs related to the MRRP.....	406
5.1.1	Brief introduction to HCs in the MR.....	406
5.1.2	The role of HCs during the Management Plan development	407
5.1.3	Actions for species that could affect HCs.....	411
5.2	Planning context.....	413
5.2.1	National Environmental Policy Act (NEPA)	414
5.2.2	Other Important Laws and Regulations.....	417
5.3	Actions that have been evaluated in the EIS and identified as part of the Preferred Alternative and their potential impacts on HCs	420
5.3.1	HC Monitoring of actions in the preferred alternative	420
5.3.2	Additional routine monitoring of value to understanding impacts of operations on HCs	421
5.3.3	Scheduling of action implementation.....	423
5.3.4	Sandbar construction for birds	425
5.3.5	Flow management to reduce inundation of bird nests and chicks.....	427
5.3.6	Sandbar augmentation and modification for birds.....	428
5.3.7	Vegetation management for bird habitat	428
5.3.8	Bird predation management.....	429
5.3.9	Human restriction measures to prevent damage to bird nests	429
5.3.10	Stocking pallid sturgeon	429
5.3.11	Channel reconfigurations for Interception Rearing Complexes	430
5.3.12	Pallid sturgeon spawning habitat.....	432
5.3.13	Pallid sturgeon spawning test flows.....	432
5.3.14	Intake passage / Fort Peck flows for pallid sturgeon	433
5.3.15	Foraging habitat for sturgeon.....	433
5.4	HCs and Adaptive Management.....	433
5.4.1	Role of the HC Work Group	433
5.4.2	HCs in the annual AM planning cycle	436
5.4.3	Clarifying the flow of information	437
5.4.4	Scoping HC issues and new information.....	439
5.4.5	Incorporation of new information	440
5.4.6	Ancillary information.....	441
5.4.7	New monitoring requests	441
5.4.8	Actions outside the MRRMP-EIS and HCs.....	445
6	Data Acquisition, Management, Reporting and Communications.....	448
6.1	Principles and practices underpinning monitoring and evaluation, data management, and effective communications	448
6.1.2	Issues of scale.....	453
6.1.3	Actionable science.....	454

6.2	Monitoring and data acquisition	455
6.2.1	<i>Pallid sturgeon monitoring data acquisition and analysis approach.....</i>	456
6.2.2	<i>Bird monitoring data acquisition and analysis approach.....</i>	457
6.2.3	<i>System status and HC data acquisition and analysis.....</i>	457
6.2.4	<i>Research data acquisition.....</i>	459
6.2.5	<i>New Information</i>	460
6.3	Data and Information Management	460
6.3.1	Overview	460
6.3.2	Purpose and Objectives.....	461
6.3.3	DSS Structure and Functionality.....	466
6.3.4	Reporting and communication.....	468
6.3.5	Proposed work plan for developing the MRRP Data Management System (DMS).....	472
6.3.6	Integrating Existing Data Management Systems.....	474
6.4	Quality assurance and quality control.....	480
6.4.1	Basic Principles for Quality Assurance	481
6.4.2	Data Quality Objectives (DQOs).....	482
6.4.3	QAPP organization and content	483
6.4.4	QAPP implementation responsibilities.....	483
6.4.5	Alternative Procedures or Variances	484
6.5	Reporting and Communications	485
6.5.1	Reporting.....	485
6.5.2	Communications	491
	References Cited	492

Report Documentation Page

List of Figures and Tables

Figures

Figure 1. Missouri River Basin showing upper and lower river reaches for pallid sturgeon and northern and southern regions for the piping plover. System reservoirs labeled in red.	2
Figure 2. Summary timeline of key events leading to the development of this Science and AM Plan.3	
Figure 3. Schematic of the process leading to development of the draft MRRMP-EIS and this AM plan..	6
Figure 4. Model framework for the MRRP.....	10
Figure 5. Simplified depiction of the AM process.	11
Figure 6. Schematic of management actions considered in the MRRMP-EIS, included in this AM Plan, and included in the selected alternative.	14
Figure 7. Primary components of the MRRP AM governance structure (not intended to represent a hierarchy).....	17
Figure 8. Process map depicting the proposed governance activities to be undertaken annually by the USACE, the USFWS, and the Missouri River Recovery Implementation Committee (MRRIC) in the implementation of AM for the Missouri River Recovery Program.	21
Figure 9. Factors affecting AM decisions for birds and the nature of those decisions.	30
Figure 10. Diagram of a decision tree for contingent information on the Upper Missouri and Yellowstone Rivers (presented as Figure 52 in Chapter 4). Passage at Intake will increase potential drift distance on the Yellowstone River to 400 km, and provides access to tributaries including the Powder River.	39
Figure 11. Timeline of events leading to the development of the MRRMP-EIS and the AM Plan. ...	50
Figure 12. Timeline for budgeting, strategic review, SP development, and the AOP.	62
Figure 13. Flowchart for decisions to implement a management action (Step 5b).	64
Figure 14. Central components of the MRRP governance structure. Entities not shown in this diagram are referenced in later sections and described in attachments to Appendix A. Hierarchical relationship not implied.	66
Figure 15. Schematic of MRRIC interactions. Implementation Teams meet (1) and MRRIC WGs hold a Joint WG meeting (2). Joint WG and other WGs develop draft recommendations (3). Team Leads provide input to Management Team (4) and Management Team develops draft SP and other recommendations (5). MRRIC and agency leadership collaborate at plenary meeting (6), and leaders make decisions.	90
Figure 16. Generic depiction of governance activities to be undertaken annually by the USACE, the USFWS, and the MRRIC in the implementation of AM for the MRRP. Labeled symbols are described above. Additional description of process provided in Sections 2.4.2.1 – 2.4.2.4 and in Appendix A.	108
Figure 17. Overview of the science update process.	109
Figure 18. Schematic of the SP showing emphasis for the strategic update process.	119
Figure 19. Strategic Plan update process.	120
Figure 20. Schematic of interactions and associated recommendations and decisions occurring annually that lead to the updating of the SP.	121
Figure 21. Schematic of the process to update the Master Manual.	130
Figure 22. Geographic scope of SAMP for terns and plovers.	147
Figure 23. Overview conceptual ecological model (CEM) for plovers (see Appendix B for full set).152	
Figure 24. Quantitative model components in relation to conceptual model elements. Elements with black text are represented explicitly in the model; elements with gray text are represented implicitly... 152	

Figure 25. The management actions evaluated in the EA, their mechanisms for affecting habitat and species and consequent effects on the fundamental species objectives and sub-objectives.....	154
Figure 26. Factors affecting AM decisions for birds and the nature of those decisions.....	161
Figure 27. Illustration of “toolbox” concept for AM, indicating action status and a range of potential AM adjustments to actions. Green boxes (A,C,E) indicate actions implemented in a given year; blue boxes (B,D) indicate actions not implemented that year; gray boxes (F-I) indicate actions not currently implementable.	162
Figure 28. Schematic of decision space using flow management for ESH creation.....	163
Figure 29. ESH characterization. a) Available ESH is measured at the maximum July flow (blue outline) observed in that year. Standardized ESH is observed at a predetermined flow (dashed line) each year. b) Standardized ESH measures changes in sandbars due to erosion from an earlier year (dark profile) to a later year (light profile). c) Available ESH area may increase from one year to next if flows are lower, even though standardized ESH area decreases from erosion and vegetation growth.	165
Figure 30. Shoreline habitat characterization. a) Available shoreline is measured as the difference between the maximum elevation inundated >160 days in the previous 2 years (dotted line) and the elevation inundated on May 15 th of the current year (solid outline). b) If the elevation inundated on May 15 th is higher than the maximum elevation inundated >160 years, the available shoreline metric = 0 ft. c) The inundation metric is the change in elevation between May 15 th (dashed line) and August 3 rd (solid line) and may be a positive number if water levels increase (shown) or a negative number if water levels decrease (not shown).	166
Figure 31. Anticipated range of “effective” combinations of flow and duration that meet standardized acreage targets given initial ambient ESH, with presumed “decision space” shown for Gavins Point and Garrison reaches.....	192
Figure 32. Conceptual diagram of how current or potentially monitored metrics support decisions. Dashed lines indicate information or relationships yet to be developed. Processing of raw data is necessary to arrive at the information in the “Monitoring” column but not all details are shown here. Additional information may be needed for monitoring effectiveness of actions.	207
Figure 33. Observed standardized ESH (black line) from 2006-2017 relative to targets (median, solid gray line; 95% confidence interval, dashed lines) for the Southern region. Black symbols indicate years when targets were met; blue symbols indicate years that the time frame of 3 out of 4 years exceeding the median target is met.	218
Figure 34. Observed exceedance of available ESH (blue) from 2006-2017 relative to target exceeded acreages for the Southern region. Lines indicate the 75%, 50%, 25% and 10% exceedance criteria specified in the targets.	218
Figure 35. Metrics of available shoreline (lines, high values are good), inundation during the nesting season (columns, low values are good).....	219
Figure 36. The relationship between reservoir habitat metrics (available shoreline and inundation) and whether the fledge ratio target of 1.14 is met (filled shapes) or not met (unfilled shapes) for a) Lake Sakakawea and b) Lake Oahe for 1993-2014. Recent years are highlighted in blue (fledge ratios were not estimated on reservoirs in 2013). Note that some labels have been omitted for legibility. The dotted line indicates combinations of the two metrics predicted by the model to meet the fledge ratio targets; data points above and to the left of the line are expected to meet the targets and data points below and to the right of the line are not.	220
Figure 37. Plover annual fledge ratios (blue) and 3-year running average fledge ratio (gray) for the Southern Region from population monitoring 1998-2017. Horizontal lines indicate targets.	221
Figure 38. Hypothetical comparison of projected population sizes under a management scenario (blue lines) with a population trajectory that meets the target (black line). Solid lines are median values of 5,000 model replicates; dashed lines are 95% confidence intervals.....	223

Figure 39. Evaluation of status over time for a) plover fledge ratio (gray lines) and population growth rate (black lines) and b) plover population size. Symbol color indicates status relative to status and needs matrix (see Table 34 for definitions.).....	228
Figure 40. Example of an evaluation of key relationships. Results of best-fit model relating plover density to fledge ratio in annual assessment of density dependence in plover population. Points indicate fledge ratios in individual reaches and years, solid line is median prediction of the statistical model, dashed lines are 95% confidence intervals.	231
Figure 41. Example of model validation for 2005-2013 for a) standard ESH and b) available ESH modeled using predicted flows (validation type 2 above) and c) plover adults and d) tern adults using predicted ESH (validation type 4 above). Solid black lines indicate the median prediction of 5,000 model replicates; dashed black lines indicate the 95% confidence interval. Thick blue lines are observations.	235
Figure 42. Example model projections of standard ESH acres for three management options using ESH construction only vegetation management only, or both combined, relative to doing nothing. Projections are the 25 th percentile of model results.	240
Figure 43. Diagnostic decision tree for a) determining why bird targets are not being met, and b) identifying recommended corrective actions.	247
Figure 44. Hierarchy of goals, objectives, metrics and targets for pallid sturgeon. TBD = To Be Determined. The goal of the AM Plan is described in more detail in Section 1.1.3 of this plan.....	256
Figure 45. Historical range and present-day occupancy of the pallid sturgeon and scope of the Missouri River included in the EA. Present day occupancy shown on the right side map includes the stretch of the river above Gavins Point Dam and below Fort Randall Dam, which is not included in the defined area of the Lower Missouri River. Pallid sturgeon may be found in reservoirs but do not prefer these habitats. Source: Figure 2 in Jacobson et al. 2016a.....	260
Figure 46. Location map for the Missouri River basin, showing dams and sampling segments (colored river sections). Inset table shows recovery-priority management areas (RPMAs) and recovery priority management units (RPMUs).	262
Figure 47. Map of the upper (A) and lower (B) river complex, showing the Yellowstone and Missouri Rivers, major tributaries, reservoirs, and river segments. The color-coding represents the delineation of each segment.	263
Figure 48. Phases 1, 2, and 3 envisioned for the EA process (Jacobson et al., 2016a).	265
Figure 49. Generalized population-level CEM showing life stages, geographic context of pallid sturgeon reproductive cycle, and management actions being considered in the upper and lower Missouri River (and described in Section 4.2). Fingerlings and yearlings less than 1 year old fit into the “exogenously feeding larvae” life stage.	266
Figure 50. Example of a life-stage component CEM showing the cause-effect linkages leading to survival to the next life-stage (Jacobson et al. 2015b).	268
Figure 51. Diagram of a decision tree for addressing contingent information for drift and dispersal related management actions in the Upper Missouri and Yellowstone rivers. In this diagram, drawdown of Lake Sakakawea (lower right) is to a level consistent with authorized purposes. The diamond in the upper left refers to the headwaters of Lake Sakakawea. Information exists to partially answer some of the questions in the diamonds, as discussed in the text. A more detailed decision tree, including other actions such as population augmentation, is contained in Appendix F (Figure F2). Source: Jacobson et al. 2016a.	283
Figure 52. Diagram of a decision tree addressing contingent information in the Lower Missouri River. Modified from Jacobson et al. 2016a.	284
Figure 53. Overview of the links among management actions, big questions, management hypotheses, and the applied research studies (described in Appendix C) being used to inform action implementation in the upper and lower rivers. Habitat and biological metrics for evaluating effectiveness of actions are described in Appendix E. Items applicable to both Upper and Lower Missouri are shown in red, those only applicable to Upper Missouri in black, and only applicable to Lower Missouri in blue.....	289

Figure 54. Overview of the decision criteria for various decisions in the Pallid sturgeon framework. The top green box refers to the decision criteria in Table 41 and Table 42. The remaining green boxes refer to the evidence and decision criteria in Appendix C, Table 43, Table 44 and Table 68. The blue box second from the bottom (“Discontinue this action, consider other options to improve survival”) is illustrated by the decision trees in Figure 51 and Figure 52.	292
Figure 55. Map of the active and discontinued fixed telemetry logging stations (Source USGS).	329
Figure 56. Map of proposed bypass channel alternative with illustrations of locations for experimental releases of hatchery origin free embryos at the (A) concrete weir, (B) bypass channel, and (C) Yellowstone River. Experimental release locations are denoted by black solid ovals (A1, B1, C1) while sampling locations of embryos are denoted by black thatched lines (A2, B2, C2). Arrows denote direction of river flow. Base map from USBR and USACE 2015.	330
Figure 57. Concept of an interception-rearing complex near river mile 162. Flow expansion and interception are shown by modeled current velocity and direction (arrows) angled away from the channel and towards the right descending bank. Background multibeam bathymetric data from USGS, July 24, 2011, 216,000 cfs. Modeled velocities are from Jacobson, Lindner, and Bitner (2015).	338
Figure 58. Comparisons of power for different sampling designs. The four graphs show statistical power when the number of IRC sites is varied from 6 to 12 with 5 to 20 years of monitoring and two IRCs added per year. The panels correspond to a 25%, 50%, 75%, or 100% increase in mean CPUE in the IRC sites.	343
Figure 59. Proposed locations of Interception and Rearing Complexes (IRCs; green symbols and text), and control bends (red symbols and text), as of February 2018. Source: Dane Morris, USACOE	345
Figure 60. Map of the 29 chute-based Shallow Water Habitats (SWHs) on the lower Missouri River.	353
Figure 61. Proposed sequencing of actions and studies for spawning habitat, revised from USFWS and USACOE (2015) to reflect current USFWS priorities and timelines.	357
Figure 62. Spawning locations of pallid sturgeon in the Lower Missouri River, 2007-2015 (Kim Chojnacki, USGS, pers. comm.).	359
Figure 63. Decision tree for spawning habitat. Source: USFWS and USACOE (2015)	368
Figure 64. Current schedule for implementation of actions in the Upper Missouri River, revised from USFWS and USACE (2015) to reflect the preferred alternative and current USFWS priorities and timelines, and described in sections 4.2.5 of this report. Arrows represent flexibility in the timing of implementation. This figure is an illustration of the intended implementation schedule. There may be further adjustments in the schedule. In-river actions at Level 2 and Level 3 are shown in bolded blue text. Changes since AMP V6 are shown in light blue.	389
Figure 65. Current schedule for implementation of actions in the Lower Missouri River, revised from USFWS and USACE (2015) to reflect the preferred alternative and current USFWS priorities and timelines, and described in section 4.2.6 of this report. Arrows represent flexibility in the timing of implementation. This figure is an illustration of the intended implementation schedule. There may be further adjustments in the schedule. In-river actions at Level 2 and Level 3 are shown in bolded blue text. Changes since AMP V6 are shown in light blue.	390
Figure 66. ProACT process used to identify, evaluate and iterate through alternative suites of actions to identify a preferred alternative	408
Figure 67. NEPA process flowchart.	415
Figure 68. Example of online observed, real time and forecast flow and stage information,	423
Figure 69. Flow of information and guidance between the Lead agencies, HC Work Group and MRRIC	438
Figure 70. Draft HC concern routing flowchart	439
Figure 71. A conceptual model depicting the management of data to inform the MRRP.	461
Figure 72. Conceptual Architecture for the MRRP DSS.	467

Tables

Table 1. Critical uncertainties related to bird management actions and associated management hypotheses.....	24
Table 2. Summary of standardized and available ESH acreage targets. Note that targets are subject to change as dictated by new scientific information	26
Table 3. Matrix for characterizing status and needs for ESH acreage and bird population. FR = Fledge Ratio (Number of fledglings observed / [number of breeding adults/2]); λ = lambda (population size in current year / population size in previous year).	28
Table 4. Big Questions and hypotheses for Level 1 and 2 components for the Upper Missouri River. Hypotheses are from Table 1 in Jacobson et al. (2016a). Note that Big Question 6 hypotheses are examples, since Rangewide Stocking and Augmentation Plan may pose different hypotheses.....	33
Table 5. Big Questions and hypotheses for Level 1 and 2 components for the Lower Missouri River. Note that Big Question 6 hypotheses are examples, since Rangewide Stocking and Augmentation Plan may pose different hypotheses.	35
Table 6. Pallid sturgeon framework for the lower Missouri River.	37
Table 7. Summary of time limits for implementation and scope of actions.....	41
Table 8. Factors enabling and inhibiting good governance of AM programs.....	54
Table 9. Summary of roles and responsibilities of entities involved with implementing the MRRP. Not all entities are represented. See following sections and attachments to Appendix A for additional details.	67
Table 10. Examples of decisions and responsibilities at the Oversight level.....	71
Table 11. Composition of the Management Team.	72
Table 12. Decisions, recommendations and other responsibilities of the Management Team.	73
Table 13. Composition of the Bird and Fish Teams.....	75
Table 14. Decisions, recommendations and other responsibilities of the Bird and Fish Teams.....	76
Table 15. Composition of the HC Team.....	78
Table 16. HC Issues Tracking Table maintained by the HC Team.	79
Table 17. Responsibilities of the Technical Team.	83
Table 18. Missouri River bird habitat segments, habitat types, river miles (RM), and segment length.	146
Table 19. Critical uncertainties related to bird management actions evaluated in the EA and associated management hypotheses.	157
Table 20. Summary of management actions for birds, their primary mechanism, whether they have been evaluated for the MRRMP-EIS and in which alternatives, and whether or not they have been included in the preferred alternative in the EIS. References to the section of this document in which the action can be found are also listed.	176
Table 21. Potential questions and study summaries for ESH construction research and active AM.....	179
Table 22. Potential questions and study summaries for sandbar augmentation and, modification research and active AM.	181
Table 23. Questions and study summaries for vegetation management research and active AM.....	183
Table 24. Potential questions and study summaries for research and active AM regarding flow management to reduce take.....	186
Table 25. Questions and study summaries for predation control research and active AM.....	188

Table 26. Questions and study summaries for human restrictions measures research and active AM.	189
Table 27. Potential questions and study summaries for habitat-creating flow research and active AM.	192
Table 28. Questions and study summaries for lowered nesting-season flow research and active AM.	196
Table 29. Questions and study summaries for non-sandbar habitat creation research and active AM.	200
Table 30. Questions and study summaries for reservoir water level management research and active AM.	201
Table 31. Effects of pallid sturgeon management actions on piping plovers and least terns	203
Table 32. Action effectiveness monitoring needs for vegetation management actions	215
Table 33. Target and observed available habitat exceedance years and acreages (2006-2017). Targets are met if the observed acres exceeded are greater than the median target acres, within each row, for each region. Likewise, when targets are met, the observed number of years will be equal to or greater than the target years. Shaded cells indicate the target is met.	217
Table 34. Status-and-needs matrix for ESH and birds. The population status and habitat action needs depend on whether the population is growing, stable, or declining based on growth rate (λ) and fledge ratio (FR) and the ESH acreage relative to targets. Bold text indicates the status relative to the targets. The cell color summarizes the status and needs: dark green = objectives are being met and current management (habitat creation rates) should continue; light green = management objectives are exceeded and management can be reduced; yellow = species may be on or near the path to meet objectives, but management increases may be necessary; orange = objectives are not being met and unlikely to be met and management must increase; red = objectives will definitely not be met and strong increases in management must occur.	225
Table 35. Summary of management condition constraints and opportunities relative to management actions.	229
Table 36. Example five-year mean compliance rates for standard ESH, plover fledge ratio, and plover population growth rate. Results are coded by color according to quintile: the top 20% is dark green, the lowest 20% is red, the middle 20% is yellow, etc.	241
Table 37. Findings from Effects Analysis for Upper Missouri River hypotheses.	276
Table 38. Findings from Effects Analysis for Lower Missouri River hypotheses.	278
Table 39. Pallid sturgeon framework for the lower Missouri River (same as Table 6)	287
Table 40. Current status of actions under consideration for both the Upper and Lower Missouri River, and relative priority of investigations at each level. Details of the formulation of alternatives and the rationale for decisions on these alternatives can be found in the Final MRRMP-EIS.	290
Table 41. Supplemental lines of evidence strategy for triggering Level 3 implementation. See above text.	293
Table 42. Summary of time limits for implementation and scope of actions.	294
Table 43. Overview of highest priority Level 1 and 2 science components for the Upper Missouri, anticipated to be completed within the first five years of the Record of Decision (ROD) (subject to budget and resource constraints). Appendix C contains a complete list of all Level 1 and 2 components, and Appendix F describes the prioritization process. Components listed in Appendix C but not in this table could be implemented beyond the 5-year, post-ROD period. Metrics and decision criteria with associated degrees of certainty for the working management hypotheses are summarized from Appendix C. Categories for Degree of Certainty: 1 = Definitive, 2 = Statistically rigorous, 3 = Indicative but not authoritative, 4 = Expert judgment of multiple lines of evidence required. BQ = Big Question, L = Level, C = Component (e.g., BQ1/L1/C2 is Big Question 1, Level 1, Component 2). Hypotheses under BQ6 are examples subject to	

change according to Recovery Team discussions and the Range-Wide Stocking and Augmentation Plan. Hypotheses are from Table 1 in Jacobson et al. 2016a.	299
Table 44. Overview of highest priority Level 1 and 2 science components for the Lower Missouri, anticipated to be completed within the first five years of the Record of Decision (ROD) (subject to budget and resource constraints). Appendix C contains a complete list of all Level 1 and 2 components, and Appendix F describes the prioritization process. Components listed in Appendix C but not in this table could be implemented beyond the 5-year post-ROD period. Metrics, and decision criteria with associated degrees of certainty for the working management hypotheses are summarized from Appendix C. Categories for Degree of Certainty: 1 = Definitive, 2 = Statistically rigorous, 3 = Indicative but not authoritative, 4 = Expert judgement of multiple lines of evidence required, BQ = Big Question, L = Level, C = Component. (e.g., BQ1/L1/C2 is Big Question 1, Level 1, Component 2). Hypotheses under BQ6 are examples subject to change according to Recovery Team discussions and the Range-Wide Stocking and Augmentation Plan. Hypotheses are from Table 1 in Jacobson et al. 2016a.	304
Table 45. Summary of focal questions and testable hypotheses for evaluating effectiveness of passage improvements at Intake Diversion Dam.	316
Table 46. Summary of monitoring activities, supporting field protocols, studies, and metrics as aligned with focal questions and testable hypotheses.	320
Table 47. Proposed monitoring activities and related sampling design considerations.	322
Table 48. Summary of the monitoring questions for Intake and the decision relevance of different answers to these questions.	332
Table 49. Biological data collections at IRC and control bends. 'X' represents site-years where monitoring occurs. Shaded boxes indicate the year in which construction will be initiated; CT refers to the control site.	342
Table 50. Types of surveys and analyses proposed for physical habitat in Interception-Rearing Complexes.	344
Table 51. Summary of focal questions and associated testable hypotheses, stated as alternative hypotheses that represent the preferred outcome.	358
Table 52. Summary of monitoring activities, supporting field protocols / related studies, and metrics as aligned with the testable hypotheses.	361
Table 53. Proposed monitoring activities and related sampling design considerations.	363
Table 54. Decision criteria to guide the interpretation of results from Level 2 spawning habitat construction.	369
Table 55. A summary of guidance for decision-making based on results of Level 2 spawning habitat construction.	370
Table 56. Proposed characteristics of Level 3 spawning cue pulses.	373
Table 57: Summary of focal questions and associated testable hypotheses, stated as alternative hypotheses that represent the preferred outcome.	374
Table 58. Summary of monitoring activities, supporting field protocols / related studies, and metrics as aligned with the testable hypotheses.	376
Table 59. Proposed monitoring activities and related sampling design considerations.	378
Table 60. Evidentiary Framework for flow observations. This decision aid is intended to determine if sufficient spawning-cue pulse events occur during the first nine years of implementation post ROD, and if an explicitly managed spawning-cue pulse release should be implemented after the ninth year to test flow hypotheses.	384
Table 61. Preliminary and qualitative assessment of the effects of bird actions on pallid sturgeon habitats and populations.	386

Table 62. Summary of the broad alignment of Appendix E, focal questions and the various effectiveness monitoring activities proposed for the upper and lower Missouri River. Focal questions that will guide decision making (Q1, Q2, ...) are summarized in Table 68.	393
Table 63. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of interception and rearing complexes.	394
Table 64. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of modifications to shallow water habitats.	395
Table 65. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of spawning habitat projects.	396
Table 66. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of spawning cue pulses.	398
Table 67. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of passage at Intake Diversion Dam.	399
Table 68. Summary of focal questions to be applied to the currently proposed set of actions in Section 4.2.5 and 4.2.6. Hypotheses listed in first column are those most relevant to the action, as discussed in section 4.2. The sections listed in the first column provide more details on the decision criteria for each action.	403
Table 69: Summary of proxies used during the development of the MRRMP-EIS	410
Table 70. Work product and other forms of information access.	469
Table 71. USACE Proposed Action (Actions Completed in 20XX).....	488
Table 72. 2018 BiOp Conservation Recommendations Annual Reporting Form	489
Table 73. Section 7(a)(1) Conservation Plan Annual Reporting Summary.	490

Preface

This report presents the Science and Adaptive Management Plan (SAMP) for the Missouri River Recovery Program (MRRP), submitted along with the Missouri River Recovery Management Plan-Environmental Impact Statement (MRRMP-EIS) in 2018. Periodic revision of this document is anticipated in accordance with the processes outlines in Chapter 2. Interim updates to the document will be noted on the “Addendum and Version Log” on the following page.

The authors have utilized the actions included in the EIS (EIS) to illustrate the concepts, methods and decision criteria necessary to an AM Plan for the MRRP. These actions include those proposed in Planning Aid Letters (PALs) from the U.S. Fish and Wildlife Service (USFWS). Discussion of these actions in this report does not constitute selection of any potential actions; their inclusion is merely to help demonstrate how AM might be implemented for various actions.

We gratefully acknowledge the following individuals for their assistance in the preparation and technical review of this report: Robb Jacobson of the USGS; Chantel Cook, Mark Harberg, Coral Huber, Ryan Larsen, Dan Pridal, Aaron Quinn, Clayton Ridenour, Randy Sellers, Brad Thompson, and Tim Welker of the USACE Omaha District; Todd Gemeinhardt of the USACE Kansas City District; Doug Latka and Mary Roth of the USACE Northwestern Division; Wyatt Doyle, Rob Holm, Steven Krentz, Casey Kruse, Landon Pierce, Dane Schuman, Carol Smith, Jordan Smith, Wayne Nelson-Stastny, and Ryan Wilson of the USFWS; Paul De Morgan of RESOLVE, Tom St. Clair of Louis Berger and Associates, and Natascia Tamburello of ESSA; David Adams, Justin Haas, Gerald Mestl and Kirk Steffensen of the Nebraska Game and Parks Commission; the Pallid Sturgeon EA Team; the Upper Bain Pallid Work Group; Sarah Miller and Bruce Pruitt of the ERDC EL; Michelle Klose, on behalf of a consortium of state representatives; and members of the AM ad hoc Task Group and MRRIC members at large who provided review comments.

Addendum and Version Log

Version (current on top):**Release Date****Draft SAMP Version 7****31 May, 2018****Addenda Since Last Version:****Release Date**

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
foot-pounds force	1.355818	joules
gallons (U.S. liquid)	3.785412 E-03	cubic meters
hectares	1.0 E+04	square meters
inches	0.0254	meters
inch-pounds (force)	0.1129848	newton meters
microns	1.0 E-06	meters
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
miles per hour	0.44704	meters per second
ounces (mass)	0.02834952	kilograms
pounds (force)	4.448222	newtons
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
pounds (mass) per square foot	4.882428	kilograms per square meter
pounds (mass) per square yard	0.542492	kilograms per square meter
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
tons (force)	8,896.443	newtons
tons (long) per cubic yard	1,328.939	kilograms per cubic meter
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

Abbreviations

AAMR	Annual Adaptive Management Report
AAR	After Action Report
AM	Adaptive Management
ANOVA	Analysis-of Variance
API	Application Program Interface
BA	Before-After
BACI	Before-After-Control-Impact
BiOp	Biological Opinion
BSNP	[Missouri River] Bank Stabilization and Navigation Project
CEM	Conceptual Ecological Model
CEP	Critical Engagement Point
cfs	Cubic Feet per Second
CI	Confidence Interval
CJS	Cormack-Jolly-Seber
CORE	Cooperating for Recovery Team
CPUE	Catch Per Unit Effort
CWA	Clean Water Act
CWT	Coded Wire Tag
DEIS	Draft Environmental Impact Statement
DOI	Department of the Interior
DQO	Data Quality Objectives
EA	Effects Analysis
EIS	Environmental Impact Statement
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act
ESC	Executive Steering Committee
ESH	Emergent Sandbar Habitat
FEIS	Final Environmental Impact Statement
FWG	Federal Working Group
FY	Fiscal Year
FY+1	The next Fiscal Year (FY+2 is the year after next, etc.)

HAMP	Habitat Assessment and Monitoring Program
H&H	Hydrology and Hydraulics
HQUSACE	Headquarters of the U.S. Army Corps of Engineers
IDM	Information Data Management
IP&S	Integrated Planning and Science
IRCs	Interception and Rearing Complexes
ISAP	Independent Science Advisory Panel
ISETR	Independent Social Economic Technical Review Panel
ISP	Integrated Science Program
ISPMT	Integrated Science Program Management Team
kcfs	thousand cubic feet per second
Master Manual	Missouri River Basin Mainstem Reservoir System Master Water Control Manual
Mitigation ACT	Mitigation Project Agency Coordination Team
MRBWMD	Missouri River Basin Water Management Division
MRRIC	Missouri River Recovery Implementation Committee
MRRMP	Missouri River Recovery Management Plan
MRRRP	Missouri River Regional Review Panel
MRRP	Missouri River Recovery Program (also Program)
NEPA	National Environmental Policy Act
NRC	National Research Council
NWD	Northwestern Division
NWO	Omaha District
NWK	Kansas City District
O&M	Operation and Maintenance
PA	Programmatic Agreement
Panel	Independent Science Advisory Panel (combined ISAP/ISETR)
P-bud	President's budget for FY+1
PDT	Project Delivery Team
PIR	Project Implementation Report
PIT	Passive Integrated Transponder
PM	Project Manager
PMBP	Project Management Business Process
PgM	Program Manager
PNNL	Pacific Northwest National Laboratories

PrOACT	Problem Definition, Objectives, Alternatives, Consequences, Tradeoffs
PSPAP	Pallid Sturgeon Population Assessment Program
QA/QC	Quality Assurance and Quality Control
QAPP	Quality Assurance Project Plan
Reclamation	U.S. Bureau of Reclamation
RM	River Mile
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measure
RPMA	Recovery Priority Management Area
SAM	Science and Adaptive Management workgroup
SAMP	Science and Adaptive Management Plan
SDM	Structured Decision Making
SP	Strategic Plan
SPA	Strategic Programmatic Assessment task group
SPDT	Senior Project Delivery Team
SWH	Shallow Water Habitat
System	Missouri River Mainstem Reservoir System
TBD	To Be Determined
T&E	Threatened and Endangered
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WG	Work Group
WRDA	Water Resources Development Act

Glossary

Accounts –Human Considerations objectives and performance criteria are organized into four accounts in accordance with U.S. Army Corps of Engineers Planning Guidelines. The four accounts are as follows:

- Environmental Quality (EQ)
- National Economic Development (NED)
- Regional Economic Development (RED)
- Other Social Effects (OSE)

Active adaptive management – The active form of AM employs management actions in an experimental design aimed primarily at learning to reduce uncertainty; near-term benefits to the resource are secondary.

Adaptive action – A course of action to be implemented as defined in the Adjust step (Step 5b of the AM process) if the performance of a particular management action is not as anticipated and requires correction. In cases where the action is pre-defined, it is referred to as a “contingency action.”

Adaptive Management (AM) – Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes advances scientific understanding and helps adjust policies or operations as part of an iterative learning process.

Alternatives –A specified combination of management actions that collectively are deemed to meet minimum performance levels for the endangered species. In the Problem Definition, Objectives, Alternatives, Consequences, Tradeoffs (PrOACT) process, the trade-offs associated with various alternatives on multiple interests are explored in order to find the alternative(s) that minimize unnecessary negative impacts and is/are otherwise thought to be the “best balance” of impacts on a wide range of interests. Alternatives are used to address the objectives.

AM Report – Annual or periodic report that documents new learning based on monitoring results, evaluates progress towards meeting species objectives, and contains recommendations for adjustments to management actions. The Annual AM Report is contained with the Annual Report on Biological Opinion (BiOp) compliance.

Annual Work Plan (AWP) – This document includes real estate actions, habitat creation actions, monitoring of physical and biological responses to actions, and research activities for a particular year within the five-year Strategic Work Plan. It is used by product delivery teams to budget and implement management actions annually.

Biological Assessment (BA) – information prepared by, or under the direction of, a Federal agency concerning listed and proposed species and designated and proposed critical habitat that may be present in the action area and the evaluation of potential effects of the action on such species and habitat.

Biological Opinion (BiOp) – Document stating the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS) opinion as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat. Specifically in the MRRP, the USFWS 2018 Biological Opinion (BiOp) found that the operation of the Missouri River Mainstem Reservoir System (System), the operation and maintenance of the Missouri River Bank Stabilization and Navigation Project (BSNP), the Operation of Kansas River Reservoir System, and the Implementation of the Missouri River Recovery Management Plan would not jeopardize the continued existence of the pallid sturgeon, piping plover, and interior least tern if the proposed management actions are implemented, including this SAMP. This SAMP was considered a component of the Proposed Action upon which the USFWS based their opinion. Earlier Biological Opinions (in 2000 and 2003) on the MRRP are referred to by their year in this document (e.g. 2003 BiOp).

Conceptual Ecological Models (CEMs) – CEMs are graphical depictions of an ecosystem that are used to communicate the important components of the system and their relationships. They are a representation of the current scientific understanding of how the system works.

Contingency action – A pre-evaluated adaptive action that is implemented when triggered by defined decision criteria without the need for further deliberation or decision.

Critical uncertainties – Uncertainties that impede the identification of a preferred alternative management action.

Critical Engagement Point (CEP) – Specific points in the formulation or implementation phases of AM when the agencies engage with the Missouri River

Recovery Implementation Committee (MRRIC) for input. These can be concurrent with, or in addition to, routine MRRIC plenary meetings.

Decision context – Involves defining what decision (question or problem) is being made, why it is being made, and also describing the scope of the playing field (bounds) for the management decision as well as its relationship to other decisions previously made or anticipated.

Decision criteria – Broadly refers to the set of pre-determined criteria used to make AM decisions. Performance metrics, targets, and decision triggers are considered to be different types of decision criteria. They can be qualitative or quantitative based on the nature of the performance metric and the level of information necessary to make a decision.

Decision space – A term used to characterize a range of operational discretion for flows (or potentially other actions) that is “acceptable” to stakeholders, effective in achieving objectives, and within the bounds of actions evaluated under NEPA. Management actions would generally occur within this region, and any operation outside this decision space would require further coordination and approval.

Decision trigger – Decision triggers are pre-defined commitments (population or habitat metric for a specific objective) that trigger a change in a management action. Decision triggers are addressed in the Evaluate step (Step 4 of the AM process) specifying the metrics and actions that will be taken if monitoring indicates performance metrics are or are not reaching target values. In some cases, a decision trigger may be learning a new piece of information that triggers the Continue/Adjust/Complete step (Step 5 of the AM process).

Delphi process – The Delphi process is a method of eliciting expert opinion (Normand et al. 1998). While many variations of the process exist, there are generally three common features: (1) qualified experts provide their responses to a set of questions in a structured format; (2) the answers to these questions are synthesized across all respondents and presented back to the same set of experts; and (3) the experts jointly discuss the reasons for variation in the first set of responses (or lack thereof), and through dialogue potentially revise their opinions. A modified Delphi process was applied by Jacobson et al. (2016b) to prioritize candidate hypotheses.

Effects Analysis (EA) – The purpose of this effort is to conceptually and quantifiably make explicit the effects of operations and actions on the listed species by specifically evaluating the effects of hydrologic and fluvial processes on the Missouri River, as well

as ongoing management actions, on the status and trends of the listed species (piping plover, interior least tern, and pallid sturgeon) and their habitats.

Environmental Impact Statement (EIS) – A document which summarizes and analyzes environmental impacts of a proposed action and alternatives.

Evaluation – Conduct analyses to compare measured results with anticipated outcomes related to decision criteria for specific management actions to determine whether the implementation should be continued, adjusted, or completed.

Event-driven reporting cycle – In addition to the annual and periodic AM reports (on a routine reporting schedule), reporting may also be event- driven, where new observations or data resulting from an unforeseen event suggest a decision trigger or targets have been reached.

First increment – The suite of proposed actions evaluated in the Management Plan/ EIS that are anticipated to be implementable in the foreseeable future (~10 – 15 years). The First Increment will include actions for pallid sturgeon for Levels 1 through 3 of the Lower Pallid Framework to ensure NEPA coverage for future implementation.

Formal consultation - A process between the USFWS or NMFS and a Federal agency that commences with the Federal agency's written request for consultation under Section 7(a)(2) of the Act and concludes with the USFWS/NMFS issuance of the biological opinion under Section 7(b)(3) of the Act.

Fundamental objectives – Fundamental objectives are used to formalize the desired outcome of the program in terms of biological response. They are derived to achieve avoidance of jeopardizing the three species from USACE actions on the Missouri River and articulate the ends the program is trying to achieve.

Global hypotheses – Set of possible, biologically important hypotheses, relevant to population dynamics that are derived from conceptual ecological models.

Human Considerations (HCs) – A set of objectives with associated metrics and proxy metrics that are related to the wide array of uses and stakeholder interests on the Missouri River. They form the basis for some of the monitoring and decision criteria in the AM Plan.

Hypotheses reserve – A concept that seeks to explicitly manage the broad suite of hypotheses developed through the (EA) and highlighted in the CEM. In this concept

hypotheses can be brought forward or moved back into reserve as information and understanding directs. The hypotheses reserve concept includes (1) hypotheses that are not deemed important to investigate at this time, (2) have high uncertainty and require further investigation, and/or (3) are outside USACE authority.

Initially modeled hypotheses – Subset of working management hypotheses determined by the USACE to be within jurisdiction and applicable authorities, and therefore selected for modeling in Phase 1 of the (EA).

Integrated Science Program (ISP) – The component of the MRRP that is responsible for conducting scientific monitoring and investigations. The ISP monitors federally listed species under the Endangered Species Act (ESA), the habitats upon which they depend, and researches and monitors critical uncertainties.

Interests (interest area) – In MRRIC, the interest areas are categories of values that people have said are important (e.g., agriculture, hydropower, cost).

Implement – Implementation of the selected alternative.

Implementation level (or Level) – Refers to one of four classifications of action that could be implemented to assist pallid sturgeon as part of the MRRP (see also *Pallid Sturgeon Framework*). The levels include the following:

- **Level 1: Research** – Studies without changes to the system (laboratory studies or field studies under ambient conditions).
- **Level 2: In-river testing** – Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.
- **Level 3: Scaled implementation** – A range of actions not expected to achieve full success, but which yields sufficient results in terms of reproduction, numbers, or distribution to provide a meaningful population response and indicate the level of effort needed for full implementation.
- **Level 4: Ultimate required scale of implementation** – Implementation to the ultimate level required to remove an issue.

Investigations – Research activities that are intended to generate information that will fill the key gaps in understanding and reduce uncertainty associated with implementation of management actions.

Jeopardy – As defined by the Endangered Species Act (ESA), jeopardy occurs when there is an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

Limiting factor – A factor that controls the growth, abundance, or distribution of an organism. For example, factors that limit the survival of terns, plovers, and pallid sturgeon have been identified and serve to identify and organize potential management actions.

Lower Missouri River – The reach of the river downstream of Gavins Point Dam (RM 810) as it pertains to management for pallid sturgeon.

Management actions – Proposed or potential actions to be taken by the USACE to address species needs on the Missouri River. Management actions were prescribed by the USFWS 2003 Amended Biological Opinion as Reasonable or Prudent Alternatives or actions outside the BiOp if necessary to achieve species objectives.

Management hypotheses – Statements (in affirmative hypothesis form) that a specific management action will be effective in eliminating factors that are thought to be limits to population growth.

Missouri River Recovery Management Plan (MRRMP; also MRRMP-EIS or Management Plan) – A suite of management actions designed to avoid a finding of jeopardy to piping plovers, interior least terns, and pallid sturgeon, thereby permitting the continued operation of the Missouri River reservoir System and the Bank Stabilization and Navigation Program (BSNP). It includes actions proposed by the Missouri River Recovery Implementation Committee, and complies with the National Environmental Policy Act (NEPA) and other statutory mandates, regulatory requirements, and authorizations. MRRMP may also refer to the 3-year process to programmatically evaluate the MRRP and develop a suite of actions that meet ESA responsibilities. The Management Plan or MRRMP-EIS are umbrella terms that include the MRRMP, the Environmental Impact Statement (EIS), and the SAMP.

Means objectives – Describe ways of achieving the fundamental objectives and specify the way and degree to which the fundamental and sub-objectives can be achieved. They are used to further develop management actions and alternatives and are potentially useful in tracking progress towards fundamental objectives in the near-term when a response in the fundamental objectives may not be detectable in shorter time frames due to a delayed species response to management actions or other reasons.

Monitoring – In the context of the MRRP AM Plan, monitoring is the process of measuring attributes of the ecological, social, or economic system. Monitoring has multiple purposes, including: to provide a better understanding of spatial and temporal variability, to confirm the status of a system component, to assess trends in a system component, to improve models, to confirm that an action was implemented as planned, to provide the data used to test a hypothesis or evaluate the effects of a management action, and to provide an understanding of a system attribute that could potentially confound the evaluation of action effectiveness.

MRRP Science and Adaptive Management Plan – The purpose of the SAMP is to describe a formal AM process led by the USACE and USFWS in implementing the Missouri River Recovery Program (MRRP or Program).

National Environmental Policy Act (NEPA) – Requires Federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet NEPA requirements, Federal agencies may be required to prepare an EIS.

Naturalization of the flow regime – Naturalization of the flow regime involves incremental changes that move the flow regime towards the hydrological attributes that would exist in the absence of dams and reservoirs, while recognizing social and economic constraints. It does not mean matching the unaltered, historical flow regime. Generally, naturalization refers to the process of using characteristics of the natural ecosystem to guide elements of river restoration, but constrained by social and economic values (Rhoads et al. 1999; Jacobson and Galat, 2008).

No-action alternative – When addressing on-going programs, the Council on Environmental Quality defines no action as “no change” from current management direction or level of management intensity. The MRRP No Action Alternative, therefore, may be thought of as continuing with the courses of action being executed at the time the Notice of Intent for the EIS was published.

Objectives – Objectives define an endpoint of concern and the direction of change that is preferred. Objectives are concise statements of the interests that could be affected by a decision — the “things that matter” to people. In ProACT, objectives typically take a simple form such as minimize costs and increase population number, increase habitat availability.

Pallid sturgeon framework– An organization of Missouri River pallid hypotheses that allows for the description of activities (research to management actions), decision criteria, uncertainty, risk, impacts, costs, time frame, and constraints.

Passive adaptive management – In passive AM, management actions are focused on achieving resource objectives; development of knowledge through monitoring and assessment for improved decision making is secondary.

Performance metric – A specific metric or quantitative indicator that is monitored and can be used to estimate and report consequences of management alternatives with respect to a particular objective. There are specific species, habitat, and economic performance metrics in the SAMP.

Preferred alternative – The preferred alternative is the alternative that the agency believes would best fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical, and other factors.

PrOACT decision-making model – An organized, structured decision-making approach to identifying and evaluating creative options and making choices in complex decision situations. PrOACT is a decision analysis approach currently employed by the USACE in the development of the Missouri River Recovery Management Plan. It is a technique used to provide analytical structure and rigor to values-based questions by clarifying the consequences of alternate solutions, including the impacts on multiple objectives. The unifying features of PrOACT analyses are that they involve: (1) clarifying the Problem to be solved, (2) listing Objectives to be considered (usually with associated performance metrics), (3) developing Alternative solutions to the problem as stated, (4) estimating the Consequences of each of the alternatives on each of the objectives in terms of the metrics (usually in the form of a consequence table of alternatives versus objectives) and (5) explicitly evaluating the Trade-offs that are revealed to exist between the alternatives, usually in a discursive setting.

Problem – A question or concern that is being addressed in the decision-making process.

Program – The “Program” refers to those elements that are at the level of the overall Missouri River Recovery Program such as the Work Plan and the Program Management Plan.

Project Implementation Report (PIR) – Contains site-specific information, alternative designs and project features, the anticipated benefits of the project, and

documentation for compliance with the National Environmental Policy Act (NEPA) disclosing the potential affects to the quality of the human environment from project implementation.

Project Management Business Process (PMBP) – USACE approach for the planning, development, and management of projects and programs.

Proxy metric – Type of performance metric. Generally, a proxy metric is an indirect metric used to represent a natural metric like population number (e.g., number of boat ramp days). Proxy criteria are those that correlate well with objectives that are otherwise difficult to measure or estimate.

Quantitative predictive models – Numerical models used to predict biological and ecological responses as a function of management or restoration actions.

Recovery plan - A document drafted by the Service or other knowledgeable individual or group that serves as a guide for activities to be undertaken by Federal, state, or private entities in helping to recover and conserve endangered or threatened species.

Risk – An uncertainty coupled with an adverse consequence, ideally expressed as the product of the two components, with uncertainty represented as a probability.

Section 7 - The section of the Endangered Species Act that requires all Federal agencies, in "consultation" with the Service, to ensure that their actions are not likely to jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat.

Selected alternative – the alternative identified in the ROD that the agency intends to implement

Spawning habitat – Functional spawning habitat produces a successful hatch of embryos. For successful hatch to take place, hydraulics and substrate must be conducive first to attraction and aggregation of reproductive adults, followed by egg and milt release, fertilization, and deposition of eggs in a protected environment.

Species objectives – see fundamental and means objectives.

Strategic Plan – A rolling, five-year implementation plan for the MRRP that is updated annually following the AM Workshop. It outlines major program elements, including the project development and construction, monitoring, research, assessment

and collaborative engagements, and includes a discussion of program risks and risk management actions.

Strategy table – A visual tool for combining management actions into thoughtfully crafted alternatives.

Structured Decision Making (SDM) – Organized approach to identifying and evaluating creative options and making choices in complex decision situations. It is used to inform difficult choices, and to make them more transparent and efficient. ProACT is a specific application of SDM to collaborative problem solving.

Sub-objectives – The sub-objectives are aspects of the fundamental objective described in more detail that need to be addressed to achieve the fundamental objective. They are intended to provide direction in the short term, provide objectives meaningful for AM, and focus efforts on the desired short-term outcomes while contributing to the fundamental objective.

Success criteria – A qualitative or (preferably) quantitative description of the conditions for which the parties agree that the objectives have been sufficiently met. Usually expressed in terms of the performance metrics.

Target – Targets are a specific value or range of performance metric that define success. Targets can be quantitative values or overall trends (directional or trajectory).

Trade-offs (also Trade-off analysis) – A trade-off occurs when one alternative performs well on one metric but poorly on another relative to another alternative. Reasonable people may disagree about which is the best alternative because they value the two metrics differently; thus, value trade-offs involve making judgments about how much you would give up on one objective in order to achieve gains on another objective. By analyzing trade-offs, the ProACT process tries to help find the alternative that (1) eliminates unnecessary trade-offs and (2) that people agree is the “best balance” of trade-offs possible.

Trigger – A form of decision criteria serving as a threshold or condition that, when met, initiates some action or decision.

Uncertainty – Circumstances in which information is deficient. Learning while doing under the AM process provides a framework for reducing program uncertainties over time.

Upper Missouri River – Mainstem of the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea, and the Yellowstone River for an unspecified distance upstream of the confluence with the Missouri River.

Variability – A measure of how much a set of conditions differs from the mean or median state.

Work Plan (also Strategic Plan) – A rolling, 5-year plan outlining the management actions, monitoring, assessment, research, and engagement needs for the MRRP. It includes the details for the current FY and the FY+1 President's Budget (P-bud) and planned activities for FY+2 through FY+4 for budgeting and other purposes.

Working dominant hypotheses – Set of plausible, biologically important hypotheses, relevant to population dynamics of pallid sturgeon. Derived from importance values in conceptual ecological model, scored by expert elicitation survey.

Working management hypotheses – Set of management hypotheses linking management actions to working dominant hypotheses. Derived from pathways identified in conceptual ecological models and matched to working dominant hypotheses. Scored by expert elicitation survey.

1 Introduction

1.1 Overview, background and context

1.1.1 Overview

This introductory chapter serves as an executive summary, provides a guide to the content of the Missouri River Recovery Program (MRRP or “the Program”) Science and Adaptive Management Plan (SAMP) and its attachments. It summarizes the key points and concepts in each chapter. Parties intending to focus on only those sections of the document most relevant to their interests should review this chapter to obtain needed context. Chapter 2 describes the organizational structure and decision processes for the governance of the AM Plan. Subsequent chapters focus on the plan elements addressing the listed species (Chapters 3 and 4), stakeholder interests (Chapter 5), and describe plans for data management, reporting, and communications (Chapter 6).

One lesson from the handful of existing AM programs for large-scale ecosystem efforts is the need for early adjustments to the decision process, decision criteria, monitoring programs, data management, and reporting and communications practices. A process that demands self-evaluation, external review, and periodic assessment of potential change is warranted, and agencies and stakeholders must seek and embrace the changes needed to ensure the program’s success. Accordingly, periodic updating of sections SAMP is expected, particularly in the first several years of implementation as knowledge of what is needed for efficient and effective operation is better understood. Adjustments to the SAMP will be noted on the “Addendum and Version Log” (page xix), and readers are encouraged to reference this document by version number and/or release date.

1.1.2 Missouri River Recovery Program (MRRP)

The Missouri River (Figure 1) was significantly altered in the nineteenth and twentieth centuries, including the congressionally-authorized construction of six large reservoirs in Montana, North Dakota, and South Dakota that constitute the Missouri River Mainstem Reservoir System (System). The System is operated by the U.S. Army Corps of Engineers (USACE) for multiple purposes, including flood control, hydropower, navigation, water supply, irrigation, water quality, recreation, and fish and wildlife. Downstream of Sioux City, IA, the river was channelized, revetted, and trained to provide a self-scouring navigation channel. The USACE constructed, operates, and maintains this 1200-kilometer (km) (735-mile) reach of the river under the Bank Stabilization and Navigation Project (BSNP).

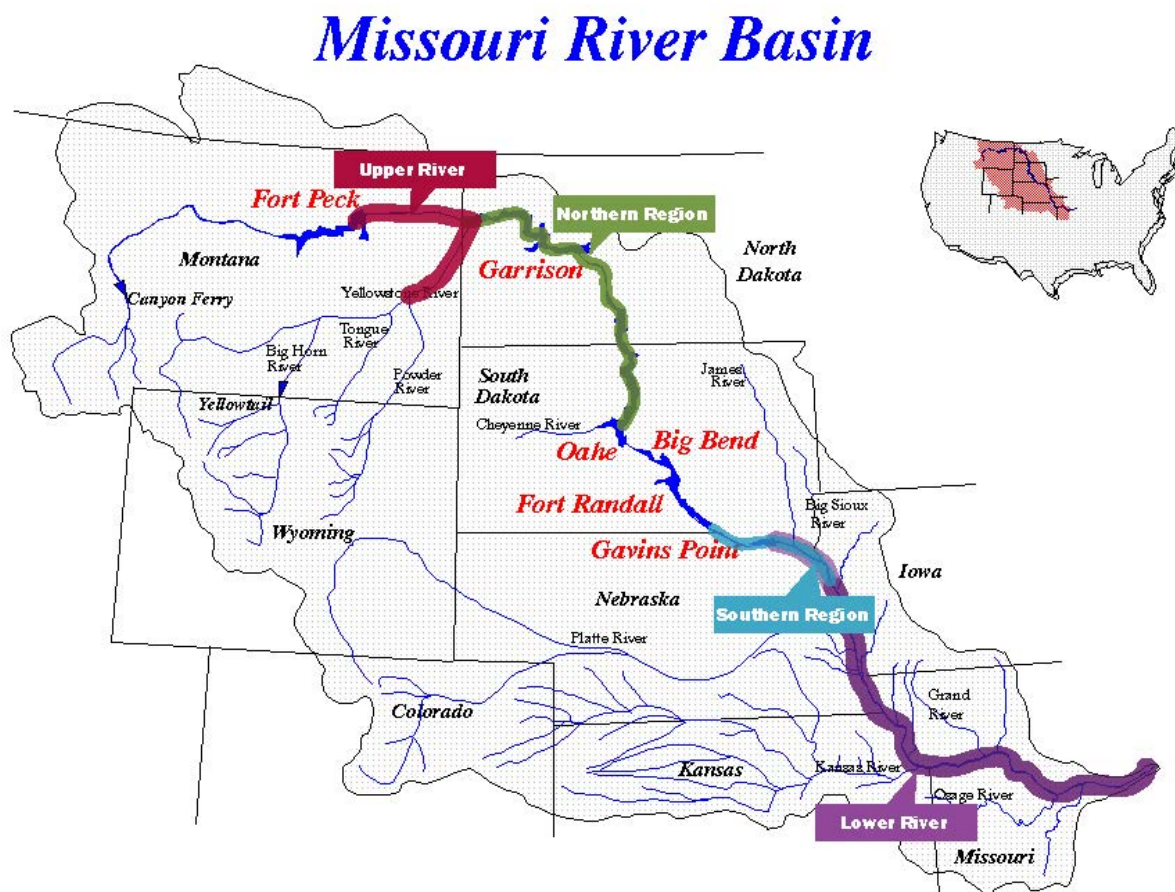


Figure 1. Missouri River Basin showing upper and lower river reaches for pallid sturgeon and northern and southern regions for the piping plover. System reservoirs labeled in red.

Substantial changes in flow and sediment loads due to the System, coupled with the physical alteration associated with the reservoirs and the BSNP, are manifest in changes to the river's channel and floodplain habitats. The river has been reduced in length by almost 320 km (200 miles), and as much as 12,000 km² (~4600 miles²) of river-corridor habitats have been lost (National Research Council, 2002; USACE, 2004; Galat et al. 2005). These changes to and losses of habitat have impacted native flora and fauna using the system, including three federally-listed species: the pallid sturgeon (*Scaphirhynchus albus*), interior least tern (*Sternula antillarum athalassos*), and the piping plover (*Charadrius melodus*) (U.S. Fish and Wildlife Service [USFWS] 2000).

The U.S. Fish and Wildlife Service (USFWS) issued a Biological Opinion (BiOp) in 2000 (see Figure 2 for an abbreviated event timeline) that found the USACE operation of the System and the operation and maintenance of the BSNP would jeopardize the continued

existence of the pallid sturgeon, interior least tern, and piping plover (USFWS 2000¹). This 2000 BiOp, which applies to the portion of the Missouri River from Fort Peck, MT, to St. Louis, MO, and identified a Reasonable and Prudent Alternative (RPA) to jeopardy consisting of several actions to be taken by the USACE. New data were obtained regarding terns and plovers and RPA II (Flow Enhancement), and the USACE requested re-initiation of formal consultation and provided a biological assessment with new proposed actions to replace the spring and summer flows element.

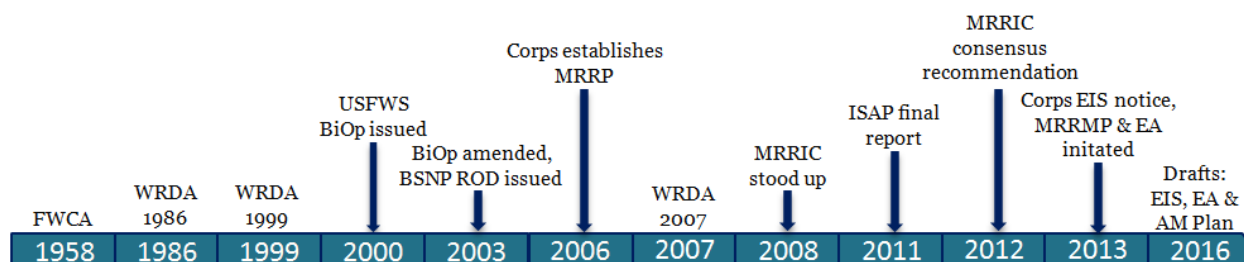


Figure 2. Summary timeline of key events leading to the development of this Science and AM Plan.

In 2003, the USFWS provided a determination that the additional actions proposed by the USACE would avoid jeopardizing the continued existence of the two listed bird species, but continued to appreciably reduce the likelihood of both survival and recovery of the pallid sturgeon, thus jeopardizing its continued existence in the wild (USFWS 2003; see Figure 2). The 2003 BiOp also called for development of an AM framework for resource management actions on the Missouri River. Given the uncertainties faced by the MRRP, AM provides a structured, organized, coherent, and transparent process that assesses and evaluates management actions in relation to program objectives so the program can make adjustments, as needed, to increase the likelihood of achieving desired outcomes (see Section 1.1.6).

The USACE established the MRRP in 2006 to implement the requirements of the BiOp and restore a portion of the Missouri River ecosystem and habitat for fish and wildlife, while maintaining the congressionally-authorized uses of the river. The MRRP consisted of the following main elements:

- construction of Emergent Sandbar Habitat (ESH) for the birds and Shallow Water Habitat (SWH) for pallid sturgeon and development and connection of low-lying lands to benefit pallid sturgeon
- changes to releases from the reservoirs

¹ Please see these documents for a more nuanced and detailed discussion of the findings.

- research, monitoring and evaluation, and AM of the management actions through an Integrated Science Program (ISP)
- acquisition of lands through the BSNP Fish and Wildlife Mitigation project, of which 66 percent were directly related to the listed species
- public involvement.

Section 5018 of the 2007 Water Resources Development Act (WRDA) established the Missouri River Recovery Implementation Committee (MRRIC), an assemblage of stakeholders representing local, state, tribal, and Federal interests throughout the Missouri River Basin, to make recommendations and provide guidance on MRRP activities. The MRRIC was stood up in 2008 and is guided by its charter and operating procedures and ground rules (see Attachments 1 and 2). The USACE and MRRIC are assisted by an Independent Science Advisory Panel (ISAP or Panel) and an Independent Social Economic Technical Review (ISETR) Panel, which afford technical oversight by providing advice on specific topics identified by the agencies and/or MRRIC.

The first set of topics presented to the ISAP dealt with expected outcomes from managed spring pulse releases from Gavins Point Dam; metrics, monitoring, investigations, and management actions; and AM. In their 2011 final report, the ISAP noted that “*there is not a comprehensive adaptive management plan for the recovery program or for other recovery program components, all of which are interconnected in their cumulative and interactive effects*” (Doyle et al. 2011). They suggested that such a plan would contain essential components of any sound AM program, including monitoring to collect the data necessary for evaluating management actions; a process to evaluate past and guide future management actions using established performance metrics and decision criteria; and a means to define success or failure. The ISAP also noted that the development of an AM plan should be preceded by and based upon an effects analysis (EA; see Section 1.1.4) that incorporates new knowledge that has accrued since the 2003 Amended BiOp was issued (Doyle et al. 2011). An important component of an EA as outlined by Murphy and Weiland (2011) is the development of an analytical framework that supports quantification of the effects of alternative management plans upon the demographics for the species of interest. This nominally requires population models for the species supported by models of the habitat and other factors affecting those demographics (see Section 1.1.5).

In August 2012, the MRRIC made a consensus recommendation to the USACE, which was based upon the ISAP’s report, and included seven proposed actions:

1. An EA should be developed that incorporates new knowledge that has accrued since the USFWS 2003 Amended Biological Opinion. As part of this analysis the following should be observed:
 - a. The effects of the Missouri and Kansas River Operations on the three listed species should be reviewed and analyzed in the context of other stressors on the listed species.
 - b. The quantitative effects of potential management actions on the three listed species should be documented to the extent possible.
 - c. These potential management actions should be incorporated into the Conceptual Ecological Models (CEMs).
2. CEMs should be developed for each of the three listed species, and these models should articulate the effects of stressors and mitigative actions (including but not limited to flow management, habitat restoration actions, and artificial propagation) on species performance.
3. Other managed flow programs and AM plans should be evaluated as guidance in development of the CEMs and the AM strategy for the MRRP.
4. An overarching AM strategy should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction, and this strategy should be used to guide future management actions, monitoring, research, and assessment activities within the context of regulatory and legal constraints.
5. Monitoring programs along the Missouri River should be designed so as to determine if hypothesized outcomes are occurring and the extent to which they are attributable to specific management actions.
6. The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
7. Aspects of how the entire hydrograph influences the three listed species should be evaluated when assessing the range of potential management actions.

The USACE and USFWS agreed to implement these consensus recommendations collaboratively with MRRIC to arrive at a new management plan for the MRRP while (a) using a “structured effects analysis” as proposed by Murphy and Weiland (2011), (b) employing an AM framework, and (c) abiding by the requirements of the National Environmental Policy Act (NEPA). The resulting process, summarized schematically in Figure 3 and described in further detail below, led to the development of this AM plan.

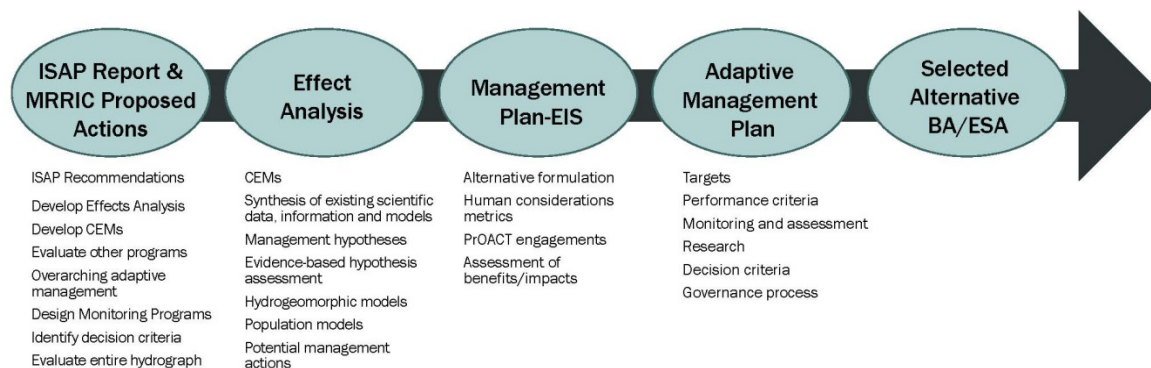


Figure 3. Schematic of the process leading to development of the draft MRRMP-EIS and this AM plan.

The USACE published a notice in the Federal Register in August 2013 to prepare an Environmental Impact Statement (EIS) for the MRRP and initiated the Missouri River Recovery Management Plan (MRRMP), a multi-year planning effort to evaluate alternatives to avoid jeopardy to the listed species in light of the findings of the EA. In December 2016, the USACE published its draft MRRMP-EIS pursuant to the National Environmental Policy Act of 1969 (USACE 2016b). The MRRMP-EIS provides a programmatic assessment of the MRRP including its impacts, cumulative effects, and alternatives to accomplish the purposes of the ESA (primarily Section 7), the 1958 Fish and Wildlife Coordination Act, section 601(a) of WRDA 1986, section 334 (a) and (b) of WRDA 1999, and section 3176 of WRDA 2007.

The MRRP used the best available science from the EA to develop the integrated MRRMP-EIS and identify a suite of actions that meets ESA responsibilities for the federally listed species using Corps' authorities (USACE 2018a). The accompanying SAMP provides the roadmap for the implementation of the selected alternative and for the identification of subsequent management needs to ultimately achieve the objectives. In addition, as a part of the Proposed Action, the USACE committed to the implementation of conservation measures and a Section 7(a)(1) plan that will further avoid and minimize effects to the listed species. Therefore, the Proposed Action will stabilize or improve the population abundance, and increase survival of the pallid sturgeon, piping plover, and interior least tern through implementation of the SAMP, conservation measures, and the Section 7(a)(1) plan.

In October 2017, USACE transmitted a letter to the USFWS requesting reinitiation of formal consultation and submitting their Biological Assessment (BA). The proposed action described in the USACE Biological Assessment submitted to the USFWS was based on the preferred alternative identified in the December 2016 draft MRRMP-EIS. USACE formally amended the Proposed Action in the 2017 BA and the SAMP in January

2018 to address new information related to pallid sturgeon condition on the lower Missouri River and to prioritize hypotheses related to flows out of Fort Peck Dam to benefit the pallid sturgeon in the upper Missouri River.

In its February 2018 draft opinion, the USFWS concluded that the Proposed Action will not jeopardize the continued existence of the pallid sturgeon, piping plover, and interior least tern and will not destroy or adversely modify designated critical habitat for the piping plover. On February 12, 2018, USACE provided a copy of the draft Biological Opinion to the U.S. Institute for Environmental Conflict Resolution for formal transmittal to the ISAP for their scientific review. Overall, the ISAP concluded that the draft biological opinion is consistent with the best available science, that there are no technical flaws that compromise the Service's determinations, and that the Service properly interpreted the data used in the draft biological opinion.

Following the ISAP review, correspondence regarding comments from the USACE, and collaboration with the MRRIC, the USFWS formally issued their Biological Opinion on April 13, 2018, concluding that the "Proposed Action will not jeopardize the continued existence of the pallid sturgeon, piping plover, and interior least tern and will not destroy or adversely modify designated critical habitat for the piping plover."

1.1.3 Purpose and scope of the MRRP

The purpose of the MRRP is to enable the USACE to operate the Missouri River System (main stem reservoirs and BSNP), in accordance with the Missouri River Master Water Control Manual, to meet its authorized purposes without jeopardizing the continued existence of three species (piping plover, least tern, pallid sturgeon) listed under the Endangered Species Act (ESA) while complying with all other laws. The MRRP is the Corp's umbrella program for the following:

- compliance with the USFWS 2018 BiOp on the operation of the Missouri River Main Stem Reservoir System (System), operation and maintenance of the BSNP, and operation of the Kansas River Reservoir System
- acquisition and development of lands as authorized by Section 601(a) of WRDA 1986 and modified by Section 334(a) of WRDA 1999 (aka, the BSNP Fish and Wildlife Mitigation Project)
- implementation of Section 3176 of WRDA 2007, extending recovery and mitigation activities on the Missouri River to the upper basin states
- Implementation of Section 5018 of WRDA 2007, establishing the MRRIC.

The MRRP is focused on implementing the requirements of the USFWS 2018 BiOp and is structured into several unique components including the following:

- construction of habitat for the listed species,
- propagation and hatchery support for the pallid sturgeon,
- research, monitoring and evaluation, and AM through an Integrated Science Program (ISP),
- collaboration with the MRRIC, and
- public involvement

The USFWS provided fundamental objectives, sub-objectives, targets, and metrics for each of the three listed species pursuant to their responsibilities for administering the ESA, and their jurisdiction and their special expertise as a cooperating agency. The Proposed Action includes the initial suite of management actions, research, and monitoring USACE would implement over the 15 years following signing of the MRRMP-EIS Record of Decision (ROD). The SAMP provides the framework for implementation, monitoring and evaluation of MRRP and adjustments as required to meet the objectives.

The need to acquire and develop riparian and aquatic habitat on 166,750 acres of land, consistent with the BSNP Fish and Wildlife Mitigation Project authorizations in WRDA 1986, 1999, and 2007, is considered still relevant and remains unchanged. Real-estate purchases for the 15-year implementation timeframe would continue to prioritize land that contributes to avoiding a finding of jeopardy, while still constituting appropriate acquisition and development under the aforementioned WRDA authorities.

1.1.4 Effects Analysis (EA) and modeling framework for the MRRP

The concept of an EA is rooted in the requirement within the ESA to use the best available science when evaluating the effects that actions proposed by federal agencies may have on listed species or designated critical habitat. Murphy and Weiland (2011) advocated for a rigorous approach to an EA that begins with a definition of the proposed action and the area affected. A conceptual model (or models) of the physical and biological relationships relating the action(s) to species outcomes is prepared. Available scientific information, including observations about the stressor and the range of stressor conditions and information on population sizes and trends, is collected and assessed for reliability. The next step includes assessment of the data, using quantitative models to integrate existing information, and identifying and representing uncertainties. The final step is to analyze the effect of proposed actions on the species to determine costs and benefits and to identify alternatives.

The USACE evaluated then ultimately adopted the ISAP's recommendations and MRRIC's corresponding proposed actions regarding the EA, and contracted with an independent team to execute the effort in August, 2013 (see Figure 2). The primary and

relevant products of the EA are summarized in a series of reports and embodied in a suite of models. Products of the EA include the following:

- Conceptual Ecological Models (CEMs) (Jacobson et al. 2015; Buenau et al. 2015)
- synthesis of existing models and scientific data/information reflecting the state of science for the species and their habitats (Jacobson et al. 2015; Buenau et al. 2015; Fischenich et al. 2015)
- hypotheses addressing critical uncertainties (Jacobson et al. 2015; Buenau et al. 2015)
- models of reservoir operations and hydraulic conditions (Fischenich et al. 2015), habitat availability (Jacobson et al. 2015; Buenau et al. 2015; Fischenich et al. 2015), and species demographics (Jacobson et al. 2015; Buenau et al. 2015)
- a variety of other papers, reports, methodologies, etc., supporting the development of species targets, management actions and alternatives, and an AM plan.

A crucial component of the EA as outlined by Murphy and Weiland (2011) is the development of an analytical framework that supports quantification of the effects of alternatives upon the demographics for the species of interest. This nominally requires population models for the species supported by models of the habitat and other factors affecting those demographics.

A modeling framework advanced for the EA (Fischenich et al. 2014) and later applied to the MRRMP-EIS is shown in Figure 4. The framework includes a suite of hydrologic, hydraulic, and system operation models that feed critical habitat and population models for each species as well as provides needed input to a wide array of algorithms and models for assessing human considerations (HC) effects. The framework includes models to address economic considerations and structured decision input.

The model types shown in Figure 4 should be regarded as categories of models or as model codes; in all, more than 25 individual quantitative models have been developed to support the combined needs of the EA and MRRMP-EIS. None of these models is stand-alone; in some way, each model serves to support another modeling need or is reliant upon other models for inputs. The specific models used in the framework and their roles in supporting AM are discussed in later chapters of this plan and in the appendices. Separate manuscripts for those models are also under development. Reports detailing the HEC-RAS and ResSim models have been prepared and used for various model reviews (references needed). All of the models have some source of uncertainty; the magnitude and significance of that uncertainty varies, of course, and an important aspect of the AM Plan is to work to improve the models and reduce uncertainty where doing so may result in better decisions.

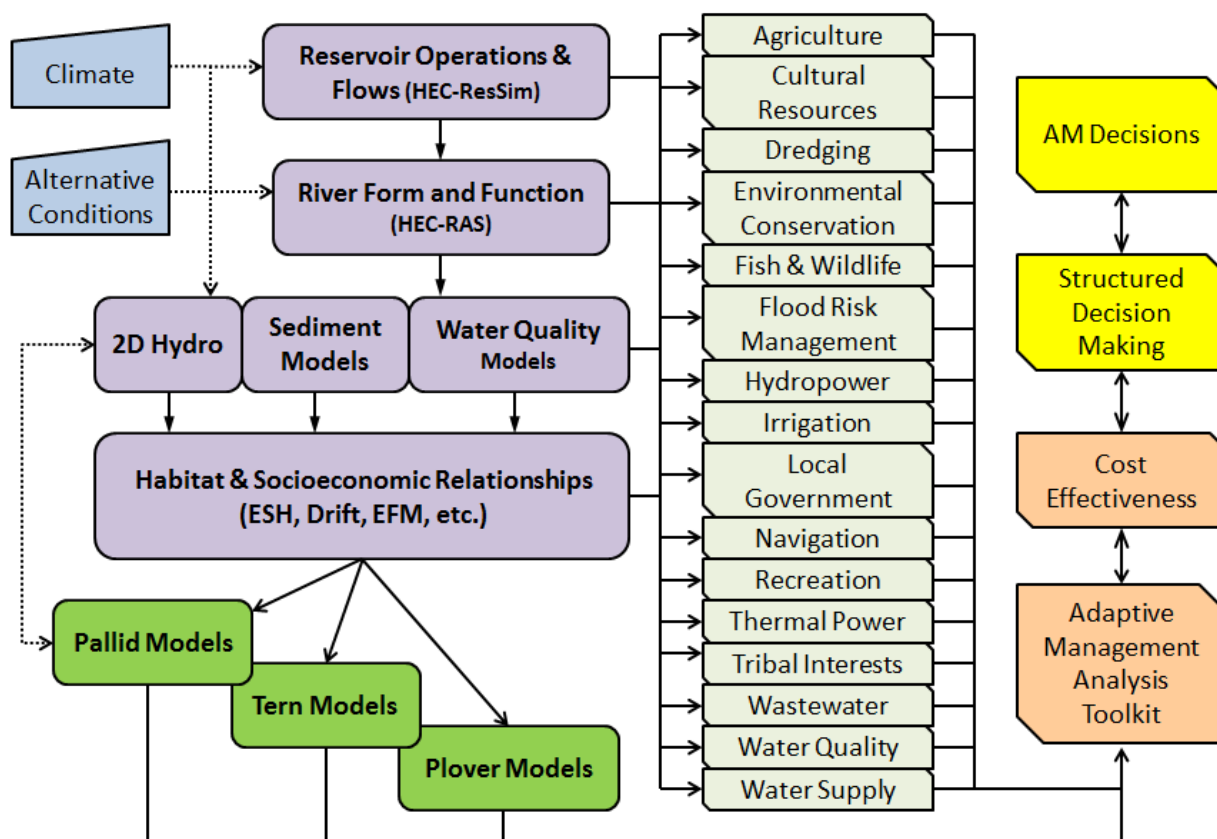


Figure 4. Model framework for the MRRP.

One logical extension of the EA models included projections of habitat availability and population response for various conditions to support alternative assessments and to develop species/habitat targets under the MRRMP-EIS. Another extension was the development of strategies to address the uncertainties and hypotheses identified as part of the EA, including the science, monitoring, and assessment activities identified in this AM plan. These products evolved through interactions among the EA team, the MRRMP Product Delivery Team (PDT), the ISAP, the Independent Social Economic technical Review Panel (ISETR), and MRRIC and its committees.

The model framework is indispensable to the MRRP's implementation under AM. As described in detail in Chapters 3 through 5, models are applied in the plan and design phase of AM to determine where, when, and how the various management actions are used to meet objectives. The models are again applied in the evaluation phase to assess the implications of observed performance (population response due to monitored habitat changes) and determine management needs (using model projections of habitat and population for alternative management actions). The models are used to consolidate information, predict outcomes, quantify performance, and provide information needed by decision makers determine the best course of action under AM.

1.1.5 AM and decision-making concepts

At its most basic level, AM has been described as doing, learning, and adjusting. In another simplified characterization (Figure 5), the “doing” part has been expanded to include assessing (covered by the EA); planning, designing and implementing (Steps 1 and 2); the learning includes monitoring and evaluation (Steps 3 and 4); and in addition to adjustments (Step 5b), learning can lead to decisions to continue with implementation (Step 5c) or complete/terminate the action (Step 5a). Adjustment might involve implementing actions that have been previously assessed in the planning process (i.e., adaptive actions) that are triggered by decision criteria, or they may involve more intensive reformulation through the planning process. Central to a progressive AM program is the notion that learning is a primary objective, whether the issue is a balanced portfolio of activities at the program level or the implementation of a specific management action.

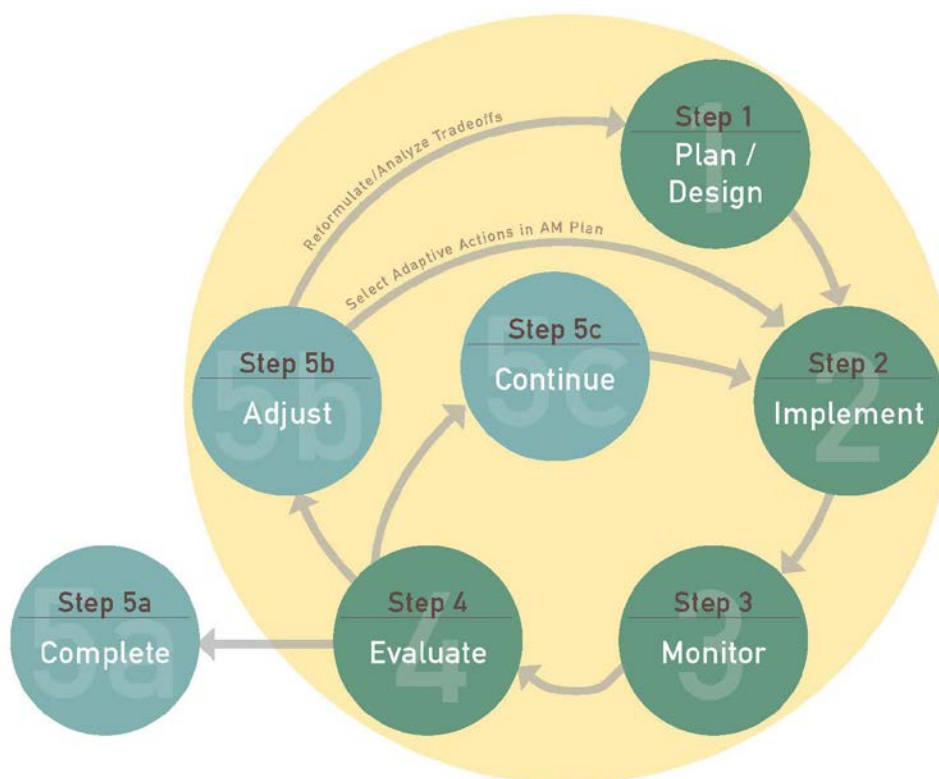


Figure 5. Simplified depiction of the AM process.

AM promotes collaboration, flexible decision-making through deliberately designing and implementing management actions to test hypotheses and maximize learning about critical uncertainties to better inform management decisions (Williams and Brown 2012). A collaborative AM approach incorporates and links credible science and

knowledge with the experience and values of stakeholders and managers for more effective management decision-making” (Sims and Pratt-Miles 2011).

The MRRP SAMP includes elements of both active and passive AM. Active AM emphasizes knowledge as an intermediate objective toward the fundamental objectives, and uses experiments or alternative management strategies to better understand system behavior (i.e., it is typically hypothesis-driven). The knowledge gained is fed back into the decision-making process, improving progress toward the fundamental objectives. Passive AM is strictly driven by fundamental objectives, considering learning gained through monitoring as secondary to the achievement of the fundamental objectives.

Establishing and implementing a formal monitoring and AM plan allows the USACE and USFWS to determine if the suite of actions being taken are meeting objectives and, if not, facilitates adjustments to those actions or the identification of new actions that may be required. A collaborative governance process supported by clear objectives, decision criteria, and a science program aimed at quantifying performance while reducing critical uncertainties helps to ensure success.

1.1.6 Relationship between MRRMP-EIS alternatives and actions in the SAMP

NEPA, in combination with the Council on Environmental Quality (CEQ) and USACE regulations, require the USACE to prepare an EIS evaluating the impacts of a proposed Federal action that will significantly affect the human environment. The EIS must rigorously explore and objectively evaluate all reasonable alternatives that meet the project's purpose and need. A thorough evaluation of the effects of alternatives on the human environment is required so that an informed decision can be made in selecting an alternative for implementation. Prior to alternative selection, the USFWS is consulted in order to ensure the selected alternative avoids jeopardy to the species. Selection of an alternative is formalized and documented in a ROD, issued by the USACE following completion of the MRRMP final EIS.

The high level of uncertainty regarding the type and extent of management actions ultimately needed to meet the species objectives (especially for the pallid sturgeon) requires a robust AM plan, which presents a challenge in identifying definitive alternatives for NEPA evaluation. The approach used to address this situation was to develop alternatives that would be initially implemented (over approximately a 15-year timeframe) to begin the AM process. At the end of that timeframe, and potentially sooner, another NEPA process could be undertaken to assess any changes, due to AM or changes in the system, in the selected alternative that would be required to meet the ESA needs. The alternatives in the EIS are combinations of management actions derived from the EA findings and further screened based on effects to human

considerations and discussions with MRRIC. Speculation regarding management actions that may be necessary to meet the species objectives beyond the 15-year timeframe was not considered in the MRRMP-EIS given the degree of uncertainty. However, effects of the alternatives were evaluated using an 82-year hydrologic period of record in order to provide an indication of effects under the variable hydrologic conditions occurring in the Missouri River basin.

The final EIS, released in October, 2018 and accompanied by this SAMP, evaluated six alternatives (see Attachment 3 of Appendix A) and identifies a Preferred Alternative. Research and related study activities needed to test hypotheses, including those hypotheses for which specific management actions have not yet been identified but may ultimately be required, are included in each alternative. These activities require little or no ground disturbance or changes to reservoir release and do not cause effects to the human environment. The research activities are thoroughly described in the EIS, the SAMP, and its appendices, and are key components of the MRRP since any of the hypotheses from the EA (and potentially others not yet identified) may ultimately need to be addressed in order to meet the species objectives.

The SAMP describes the following:

1. The activities anticipated to be undertaken to assess the effectiveness of actions implemented under the selected alternative,
2. The decision criteria used to determine if changes to management actions or to the selected alternative are necessary,
3. Research and study activities to address hypotheses for which specific management actions have not yet been identified, and
4. A governance process used to collaborate with stakeholders and make decisions.

The selected alternative, as identified in the ROD, represents the agencies' best estimate of the initial set of actions needed to achieve the species objectives. The SAMP accompanying the EIS serves as the implementation plan for the selected alternative and the MRRP into the foreseeable future. The SAMP identifies the process and criteria to implement the selected actions, assesses hypotheses, and introduces new actions should they become necessary. The USACE developed its Biological Assessment (BA) on the basis of the MRRMP-EIS "package" including the SAMP and the actions outlined in its January 2018 BA amendment letter. The SAMP serves as the implementation plan for the selected action and the MRRP into the foreseeable future.

A formal science and AM plan provides the process for obtaining and evaluating information regarding the effects of the action that the USFWS uses to inform its 7(a)2

analysis, and allows for adjustments to those actions or identification of new actions within an AM framework. Because the AM process may ultimately indicate the need for actions that address hypotheses outside the scope of the selected alternative, a range of potential actions are discussed within this SAMP. Figure 6 is a schematic showing that the management actions included in the Preferred Alternative are a subset of those in the AM Plan and considered in the MRRMP-EIS, which in turn are a subset of the management actions identified in the EA. The range of actions ultimately implemented could include those in any of the three categories in Figure 6 as well as actions not yet evaluated. However, the pathway to implementation, including required collaboration with MRRIC, additional NEPA analysis, public engagement, and other requirements depends upon the category in which the action lies (see Section 2.2.5). Only those actions that are part of the selected alternative, as described in the ROD, could be implemented without further requirements.

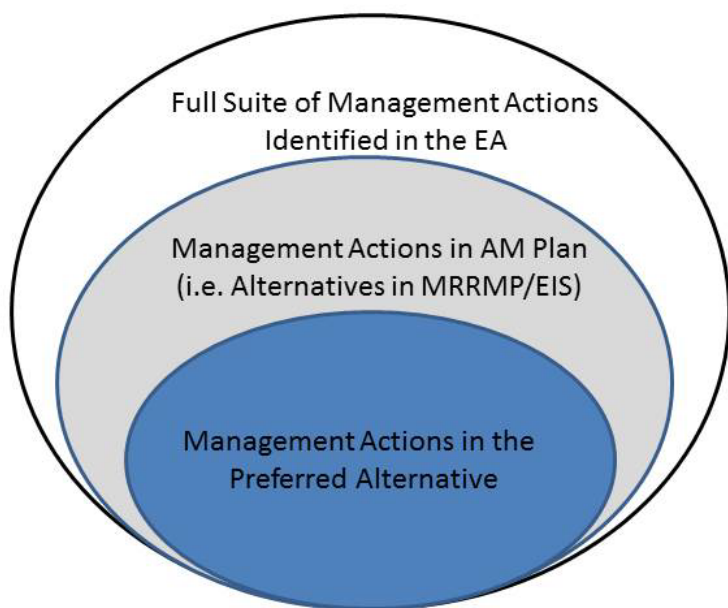


Figure 6. Schematic of management actions considered in the MRRMP-EIS, included in this AM Plan, and included in the selected alternative.

Due to the nature of the interrelated Federal actions on the Missouri River, the MRRMP-EIS employed a programmatic NEPA EIS, which enables the USACE to tier future project proposals from the overarching programmatic EIS analysis, helping to streamline future environmental reviews. CEQ regulations define tiering as covering “general matters” in policy or program EISs with subsequent tiered or narrower environmental analyses, while referencing the general discussion and focusing on the project-specific impacts important to the decision maker. This approach is well suited to the MRRP, as it integrates very well with AM. A programmatic EIS facilitates

responsiveness when monitoring indicates change to Federal actions because objectives are not being met or new scientific understanding dictates alternative strategies, thus strengthening the implementation of the plan. Implementation of specific projects or management actions may require subsequent analysis that can be tiered from the EIS. If the AM process provides new and significant information that requires actions not included within the range of impacts and alternatives considered in this EIS, additional NEPA analysis will be required. These considerations are described further in Chapter 4 of the EIS and in Section 2.4.5 of the SAMP.

1.2 AM governance

Chapter 2 addresses the governance of the MRRP AM Plan, including a description of what decisions need to be made, who would be involved in the decision-making process, how decisions would be made, and when they would be required. Effective systems of governance contribute to trust-building, knowledge generation, collaborative learning, understanding of preferences, and conflict resolution. The proposed governance structure and process for the MRRP is intended to achieve the program's aims and to promote collaboration among the lead agencies, MRRIC, and others, while maintaining the statutory decision-making responsibilities of each agency. While there are lessons to be learned from other programs, there is no one-size-fits-all strategy; governance of the MRRP needs to be designed for the MRRP, and be flexible enough to evolve as needed.

1.2.1 AM decision needs

Governance of the MRRP involves making decisions about topics ranging from highly technical considerations, such as the selection of monitoring sites and sample sizes, to policy- and value-laden issues, such as whether to adjust reservoir operations criteria. Major policy decisions are made by the Corps' Division and District Commanders—subject to their authorities and appropriations—with input from the USFWS, MRRIC, and the public, when appropriate. Some decisions are a joint USACE and USFWS function (e.g., changes to targets, decision criteria, or management actions). The MRRIC works closely with the USACE and USFWS (agency) leaders, providing input on a full range of decisions, and may provide consensus recommendations on any decision.

Section 2.2 describes the various decision needs, organized according to the AM cycle (Figure 5) and at three levels of responsibility: oversight, management, and implementation. Overlapping needs for the birds and fish are discussed in Section 2.2.2. Program activities generally focus separately on the species, as there are few synergistic or antagonistic effects from the proposed management actions due to the geographic and temporal differences in species life-cycle needs and the limited scope of the actions in the Preferred Alternative. However, decisions may be substantially affected by

unpredictable (in the long-term) processes and conditions, such as basin runoff and the intermittent need to create ESH. Balancing species needs that differ over time requires ongoing analysis, planning, risk management, and flexibility, and may require acceptance that one or more objectives may not always be met.

Several processes external to the MRRP impose important constraints on the timing of planning, engagements, decisions, and implementation of the MRRP. Most significant are the Corps' annual budget process for Civil Works and the development of the Annual Operating Plan (AOP) for the Missouri River Mainstem Reservoir System (System). Section 2.2.3 describes these processes and their implications.

A recent study of judicial decisions on AM programs cited lack of decision criteria as one of three key deficiencies that could lead to overturning of agency practice by the courts (Fischman and Ruhl 2016). This AM Plan provides numerous decision criteria that indicate actions based on performance of preceding actions, System status, species populations, or results of hypotheses testing (see Section 2.2.4). New information or understanding can inform adjustments to decision criteria, targets, MRRP objectives, scope, or even MRRP governance structure and process itself (see Section 2.5).

Decision criteria are used in the MRRP to accomplish the following:

- define requirements for compliance purposes (e.g., ESA, NEPA, USACE policies)
- ensure that decisions incorporate best available science
- facilitate complex or time-sensitive decisions
- provide a clear(er) roadmap for participants (i.e., they define the decision space).

Section 2.2.5 discusses the NEPA EIS process and how it affects decisions related to the implementation of management actions. The MRRMP-EIS employed a programmatic NEPA EIS, which enables the USACE to tier future project proposals from the overarching programmatic EIS analysis. Site-specific NEPA assessments may be required in order to implement some elements of the Selected Alternative included in the ROD, while others with adequate coverage in the EIS will be fully implementable. Actions outside the ROD that may later be identified for implementation through the AM process may require supplemental NEPA analysis and, if they involve flows, will require updating of the technical criteria in the Master Manual.

1.2.2 Program composition, roles, and responsibilities

As proposed in the SAMP, governance starts with interagency teams working together, with the support of a Technical Team to interpret what has been learned to date and to apply that knowledge to future decisions. The Bird, Fish, and Human Considerations

(HC) Teams, which include component MRRIC Work Groups (WGs) that provide expertise and perspective while also keeping the full MRRIC apprised of the teams' activities, propose management actions, monitoring, and assessment. The Management Team integrates the proposals from the Implementation Teams into a draft Strategic Plan (SP) that is reviewed by agency leadership and the MRRIC. Figure 7 shows the elements that make up the basic governance structure for the MRRP.

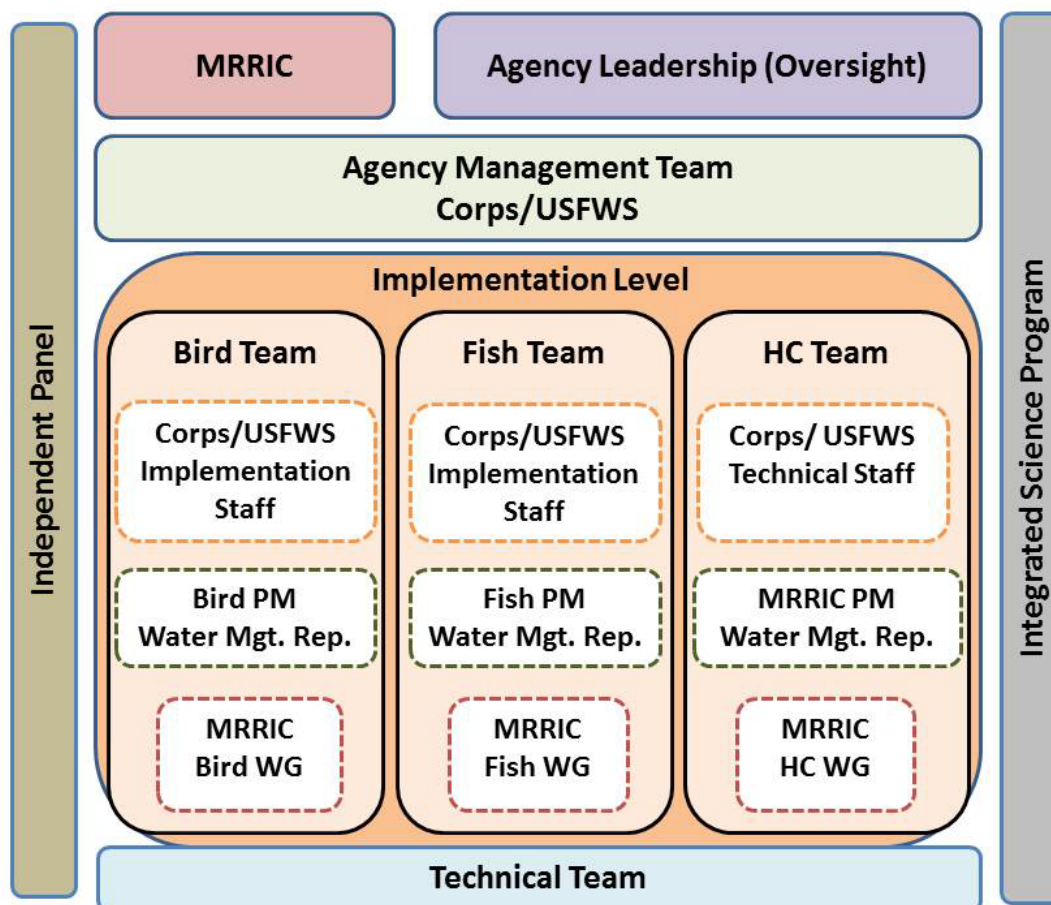


Figure 7. Primary components of the MRRP AM governance structure (not intended to represent a hierarchy).

A Technical Team patterned after the EA provides a non-decisional technical support function for the program (see Section 2.3.4). The Technical Team analyzes data, conducts studies, and generates information used by the other teams for developing decisions. The Technical Team includes subject matter expertise in ecology, biostatistics, hydrodynamics, fluvial processes, decision analysis, river operations, and socio-economics, and includes individuals with expertise and experience in assimilation and analysis of information related to plovers, least terns, pallid sturgeon, and the hydrogeomorphology of the Missouri River. Composition of the Technical Team may include Federal and state agency personnel, university professors, and contractors

selected to address the underpinning science for the program. The Technical Team is overseen by the AM Program Manager (AM PgM) through the Integrated Science Program (ISP). Section 2.3.5 discusses the role of the ISP in overseeing much of the contracting and implementation of the research, monitoring, and assessment for the program. Attachent 14 of Appendix A provides details on the operation of the ISP.

Bird and Fish Teams comprised of agency implementation personnel and MRRIC WGs, and overseen by the Bird and Fish PMs, respectively, serve to filter the science and performance information provided by the Technical Team, assess site characteristics and alternative designs for management actions, consider model predictions of future conditions, and make prioritized recommendations to the Management Team regarding management actions for consideration as part of the SP. A description of the teams and their decision responsibilities is provided in Section 2.3.3.1.

Decisions related to the SP process by the Management Team also receive input from the HC Team, which is comprised of agency managers and technical experts together with the MRRIC HC WG (see Section 2.3.3.2). The HC Team reviews and makes recommendations for monitoring and assessment associated with the effects of MRRP actions on HC interests. The Management Team, comprised of senior agency managers (Section 2.3.2) uses input from the species and HC teams and formulates a draft SP for consideration by agency leadership and the MRRIC. The species teams make some on-the-ground implementation decisions, and the Management Team has a number of responsibilities beyond development of the SP, mostly associated with budgeting, resource allocation, product delivery, collaboration, and communications.

Each agency has the sole authority and jurisdiction to make decisions appointed it by law. Senior leaders for the agencies provide oversight for the MRRP and are the ultimate decision makers. The Corps Northwestern Division (NWD) Commander sets direction for the Program, while the District Commanders are responsible for its execution. The NWD Director of Programs frequently represents the USACE in meetings with the MRRIC and/or USFWS, and may make decisions related to the development of the SP, scheduling, resource allocation, and other similar programmatic issues. The Region 6 Director is responsible for input and decisions for the USFWS, while the Assistant Director for Ecological Services is the USFWS counterpart to the NWD Director of Programs. The Oversight level of the MRRP is described in Section 2.3.1.

In addition to the senior leaders and teams described above, Chapter 2 outlines the roles and responsibilities of certain groups supporting leadership, including the ISP (Section 2.3.5) and the Executive Steering Committee (ESC) (Section 2.3.6.1). Chapter 2 also provides descriptions of a number of the key positions supporting the Program's

oversight (see Section 2.3.6). As with all federal agencies, authorities and priorities may change any of the positions described herein.

The (MRRIC) represents stakeholder interests for the MRRP. The MRRIC provides the agencies with input on the Program's implementation, including recommendations for changes to the implementation strategy from the use of AM. An overview of MRRIC role and responsibilities is provided (Section 2.3.7), following a set of guiding principles, an articulation of the MRRIC process and operating rules, and description of the levels of engagement. Section 2.3.7.2 outlines the value and role of WGs to interface between the MRRIC and the agencies on technical issues. By immersing in the science and participating in related deliberations, WGs provide an effective means to build trust, increase knowledge, and promote good decision-making that minimizes impacts to stakeholder interests. The chapter describes the role of an ISAP (Section 2.3.7.3) that provides review and guidance on science matters, and a Third Party Science Neutral (TPSN, Section 2.3.7.4), which manages the ISAP. The roles of basin states, other Federal agencies, and Tribes outside the MRRIC collaborative process are addressed in Section 2.4.6.

1.2.3 AM decision process

The MRRP employs a rolling, adaptive, 5-year Strategic Plan. Because of the uncertainty regarding some of the management actions required to meet species needs, future implementation decisions for the MRRP depend upon the performance of earlier actions and results of research addressing critical uncertainties (see Section 2.4.1). Knowledge gained from project and system performance informs adjustments to the SP. The process is constrained by several factors, most notably the timing of the Corps' budget cycles, which dictate that updates to the SP include only minor adjustments to the current fiscal year (FY) and the following FY (FY+1) budgets; center on development of the FY+2 activities for budgeting purposes; and include anticipated needs for later years (FY+3 and FY+4).

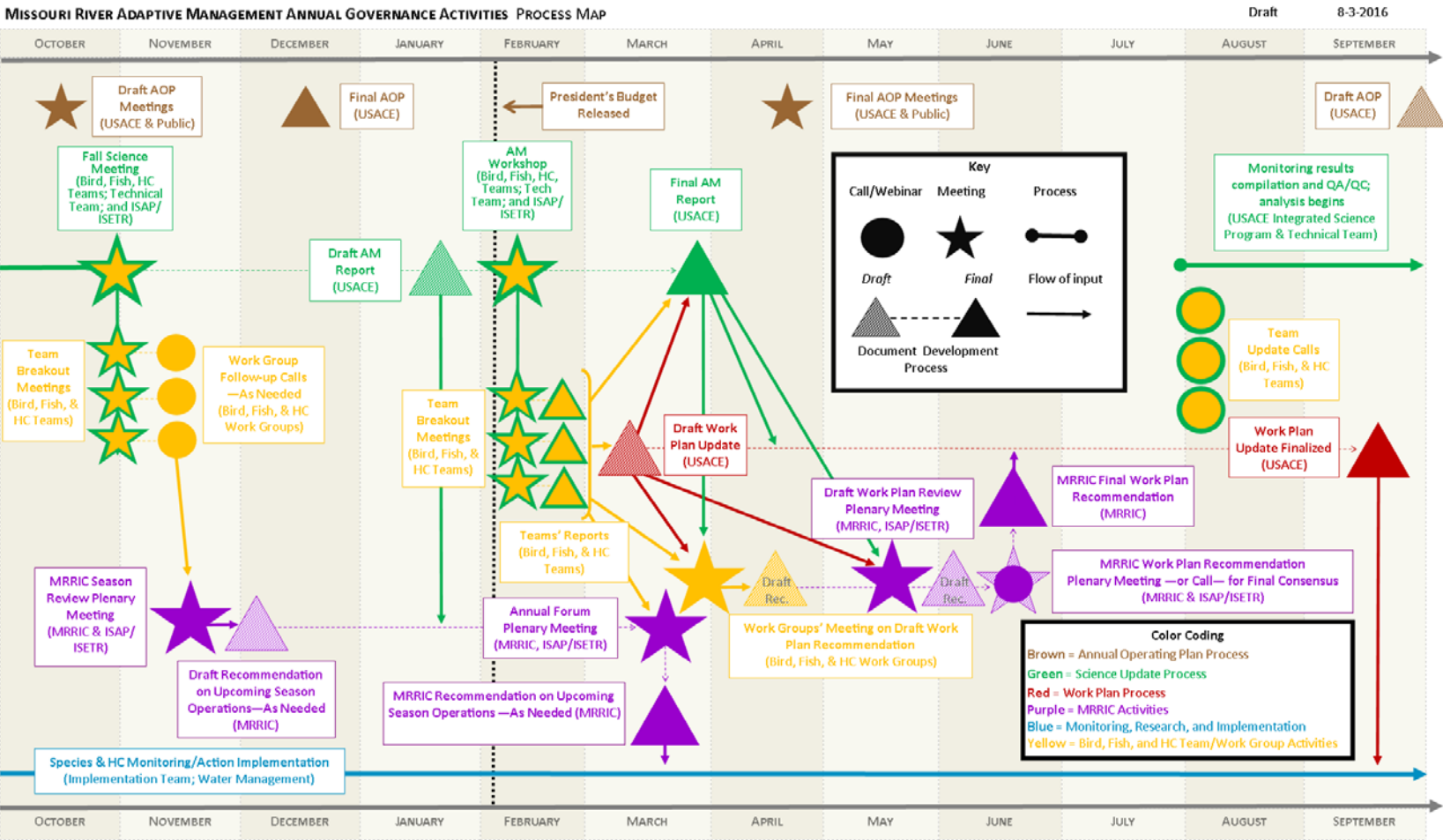
The processes and procedures by which the decisions are made are summarized in Section 2.4.1. The annually recurring engagement process for the MRRP revolves around science updates and the generation and sharing of information about program performance, then using that information for the development/adjustment of the SP. Figure 8 provides an overview of the process, which recurs each year for the Program. The elements in the figure are described in Section 2.4.2.1.

In the beginning of each FY, the Technical Team meets with other entities at a Fall Science Meeting to discuss the previous year's activities and to determine emerging analytical needs and needs for modification of research plans. The Technical Team then

assesses actions implemented to date and the overall program performance; summarizes significant findings from research, monitoring, and assessment; updates the conceptual ecological models and hypotheses; makes model projections of habitat and species populations; assesses Reservoir System status; and undertakes other tasks or studies needed to support decisions (Section 2.4.2).

Information generated by the Technical Team is incorporated into the annual AM Report and is presented ahead of an AM Workshop held each February, which provides an opportunity for USACE and USFWS decision-makers, technical staff, contractors, and MRRIC to discuss the results of research and monitoring for the previous year and plans for upcoming years (Section 2.4.3). The Bird and Fish Teams use information generated by the Technical Team to discuss program needs for each species with respect to key issues potentially affecting the Program's strategic direction. The HC Team reviews monitoring and assessment results related to the program's effects on HC metrics and considers adjustments to the monitoring and assessment strategy. The Teams (including the MRRIC WGs) meet during the AM Workshop to address the implications of the science on program direction. Agency Leads for each Team prepare a Memorandum for Record (MFR) with recommendations regarding any key issues, proposed sub-program composition, risk management strategies and prioritized work packages for accelerated program implementation. The MFRs are submitted to the Management Team. The MRRIC WGs develop a separate report to MRRIC and the agencies.

The Management Team uses input from the Science Update Process and, in particular, MFRs from Agency Leads update the SP (Section 2.4.4). The update requires integration of the recommendations from the Bird, Fish, and HC Teams, and applying a programmatic perspective that considers many factors, including the existing SP makeup, guidance and direction provided by agency leadership, budget trends, the status of the science, risk management, and effects on authorized purposes. A draft of the revised SP, developed in early March, is provided to the agencies and MRRIC for review. Proposed revisions are discussed at the March MRRIC meeting, and a joint WG meeting is held to prepare a draft recommendation on the SP for MRRIC's consideration. Additional analyses and adjustments could be made during this process depending on the feedback received from agency leaders or MRRIC. MRRIC may elect to provide a consensus recommendation at their May/June meeting prior to the agencies' finalizing any adjustments to the plan.



1

2 Figure 8. Process map depicting the proposed governance activities to be undertaken annually by the USACE, the USFWS, and the Missouri River Recovery
3 Implementation Committee (MRRIC) in the implementation of AM for the Missouri River Recovery Program.

1.2.4 Protocols and procedures

A process section identifies a number of protocols and procedures that are necessary for the administration and implementation of, and changes to the AM Plan (Section 2.5). These include, for example, the procedures or protocols for changing the governance structure, resurrecting reserve hypotheses, dispute resolution, and addressing cultural resources uncovered during operations, as well as a host of other considerations. Details of these procedures are presented as attachments to Appendix A.

1.2.5 Other key points and issues

Governance for the MRRP is likely to evolve over time as lessons are learned about how collaboration should occur and as program needs change. To that end, routine and periodic reviews of the effectiveness of the program's governance are needed, along with a mechanism for change. As trust and understanding develop, decisions may be delegated to lower levels and collaborative engagements will likely become less formal and more effective. Section 2.5.2 lays out the processes for routine and periodic reviews and the process for adapting the governance to fit learning and evolving program needs.

1.3 AM for plovers and terns

Managing for piping plovers and interior least terns largely involves ensuring sufficient availability of ESH to support nesting and foraging for plovers, which the USFWS has determined also meets habitat needs for terns, while accounting for any benefits to bird populations from use of reservoir shorelines. Habitat and population models developed for the plovers provide a powerful planning tool for managing the program, but uncertainty about parameter estimates in the habitat models, coupled with observation errors and uncertainty about dispersal, demographic rates, and their trends in the population models provide significant opportunities for improvement in understanding and management decisions.

The greatest near-term source of uncertainty is in estimating future flows, which drives ESH availability. Managers will be required to make decisions about how much ESH to create annually and how best to create it with consideration of the risk of falling short of ESH targets. AM will likely revolve around the above issues, but opportunities exist for meaningful improvements to the ESH construction methods, predator management, and foraging habitat, among other things. Questions regarding the long-term availability of sediments for building ESH in the riverine reaches will challenge team members to find ever more efficient mechanisms to build and sustain needed habitat.

1.3.1 Bird objectives, uncertainties, and targets

The overall objective for piping plovers and least terns is to prevent USACE activities from jeopardizing the continued existence of both bird populations in the Missouri River. Objectives must be met for the Northern Region (Lake Sakakawea, Garrison Reach, and Lake Oahe, see Figure 1) and the Southern Region (Fort Randall Reach, Lewis and Clark Lake, and Gavins Point Reach, see Figure 1). Specific sub-objectives pertain to long-term population persistence, population growth, increasing and maintaining breeding success, and maintaining geographic distribution (see Section 3.1.1).

The EA built upon the Conceptual Ecological Models (CEMs) developed in 2013, identifying critical uncertainties, management hypotheses, and a suite of associated actions (see Section 3.1.2.4, Section 3.1.2.5, Table 1) that can be used to affect bird populations. These overarching scientific uncertainties are the following:

- How much habitat is needed to maintain a resilient population of birds, and how should it be distributed in space and time?
- How are the Missouri River populations of plovers and terns affected by migratory and metapopulation dynamics?
- How will long-term changes in climate and channel morphology affect habitat and species management?
- How can the AM program buffer against natural (especially hydrologic) variability and uncertainty for long-term success?
- How can the bird AM program buffer against institutional and socioeconomic variability and uncertainty for long-term success?

The management uncertainties, actions, and hypotheses are summarized in Table 1 and are discussed in Section 3.1.2.5.

A suite of models that relate reservoir operations, river flows, ESH availability, and bird populations is discussed in Section 3.1.2.3. The models provide a mechanism for projecting the probability distribution of future habitat area and bird population size. Using historical hydrological data, the models were applied to help establish targets for habitat based on a population viability analysis (see Section 3.1.1 for information on the models). Targets, as specified in the 2018 BiOp, are presented in Section 3.2.3 for both ESH (see Section 3.2.2.1) and species metrics (see Section 3.2.2.2).

Table 1. Critical uncertainties related to bird management actions and associated management hypotheses.

Management Critical Uncertainties	Actions	Management hypotheses
Creating New Habitat What is the most effective and efficient way of creating habitat within the larger context of management and uses of the Missouri River? a. Are there effective and implementable ways of using flow modification to provide and enhance habitat availability and quality? b. Can habitat be mechanically created in an effective and sustainable manner? c. What are the effects of habitat creation actions on HCs?	Habitat-creating flows	Habitat-creating flows of sufficient magnitude and duration increase the area of nesting/brood rearing habitat and foraging habitat on the river by increasing deposition, assuming sediment is available, thereby increasing fledgling productivity.
	Mechanical habitat creation on river	Mechanical habitat creation of sandbars in river segments increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability. Mechanical habitat creation of sandbars in river segments increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.
	Mechanical habitat creation on reservoir shorelines or islands	Mechanical habitat creation of habitat on reservoir shorelines/islands increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability. Mechanical creation of habitat on reservoir shorelines or islands increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.
	Mechanical creation of hydrologically-connected non-ESH habitat on river segments	Mechanical habitat creation of habitat other than ESH or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability. Mechanical habitat creation of habitat other than ESH or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.

Maintaining Existing Habitat To what extent can maintaining existing habitat contribute to population objectives compared to creating new habitat? a. Does maintained habitat improve habitat metrics and support production equivalent to new habitat? b. Can flow be used to maintain habitat without increasing net erosion?	Modification or augmentation of existing sandbars	Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation. Modification or augmentation of sandbars increases nesting/brood-rearing and foraging area, which increases food availability and hence survival of chicks to fledglings. Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.
	Vegetation removal (spraying/mowing) on river/on reservoir	Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation (by increasing area and by removing cover for predators). Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of chicks to fledglings by increasing food availability. Vegetation removal increases nesting/brood-rearing and foraging area relative to habitat condition and availability of at other breeding areas, thus increasing the number of adults through net immigration from other areas.
	Habitat-conditioning flows	Habitat-conditioning flows are not of sufficient magnitude and duration to create new sandbars, but scour vegetation or deposit new sediment on existing bars, increasing the area of nesting/brood-rearing habitat, thereby increasing fledgling productivity.
Improving Availability of Existing Habitat To what extent can improving existing habitat availability through flows contribute to population objectives compared to creating new habitat?	Reservoir water level management	Declining reservoir water levels between years and/or steady or declining water levels during the nesting season increases the area of suitable nesting/brood rearing and plover foraging habitat on the reservoirs, thereby increasing fledgling productivity.
	Lowered nesting season flows	Lowered nesting season flows increase the area of suitable riverine nesting and brood rearing habitat and foraging habitat, thereby increasing fledgling productivity.
Population Protection To what extent can population protection actions positively contribute to the success of birds on the Missouri River?	Flow management to reduce take	Steady or declining reservoir levels and/or river flows during the nesting season increases survival from egg to chick and chick to fledgling by reducing the risk of nest inundation and chick stranding and by maintaining or increasing foraging habitat.
	Predator removal	Predator removal increases survival of eggs to chicks and chicks to fledglings.
	Nest caging	Nest caging protects plover nests from predators, increasing survival of eggs to chicks, though survival of adults may be negatively affected by cages.
	Human restrictions measures (signs, barriers, education)	Human restriction measures reduce activity on nesting and foraging habitat, increasing survival both by decreasing direct mortality and indirect effects on survival caused by stress.

ESH targets for the Northern and Southern Regions are presented as a range of standardized ESH values (number of acres above a reference elevation) that should be met in 3 out of 4 years, and exceedance values for available ESH (number of acres at the highest stage during the nesting season) that must be met on a rolling 12-year average (see Table 2). USACE will assess and refine the sub-objectives, means objectives, performance metrics, and targets through the AM process as dictated by new scientific information. Targets, in particular, are subject to change in association with evolving conditions and improvements in models.

Table 2. Summary of standardized and available ESH acreage targets. Note that targets are subject to change as dictated by new scientific information

		Acres of ESH					
		Northern Region			Southern Region		
		2.5%ile	Median	97.5%ile	2.5%ile	Median	97.5%ile
Standardized ESH Acres		190	450	2160	330	1180	4720
Available ESH Acres Exceeded for Percentage of Years	75%	170	270	555	300	430	720
	50%	420	680	1295	500	740	1550
	25%	960	1920	2670	750	1410	3075
	10%	1965	3000	5165	1125	2240	4945

Quantitative targets are provided for the piping plover only; the USFWS has determined that, by meeting the plover habitat objectives, the USACE will also fulfill least tern habitat needs for the Missouri River. Quantitative targets for the least tern may be added pending decisions regarding delisting and development of conservation plans.

1.3.2 Implementing, monitoring, and evaluating bird actions

Implementers of the MRRP will be faced with decisions about the above management actions with limited knowledge of future conditions that could significantly affect the amount of habitat and species populations, and without knowing precisely how the habitat and species will respond to those uncertain conditions. The role of AM in managing the birds is to improve decision-making in light of an uncertain future system state—an uncertainty that can never fully be resolved—and through improved understanding of how the system functions and responds to various management actions. This, and the need to balance multiple and sometimes competing objectives for species and HCs, supports the use of a “toolbox approach” wherein many management actions and options are available to accommodate natural variability and socioeconomic uncertainty (see Table 1). The initial set of management actions in the toolbox, and their specifications, are specified in the ROD. As the AM Plan is implemented, knowledge

gained about the performance of implemented actions, including their effects on HC objectives, will be used to make adjustments that increase their effectiveness. New knowledge may also result in the addition or removal of management actions from the toolbox. Decisions about such changes will be evidence-based and made in collaboration with MRRIC. HC metrics (discussed in Chapter 5) are also identified in Chapter 3 where applicable to management actions for the birds.

The following metrics are used when testing the hypotheses in Table 1 and to support management decisions (see Chapters 2, 3 and 5):

- Habitat metrics
 - Standardized ESH (acres)
 - Available ESH (acres)
 - Available shoreline (feet)
 - Inundation during the nesting season (feet)
- Species metrics
 - Population size
 - Population growth rate
 - Fledge ratio
- Metrics of management conditions
 - Standardized ESH (acres) and distribution
 - Vegetated habitat (acres)
 - Storage in reservoirs (million acre-feet) and planned releases (cubic feet per second [cfs])
 - Tributary flows (cfs) and downstream stage (elevation)
 - Bird population density (adults/acre)
 - Budget (\$)

Some of these metrics have historically been collected under the Tern and Plover Monitoring Program. Revisions to the monitoring program, which are under development, will be described in Section 3.3 when completed.

Section 3.2.4 provides important details for each of the management actions under consideration in the MRRMP EIS, including a description of each action, implementation criteria, constraints to implementation, performance metrics, HC metrics, uncertainties and needed research, criteria for adjusting an action, and the decision and collaboration level. Details are provided for actions in the Preferred Alternative and for those considered in other alternatives. Following the ROD, actions included in the Selected Alternative will be available for full implementation, while actions evaluated but not included may be considered for research or pilot projects.

Section 3.2.4.3 includes management actions not evaluated in the MRRMP EIS. These actions have greater uncertainty about effectiveness but have been identified as potential actions that should be evaluated through research, modeling, and pilot projects. The evaluation process includes assessing ESH and population status, management needs, hypotheses, and the updating and validation of predictive models. Assessment of ESH status involves the use of the models, along with remotely sensed imagery, to determine both standardized and available habitat during nesting and fledging seasons. ESH acreage relative to median and 95% confidence intervals for targets, along with trends, are evaluated for planning ESH creation needs (see Section 3.5.1; also see Table 2). Evaluating population requires assessment of population resiliency under current management conditions through modeling and assessment of observed fledge ratios and population growth and their trends (see Section 3.5.2).

Section 3.5.3 provides guidance for the overall evaluation of status and management needs. Table 3 (reproduced from Table 34) categorizes ESH and species status and communicates a recommended management pathway (e.g., continue, increase, or decrease current rates of habitat creation). An evaluation of management conditions including system storage, snowpack, ESH condition, vegetation and predator status, budget, and the pallid sturgeon research and management needs provides understanding of how the decision space may be constrained (see Section 3.5.4).

Chapter 3 also discusses the evaluations needed to address new information (Section 3.5.5), evaluate key relationships, hypotheses, and science questions (Section 3.5.6), update and validate models (Section 3.5.7), deal with ancillary information (Section 3.5.10), and assess unexpected outcomes (Section 3.5.11), reinforcing the discussion of those processes in Chapter 2 by providing examples for the birds.

Table 3. Matrix for characterizing status and needs for ESH acreage and bird population. FR = Fledge Ratio (Number of fledglings observed / [number of breeding adults/2]); λ = lambda (population size in current year / population size in previous year).

Population Status	Emergent Sandbar Habitat Status			
	Acreage < Lower Bound	Lower Bound < Acreage < Median	Median < Acreage < Upper Bound	Upper Bound < Acreage
GROWING POPULATION	On track to meet objectives	Meeting objectives	Meeting objectives	Exceeding objectives
FR and λ	Status: Small population OR density dependence less than expected	Status: Moderate population, not habitat limited	Status: Moderate to large population, not habitat limited	Status: More birds and much more habitat than needed Need: Maintain habitat quality

> target	<i>Need:</i> Continue pace of habitat creation	<i>Need:</i> Continue habitat creation at current or slower pace	<i>Need:</i> Maintain existing acreage and quality	
STABLE POPULATION	Unlikely to meet objectives <i>Status:</i> Small to moderate population, becoming habitat limited <i>Need:</i> Increase rate of habitat creation	Meeting objectives <i>Status:</i> Moderate population, habitat may become limiting <i>Need:</i> Continue pace of habitat creation	Meeting objectives <i>Status:</i> Moderate to large population <i>Need:</i> Maintain existing acreage and quality	Exceeding objectives <i>Status:</i> More birds and more habitat than needed <i>Need:</i> Maintain habitat quality
DECLINING POPULATION	Will not meet objectives <i>Status:</i> Small to large population, very habitat limited <i>Need:</i> Rapidly increase rate of habitat creation	Unlikely to meet objectives <i>Status:</i> Moderate to large population, habitat limited <i>Need:</i> Increase pace of habitat creation	Potential reversal <i>Status:</i> Large population returning towards equilibrium <i>Need:</i> Continue pace of habitat creation and maintain habitat	Reversal <i>Status:</i> Large population returning towards equilibrium OR density dependence much higher than expected <i>Need:</i> Maintain habitat quality, consider maintaining acreage

1.3.3 Decisions and planning contingencies

The decision process, decision criteria, necessary information and model projections, as well as guidelines and decision criteria for proceeding with specific management actions are presented in Section 3.6. This section also covers steps to be considered if objectives are not being met. Decisions can range along a continuum, and may include implementing the same actions as in previous years, adjusting action specifications or criteria, adding new management actions, and changing targets or objectives. The decision process generally involves using information from monitoring and research, modeling of habitat and population response, and management conditions. Contingency plans that provide a pre-specified roadmap to decisions are identified where feasible owing to their efficiency and effectiveness; however, the system is too complex and variable to pre-specify every contingency in a way that would be preferable to on-the-ground management decisions employing available information. Decisions are outlined for those actions evaluated in the MRRMP-EIS, not just those in the ROD, to provide an overview of the full range of management possibilities during the course of AM.

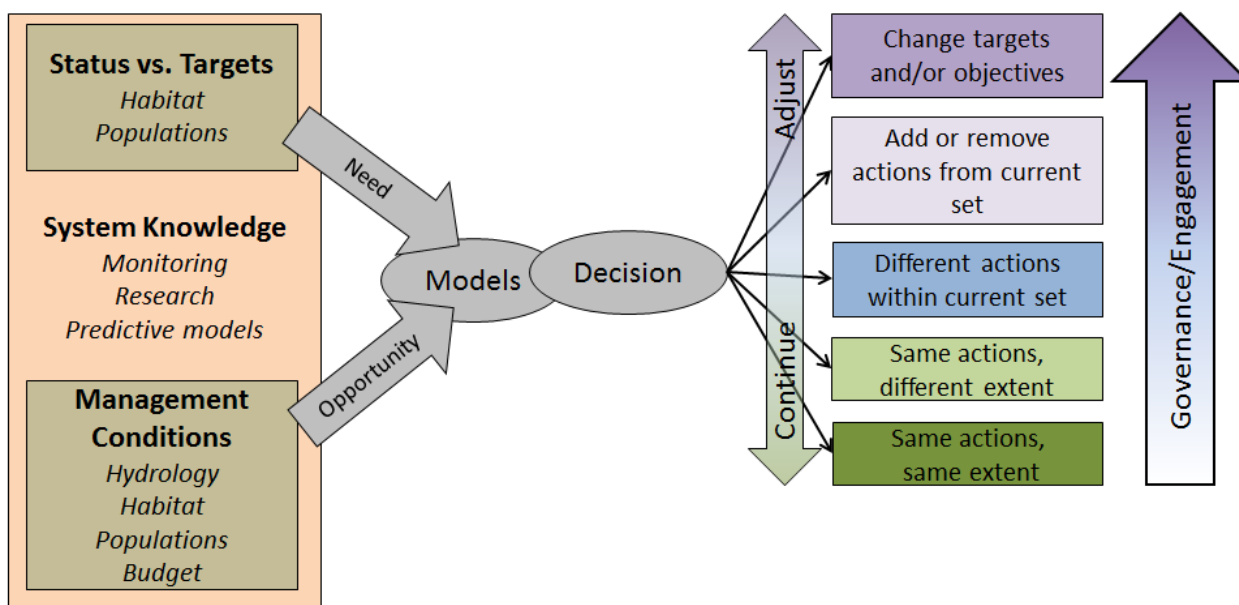


Figure 9. Factors affecting AM decisions for birds and the nature of those decisions.

The incremental costs and benefits of any management action(s) are considered during the decision cycle (as part of the SP development process). When more than one management action is possible, combinations and degrees of intensity for each action should be considered to arrive at an optimum, or at least a preferred alternative. The predictive models are necessary tools for these decision-support efforts. They also provide a means of quantifying the risks associated with any decision. Model projections of management actions are discussed in Section 3.6.2.1.

Decisions about how to create ESH (mechanical vs. flows) are discussed in Section 3.6.3.1. (That description includes flow modifications analyzed in the MRRMP EIS but not included in the Preferred Alternative.) As previously identified, these decisions largely turn on the amount of ESH needed as determined from the assessment stage, coupled with an estimate of available budget (e.g., are funds available to mechanically construct the full amount needed?), the potential for using flows (e.g., is system storage sufficient and other conditions generally acceptable to the needed magnitude and duration of flow releases?), and assessments of potential HC effects (positive and negative), synergistic interactions, additional information learned, and pallid sturgeon management needs. Close collaboration is required prior to implementation of any habitat-creating flows, decisions to do so must be made at the Oversight level and other policy requirements (e.g., NEPA evaluation, adjustments to Master Manual criteria) must be fulfilled.

Section 3.6.3 discusses decisions about whether to lower nesting season flows. Flexibility to do so exists within the current technical criteria in the Master Manual

under some hydrologic conditions. Lowered summer flows can expose more nesting habitat and delay creation of new ESH. Collaboration on lower nesting season flows (within current Master Manual criteria) occurs through the AOP process, as has been practiced in the past and/or communicated to stakeholders if made in real time by the Missouri River Basin Water Management Division (MRBWMD). If lowered summer flows as a deliberate, planned activity are anticipated, or if adjustments to the Master Manual would be required to accommodate more substantive flow management, a high level of collaboration including public involvement would occur, and those decisions would be made at the Oversight level.

Decisions about modifying existing habitat (Section 3.6.3.2) and predation management build upon existing knowledge and practice for these activities, as well as proposed monitoring that should enhance understanding of key relationships for these factors. The Management and Bird Teams generally make these decisions with lower level collaboration and related actions would be included in the SP.

Decisions related to experiments and research activities are discussed in Section 3.5.6. In addition to research targeting biological and management hypotheses, opportunities for experimental implementation of management actions can be exercised to develop more productive, efficient, and cost-effective means of achieving objectives. For example, improvements in construction methods and resource (sand/sediment) utilization may make mechanical construction more feasible. Similarly, innovative methods for reducing erosion of ESH or managing vegetation and predators can extend the life of existing ESH and help meet bird targets. Even improvements to monitoring methods and more efficient analytical methods provide potentially significant opportunities for programmatic cost savings and more effective decision-making. Collaboration on research and experimental management actions will vary depending on the nature of the activity, but would generally be consistent with any management action included in the SP.

As models and scientific understanding are updated to reflect learning, the ESH targets are recalculated to promote more efficient management. This occurs often enough to allow learning to improve management outcomes, but not so frequently as to hinder reasonable planning and assessment processes. Decisions to update habitat targets to reflect learning or to revise targets or target criteria are addressed in Section 3.6.5. Changes to the numerical targets to reflect new scientific understanding would be a relatively routine process, but may warrant reviewed by the ISAP. Changes to target criteria, or to objectives reflecting changes in regulations, values, or acceptable levels of risk would involve technical review, but also require a higher level of collaboration and Oversight-level approval.

1.3.4 Other key points or issues

While the understanding of the needs for the birds is significantly greater than for the pallid sturgeon, costs for managing the birds can be high. Moreover, bird populations (especially plovers) respond rapidly to the dynamic shifts in available habitat, and there are many challenges to addressing their needs while minimizing impacts to HCs. These factors contribute to the need for an active, progressive AM strategy as part of the MRRP. Flow management for the birds remains a contentious issue, and should the need for its use emerge, a progressive AM strategy with appropriate levels of collaboration will be required to facilitate its implementation.

1.4 AM for pallid sturgeon

Despite considerable effort, the identification of the specific factors causing recruitment failure for pallid sturgeon and a clear nexus between management actions and population response remains elusive for the lower river (downstream of Gavins Point Dam). While fragmentation is clearly the primary factor in limiting or preventing recruitment on the upper river (Ft. Peck Dam to the Lake Sakakawea Headwaters), other secondary factors may also play a significant role and confound management decisions. Given the lingering uncertainties regarding the scope and scale of the management actions necessary for the USACE to avoid jeopardizing the continued existence of pallid sturgeon, a strategy reliant upon a progressive AM program is the most effective way to manage risks to the pallid sturgeon.

1.4.1 Overview of Chapter 4

Chapter 4 is organized around the AM cycle, beginning with the “Assess” step by identifying the goals and objectives for pallid sturgeon (Section 4.1.1) and a summary of the key findings of the EA (Section 4.1.2), including the hypotheses that emerged from the effort, and the EA’s conclusions on those hypotheses. A pallid sturgeon framework (developed jointly by the USACE and USFWS for the Lower Missouri River) is presented in the “Plan/Design” step, and serves as a foundation for much of the AM strategy (see Section 4.2.1). The framework describes four “levels” of action with progressively greater influence on pallid sturgeon populations: Level 1 is research, Level 2 is focused field-scale experiments, Level 3 is limited-scale implementation, and Level 4 is full-scale implementation of management actions. Level 1 and 2 components of the framework are detailed in the Appendix C. Details for Level 2 and Level 3 actions are presented in remaining sections of the chapter, and are generally summarized as they pertain to the Upper Missouri River and Lower Missouri River. The methods used to monitor and evaluate the effects of Level 2 and Level 3 actions are described in Appendix E.

1.4.2 Pallid sturgeon objectives and key uncertainties

The fundamental objective for pallid sturgeon, developed by the USFWS in 2013, is to keep USACE actions from jeopardizing the continued existence of pallid sturgeon in the Missouri River. Sub-objectives are to increase recruitment to age-1, and to maintain or increase numbers of pallid sturgeon as an interim measure until sufficient and sustained natural recruitment occurs (see Section 4.1.1 for more details). Multiple metrics have been defined for these sub-objectives, but targets for these metrics are still to be determined.

The EA evaluated available reports and models, as well as other scientific literature, to provide an integrated assessment of the current state of the science and understanding of the potential benefits of management actions for pallid sturgeon in the Missouri River, and associated uncertainties in that assessment (see Section 4.1.2). The EA also introduces development of a collaborative population dynamics model developed to support the MRRP AM Plan (Section 4.1.2.3).

Uncertainties for pallid sturgeon identified in the EA have been expressed as Big Questions related to potential management actions with underlying hypotheses. The EA included six Big Questions each for the Upper River and the Lower River, and each Big Question includes underlying hypotheses. These are summarized in Table 4 and in Table 5 for the Upper Missouri River and Lower Missouri River, respectively. New information (see Sections 2.5.3 and 6.2.5) may arise which leads to a re-examination of hypotheses from the reserve list of EA hypotheses, the addition of new hypotheses, the revision of existing hypotheses, or the removal of some of the existing hypotheses in the event of strong evidence against them. As an example of the new information process, Big Question 7 has been added for the Lower Missouri in 2018, due to the results of investigations into fish condition (described in section 4.1.2.4).

Table 4. Big Questions and hypotheses for Level 1 and 2 components for the Upper Missouri River. Hypotheses are from Table 1 in Jacobson et al. (2016a). Note that Big Question 6 hypotheses are examples, since Rangewide Stocking and Augmentation Plan may pose different hypotheses.

Big Question 1 – Spawning Cues: Can spring pulsed flows from Fort Peck synchronize reproductive fish, increase chances of reproduction and recruitment?
Associated Hypothesis: H2. Attractant flow releases at Fort Peck will result in increased reproductive success through increased aggregation and spawning success of adults.
Big Question 2 – Food and Forage: Can naturalization of the flow regime from Fort Peck contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?

Associated Hypothesis:

H1. Naturalized flow releases at Fort Peck will result in increased productivity through increased hydrologic connections with low-lying land and floodplains in the spring, and decreased velocities and bioenergetic demands on exogenously feeding larvae and juveniles during low flows in summer and fall.

Big Question 3 – Temperature Control: Can water-temperature manipulations at Fort Peck contribute significantly to increased chance of reproduction and recruitment?

Associated Hypotheses:

H4. Warmer flow releases at Fort Peck Dam will increase system productivity and food resource availability, thereby increasing growth and condition of exogenously feeding larvae and juveniles.

H5. Warmer flow releases from Fort Peck Dam will increase growth rates, shorten drift distance, and decrease mortality by decreasing free embryos transported into headwaters of Lake Sakakawea.

Big Question 4 – Sediment Augmentation: Can sediment bypass at Fort Peck contribute significantly to increased chance of reproduction and recruitment?

Associated Hypothesis:

H6. Installing sediment bypass at Fort Peck will increase and naturalize turbidity levels, resulting in decreased predation on embryos, free embryos, and exogenously feeding larvae.

Big Question 5 – Drift Dynamics: Can combinations of flow manipulation from Fort Peck, drawdown of Lake Sakakawea, and fish passage at Intake Dam on the Yellowstone River increase probability of successful dispersal of free embryos and retention of exogenously feeding larvae?

Associated Hypotheses:

H3. Reduction of mainstem Missouri flows from Fort Peck Dam during free-embryo dispersal will decrease mainstem velocities and drift distance thereby decreasing mortality by decreasing numbers of free embryos transported into headwaters of Lake Sakakawea.

H7. Fish passage at Intake Diversion Dam on the Yellowstone River will allow access to additional functional spawning sites, increasing spawning success and effective drift distance, and decreasing downstream mortality of free embryos and exogenously feeding larvae.

H10. Drawdown of Lake Sakakawea will increase effective drift distance, decreasing downstream mortality of free embryos and exogenously feeding larvae.

Big Question 6 – Population Augmentation. Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?

Associated Hypotheses:

H8. Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.

H9. Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.

Table 5. Big Questions and hypotheses for Level 1 and 2 components for the Lower Missouri River. Note that Big Question 6 hypotheses are examples, since Rangewide Stocking and Augmentation Plan may pose different hypotheses.

<p>Big Question 1 – Spawning Cues: Can spring pulsed flows synchronize reproductive fish, increase chances of reproduction and recruitment?</p>
<p>Associated Hypothesis: H11. Naturalization of the flow regime at Gavins Point Dam will improve flow cues in spring for aggregation and spawning of reproductive adults, increasing reproductive success.</p>
<p>Big Question 2 – Temperature Control: Can water-temperature manipulations at Fort Randall and/or Gavins Point contribute significantly to increased chance of reproduction and recruitment?</p>
<p>Associated Hypothesis: H15. Operation of a temperature management system at Fort Randall Dam and/or Gavins Point Dam will increase water temperature downstream of Gavins Point, providing improved spawning cues for reproductive adults.</p>
<p>Big Question 3 – Food and Forage: Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?</p>
<p>Associated Hypotheses: H12. Naturalization of the flow regime at Gavins Point Dam will improve connectivity with channel-margin habitats and low-lying floodplain lands, increase primary and secondary production, and increase growth, condition, and survival of exogenously feeding larvae and juveniles. H13. Naturalization of the flow regime at Gavins Point Dam will decrease velocities and bioenergetic demands, resulting in increased growth, condition, and survival for exogenously feeding larvae and juveniles. H17. Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles. H18. Re-engineering of channel morphology will increase channel complexity and minimize bioenergetic requirements for resting and foraging of exogenously feeding larvae and juveniles.</p>
<p>Big Question 4 – Drift Dynamics: Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to decreased direct mortality and increased interception of free embryos into supporting habitats?</p>
<p>Associated Hypotheses: H14. Alteration of the flow regime at Gavins Point can be optimized to decrease mainstem velocities, decrease effective drift distance, and minimize mortality of free embryos. H19. Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.</p>
<p>Big Question 5: Spawning Habitat. Can channel reconfiguration and spawning substrate construction increase probability of survival of eggs through fertilization, incubation, and hatch?</p>
<p>Associated Hypothesis: H16. Re-engineering of channel morphology in selected reaches will create optimal spawning conditions -- substrate, hydraulics, and geometry -- to increase probability of successful spawning, fertilization, embryo incubation, and free-embryo retention.</p>
<p>Big Question 6: Population Augmentation. Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?</p>

Associated Hypotheses:

H20. Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.

H21. Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.

Big Question 7 - Fish Condition: Are there combinations of management actions (flow alteration, channel re-configuration, population augmentation, water quality management, or management of other fish species) which could improve the condition of pallid sturgeon within key segments of the Lower Missouri River, resulting in population stability or growth?

Associated Hypotheses:

HFC1. 2011 flood altered fish habitats and populations.

HFC2. Intraspecific competition among pallid sturgeon resulting from overstocking and high survival of hatchery-origin fish puts populations closer to carrying capacity.

HFC3. Interspecific competition from shovelnose sturgeon and Asian carp has reduced prey available for pallid sturgeon.

HFC4. Lack of fish prey

HFC5. Diminished fish health, related to hatchery practices.

HFC6. Diminished fish health, related to contaminant exposure.

HFC7. Long-term channel adjustments to the dams and the Bank Stabilization and Navigation Project have reduced favorable habitats for pallid sturgeon or their prey.

HFC8. Observed variations in condition are the normal range of variability and declines reflect a return to normality

HFC9. Senescence. Some of the large, low-condition fish in the Lower Missouri River may be older, wild-origin fish reaching the end of their lifespan.

Priority research activities are still to be determined for BQ7. Candidate research activities are described in Randall et al. (2017).

1.4.3 Pallid sturgeon framework

The USACE and USFWS collaborated to develop a framework for adaptively managing pallid sturgeon on the lower river. Referred to as “the Framework”, it consists of four levels of activity as described in Table 6. As information is developed through Level 1 and 2 research and experiments (see Appendix C) or through monitoring of effectiveness of management actions, decision criteria described in the Framework and in Chapter 4 will be used to determine when and what actions should follow. Decisions might include (a) accepting that the scientific information supports the hypothesized action and moving to the next issue or level of implementation; (b) determining that the scientific information does not support the hypothesized action and refining or rejecting the hypothesis; or (c) deciding to implement at Level 3 because an agreed-upon time limit has been reached and results remain equivocal (studies at Levels 1 and 2 might continue concurrently). At any time during implementation, it may become apparent

that: 1) a particular action is not needed, 2) a proposed action requires modification to be effective, or 3) some new action not previously evaluated is required.

Level 1 and 2 studies are directly tied to those uncertainties and management hypotheses highlighted in the EA that, if resolved, could significantly affect the implementation of management actions. Studies at Levels 1 and 2 may continue concurrently with Level 3 efforts, but are generally intended to inform actions at Level 3. Although Level 2 studies have learning as a primary objective, they can also provide measurable benefits to pallid sturgeon populations and, in such cases, are counted toward targets in the same manner as Level 3 actions. Criteria for accepting or rejecting specific hypotheses, for assessing the results of scaled experiments, and for moving from Level 1 to Level 2 or Level 2 to Level 3 actions, are described in section 4.2.4.

Table 6. Pallid sturgeon framework for the lower Missouri River.

Level 1: Research	Population Level Biological Response IS NOT Expected	Studies without changes to the system (laboratory studies or field studies under ambient conditions)
Level 2: In-river Testing		Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.
Level 3: Scaled Implementation	Population Level Biological Response IS Expected	In terms of reproduction, numbers, or distribution, initial implementation should occur at a level sufficient to expect a meaningful population response progressing to implementation at levels that result in improvements in the population. The range of actions within this level is not expected to achieve full success (i.e., Level 4).
Level 4: Ultimate Required Scale of Implementation		Implementation to the ultimate level required to remove as a limiting factor.

The Framework is expected to accelerate the identification of recruitment bottlenecks, resulting in a more strategic and focused implementation of appropriate management actions. This approach has the added benefit of minimizing impacts to stakeholders and avoiding unnecessary implementation costs. Though developed for use on the Lower River, the terminology from the Framework is used in describing needs for the Upper River as well.

1.4.4 Pallid sturgeon in the Upper Missouri River

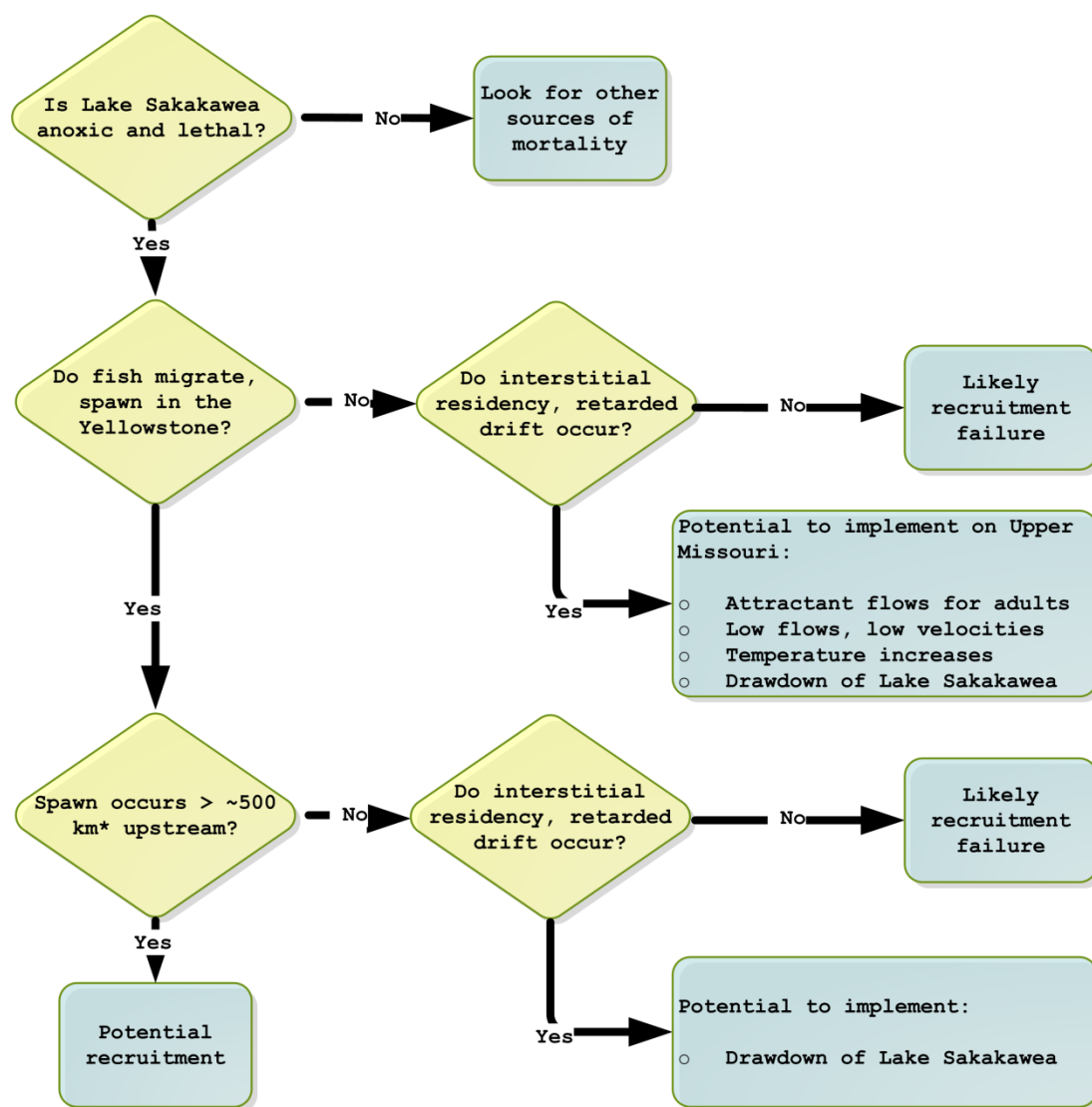
For the Upper Missouri and Yellowstone Rivers, fragmentation that limits the available drift/dispersal distance and hypothesized inhospitable headwaters of Lake Sakakawea due to anoxic sediments pose a distinct constraint on recruitment. Big Questions for the

Upper Missouri River relate to management actions that are hypothesized to increase natural recruitment (see Table 4). From this broader set of Big Questions and hypotheses, policy determinations have been made to focus implementation on actions that are either currently being implemented and re-evaluated (e.g., population augmentation, under review by the Pallid Sturgeon Recovery Team) or are proposed (e.g., fish passage at Intake Diversion Dam), or are under consideration (e.g., altered flows at Fort Peck dam to improve spawning and recruitment to age-1).

Implementation of fish passage at Intake Dam has been identified by the USFWS in the Pallid Sturgeon Recovery Plan as a priority 1 action. The fundamental scientific uncertainty related to Intake passage is whether reproductive adults will find passage around or over Intake Dam and migrate a sufficient distance upstream for spawning (500 kilometers [km] is the hypothesized distance needed for drift of free embryos). Resolution of this uncertainty will have a profound effect on the ability to predict whether recruitment is possible in the Upper River.

The Bureau of Reclamation will monitor the key metrics for the fish passage structure, as described in the Monitoring and Adaptive Management Plan for the Lower Yellowstone Passage Project (Reclamation 2016). Monitoring under the AM Plan for the MRRP is focused on using telemetry tags on adult pallid sturgeon to test the response of adult spawning in the upper Yellowstone River to improved passage at Intake, assessing drift of free embryos downstream past Intake Dam, and assessing the longer term population response to passage improvements at Intake Dam.

As part of the MRRP, the USACE will maintain support of population augmentation in the Upper Missouri River (as revised by the Pallid Sturgeon Recovery Team) and will undertake a series of Level 1 studies aimed at addressing issues related to anoxia in the headwaters of Lake Sakakawea, interstitial hiding of sturgeon free embryos, and drift of free embryos downstream of Ft. Peck, to determine if related management actions might be effective should fish passage at Intake Dam fail to achieve objectives. These efforts follow a decision tree (Figure 10) outlining the strategy for addressing uncertainties and resultant contingent decisions for this reach. Additional NEPA efforts would likely be required before decisions would be made by regulatory authorities to implement other potential actions identified in Figure 10.



* 500 km distance upstream is a coarse guideline because it would provide about 9 days for drift and development under purely passive drift assumptions.

Figure 10. Diagram of a decision tree for contingent information on the Upper Missouri and Yellowstone Rivers (presented as Figure 52 in Chapter 4). Passage at Intake will increase potential drift distance on the Yellowstone River to 400 km, and provides access to tributaries including the Powder River.

If pallid sturgeon do not successfully spawn on the Yellowstone River but subsequently recruit at sufficient levels, then the ability to manage for spawning on the Missouri River may hinge on whether delayed drift (interstitial hiding) occurs. If it occurs, then potential actions include flow management (low flows), temperature management (increased temperature), or drawdown of Lake Sakakawea. The question of whether delayed drift (interstitial hiding) occurs is important to spawning on the Yellowstone River as well. The necessary upstream migration distance (and hence available drift

distance) could be substantially reduced by interstitial hiding. Interstitial hiding is discussed further (see additional discussion in the EA summary, section 4.1.2).

Judicial delays in the implementation of passage at Intake Dam have led to uncertainty about the status and timing of implementation of this action, and as a result, a closer examination of other potential actions in the Upper River (USACE 2018). In particular, USACE will explore the potential for changing flows at Fort Peck Dam so as to improve spawning and recruitment to age-1. Proposed methods for monitoring and evaluating the effects of passage at Intake Dam (which could be adjusted to monitor the effects of flow changes at Fort Peck Dam), are described in Appendix E.5.

Implementation of these other actions would require evidence from related Level 1 and Level 2 studies to suggest that some combination of actions would improve survival to first feeding in the Upper River. Each of the potential actions, with associated hypotheses, objectives, metrics, and decision criteria, are discussed in Chapter 4.

1.4.5 Pallid sturgeon in the Lower Missouri River

Uncertainties for the Lower Missouri River revolve around how pallid sturgeon use the river, its tributaries, and the Mississippi River. Big Questions relate to possible actions to ensure survival and recovery of pallid sturgeon in the Lower Missouri River (see Table 5). In their framework for pallid sturgeon in the Lower River, the USFWS and Corps (2015) identified a suite of four actions anticipated to avoid jeopardizing pallid sturgeon in the Lower River, with associated targets and time limits for implementation (Table 7). The four actions include population augmentation, interception and rearing complexes (IRCs), spawning habitat, and (potentially) manipulation of flows. Proposed methods for monitoring and evaluating the effects of these actions are described in Appendix E.1 and E.2 (IRCs), Appendix E.3 (spawning habitat), and Appendix E.4 (flows). Through the process of AM and ongoing evaluation of monitoring data, these actions may in time be expanded, reduced or modified.

The uncertainties in the Lower River will be reduced using the framework shown in Table 6. Level 1 and 2 studies are directly tied to those uncertainties and management hypotheses highlighted in the EA that, if resolved, could significantly affect the implementation of management actions. These are presented in detail in Appendix C.

The USFWS and USACE (2015) identified a suite of four actions that, subject to the findings of Level 1 and Level 2 studies and further ongoing coordination, that are anticipated to avoid jeopardizing pallid sturgeon in the Lower Missouri River. They also identified targets and defined time limits for implementation of these actions (Table 7). As knowledge is gained from Level 1, 2, and 3 actions, the timeframe for implementation

may be adjusted, targets may be changed, management actions may be refined, and hypotheses may be dismissed. The “rules” by which these decisions will be made are outlined in the decision criteria for the respective management hypotheses, subject to the overarching governance and decision process laid out in Chapter 2 of this SAMP. Chapter 4 of the SAMP proposes a more accelerated timeline for high priority Level 1 actions (implemented in parallel rather than sequentially), as discussed in section 4.3.

Table 7. Summary of time limits for implementation and scope of actions.

Action Category	Time Limit*	Minimum Scope	Maximum Scope
Population augmentation	Immediate	Current stocking rate as directed by USFWS Range-wide Pallid Sturgeon Stocking and Augmentation Plan (in preparation).	Variable over time as directed by USFWS Range-wide Pallid Sturgeon Stocking and Augmentation Plan (in preparation).
IRC habitat development	Stage 1 - study phase (years 1-3 post-ROD)	Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr of suitable habitat, using staircase design ¹ . Assess potential for refurbishing existing SWH sites as IRCs.	
	Stage 2 – continue study phase (years 4–6 post-ROD)	Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr ¹ of suitable habitat. Refurbish SWH sites in addition to study sites (rate TBD).	
	Stage 3 - Level 3 implementation (years 7–10 post-ROD)	Continue assessing IRC sites and refurbishing new SWH sites, adding at least 66,000 ac-d/yr ¹ of suitable habitat. Determine required rate of Level 3 implementation based on stages 1 and 2.	
	Stage 4 – Level 4 implementation	Remove IRC habitat limitations to pallid sturgeon survival by implementation at Level 4.	
Spawning habitat ²	2 years	1 spawning site	See decision tree in Figure 63
Spawning cue flows	9 years	Requirement for spawning cue flows (and appropriate scope) depends on the outcome of Level 1 and Level 2 monitoring and modeling studies during years 1–9. ³	

Notes

1. Units of ac-d/year are calculated based on how the flow regime and channel configuration result in cumulative days of availability of suitable habitat during the growing season. Progression through each stage of IRC habitat development is contingent on outcomes and hypothesis tests (USFWS 2016); efforts could be halted if evidence shows IRCs are not successful. Experimental design for IRC sites, and associated metrics, are described in section 4.2.6.2 and Appendix E. Refurbishment of SWH sites into IRCs is described in section 4.2.6.3.

2. Anticipated as a Level 2 pilot project focused on developing and evaluating high-quality spawning habitat. Spawning habitat implementation will be guided by the decision tree in section 4.2.6.3. The evaluation of spawning areas will be based on comparing attraction, egg survival, and hatch to existing spawning areas (see section 4.2.6.2).

3. See evidentiary framework in section 4.2.6.4.1. Pallid population modeling will be used to set minimum spawning flow needs. Bird impacts and status, reservoir levels, and HC impacts will inform decisions regarding spawning cue flows below Gavins Point Dam in any particular year.

At any time during the Framework's implementation, it may become apparent that: (1) a particular action is not needed, (2) a proposed action requires modification to be effective, or (3) that some new action not previously evaluated is required.

The artificial propagation program is already taking place at a level having a measurable effect on the population (i.e., Level 3). As knowledge is gained from Level 1, 2 and 3 studies, the timeframe for implementation may be adjusted, targets may be changed, management actions may be refined, and hypotheses may be adjusted or rejected. The "rules" by which these decisions are made are outlined in decision criteria for the respective management hypotheses, subject to the overarching governance and decision process laid out in Chapter 2. Chapter 4 proposes an accelerated timeline for high priority Level 1 actions (implemented in parallel rather than sequentially), as discussed in Section 4.3.

Improvements to address genetic concerns (e.g., maintaining genetic variation similar to the natural population, minimizing threats of hybridization), disease, stocking size, amount of stocking relative to carrying capacity, etc., would be pursued collaboratively with the USFWS and others to be consistent with the Range-wide Pallid Sturgeon Stocking and Augmentation Plan, presently (April 2018) under revision by the USFWS. While population augmentation is a component of recovery of the pallid sturgeon, the ESA requires a self-sustaining population (i.e., a spawning population that results in sufficient recruitment of naturally-produced Pallid Sturgeon into the adult population at levels necessary to maintain a genetically diverse wild adult population in the absence of artificial population augmentation; UFSWS 2014, pg. 54). Augmentation can help severely depleted populations recover numbers of individuals sufficiently to provide reliable evaluations of the effectiveness of alternative actions.

Level 1 and 2 activities associated with IRCs focus on: (1) the need for additional IRC habitat, (2) refining the relationship between the habitat components and flow (utilizing current operations), and the biological requirements of each habitat type, (3) the needed habitat characteristics and their spatial and temporal distributions, and (4) determining the effectiveness of various mechanical activities and the potential for flow management actions to contribute to future IRC needs. Level 3 actions include physical manipulation of habitats and structures on the Missouri River to create or improve areas having hydraulic conditions to intercept drifting free embryos combined with food-producing habitats and foraging habitats. Actions can be directed at one or any combination of the three components of IRCs. Examples include adjustments to navigation training or bank stabilization structures, channel widening, floodplain modifications or other adjustments to channel geometry, placement of structures to encourage development of needed habitat or habitat complexity, chute development or adjustments to existing

chutes, etc. Level 3 actions and outcomes are focused on helping to understand and describe future Level 4 actions and targets, which will be based on bioenergetics requirements of the Missouri River pallid sturgeon population. An experimental design and monitoring plan for IRCs is included in Appendix E of this SAMP; it involves 12 treatment-control pairs implemented over 7 years in a large scale Level 2 management experiment (see Appendix E1), and modification of selected chute-based, shallow water habitat projects into IRCs (see Appendix E2).

The spawning habitat hypothesis (H16) provides an example of application of actions at Level 1 and 2 to reduce critical uncertainties affecting management decisions and targets. An early emphasis will be to utilize information from spawning habitats in the Yellowstone River as the best natural reference condition to inform the design of Level 2 pilot projects on the Lower Missouri River, while also continuing to examine the habitat characteristics of spawning sites on the Lower Missouri. Initially only one spawning habitat would be constructed on the Lower Missouri, in a location and form which maximizes the potential for aggregation of males and females. This pilot project will be monitored for effectiveness based on metrics ranging from observed aggregation and spawning to the number of free embryos in the water column (described in Appendix E.3).

Another example of applying Level 1 research within the Framework is testing the spawning cue hypothesis, H11 (see Table 5). Observational studies (e.g. tracking tagged pallid sturgeon movements and spawning over contrasting flow conditions) will be conducted over a 9-year period following the ROD. Analyses of these data and application of an evidentiary framework (section 4.2.6.5) will then be used to determine whether it is appropriate to conduct a one-time spawning cue test flows at Gavins Point to support or refute this hypothesis. The evidentiary framework will examine the correlations between flows and movement, aggregation, and spawning success, using tagged pallid sturgeon in reproductive condition. Testing hypothesis H11 involves both temporal and spatial contrasts, as described in Appendix E.4.

The uncertainties for the pallid sturgeon are both extensive and fundamental to management strategies. Therefore, AM for pallid sturgeon will rely heavily upon research conducted in conjunction with the implementation, monitoring, and adjustments of management actions. This research has been prioritized to focus on critical uncertainties that have a strong influence on decision trees. Early implementation of actions will generally be of an experimental nature (i.e., Level 2) and could involve several concurrent studies that are potentially confounding. This will require careful consideration of what studies will be implemented and when, along with sound experimental designs.

1.5 Human Considerations (HC)

The term Human Considerations (HC) is used in the MRRP to address the interests of all perspectives beyond those of the ESA. These include a wide array of objectives related to the authorized purposes for the System and BSNP (e.g., flood control, navigation, fish and wildlife, irrigation, power, recreation, water supply, water quality) as well as the many other services afforded by the Missouri River. The fundamental premise of any action taken is that it allows USACE to continue to operate for all authorized purposes while complying with all applicable laws, regulations, and treaty and trust responsibilities. Actions are implemented and monitored to avoid negative impacts to the System's authorized purposes. Several aspects of the SAMP are geared specifically toward achieving this objective. Chapter 5 discusses how HCs were programmatically addressed during the MRRMP-EIS and how they will be considered during implementation of the MRRMP.

1.5.1 How HCs are considered

Section 5.1 presents a brief introduction to HCs in Missouri River basin. It summarizes the range of HCs that may be directly affected by the MRRMP and outlines how HCs were evaluated during the development of the MRRMP-EIS.

Section 5.2 presents planning context related to the Corps' Missouri River responsibilities and authorities. In practice, steps taken to minimize impacts to HCs occur at varying levels of planning, design, construction and maintenance. The degree to which the USACE can minimize impacts to HCs is informed by the basis for and limits of these responsibilities and authorities.

Section 5.3 discusses how the specific actions in the preferred alternative could potentially affect HCs, and how USACE plans to avoid or minimize adverse impacts to the HCs, while fulfilling the requirements of the ESA. Because all impacts may not be avoidable, and more than one HC has the potential to be impacted, there may be tradeoffs to be considered.

Section 5.4 discusses issues concerning the adaptive management of HCs, such as:

- SAMP governance and HCs
- Responding to new situations or concerns that arise while implementing the preferred alternative.
- Screening and prioritizing HC monitoring.
- Tradeoffs involving HCs.

1.5.2 Monitoring and assessment of HCs

Section 5.3 addresses the potential for monitoring of HC-related issues. It outlines how the USACE currently monitors HC-related issues, the sources of uncertainty in predicting HC impacts and how those sources might be reduced through monitoring. The section discusses the factors future conversations about HC monitoring requirements should consider when identifying and screening specific monitoring actions. It presents current and potential future monitoring associated with each management action in the EIS.

1.5.3 HCs and Adaptive Management

Section 5.4.1 addresses roles the HC Team / Work Group can play that add sufficient value and do not confuse or overlap with existing regulatory and engagement processes. The following roles are discussed:

- Provide draft recommendations to MRRIC on mechanical habitat siting decisions
- Help to co-ordinate and track the flow of information about Missouri River HC issues as they arise
- Make suggestions to MRRIC concerning any issues that have relevance for the program as a whole
- Make recommendations for MRRIC to consider concerning new issues that emerge and that may require monitoring or actions
- Make recommendations for MRRIC to consider regarding HC adjustments to the Strategic Plan
- Help in the consideration of actions outside the MRRMP that may be required in future
- Help MRRIC act as a trusted, engaged and informed advisory body that can knowledgeably comment on HC issues that arise

Section 5.4.2 describes the annual cycle of decision making from perspective of HCs and HC Work Group members, while Section 5.4.3 clarifies the flow of information as part of that cycle and how the HC Work Group contributes.

Section 5.4.4 outlines the scoping of HC issues and new information. A draft flowchart that was developed to help route issues that arise to the most appropriate forum for their discussion is presented. The draft flowchart poses a series of questions that help to ensure that the HC Work Group is the best forum for a conversation, recognizing there are many forums for addressing issues with the USACE and USFWS.

Sections 5.4.5 and 5.4.6 describe the roles of the HC WG and Team in addressing new and ancillary information. In the former case, the process outlined in Section 2.5.3 offers details of the new information process while Chapter 5 discusses how the HC Team may be engaged if the new information relates to an HC issue. In the latter case, the HC Work Group may play an informal role in collecting additional information that reflects learning or provides important insight into decision making but was not targeted through specific monitoring or studies.

Section 5.4.7 describes an approach to identify, screen and prioritize candidate target HC studies during the adaptive implementation of the MRRMP. Section 5.4.8 addresses HCs and actions outside the EIS. It extends the consideration of monitoring for HC issues to those that need only be undertaken in the event of a flow modification, and considerations for potential future management actions.

1.6 Data acquisition, management, reporting and communications

AM decisions should be based on “best available science,” including information that is relevant, reliable, objective, timely, and accessible, among other attributes. Acquiring and managing the data necessary for the MRRP will be a significant undertaking. An elaborate system is needed just to manage outputs from the dozens of models supporting the program, for example.

Monitoring of discrete projects spread along more than 1700 miles of river and involving physical, chemical, biological, economic, and social metrics will generate considerable data at varying spatial and temporal scales that must be compiled, classified, subjected to quality control (QC) measures, summarized, transformed, or otherwise analyzed, and stored in a system that permits easy identification and acquisition.

The successful execution of the MRRP also requires reporting on project performance, System and species status, and communicating Program activities, analysis results, and key decisions to agency personnel, stakeholders, and to the public. Data and analysis results, unless otherwise prescribed by law, should be made available to the decision makers, stakeholders and the public in useful formats.

1.6.1 Monitoring and other data acquisition issues

Monitoring plays a critical role in AM applications by providing information needed for learning and to support sound decisions. Choice of which attributes to monitor and how to monitor them (frequency, extent, intensity, etc.) must be linked closely to management actions, decisions, and monitoring purpose. Monitoring must be

consistent with the analytical requirements and principles in the evaluation step and in each subsequent step of the AM cycle (see Section 6.1).

Monitoring and data acquisition are addressed for pallid sturgeon (see Section 6.2.1), birds (see Section 6.2.2), and HCs potentially affected by water and land management actions (see Section 6.2.3). The multi-team approach employed for the MRRP has advantages: consistent approach and sustained expertise; improved agency coordination; and reduced bias. Weaknesses include turnover and inexperience of some personnel, challenges in training and QA/QC procedures, and occasional inconsistency in methods. Future monitoring efforts will build upon the strengths and incorporate measures to address weaknesses.

Section 6.2.4 describes a Research data acquisition strategy employing a competitive proposal solicitation process, clear selection criteria, independent peer review, and data submission requirements, and overseen by the ISP to ensure the best return on investment in research and development (R&D).

1.6.2 Data management

Information needs vary at different stages of the AM cycle (see Section 6.1). Users include: agency leadership, MRRIC, the general public, the Management, Fish, Bird, HC and Technical Teams, and researchers (see Section 6.3.1). For optimum learning to occur, a variety of data must be collected in meaningful ways, processed as needed, stored and communicated in accessible formats to serve multiple categories of users, and presented at the right time to assist in decision making (see Section 6.3.2).

The goal of the MRRP Data Management System is to provide a single user-friendly access point for MRRP relevant information that is available on a timely basis, in appropriate formats, and meeting required quality standards. Section 6.3 includes specific discussions of users and their needs for information (6.3.1), purpose and objectives of data management (6.3.2), proposed forms of reporting and communication (6.3.3), a proposed plan for developing a data management system (6.3.4), the proposed structure and functionality of a data management system (6.3.5), and a review of existing data management systems (6.3.6).

Requirements for the Data Management System are being further defined through a user needs assessment initiated in the fall of 2016. Section 6.3.4 summarizes a proposed Work Plan for developing the Data Management System, involving five phases: (1) a requirements analysis describing in detail the functions and work products that each user group will require, when, and how they will interact with the system (developed through the user needs assessment); (2) a detailed review of systems currently used by

MRRP, candidate data portals, and available technologies; (3) identifying implementation barriers; (4) developing a report on system requirements; and (5) prioritized development, implementation, and testing of the Data Management System.

Section 6.3.5 describes some of the intended structural features of the MRRP Data Management System and its functionality, and provides examples of these features from existing data management systems. Potential features include: a single portal to information and tools all users; controlled access for certain information and tools; distributed management by the agencies currently generating those data; comprehensive and searchable metadata; and a variety of user-friendly tools to facilitate information access in tabular, graphical, and map-based formats. Existing data management systems, including the Least Tern and Piping Plover Data Management System (TPDMS) and the Pallid Sturgeon Population Assessment (PSPA) Website, are described in Section 6.3.6.

1.6.3 Reporting and communications

Communicating results of monitoring and assessment to decision makers involved in the planning and implementation of the MRRP is a primary objective. Others' information and communications needs must be met as well, requiring a range of products and information access, potentially including: an online portal for raw monitoring data, data summaries, calendars, maps and other work products; technical reports; draft and final AM reports; system scale AM evaluation reports, technical memos explaining adjustments to management actions, draft and final SPs, fact sheets, journal publications, science blogs and videos; and model manuals. Chapter 6 discusses how these products can be used with the more traditional face-to-face meetings and webinars to meet the Program's communications needs.

1.6.4 Quality assurance (QA) and quality control (QC)

The complexity of the data collection and assessment operations to support the MRRP AMP demands a systematic process for data QA/QC to ensure that decision-makers and stakeholders have confidence that the data they use are scientifically sound, of known and documented quality, and suitable for their intended use. Section 6.4 lays out the basic principles and objectives for a sound QA/QC program, employing the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) as its basis. All agencies and contractors involved in environmental data acquisition during MRRP implementation are required to adhere to the QAPP.

An independent biennial Quality Assurance Review (QAR) will be conducted to provide MRRP management and stakeholders with an assessment of the state of data quality for

MRRP. The goals of the QAR are to identify practices that contribute to data quality, identify problems and best management practices, report on the activities of the AM Teams, and recommend improvements to the quality system for MRRP monitoring.

Data Quality Objectives (DQOs) have been defined for the MRRP to bring awareness to participants of the minimum data quality required. The DQOs define the type, quality, and quantity of data needed to make defensible decisions. They identify the requirements for field investigations and limits on tolerable error rates, and indicate the intended end use of the data, including decisions that may be made based on the information generated.

The ISP, working and coordinating with the various AM Teams is charged with implementation and oversight of the MRRP QA/QC program and will ensure that monitoring adheres to the QAPP. The ISP is responsible for dealing with QA issues, establishing a mechanism for distribution of quality system information and changes, and ensuring data meet or exceed the DQOs of the AMP.

1.7 Summary

Figure 11 illustrates the timeline of events leading to the MRRMP-EIS and this AM Plan. The EA demonstrated that the best available science and current understanding of the effects of the operation and maintenance of the System and the BSNP are not sufficient to clearly identify the scope of actions necessary offset the effects of operations on pallid sturgeon. Furthermore, the timing and scope of necessary actions for the piping plover and least tern are uncertain at relevant timescales because of the dynamic nature of those species' critical habitat; predicting needs beyond 1 or 2 years and meeting them within constraints presents challenges and requires trade-offs.

Given the uncertainties identified by the EA, the lead agencies deemed it prudent to proceed by identifying a Preferred Alternative in the MRRMP-EIS that addresses the priority hypotheses from the EA, but to also prepare an AM Plan that provides the framework, performance standards, decision criteria, and governance processes needed to guide the MRRP's implementation so that knowledge gained over time would translate into refinements of or adjustments to the management actions necessary to meet the Program's objectives.



Figure 11. Timeline of events leading to the development of the MRRMP-EIS and the AM Plan.

In lieu of a more definitive but comprehensive set of actions that might have otherwise been prescribed, the AM approach provides (a) time and latitude to implement, monitor and assess actions in a structured fashion to promote learning, (b) opportunities for research and studies that may yield answers to critical questions more quickly than would occur through implementation alone, and (c) the flexibility to reject, modify, or introduce new actions and/or adjust targets based on knowledge gained through the process. This approach recognizes the trade-offs between time and knowledge, and balances the risks and uncertainties so as to benefit of the species, while minimizing costs and impacts.

The AM strategy builds upon the products of the EA, employing rigorous hypothesis testing, project and Program monitoring and assessment, and predictive numerical modeling of habitat, species status and effects of alternative management actions. A science update process affords decision-makers needed information to make annual update to a 5-year strategic SP for the MRRP. Annual updates may include adjustments to plans for the current and next FYs, but are focused on the FY+2 Program to align with the USACE's Civil Works budget needs.

Interagency Bird and Fish teams that include MRRIC WGs use information generated by a non-decisional Technical Team to formulate recommendations and prioritized actions for each species. An HC Team reviews monitoring and assessment results as they relate to effects of actions on HC interests and provides recommendations for related needs. An interagency Management Team drafts adjustments to the SP using the Bird/Fish/HC Team recommendations and guidance regarding resource availability. Draft updates to the SP are vetted through engagements between the lead agencies and MRRIC at plenary meetings that provide opportunities for input, collaboration, and consensus recommendations. The same process is used to address adjustments to the Program's governance, to resolve disputes, etc.

Managing for the birds involves meeting targets for ESH while minimizing impacts to authorized purposes, balancing other Program needs, and accounting for constraints. The challenge lies in uncertain future conditions regarding system runoff and operations, which affect habitat availability and population responses. The habitat and population models provide powerful tools to support management decisions. AM opportunities center on improvements to these tools, better and more cost-effective methods for creating and maintaining ESH, and predator and vegetation management.

Managing for the pallid sturgeon presents more significant challenges. Uncertainties regarding the specific factors causing recruitment failure for pallid sturgeon and the inability to link management actions with population response prevent the clear

identification of the System manipulations required to address the species' needs. A framework and strategy reliant upon a progressive AM program is the most effective way to manage risks to the pallid sturgeon, address the key uncertainties, and identify the scope and scale of actions ultimately required.

In addition to the above considerations, this AM Plan includes a number of processes, protocols, and procedures that will be necessary for the implementation of the program, a description of the data management, reporting and communications needs and strategy, and a discussion of how HCs can be addressed. An accompanying set of appendices provide important details regarding the needed research, experimental designs for hypothesis testing, monitoring and assessment protocols, etc. Updates and improvements to the SAMP over time as understanding grows and the needs of the program change have been anticipated, and processes for periodic adjustments have been incorporated into its design.

2 Governance of the AM Program

Chapter 2 addresses the governance of the MRRP, which is the management and decision making structure and processes for the program. Several important principles and attributes of good governance are presented. The range of decisions required for the plan development and its implementation are discussed in Section 2.2. The roles and responsibilities of the primary entities involved in governance are described in Section 2.3. The decision process, and in particular the interactions occurring around the development and update of the SP are discussed in Section 2.4. The chapter concludes with a presentation of several important protocols and procedures (see Section 2.5). The decision making structure contained in this section is in no way delegation of decision making authority. Nothing in this chapter is designed to replace, impede or conflict with any statutory authority of any party described. To the extent any inconsistencies may exist, the statutes and regulations shall govern.

2.1 Definition, principles and key attributes for effective governance

2.1.1 Governance defined

Although several definitions of governance are available, a broadly held view is that it includes a consideration of authority, administration, decision-making, and accountability. Governance of an AM program includes the approach for converting knowledge into improved management through decision making, identifying:

- **what** decisions need to be made,
- **who** is involved in the decision process,
- **how** decisions are made, and
- **when** decisions are required.

The concept of “adaptive governance” has recently emerged in the context of AM, adding consideration of the need for organizational and institutional flexibility to change, which is a crucial concern for the MRRP SAMP given the likelihood that the governance strategy will need to be adjusted to suit program needs, and that the lead agencies and MRRIC will also need to adjust to this way of doing business.

2.1.2 Attributes of governance that enable AM

Although AM has been applied to natural resource management for decades, implementation has not been easy. Obstacles include concerns that implementing, rigorously evaluating, and potentially adjusting management actions may be too costly, too risky, and/or contrary to values of some stakeholders, as well as perceptions that a

shift to AM threatens existing management, research and monitoring programs. The ideal setting for AM is one in which there is agreement around the objectives and policies, while allowing for disagreement around causation and the effects of different management actions. Because it cannot always be avoided, a good AM program should also have processes for resolving value-based conflict.

Effective systems of governance and organizational networks for AM serve several functions, including: (1) trust-building, (2) knowledge generation, (3) collaborative learning, (4) preference formation, and (5) conflict resolution (Green et al. 2015). A robust system of governance that can execute, innovate and learn is preferred for AM (Duit and Galaz 2008). Attributes that enable AM can be divided into three sequential and mutually supportive subsets (Greig et al. 2013). Governance first requires mechanisms of conflict resolution and trust building. Attributes related to problem definition, communication, leadership, executive direction, and organizational structure are the second set of critical elements to establish. If done well, the third set of attributes will follow: community involvement, planning, funding, staff training, and AM science. Table 8 summarizes factors enabling and inhibiting good AM governance.

Table 8. Factors enabling and inhibiting good governance of AM programs.

Factors Enabling Good Governance	Factors Inhibiting Good Governance
Collaborative, interdisciplinary working environment with free-flowing communication and easy access to well-synthesized information.	Communication among components/departments hindered by different mandates or between disciplinary specialists (i.e, stovepiping). Difficult to access required information.
Frequent re-examination of management and restructuring as needed.	Management done the same way for a very long period of time.
Leaders deliberately challenge themselves and staff to recognize change, innovatively adapt to challenges, and take calculated risks.	Leaders resist change, discourage risk and innovation, and create organizational culture of status quo.
Collaborative inputs to decision making over sustained period, generating buy-in and trust, allowing stakeholders to move from positions to interests, clarifying areas of agreement and disagreement.	Institutions isolated from public/stakeholders; very limited and inconsistent consultation. "Inform" rather than listen.
Recognize critical uncertainties and plan experiments to test alternative hypotheses/actions.	Plan based on past experience, practices, procedures established by senior staff.
Stress high-quality science at appropriate scales, with independent review panels. Data made available; different interpretations of data welcomed, used to postulate alternative hypotheses and design management experiments. Wide publishing of scientific findings.	Science discouraged or use of "advocacy science" to support agency's position (see Section 2.1.3). Data kept internal; selective evidence used; insist on single, dogmatic agency position regarding data analysis.

There is no “one-size-fits-all” approach to effective governance. An effective system will depend on the intended purpose/need and will have clear expectations around outcomes (Rijke et al. 2012). Although lessons can be learned from other AM programs (e.g., Platte River, Trinity River, Glen Canyon), an effective system of governance for the Missouri River requires consideration of how the above attributes and functions apply within the context of the unique ecological and social conditions for the Missouri Basin.

The MRRIC (2011) indicated that the engagement approach for developing and implementing an AM strategy should:

- be understood and trusted by MRRIC members
- provide a satisfactory level of participation in the systematic process for MRRIC members
- afford opportunities for MRRIC to identify any social, economic, or cultural issues that may result from the proposed action(s)
- be implementable for both the agencies and MRRIC
- be focused on resolving scientific uncertainties necessary to inform management decisions
- provide for collaboration that allows the agencies to implement the MRRP in a timely manner.

Gunderson and Light (2006) point out that the Comprehensive Everglades Restoration Program has been hindered by long standing feuds among special interest groups (e.g. agricultural and environmental) who seek certitude in policy, rather than understanding through experimentation. AM accepts that “failures” will occur in the short-term but that those failures are critical to learning and long-term success. Other approaches seek to avoid policy failure, which reinforces the status quo and precludes opportunities for learning while doing (Blann et al. 2003; Light, 2001).

To be successful, AM must be applied under and supported by a governance structure that understands AM, values it, and is willing to commit the necessary resources to allow its processes to work (Loftin 2014). AM and accountability are closely linked; both answer questions about whether progress is being made using ecosystem and program information (Puget Sound Partnership 2008). While the USACE is ultimately accountable for executing the program so as to avoid jeopardizing the listed species, each of the entities involved in the MRRP must be accountable for their roles in executing the plan. The use of performance metrics, decision criteria, and other triggers can improve accountability (Nie and Schultz 2012) and are therefore emphasized in this plan.

Fischenich (2012) indicated that AM works best when (a) management flexibility is incorporated into the design and implementation of programs or projects; (b) projects and programs can be implemented in phases to allow for course corrections based on new information; (c) interagency collaboration and productive stakeholder participation are fostered; and (d) scientific information is introduced into the decision-making process and guides managers not only during planning, but also after project implementation.

Governance can take several forms. The “governance” implicit in the decision criteria, contingency plans, and other guidance incorporated into the SAMP, which are decisions agreed upon prior to implementation, are as important as the governance that occurs through post-implementation decisions.

2.1.3 Ensuring objective and reliable science in the Missouri River Recovery Program

AM requires reliable information for improved decision making, increased effectiveness of management actions, and increased ability to meet program objectives. Decision makers and stakeholders must be confident that the underpinning science is unbiased and sound. The utility and credibility of science is reduced when influenced, or perceived to be influenced, by agendas, political pressures, advocacy, and bias. This is a common challenge among science programs and especially for those involving contested, controversial, or politically-charged topics. Scientists must adhere to, and organizations must promote, practices and conduct that contribute to the best available scientific data and information, and generate objective, relevant information for decision makers.

The MRRP Integrated Science Program (ISP) relies on partner agencies to conduct research and monitoring, analyze data, and report findings. An advantage of this approach is that significant expertise –often not available elsewhere– exists within these agencies. Work conducted by multiple partners can benefit from the broad perspectives those partners provide. However, agencies have their own missions and, in some cases, advocacy roles. For the MRRP, scientists must follow scientific codes of conduct and accurately report findings, even when results do not support agency positions. Potential conflicts of interest and unsound scientific practice must be identified and addressed to prevent their influence on the scientific data and information used in the MRRP. Agency leadership, scientists, independent advisors, and stakeholders all play important roles in addressing this concern.

The potential for bias is ever present and guarding against it by relying upon the Program’s ability to identify and engage only unbiased entities is not an effective solution. Because even the perception of bias will undermine credibility and ultimately

the utility of science, the solution must be broad, transparent, confidence-building, and continually monitored for effectiveness. The following mechanisms will be employed to help minimize bias, increase transparency, build confidence among agency decision makers and stakeholders, and ultimately maximize the credibility and usefulness of the data and knowledge underpinning decisions for the MRRP:

1. Embrace independent review. Independent review, (e.g. ISAP and external peer review) provides opportunity for critical, independent, and transparent evaluation of experimental designs, science findings, interpretations, and resulting decisions. Independent review, especially when performed transparently with opportunity for engagement by interested parties and open scientific deliberations, dramatically increases trust in a science program. Successful use of independent reviews requires commitment by scientists, stakeholders, and decision makers to embrace the process. Subjecting MRRP science to peer-review and publication standards is also important and should be a requirement of scientists working on the MRRP.
2. Engage expertise within and outside the basin. When little scientific input or interaction occurs among scientists within and outside the basin (e.g., those studying pallid sturgeon on the Mississippi River, other sturgeon species, or other highly altered river restoration efforts), science efforts can become myopic or suffer from lack of perspective and lessons learned by others. This is especially true for pallid sturgeon and piping plover science efforts given that these species occur and are extensively studied outside of the Missouri River basin. Recurring, structured interactions among system- and subject-matter experts both within and outside the basin, including Recovery Teams, will ensure that science efforts are coordinated, well-informed, and considerate of relevant knowledge and expertise.
3. Diversify partnerships and increase reliance on a competitive proposal process. Striking the proper balance between the need for consistency and development of expertise with the benefits of new partnerships and additional scientific perspective is a challenge for any program. The ISP and MRRP should, where practical, seek to involve new science partners and pursue proposals for research efforts through competitive processes that generate alternative strategies, foster new collaborations, and bring innovative concepts to bear upon the challenges of the MRRP. Because the Program is hypothesis based, scopes of work can be clearly defined, creating a competitive proposal process with several inherent benefits.
4. Maximize transparency. The ISP and all MRRP parties must continue to function transparently, ethically and openly. Collected data, analyses, scientific deliberations, recommendations, and science prioritization should be accessible. Continued emphasis on frequent and effective communication is essential. To this end, the development of a web-based data management and reporting system should be a near-term programmatic objective (see Section 6.3).

5. Predefine data collection and analyses requirements and follow the plan. Clearly defined procedures in the SAMP increase transparency and reduce opportunities for bias. Monitoring and assessment protocols must be followed, related analyses completed, and results shared, regardless of the findings. Scientists cannot have the opportunity to selectively analyze data or report only those findings consistent with the scientist's or their agency's aims. Acceptable monitoring, assessment, and analytical practices, as driven by program needs and professional standards of practice, will be identified and incorporated into the MRRP through compulsory protocols published in the SAMP and identified in any work orders or contracts.
6. Optimize institutional structure to minimize conflict between policy and science. The ISP cannot act or be perceived to filter information so as to support an agency agenda. Instead, the role of the ISP must be to ensure that sound scientific processes are followed, that appropriate checks and balances are in place to counter inherent bias, and that all relevant information is considered and evaluated. To this end, structuring of the MRRP should provide confidence that science practice is clearly separated from undue influence of advocacy and peripheral agendas.

2.2 Decision needs for adaptively managing the MRRP

Planning, implementing, and adaptively managing the MRRP requires hundreds of decisions ranging from relatively mundane issues like what type of net to use for sampling to significant and potentially contentious issues like whether to adjust flow releases from a reservoir to create habitat. Decisions are required at many points in the process and by each of the main entities.

The USACE Commander for the Northwestern Division (NWD) is ultimately responsible for most of these decisions. However, the sheer volume demands that many decisions be delegated to the District Commanders or others within the agency. USACE's senior leadership relies upon recommendations from subordinate staff familiar with the issues and from subject-matter experts engaged by the MRRP for that purpose. They also rely upon input from MRRIC, other agencies, Tribes and the public, where appropriate, when making decisions. The USACE has a long history of operating in this fashion, which is an important consideration when fashioning a governance structure for the MRRP. However, it is important to understand that personnel structures and programs evolve thus the positions described in the SAMP are subject to change.

The USFWS is responsible for compliance-related decisions, including policy determinations regarding the application of AM to the ESA. As knowledge about species and their responses to management is gained through implementation, it may be

necessary to adjust the targets, decision criteria, and/or required management actions in order to sustain a determination that the operation of the System and BSNP is not likely to jeopardize the listed species or their habitats. The USFWS Mountain-Prairie and Midwest Regional Directors will work closely with the USACE, MRRIC, and the other entities listed above when making these decisions.

MRRIC shares responsibility for the Program performance given their input and recommendations influence agency decisions. MRRIC may provide a consensus recommendation regarding any aspect of the Program, and discussions that occur through the collaborative engagements outlined in this SAMP help frame agency actions. AM demands the commitment of time, resources, and active engagement of stakeholders, as well as their commitment to actively engage in the governance process and provide the necessary input to decision makers.

Importantly, certain parties are explicitly excluded from decision-making roles. Facilitators promote group participation, trust, mutual understanding, and shared responsibility for decisions, but are not themselves decision makers, so must maintain a neutral posture on any decision. Similarly, technical experts engaged by the program (e.g. members of the Technical Team and ISAP) play an important role by helping to link objectives and management decisions to system understanding, but are not themselves stakeholders, so should not be involved in objective/value development or decision making. These entities must be viewed by agencies and stakeholders as neutral third parties, and must be capable of performing as such (see Section 2.1.3).

2.2.1 Scope of decisions in the MRRP

The most evident and essential function of governance for an AM program is to facilitate effective, transparent decision making. However, decisions for the MRRP (and all other large-scale, ecosystem-based programs) are complicated by several important legal, social, political, and economic dimensions. The design of the Program's governance structure and processes must, therefore, anticipate the wide range of decisions needed to translate knowledge gained about the system and species into effective and acceptable management. Governance design should also promote decision making at the lowest practicable level and be sufficiently flexible to allow for efficient, timely decisions, accommodate unanticipated decision needs, and to grow/change with the Program.

Attachment 16 of Appendix A includes a table with examples of the decisions required to adaptively manage the MRRP. Some of the organizational elements listed in the table have not been previously described in this SAMP (see Section 2.3 for descriptions of entities involved). Information presented in the attachment is meant as a general guide; appropriate decision authority will be at the agencies' prerogative except where

specifically prescribed by policy or other agreements and may necessarily change over time. Decisions for the program are made at three general levels of authority within the agencies (defined herein as Oversight, Management and Implementation).

- 1) The Oversight level includes agency senior leaders, who are responsible for decisions related to Federal policies and protocols and other issues that may significantly affect stakeholder interests or authorized purposes, and therefore involve collaboration with the MRRIC. These decisions are primarily made during the Plan/Design step (Step 1) of the AM cycle as the Program is developed, but because they are periodically revisited, could occur during the Adjust/Continue step (Step 5).
- 2) The Management level, which includes agency program and project managers, develops the draft SP and makes decisions regarding resource allocation, reporting and communication, and collaboration. Management-level decisions are primarily made at the Plan/Design and Implementation steps (Steps 1 and 3) of the AM cycle, but can include decisions at each step of the process.
- 3) Implementation-level decisions include the wide ranging and numerous judgments needed for the day-to-day operation of the Program. These include how monitoring programs are implemented, how assessments are conducted and reported, how projects are implemented, etc. Note, however, that the real-time flow management decisions made by the Corps' Water Management Division following the procedures and requirements in the Missouri River Mainstem Reservoir System Master Water Control Manual are Oversight-level decisions (see Section 2.3.1).

2.2.2 Balancing needs

Because objectives and management actions have been identified separately for the birds and fish, the potential exists for actions aimed at one species to adversely affect the other; they can also synergize with or have no measureable influence on the others. Actions aimed at either can have adverse and/or beneficial effects on stakeholders. A key stage in the planning of actions is the assessment of their effects on the target species, on other species, and on the various HC interests. Where possible, actions should be adjusted to avoid and minimize adverse effects and to maximize benefits. Actions with unavoidable adverse impacts should be judged against associated trade-offs and other alternatives.

Potentially overlapping effects of management actions are considered at several stages in the process. The initial set of actions included in the preferred alternative, as well as the other actions considered in the full range of alternatives, were evaluated in detail as part of the MRRMP-EIS process (see Chapter 4 of the EIS and Sections 3.2.4 and 4.2 of

this SAMP). Overlapping effects are substantially reduced by geographic realities; aside from that portion of the Southern Region for the birds downstream of Gavins Point Dam, the targeted areas for the birds and fish do not coincide. Direct and localized secondary effects of habitat construction – the focus of the preferred alternative – are therefore generally restricted to the target species (see further discussion in Sections 3.2.5 and 4.2.7). The greatest opportunity for intersecting effects occurs with flow management actions. A spring release aimed at pallid sturgeon spawning, for example, might create some emergent sandbar habitat and might also delay bird nesting (see Section 3.2.5).

Similar analyses will be conducted for any new management actions identified in the future, and the cumulative effects of management actions will be considered as part of the SP formulation process whenever new actions are proposed (see Section 2.4.5). Management actions should be optimized at the concept and design stages to avoid and minimize impacts (or optimize benefits vs. impacts), and adjusted as needed through the AM process. Planning for the MRRP will continue under AM at both the project and program levels and will incorporate the necessary trade-off analyses as part of each.

Whereas potentially overlapping effects of management actions are few and infrequent, balancing the needs for bird and fish in terms of Program focus and budget will remain an ongoing requirement. For pallid sturgeon, the research and implementation strategy needed to overcome critical uncertainties could fully exploit available Program resources. However, the extent to which the Program focuses on pallid sturgeon needs will likely be driven by habitat requirements for the piping plover. Historical patterns of runoff and System storage – which will presumably continue – have resulted in periodic high flows (e.g., 1952, 1975, 1997, and 2011) that create abundant ESH. These events are typically followed by periods of declining ESH acreage as the sandbars erode under normal operations. When the acreage approaches or drops below targeted levels, construction will be needed to offset losses and maintain sufficient habitat for the birds.

Balancing bird and fish needs that differ over time requires ongoing analysis, planning, risk management, and flexibility. Program resourcing (budget and personnel) will need to be periodically shifted to address changing requirements. The need for additional ESH will seldom be a surprise; erosion rates are reasonably predictable, and modeled acreage projections can be used, to some degree, to identify when shortfalls are likely. Conversely, shortfalls can be abated by an unforeseen high flow event, requiring decisions about alternative use of funding intended for ESH planning, design and construction. Moreover, decisions about when to begin ESH construction as habitat acreage declines, and how much to build in any year, involves weighing the risks of not meeting targets and required trade-offs in terms of lost opportunity for pallid sturgeon

research or project implementation. Management decisions that properly balance these considerations should improve over time, applying the best combination of a) variable budgets that reflect ESH needs, b) trade-offs between the birds and fish, c) occasional use of flows to meet ESH targets, d) acceptance that targets for one or both species may not be met at times, or e) some as yet unforeseen approach.

2.2.3 Timing of AM decisions

Though dramatic shifts in the strategy or emphasis of the MRRP can occur based on new information, changes in system status, or unanticipated budget adjustments. However, change is more likely to be infrequent and slow. Testing of the EA hypotheses requires the exercise of rigorous experimental designs that can take 5 to 10 years before trends are evident and decisions about the effectiveness of a management action effectiveness can be made with any confidence.

Several policies and processes outside the MRRP impose important constraints on Program scheduling and execution (Figure 12). The most significant Program constraint is the Corps' annual budget process for Civil Works, a two-year development process that can be generally summarized as a develop-defend-execute cycle. The Corps budgets and executes its mission on an FY basis. The FY begins October 1 and ends September 30 the following year.

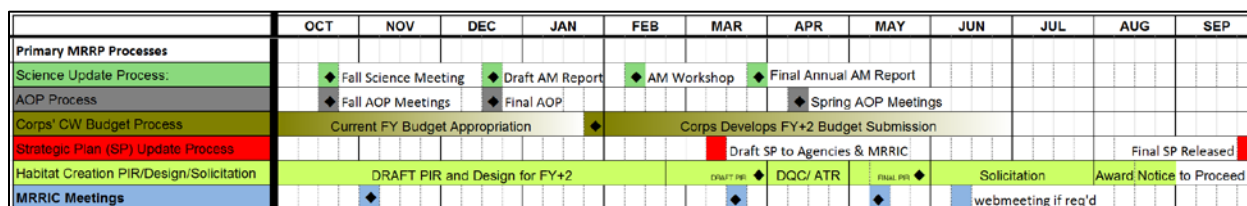


Figure 12. Timeline for budgeting, strategic review, SP development, and the AOP.

The above realities dictate a “strategic” rather than a “tactical” approach to managing the MRRP. Activities within the current Fiscal Year (FY) or the next FY (or FY+1) may be subject to minor adjustment only given the budgets are already fixed, actions planned, and mechanisms to shift those actions limited. Emphasis should therefore be placed on establishing needs to set the future Program direction and budget. Defining needs for the FY+2 Program and budget, in particular, is the focus of the agencies and MRRIC on an ongoing, annual basis. Given the USACE’s Civil Works budget process, the Program should be aligned to define those needs no later than June and preferably earlier in any year.

2.2.4 Role of decision criteria in the MRRP

The term “decision criteria” refers to the set of pre-determined conditions that trigger or guide a decision or the implementation of a contingency plan. They can be qualitative or quantitative based on the nature of the performance metric and the available information to support a decision, and occur in a variety of forms. A recent study of judicial decisions on AM programs cited the lack of decision criteria as one of three key deficiencies leading to possible overturning by the courts of agency practice (Fischman and Ruhl 2016).

Decision criteria play several roles in the MRRP; they are designed to:

- define requirements for compliance purposes (e.g., ESA, NEPA, USACE’s policies)
- ensure that decisions incorporate best available science
- facilitate complex decisions, or decisions that must be made quickly during implementation
- provide a roadmap for participants (i.e., they define the decision space).

Decision criteria utilized in the MRRP take various forms, including quantitative triggers (e.g., the criteria for the Lower River Pallid Sturgeon Framework in Section 4.2.1.3), decision trees (e.g., diagram addressing drift and dispersal in the Upper Missouri and Yellowstone Rivers in Figure 51), planning rubrics (e.g., the matrix for ESH needs in Table 34), heuristics (e.g., the decisions for flow creation vs. construction in Table 35), and schedules and Gantt charts or flowcharts (e.g., the timeline to implement actions in Table 42). Even guiding principles, which are evident throughout the SAMP, can broadly be considered a form of decision criteria.

Criteria cannot be developed for every decision faced in executing the MRRP. Some decision criteria may elude development during the initial planning stages; useful criteria cannot be developed until details of actions are known in some cases. As knowledge grows, it will likely become apparent that some criteria need to be changed. To address these realities, the SAMP includes a suite of objectives and principles along with a process to guide the development/revision, review, and approval of decision criteria in the future. Attachment 6 of Appendix A provides details on the process to change criteria.

2.2.5 NEPA, the Master Manual, and decisions regarding management actions

Adjusting management actions would necessitate decisions be made on additional NEPA review. The CEQ NEPA Regulations require agencies to prepare supplements to their final EISs under two circumstances: (1) “the agency makes substantial changes to

the proposed action that are relevant to environmental concerns”, or (2) “if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts” (40 CFR 1502.9(c)). If adaptive management provides significant new information affecting selection of the preferred alternative and the actions and potential impacts are not within the range of impacts and alternatives considered in the MRRMP-EIS, supplemental NEPA analysis would be required. Implementation of actions not contemplated in the MRRMP-EIS, or based on a decision not to supplement the EIS, would require a separate NEPA process. This process would be initiated and conducted according to appropriate CEQ and USACE regulations and policies associated with NEPA. Figure 13 illustrates the NEPA and environmental review process.

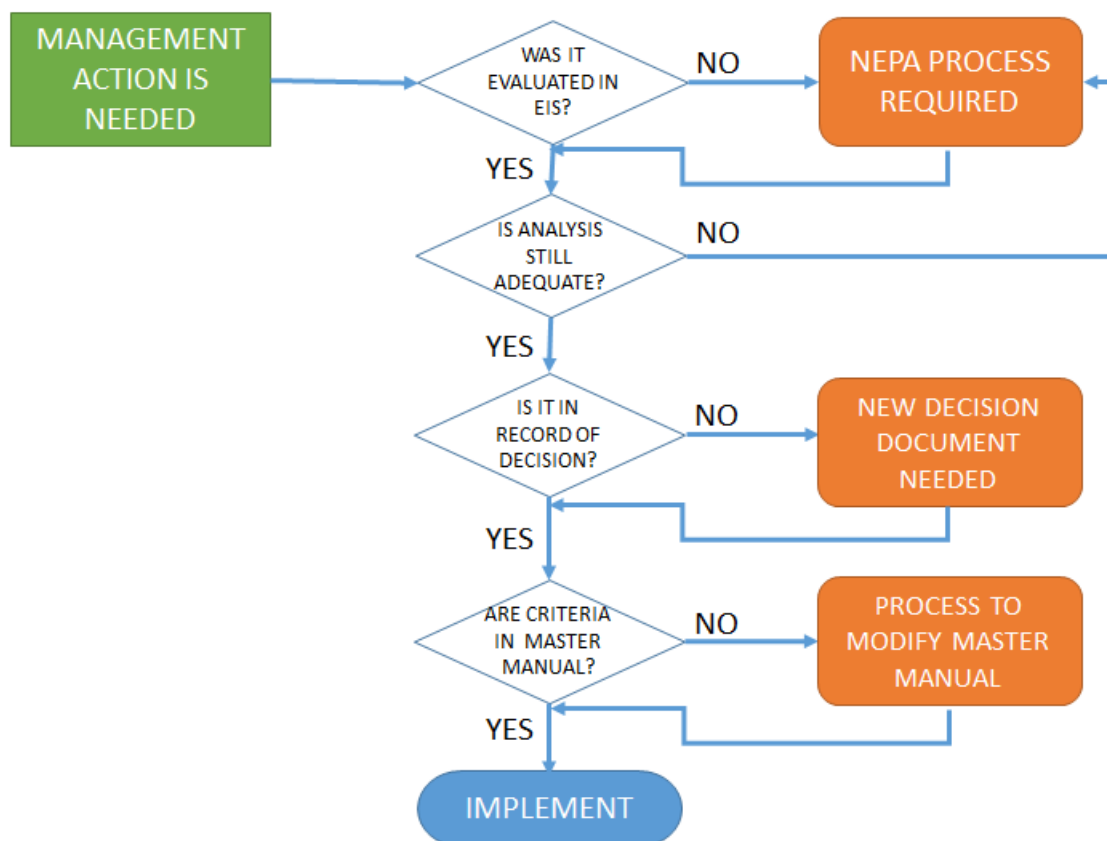


Figure 13. Flowchart for decisions to implement a management action (Step 5b)¹.

It is possible that USACE may decide to adjust to an action that was adequately assessed in the MRRMP-EIS but was not part of the selected alternative. In this case, USACE may

¹ Note that the last step, involving technical criteria in the Master Manual, would only apply to flow actions.

issue a new decision document to reflect the change. Finally, if USACE decided to adjust to an action that included flow modifications inconsistent with the technical criteria in the Master Manual, modification of the Master Manual would be necessary (see Attachment 5 of Appendix A for details on the procedures for changing the technical criteria in the Master Manual).

2.3 AM program composition, roles, and responsibilities

The MRRP is a collaborative effort amongst the USACE, USFWS, and MRRIC. Notwithstanding the collaborative nature of the Program, the lead agencies have statutory responsibilities that cannot be delegated. Similarly, engagement with MRRIC is not a substitute for public involvement requirements, such as NEPA, or Government-to-Government consultation obligations with basin Tribes. The role of MRRIC is defined by relevant legislation (e.g., Sec. 5018 of WRDA, FACA). Descriptions of the composition, roles and responsibilities for the entities outlined in this section are intended to (1) comply with legal requirements, (2) maintain transparency and involve all three entities in the AM learning process and in the formation of recommendations for actions and research, and (3) efficiently achieve the Program's goals and objectives.

Adaptively managing the MRRP is a monumental effort requiring the support of hundreds of individuals from numerous organizations. Not all of those individuals or organizations are represented in this SAMP. The USACE, in particular, has numerous management and staff positions devoted to supporting the Program that are not reflected in the diagrams, tables, and descriptions in this chapter of the SAMP. Instead, Chapter 2 focuses on those elements and personnel central to the decision-making process who liaise with and represent the elements of the broader team through engagements among the USACE, USFWS, and MRRIC. Descriptions of the broader team components, which may change over time as the Program emphasis changes, can be found in the Program Management Plan (Attachment 13, Appendix A).

As described above, the central governance structure consists of several elements generally organized around three levels of authority (Oversight, Management and Implementation), along with technical support and independent review groups in non-decision roles. The composition, roles, and responsibilities of the central elements are summarized in Figure 14 and in

Table 9, and are discussed in more detail in the following sections and Attachment 13 of Appendix A. Interaction points and the mechanisms by which these elements function together are described in the AM Decision Process Section (Section 2.4).

Program success demands the commitment of necessary resources to effectively implement and govern the program, commitment on the part of MRRIC and the agencies to engage in a collaborative, transparent process, and the flexibility to change when and where needed. This includes maintaining staffing and contracting capacity to ensure needed expertise is available to the Program, as well as the flexibility to apply available resources to shifting priorities. The actions needed to achieve the Program objectives are uncertain and may evolve, so MRRIC and the agencies must continue their engagement and willingness to work together to identify solutions.

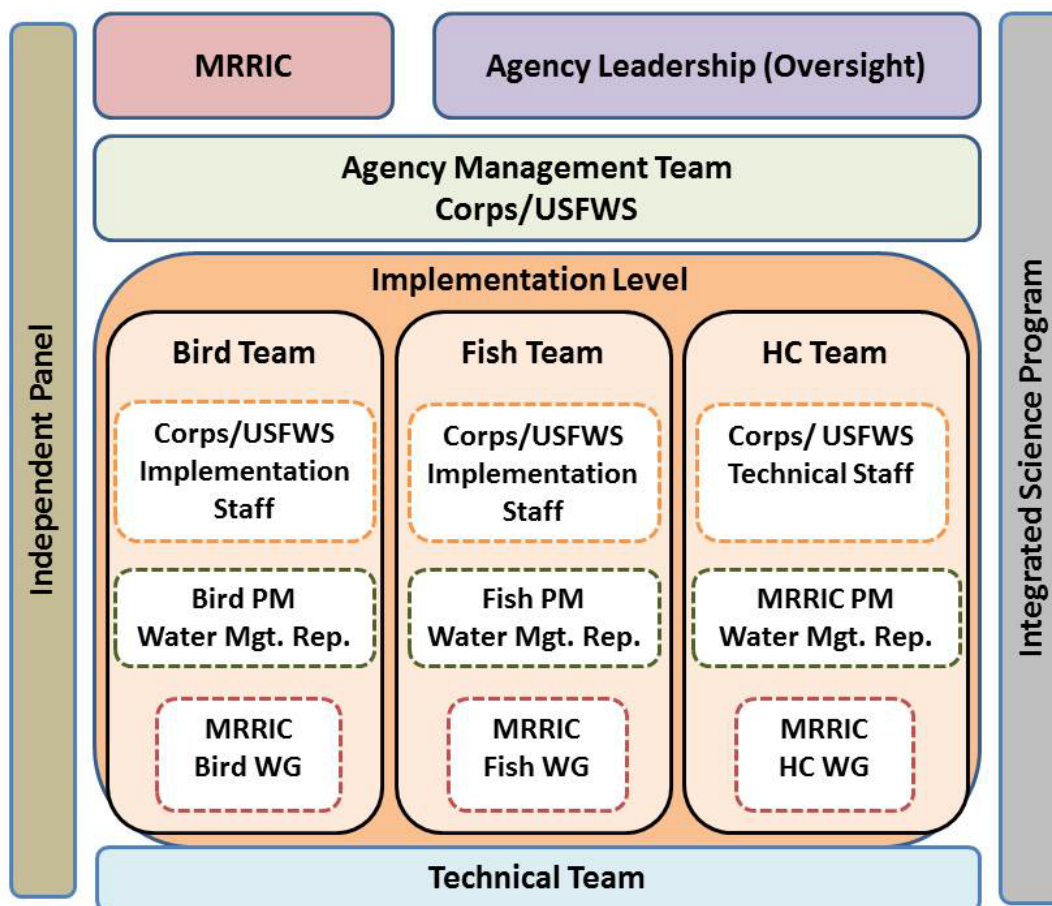


Figure 14. Central components of the MRRP governance structure. Entities not shown in this diagram are referenced in later sections and described in attachments to Appendix A. Hierarchical relationship not implied.

Table 9. Summary of roles and responsibilities of entities involved with implementing the MRRP. Not all entities are represented. See following sections and attachments to Appendix A for additional details.

Entity	Composition	Primary Roles and Responsibilities
Technical Team (Section 2.3.4)	Experts supporting the MRRP in a non-decision, technical role; organized similar to the Effects Analysis Teams	<ul style="list-style-type: none"> • Conduct annual assessment of monitoring data, study reports, research results and other relevant information and prepares an annual AM Report on program performance. • Evaluate hypotheses, CEMs, targets, etc. and provides information in support of annual science update process • Execute studies, conduct research, develop and apply models to predict habitat, species demographics, etc., as needed • Provide technical support at Fall Science Meetings & AM Workshop, MRRIC meetings, Team Meetings, etc., as directed
Bird and Fish Teams (Section 2.3.3)	Implementation PMs for each species (agency leads) USFWS species representatives USACE technical staff MRRIC Bird and Fish WGs	<ul style="list-style-type: none"> • Attend Fall Science Meeting, AM Workshop and Team meetings to review and discuss management actions, research, monitoring, and assessment results • Identify and prioritize needed research, technical assessments, etc. • Collaborate in tool development for program-level screening, siting, and other planning
HC Team (Section 2.3.3)	MRRIC PM and AM PM (agency leads) USFWS representative USACE technical staff MRRIC HC WG	<ul style="list-style-type: none"> • Attend Fall Science Meeting, AM Workshop and Team meetings to review and discuss management actions, research, monitoring, and assessment results • Identify and prioritize needed research, technical assessments, etc. • Collaborate in the development of program-level screening, siting, and other planning tools, including working with the Bird and Fish Teams in tool development

Entity	Composition	Primary Roles and Responsibilities
Management Team (Sections 2.3.2, 2.3.6)	MRRP Senior PgM USFWS MR Coordinator NWD Representative Water Management Representative MRRIC PM AM PM Implementation PMs for each species ISP Manager	<ul style="list-style-type: none"> Make decisions regarding allocation of budget, staff, and material Make recommendations on action and research prioritization and flow modifications Prepare Draft and Final Strategic Plan annually Recommend changes to program components and governance
Executive Steering Committee (ESC) (Section 2.3.6)	Chiefs of Programs and Project Management (NWO and NWK) Chief of MRBWMD Non-voting members: Chief of CW (NWO and NWK) Chief of Planning (NWO and NWK)	<ul style="list-style-type: none"> Review and recommendations on SP Ensures that the MRRP is implemented according to the direction and guidance provided by the Oversight level Ensures regional, systems perspective Resolves district and cross-district disputes Approves/decides on budget and staffing issues
Oversight Level (Section 2.3.1)	NWD Commander USACE District Commanders NWD Director of Programs USFWS Region 6 Director USFWS Assistant Regional Director	<ul style="list-style-type: none"> Make decisions about priorities Make decisions regarding flow actions Make decisions about targets and objectives Make decisions about program structure and changes Resolve disputes
MRRIC (Section 2.3.7)	Plenary as defined in Charter	<ul style="list-style-type: none"> Make recommendations on program needs and priorities in Draft Strategic Plan Provides input to agencies on implementation of the AM program (including SAMP) Provide feedback and input on HC assessments/issues of concern
	Bird and Fish WGs (Section 2.3.3)	<ul style="list-style-type: none"> Works in conjunction with agency staff on Bird/Fish Teams to draft recommendations regarding research priorities, project implementation, monitoring, evaluation, and adaptive actions of the MRRP. Provide information to the full body of MRRIC regarding insights based on science findings, and assist with MRRIC recommendations
	HC WG (Section 2.3.3)	<ul style="list-style-type: none"> Works in conjunction with agency staff on HC Team, and with the Bird/Fish Teams and WGs to guide recommendations on HC monitoring and assessment priorities

Entity	Composition	Primary Roles and Responsibilities
		<ul style="list-style-type: none"> Provide information to the full body of MRRIC regarding insights based on HC effects, and assist with MRRIC recommendations
	Other standing and ad hoc WGs	<ul style="list-style-type: none"> As outlined in WG Charge
Independent Science Advisory Panel	As defined in enabling documentation	<ul style="list-style-type: none"> Participate in Fall Science Meeting & AM Workshop; review substantive products. Provide independent scientific and technical advice and recommendations to MRRIC and the lead agencies
Integrated Science Program (Section 2.3.5)	ISP Manager AM PM Terrestrial Science Coordinator Aquatic Sciences Coordinator Support Staff (including partners)	<ul style="list-style-type: none"> Oversee monitoring and assessment Oversee research and focused studies Contract for the Technical Team Provide advice to senior leadership and represent the program on science matters
Tribes (Section 2.3.6)	As recognized	<ul style="list-style-type: none"> Provide input into the process through communication participation, coordination, and consultation with MRRP
Agencies Acting Outside MRRIC (Section 2.3.6)	State and other Federal agency departments with defined roles outside MRRIC process	<ul style="list-style-type: none"> Regulatory compliance and input on site-specific projects
Public	Refers to individuals acting outside the above categories	<ul style="list-style-type: none"> Provide input to the MRRP in response to any public notice related to the Program

2.3.1 Oversight level

Oversight of the MRRP is provided by the USACE Division and District Commanders, the USFWS Regional Directors and the MRRIC. The USACE Commander of the Northwest Division (NWD) establishes clear boundaries for the program, makes major policy decisions, and resolves disputes that cannot be realized through the Issue Resolution Board. Decisions regarding scheduling, staffing, and other resourcing; planning, engineering and design of management actions; management and execution of the ISP; and other corresponding activities undertaken at the USACE District offices are overseen by the Omaha and Kansas City District Commanders. However, it is important to understand that personnel structures and programs evolve thus the positions described in the SAMP are subject to change.

The NWD Commander may elect to delegate decisions to senior leaders within the command. Decisions regarding the real-time operations of the reservoirs on the Missouri River are typically delegated to the Chief of the MRBWMD, for example. The NWD Director of Programs is the NWD Commander's delegate for general oversight of the MRRP. The Director of Programs frequently represents the USACE in meetings with the MRRIC and/or USFWS and may make decisions related to the development of the

SP, scheduling, resource allocation, and other similar programmatic issues. The Director of Programs may rely upon the MRRP Senior PgM and/or senior NWD staff to represent the program on day-to-day issues and for interactions with MRRIC WGs.

The USFWS Mountain-Prairie (Region 6) Regional Director provides oversight and is the ultimate guidance and decision-making authority on the MRRP for the USFWS. Examples of related decisions include the approval of recommended changes to targets and decision criteria, disposition of hypotheses, introduction of new management actions, advancement of implementation levels for pallid sturgeon, etc. The Region 6 Director coordinates and communicates with the Midwest Region (Region 3) Director. The Regional Director may delegate decisions to subordinate leaders, and frequently relies upon the Region 6 Assistant Regional Director for Ecological Services to represent the agency in meetings with the MRRIC and/or USACE, and to provide guidance to subordinate teams. The Missouri River Coordinator represents the USFWS on day-to-day implementation of the MRRP.

The MRRIC provides guidance and recommendations to the USACE and USFWS regarding Program implementation and AM. The roles and responsibilities of the MRRIC are discussed further in Section 2.3.7. In addition to input from the MRRIC, including consensus recommendations of the committee, decisions at the Oversight level by the lead agencies are informed by recommendations from the Management Team. An Executive Steering Committee (ESC) provides budget, resourcing and other guidance to the Management Team and provides input to Corps Commanders on program execution matters. Composition of the ESC is discussed in Section 2.3.6.1. Oversight may seek input from the ISAP and the Technical Team on science matters and their decisions are also informed by Tribes and Federal or state agencies as required by applicable laws and regulations, as well as by public input.

Table 10 provides examples of the decisions and responsibilities at the Oversight level. The processes and procedures by which the decisions are made are summarized in Section 2.4. Some decisions are effectively a joint USACE and USFWS function (e.g., changes to targets, decision criteria, or management actions); wherein each agency works within their authorities to provide decisions that collectively address the broader issue. Their interaction on these issues with MRRIC is primarily through periodic meetings (see Section 2.4.2.4). Interactions between senior leadership at the Oversight level and other agency teams, as well as with MRRIC, are discussed further in Sections 2.3 and 2.4) and in Attachment 13 of Appendix A (for internal Corps decisions).

Table 10. Examples of decisions and responsibilities at the Oversight level.

Decision or Responsibility	Responsible Entity ¹
Make decisions with implications for compliance with the ESA and involving significant change to the Program (e.g., targets, decision criteria, new management actions, etc.).	NWD Commander and USFWS Regional Directors
Approve the Final SAMP and changes to the plan, including objectives, targets, decision triggers, governance, and decision-making structure	NWD Commander and USFWS Regional Directors
Make decisions on program-level changes affecting HCs	NWD Commander
Make decisions regarding flow operations, including non-routine flows (within ROD and Master Manual but outside of standard operations)	NWD Commander
Approve annual SPs for the MRRP	NWD Commander
Convey consensus recommendations of the MRRIC to the agencies	MRRIC Chair
Represent the agencies in interactions with MRRIC, including development and presentation of SPs, etc.	NWD Director of Programs and USFWS Deputy Regional Director
Approve program-level budgetary decisions and resource allocations	NWD Director of Programs
Collaborate with the full MRRIC on human considerations and values-driven trade-off decisions (e.g., channel modifications, flow modifications)	NWD Director of Programs or District Commanders
Coordinate as appropriate with Tribes, federal agencies, state and local government, and the public on site-specific project implementation	District Commanders
Approve District level budgetary decisions and resource allocations	District Commanders
Decisions related to constructed project design, implementation, operation and maintenance (O&M), etc.	District Commanders
Make decisions regarding flow operations for the authorized purposes and within existing criteria, or real-time operational decisions	Chief, Water Management
Resolve disputes for subordinate teams	District Commanders (USACE) or Regional Director (USFWS)

¹ In cases where the decision authority is commonly delegated, the delegate is shown as the responsible entity in this table.

2.3.2 Management Team

The Management Team, which is co-led by the MRRP Senior PgM and the USFWS Missouri River Coordinator, is responsible for development of the Strategic Plan (SP), development of resource allocation recommendations and oversight of Program implementation with guidance from ESC and senior leaders. Membership generally includes senior PgMs for the MRRP from both the USACE and USFWS, with other agency personnel listed in Table 11. Members of the Management Team represent other entities, as shown in Table 11, and are responsible for communicating activities of the Management Team with those entities.

Table 11. Composition of the Management Team.

Member	Role	Represents / Liaison With
USACE		
Senior PgM for MRRP	Co-Chair	District Leadership; District PMs; District PDTs
NWD Representative		NWD Leadership; ESC
MRRIC Project Manager		MRRIC; HC Team
AM Process Manager		AM Team; Technical Team
ISP Manager		ISP; Other technical groups
Water Management Representative		MRBWMD
Bird and Fish PMs		Bird and Fish Teams; District PDTs
OC Representative	Ad hoc	District/Division OC
USFWS		
MR Coordinator	Co-Chair	USFWS leadership; FAC Supervisors; ES Project Leads
Bird and Fish Team Members		Bird and Fish Teams

The Management Team develops the draft SP for presentation to agency leadership and the MRRIC based upon input from the Technical Team and the Bird, Fish, and HC PDTs and following guidance provided by the ESC regarding resource availability, acquisition strategies, etc. The draft SP includes updates to the Current Fiscal Year (CFY) Work Plan (WP) based upon appropriations and presents a draft of the FY+1 WP based upon the President's Budget. The Draft SP also includes level-of-effort assessments of program needs for FY+2 through 4, significant study proposals, proposed changes to components of the SAMP, and other recommendations for consideration of the MRRIC and agency leaders.

The Management Team develops cost estimates for the program, and makes recommendations to senior leadership on issues requiring Oversight-level decisions, including any issues that merit discussion during a MRRIC Plenary meeting. They ensure day-to-day implementation of the MRRP is consistent with direction from senior leadership, SAMP, SP, and the Program Management Plan (PgMP; see Attachment 10 of Appendix A). They are responsible for the allocation of program resources (staff, budget, and material) with guidance from the ESC and subject to the approval of the District Commanders (DCs).

The Management Team provides leadership for the HC (MRRIC PM) Team and for the Bird and Fish Teams (Implementation PMs). They participate in the annual Fall Science Meeting and the AM Workshop, using these engagements for discussions with the Technical and Bird/Fish Teams that inform adjustments to the SP. They participate in MRRIC plenary meetings and meet as needed to address other Program considerations. The primary responsibilities of the Management Team in implementing the MRRP AM are summarized in Table 12.

Table 12. Decisions, recommendations and other responsibilities of the Management Team.

Responsibilities	Step in AM Cycle	Category
Decisions¹		
Criteria for implementing the actions	Plan/design	Plan design
How learning is incorporated into decisions	Plan/design	Plan design
How status and decisions will be reported and communicated	Plan/design	Plan design
What monitoring will be conducted	Plan/design	Plan design
Criteria for implementing population interventions	Plan/design	Population interventions
Criteria for implementing habitat construction/modifications	Plan/design	Habitat construction
How much new habitat should be constructed	Adjust/Continue	Habitat construction
Should current habitat be modified	Adjust/Continue	Habitat modification
How resources will be allocated to program components	Adjust/Continue	Program-scale
Whether an active hypothesis should be rejected ²	Adjust/Continue	Research
Whether a reserve hypothesis should be activated ²	Adjust/Continue	Research
Recommendations		

¹ Subject to approval by agency leadership/oversight following MRRIC engagement and deliberation.

² Note that the research program is run by the Integrated Science Program (ISP), and the ISP Manager has decision authority over program components.

Responsibilities	Step in AM Cycle	Category
Make recommendations to the Oversight level to adjust objectives, targets, governance structure and processes	Plan/design	Plan design
Make recommendations to the Oversight level when new management actions may be needed	Adjust/Continue	Flow management
Elevate decisions regarding human considerations (e.g., channel modifications, flow modifications) that require tradeoff analyses to Oversight level for engagement with MRRIC	Adjust/Continue	Program-scale
What additional basic research (demographics, behavior, habitat quality, etc.) is needed; Note: ISP Manager is primary decision maker ²	Adjust/Continue	Research
Whether funding for existing research programs should be continued or resources used elsewhere. ²	Adjust/Continue	Research
Other Responsibilities		
Communicate performance, decisions, and recommendations to the Oversight level, MRRIC, and the Independent Panel, in face-to-face meetings, webinars, and annual and periodic AM reports	Adjust/Continue	Communications
Ensure AM process is implemented throughout the MRRP	Adjust/Continue	Program-scale
Ensure AM process is addressing program needs	Adjust/Continue	Program-scale
Ensure AM recommendations and priorities are reflected in SP	Adjust/Continue	Program-scale
Allocate staff, funding, and other resources for the MRRP within the two agencies, subject to approval of the DCs	Adjust/Continue	Program-scale
Decide based on evaluation results to complete/terminate, adjust, or continue a management action	Adjust/Continue	Habitat construction
Using input from the Implementation Team, develop and finalize SPs, and brief the Oversight level	Adjust/Continue	Program-scale
Approve other recommendations (e.g., revisions to hypotheses, modifications to monitoring efforts)	Adjust/Continue	Plan design
Ensure collaborative process is working and effective	Adjust/Continue	Communications
Engage in the collaborative process at all levels as necessary	Adjust/Continue	Communications
Regularly assess program performance and identify necessary improvements	Adjust/Continue	Program-scale
Responsible for elevating all decisions necessary at Oversight level and ensuring Oversight leadership are provided necessary information to support decision making	All	All

2.3.3 Implementation-Level Teams (Bird, Fish and HC)

Implementation of the MRRP is informed by three teams comprised of management and technical staff from the USACE and USFWS, along with technical work groups representing the MRRIC. The Bird, Fish and HC Teams assess the strategic direction of the MRRP through regular interactions associated with the science and strategic planning processes as outlined in Section 2.4 of the SAMP. The Teams discuss strategic

science, technical, and implementation considerations that relate to the program's objectives and sub-objectives. Membership and responsibilities of the Implementation Teams is discussed in the following sections. The role of USACE Project Delivery Teams (PDTs) in supporting the Implementation Teams is also described. Attachment 15 of Appendix A provides additional details.

2.3.3.1 Bird and Fish Teams

Composition of the Bird and Fish Teams roughly parallel each other, with the differences consisting primarily in the expertise of individual members. Each team is chaired by a USACE-appointed Team Lead, usually a PM responsible for implementing the MRRP actions for the respective species. The USACE also appoints an alternate Lead. Other USACE members are appointed to represent the critical activities of the Corps PDTs as shown in Table 13, and have responsibilities to represent those entities contributing to the Program to ensure their needs and perspectives are presented during Team deliberations. Members serve to liaise with those elements to keep them informed of deliberations and decisions.

MRRIC WGs, one for the birds and another for the fish, serve as components of the Bird and Fish Teams and are primarily responsible for exchanging and discussing information with the agencies and keeping the MRRIC apprised of issues that may need a formal recommendation from the full committee (see Section 2.3.7.2). The USFWS appoints a USFWS Lead Representative who, along with the USACE Lead and Alternate, Work Group POCs and the Facilitator, is a member of the Team's Planning Group. The USACE Lead for each Team will ensure the current team membership is posted on the MRRIC APAN site (or current applicable web site for information accessible to MRRIC and the agencies).

Table 13. Composition of the Bird and Fish Teams.

Member	Assignment	Represents and/or Liaises with
USACE		
Team Lead	Team Chair; Agency Rep to WG; Planning Group Member	Management Team; District Science, Planning, & Implementation PDTs; Technical Team; Fish/Bird/HC Work Group; Interagency Meetings
Alternate Team Lead	Member; Alternate Chair; Agency Rep to WG; Planning Group Member	See above
USACE Team Members	Members	ISP; Planning; Engineering; Construction; Regulatory; MRBWMD; OC

USFWS		
USFWS Team Representative	Member; Planning Group Member	Recovery Teams; MRNRC Coordinator; ES Biologists; States (FWCA)
MRRIC Bird/Fish WG		
WG POCs	Members; Planning Group Members	MRRIC; Agency Team Lead & Alternate
WG Members	WG Members	MRRIC; Stakeholders

The Bird and Fish Teams meet twice annually - during the Fall Science Meeting and at the AM Workshop - to participate in discussions regarding the advancement of scientific understanding, performance of actions relative to objectives and targets, and strategic planning implications for the program. Additional engagements will be driven by needs, but will be managed using calls and web-based meetings to the extent practical. Team members are expected to interact with the entities they represent before and after each engagement, and keep those groups apprised of Team activities and products. Multiple engagements of the Team may occur during the SP development period, including a joint meeting of the Bird, Fish, and HC Teams. Additional details regarding these interactions are provided in Sections 2.3.6, 2.3.7.2, 2.4.2, and 2.4.3, and may be elaborated in Attachment 15 of Appendix A.

All team members are expected to attend the Fall Science Meeting and AM Workshop and any preparatory or follow-up calls and webinars, participate in discussion of technical issues within the realm of their expertise during Team meetings and calls, and coordinate with those they represent ahead of any Team meetings and report back any substantive Team discussions. The Agency Leads and MRRIC WG POCs have additional responsibilities associated with their positions and roles on the Planning Groups. An overview of responsibilities are summarized in Table 14; additional detail can be found in Attachment 15 of Appendix A.

Table 14. Decisions, recommendations and other responsibilities of the Bird and Fish Teams.

Roles and Responsibilities for Indicated Members	Products
Team Lead	
Chairs Team meetings	Agenda; Team Roster; Meeting Summaries
Serves as a Planning Group member (see responsibilities below)	
Serves as an agency representative to the corresponding MRRIC WG	
Attends the Fall Science Meeting and AM Workshop and any preparatory or follow-up calls and webinars, and attends agency and interagency meetings	

Roles and Responsibilities for Indicated Members	Products
as required to prepare for the Fall Science Meeting, AM Workshop, or MRRIC meetings	
Ensures MFRs following Team interactions are prepared and shared with the Management Team and MRRIC	MFR
In coordination with the MRRP SPgM, and as appropriate the ISP Manager and other Team leads, makes recommendations to the Management Team regarding habitat implementation, research, monitoring, and assessment needs and priorities	
Coordinates with and (as appropriate) provides guidance to the relevant Project Delivery Teams (PDTs) based on information exchanged by the team	
Alternate Team Lead	
Serves as a Planning Group member (see responsibilities below)	
Serves as an Agency Representative to the corresponding MRRIC WG	
Chairs meetings and calls of the Team when the Agency Lead is unable to attend	
Attends the Fall Science Meeting and AM Workshop and any preparatory or follow-up calls and webinars	
Performs the roles outlined for other USACE Members (see below)	
Other USACE Team Members	
Attend the Fall Science Meeting and AM Workshop and any preparatory or follow-up calls and webinars	
Help inform the discussion of technical issues within the realm of their expertise during Team meetings and calls	
Coordinate with elements of the USACE PDTs ahead of any Team meetings and relate any substantive discussions to the PDTs as charged by the Team Lead and/or MRRP SPgM	
Conduct assessments, give presentations, interact/engage with other Teams, and perform other duties as directed by the Team Lead and/or MRRP SPgM	
USFWS Representative	
Serves as a Team member and is responsible for providing technical input on issues within the purview of the USFWS	
Coordinates with the entities identified in Table 13 and may make recommendations to recovery teams or to state fish and game agencies as part of fish and wildlife coordination act responsibilities	
MRRIC WG Members	
WG POCs; Serve as members of the Planning Group (see duties below) and perform other functions of WG members	Agendas
Participate in the Fall Science Meeting and associated Team deliberations, as laid out in the SAMP, to discuss information received and consider implications of the results on strategic direction of the program	Draft Recommendations
Participate in the AM Workshop and associated Team deliberations, as laid out in the SAMP, to hear about, question, assess, and understand the technical results and implications of AM Plan implementation efforts	Draft Recommendations
Team Planning Group Members	

Roles and Responsibilities for Indicated Members	Products
Develop agendas for Team meetings and invite individuals to give presentations, or participate in discussion, etc. [NOTE: the USACE Team Lead and Alternative take the lead in development of the agenda for Team related events]	Team Agendas
Setting the agenda and scheduling meetings and calls of the WG [NOTE: the WG Co-POCs take the lead in development of the agenda for work group related events]	WG Agendas
Coordinating the exchange and distribution of information, MFRs, draft recommendations, etc., intended to keep team members, agencies, and MRRIC apprised of meeting outcomes, significant developments, etc.	Agency/MRRIC Presentations; Team Updates

2.3.3.2 Human Considerations (HC) Team

The HC Team is chaired by a USACE-appointed Lead, who is responsible for convening the Team, keeping members informed of relevant issues and activities, and representing the HC Team as a member of the Management Team (see Table 15). The USFWS also appoints a representative. A USACE Alternate Lead is a standing member; other USACE members are included on the team as needed, generally technical specialists representing specific interests of the team at that time. The MRRIC HC WG is a component of the HC Team and is primarily responsible for exchanging and discussing information with the agencies and keeping the MRRIC apprised of issues that may need a formal recommendation from the full committee. The USACE Lead and Alternate, together with the USFWS Representative, the WG POCs, and the Facilitator constitute the HC Planning Group. See Section 2.3.7.2 and Attachment 16 of Appendix A for more details about the role and composition of the HC WG and HC Planning Group.

Table 15. Composition of the HC Team.

Member	Assignment	Represents / Liaison With
USACE		
HC Team Lead	Team Chair; Agency Rep to HCWG; Planning Group Member	Management Team; District PDTs; Technical Team; HC Work Group; Attendees of Interagency IPRs
Alternate HC Team Lead	Member; Alternate Chair; Agency Rep to HCWG; Planning Group Member	See above
USACE Team Members	Members	ISP; Planning; Engineering; Construction; Regulatory; MRBWMD; OC
USFWS		

USFWS HC Team Representative	Member; Planning Group Member	Recovery Teams; MRNRC Coordinator; Endangered Species Biologists; States (FWCA)
HC WG		
WG POCs	Members; Planning Group Members	MRRIC; HC Team Lead & Alternate
WG Members	Members	MRRIC

The HC Team meets at least twice annually - during the Fall Science Meeting and the AM Workshop - to participate in discussions regarding the advancement of scientific understanding as it relates to the effects of MRRP actions on human considerations and the strategic planning implications for the program. Additional engagements will be driven by needs, but will be managed using calls and web-based meetings to the extent practical. Team members are expected to interact with the entities they represent before and after each engagement (e.g. agency members interact with PDTs, HCWG members interact with MRRIC), and keep the groups they represent apprised of the activities and decisions/recommendations of the Team. The HC Team may work with the Bird and Fish Teams to address issues involving both species and HC interests, and may be involved in multiple engagements (usually conducted by web meeting) during the SP development period. Additional details regarding these interactions are provided in Sections 2.3.6, 2.3.7.2, 2.4.2, and 2.4.3 of the SAMP and Attachment 15 of Appendix A.

The HC Team provides input to the MRRP regarding monitoring and assessment related to HCs and the effects of Program decisions on conditions of interest to stakeholders. The Team identifies monitoring and assessment needs of strategic priority for the Management Team to consider in developing/updating the MRRP SP. They may participate in the development of screening tools to support planning and design of management measures; these activities generally involve coordination and collaboration with the Bird or Fish Team. The Team must be able to respond to new knowledge and to changing conditions in the field, to evaluate monitoring and assessment results provided by the Technical Team, to assess protocols for monitoring and assessment, and to follow the guidance in the SAMP or recommended changes to the guidance in the event objectives are not being met. Their responsibilities are generally the same as those of the Bird and Fish Teams, as shown in Table 14. The HC WG also maintains an HC Issues Tracking Table similar to that shown in Table 16.

Table 16. HC Issues Tracking Table maintained by the HC Team.

General Issue	Specific Question, Concern, or	Resource People/ Decision Makers	Potential Answers, Solutions, and Next Steps Proposed	Steps Taken (By whom, Date)	Answers/ Resolution(s) Agreed Upon
---------------	--------------------------------	----------------------------------	---	-----------------------------	------------------------------------

	Request (Raised by, Date)		(Suggested by, Date)		(By whom, Date, Step in the Routing Sketch)
Current Issue #1					
Issue #2					

2.3.3.3 USACE Project Delivery Teams (PDTs) and Project Management Plans (PMPs)

The USACE employs a Project Management Business Process (PMBP) for the planning, development, and management of projects and programs. Under the PMBP, each project is placed in the hands of a PDT. The PDT process follows the guidelines and policies set forth in ER 5-1-11, *Management – U.S. Army Corps of Engineers Business Process*.

The PDT consists of everyone necessary for successful development and execution of all phases of the project, including the PM, technical experts within or outside the USACE districts, consultants/contractors, and vertical members from division and headquarters that are necessary to effectively develop and deliver the project. The MRRIC and stakeholders, participate through the venues set up for their input. The PgM manages project resources, information and commitments, and, together with the PM, leads and facilitates the PDT towards effective project development and execution.

To meet mission objectives, each project is managed under a project management plan (PMP). A PMP is a roadmap for quality project delivery. The plan is developed by the PgM and PDT and is updated as conditions change. All work is managed using the PMP, which is maintained at a level of detail commensurate with the scope of the project. PMPs should be concise and succinct, but address all processes and areas necessary to ensure effective project execution. Minimum requirements for PMPs are found in the ER 5-1-11. Management of similar projects of limited scope using a Program Management Plan (PgMP) rather than an individual PMP for each is acceptable. However, when a project under a program is of such scope that it is no longer manageable under the PgMP, it shall be managed with a separate PMP.

The MRRP employs several PDTs with their own PMPs that operate under a Senior PDT and a MRRP PgMP. The MRRP SPgM is the lead for the Senior PDT, which includes the Management Team and others identified by the SPgM. The PgMP is presented in Attachment 13 of Appendix A. The PgMP outlines the programs' work breakdown, roles and responsibilities of the MRRP Senior PDT, schedules and resource management for

the program, acquisition strategies, an assessment of risks, and other information to guide program implementation. The ISP is a sub-PDT, and maintains its own PMP (Attachment 14 of Appendix A). A discussion of the ISP is provided in Section 2.3.5.

Sub-program PDTs are also established for the Birds and Fish. Members of the species PDTs are typically responsible for conducting “on-the-ground” tasks for implementing habitat and population management actions and/or actions and activities associated with the research and monitoring program, including making decisions about the way in which many of the actions are carried out. The PDTs are responsible for planning of management actions and developing the Preliminary Engineering and Design (PED) for projects. They work with the Technical and Implementation Teams to develop a prioritized list of actions for the Management Team to consider in developing/updating the MRRP SP. The Bird and Fish PDTs must be able to respond to new knowledge and to changing conditions in the field, to differentiate between AM and O&M needs, and to implement the guidance in the SAMP with the support of decision criteria and contingency plans.

Each PDT is empowered and supported by senior organizational leaders to make project decisions within the bounds of the approved PMP. Senior leaders are responsible to ensure the PDT has the resources, tools, skills, and experience needed to deliver a quality project. Though projects may include many distinct, separate phases, they must be approached from an integrated, life-cycle perspective focused on meeting the project's goals, objectives, and expectations.

2.3.4 Technical Team

A Technical Team provides analytical and AM support to the MRRP. The Technical Team is not a decision-making body; it provides scientific information based on research, monitoring and evaluation to the agencies and MRRIC in support of the decision process. They serve two primary roles: 1) analysis, modeling and synthesis necessary to deliver the best scientific information to the decision-making process, and 2) providing AM expertise to support implementation of the SAMP and improve MRRP performance.

The Technical Team is a small group (typically 5 or 6) of subject matter experts in ecology, biostatistics, hydrodynamics, fluvial processes, decision analysis, river operations, spatial statistics and socio-economics, who also have expertise and experience with plovers, least terns, pallid sturgeon, and the hydrogeomorphology of the Missouri River. Composition of the Technical Team may be adjusted over time to reflect program needs. The Technical Team employs additional support as needed and may create sub-teams composed of additional personnel with needed expertise to address a

particular task or set of tasks. The Technical Team works closely with the ISP Manager and is overseen by the AM Process Manager, who provides taskings to the Team.

The Technical Team uses information from research and monitoring to develop an annual AM Report that assesses program performance relative to objectives and updates the best available science (see Section 2.4.3.3). They develop and compile information used by the other teams and by the Oversight level to make decisions. They provide expertise in AM and perform assessments of Program performance and make suggestions for improvements. They engage with the agencies, MRRIC, ISAP, and their work groups, and provide technical support as required. At a minimum, the full team participates in the Fall Science Meeting and the AM Workshop, and they are represented at any meeting of the Management, HC, Bird, and/or Fish Team. At all times, they seek to operate in a transparent, objective manner using accepted standards of professional practice. Table 17 provides examples of their responsibilities.

Technical Team tasks undertaken as part of the AM Report include:

1) Annually:

- a) Analysis and interpretation of annual monitoring data and other regularly collected information (some may be collected at intervals other than annually).
- b) Literature reviews (e.g. relevant publications from other investigators).
- c) Model updates and evaluation (verification and validation).
- d) Synthesis activities (e.g. hypothesis assessments, meta-analysis, weight of evidence assessments).
- e) Model evaluation of potential management options, creation of consequence tables, etc.

2) As necessary (and with direction/approval from the AM PM):

- a) Analysis of data from ongoing or completed management actions or research projects. Depending on who conducts the research/monitoring, others may do some or all of the assessment as part of their contracts before providing results to the Technical Team to synthesize and apply. The Technical Team may need to do additional analyses on the original data.
- b) Analysis of existing data that has not yet been analyzed or needs to be synthesized to address a hypothesis or formulate a model. These analyses can be identified by the Bird, Fish or HC Teams, the Technical Team, or at the management/oversight levels.
- c) Assessment of “new information”, which may include surprising monitoring results requiring additional assessment, findings by other researchers, or other topics that were not in the work plan as a research strategy.

Table 17. Responsibilities of the Technical Team.

Responsibilities	Step in AM Cycle	Category
Establish sub-groups with specific expertise, as needed	Plan/Design	Program
Develop experimental design for management actions	Plan/Design	Program
Make recommendations on information management, including data systems, publications, etc.	Plan/Design	Program
Make recommendations to the Management and Implementation Teams about monitoring and research	Plan/Design	Monitoring and Research
Evaluate, test and update numerical and conceptual ecological models (CEMs)	Evaluate	Program
Test and evaluate hypotheses and make recommendations on hypothesis priorities	Evaluate	Program
Update, revise, and prioritize assessments of critical uncertainties	Evaluate	Program
Simulate the outcomes of management actions using quantitative models	Evaluate	Program
Provide evaluations and recommendations to the Bird and Fish Teams and the Management Team as needed	Evaluate	Program
Engage with MRRIC, the Independent Panel, and MRRIC WGs as part of the Science Update process	Evaluate	Program
Undertake special studies or conduct research as directed	Evaluate	Research
Recommend ad hoc peer review panels to conduct independent scientific review	Evaluate	Program
Translate new scientific information into the technical component of AM reports	Evaluate	Program
Synthesize and evaluate data to compare monitoring and research results to decision triggers and targets	Evaluate	Monitoring

2.3.5 Integrated Science Program (ISP)

The ISP is the component of the MRRP responsible for overseeing and conducting scientific monitoring and investigations to assist the USACE in avoidance of jeopardy and compliance with the BiOp. The ISP monitors the effects of Corps' actions on federally-listed species and the habitats on which they depend, and it conducts research and monitoring to address key uncertainties in support of AM. The ISP coordinates science activities in a collaborative manner among USACE, state and Federal partners.

The purpose of the ISP includes the following:

1. Implementation of system-wide monitoring activities and focused investigations to address BiOp mandates and jeopardy avoidance for the federally-listed species;
2. Evaluation of MRRP actions on the federally-listed species;
3. Provision of scientific and technical support for MRRP efforts, planning, design, and construction; O&M, and the AM process; and
4. Communication of Missouri River Basin science to stakeholders including Federal, state, local agencies, tribal governments, and MRRIC.

Although Corps District staffed and supervised, the ISP is implemented at the District level and works closely with leadership for both Districts and the NWD in support of the Program objectives. The ISP Manager oversees the day-to-day ISP execution and is a member of the Management Team. The ISP is organized into two disciplines: (1) Terrestrial Science; and (2) Aquatic Science. Senior scientists serve as coordinators for these components of the ISP, report to the ISP Manager, and are members of the Bird and Fish Teams, respectively. The AM Process Manager (AM PM) reports to the ISP Manager. Details regarding the composition and roles of the ISP are provided in the ISP Program Management Plan (see Attachment 14 of Appendix A). Details on the requirements and procedures of the ISP are presented in Appendix J.

The ISP implements the focused investigations and research activities of the MRRP and sets the standards and requirements for related activities. The ISP ensures appropriate monitoring, assessment, and research activities are implemented in a timely manner to track progress towards meeting program objectives, reducing uncertainties, and identifying needed program adjustments. The ISP provides contract and staffing support to all science activities and ensures that research and monitoring meet Program standards, and are properly coordinated, collaborative and efficient.

The ISP Manager is responsible for communicating findings in an objective and transparent way to the agencies, MRRIC and Missouri River Basin stakeholders through various reporting mechanisms, such as the annual AM report, periodic reports, update

presentations, and a variety of other reports (see Chapter 6). The ISP Manager is also responsible for planning and conducting the annual Fall Science Meeting, during which major findings, research results, etc., are reported and upcoming monitoring and research activities discussed (see Section 2.4.3.2).

2.3.6 Other MRRP entities and position descriptions

2.3.6.1 Executive Steering Committee (ESC)

The ESC is a USACE entity composed of the Chiefs of Programs and Project Management for the Omaha and Kansas City Districts and the Chief of the Missouri River Basin Water Management Division. Additional (non-voting) members of the ESC include the following¹:

- Chiefs of Civil Works (NWO and NWK)
- Chiefs of Planning (NWO and NWK)
- MRRP Senior PgM
- NWD Representatives

The ESC ensures that the MRRP is implemented according to the direction and guidance provided at the Oversight level and that the SP reflects a regional, systems approach to achieving its objectives and is consistent with budget, acquisition, and other constraints. They ensure appropriate staffing and the effective use of district resources, considering the needs of the MRRP, other water resources projects on the Missouri River, and other Civil Works demands in the basin. The ESC meets quarterly or more frequently as issues require. Specifically, the ESC has the following responsibilities:

1. Provide guidance and direction to the Management Team on implementation of the program to achieve program overarching goals and objectives.
2. Work to resolve inter-district/interagency conflicts in support of regional operation.
3. Act as liaison with senior leadership at the districts and division.
4. Provide review and approval for resourcing requirements prepared by the Management Team.
5. Direct and manage the following:
 - a. Staffing, organization, and resource acquisition needs
 - b. Other resources needed to support the MRRP
 - c. Workload balancing between districts to maintain technical quality/capability
 - d. Acquisition strategy for MRRP activities.

¹ The role of these and other ad hoc membership is to provide continuity between the Management Team and the ESC

2.3.6.2 Senior Program Manager (SPgM) for MRRP

The role of the SPgM is to ensure implementation of the MRRP is consistent with USACE policy, and to communicate the MRRP strategic vision, goals, relevant guidance from senior leadership to all internal and external MRRP teams and stakeholders. The SPgM works to ensure that relationships are maintained with Federal agencies, states, tribes, MRRIC and other entities involved with the MRRP. The MRRP SPgM serves as the Management Team lead, and coordinates efforts among other Teams to ensure that actions and communication are consistent with programmatic goals. The SPgM develops and assigns budgets and tasks for communications, outreach, and tribal consultation, and works with the ESC to ensure the Program is properly resourced to meet its objectives. Specific tasks of the SPgM may include the following:

- Development and updating of three-year budget requests and a five-year strategic program plan through full coordination with, and input from, other agency Teams, MRRIC, and senior leadership (Oversight)
- The SPgM coordinates and oversees the preparation of a programmatic SP by the Management Team, based on prioritized recommendations of the species teams and considering input from the MRRIC HC WG and Tribes
- Development, facilitation, and implementation of a Tribal Engagement Strategy with tribes in the Missouri River Basin through close coordination with the MRRP Tribal Lead and district tribal liaisons
- Coordination of all MRRP outreach, communication, and collaboration including support to MRRIC
- Implementation and maintenance of data management and communications systems/programs, including automated reporting, development, and distribution of annual reports, fact sheets, and other MRRP-funded reports

The SPgM is ultimately responsible for critical outputs from the MRRP Program, and will track progress toward milestones for all Program products. The SPgM will issue tasks to subordinate team members outlining the products for which they are responsible, and ensure they are implemented efficiently and effectively (i.e., cost and quality).

2.3.6.3 Missouri River Recovery Implementation Committee Project Manager (MRRIC PM)

The MRRIC PM facilitates the collaboration among the MRRIC, Federal, tribal, and state partners and stakeholders. The MRRIC PM is the Chair of the HC Team, member of the Management Team and coordinates MRRIC-related processes and activities within the USACE, including the vertical team and with the Federal Working Group (FWG). Responsibilities of the MRRIC PM are: (1) plan, support, and manage

interactions between the USACE and MRRIC; (2) plan and manage the MRRIC budget and schedule; and (3) coordinate with the U.S. Institute for Environmental Conflict Resolution on contract matters related to the MRRIC. The MRRIC PM works closely with the SPgM on all matters, and with the ISP Manager and AM PM on science issues, including the contracting of the ISAP.

2.3.6.4 Missouri River Adaptive Management Process Manager (AM PM)

The AM PM is responsible for coordinating the AM program and works closely with the SPgM, ISP Manager, and the AM Team Leads to ensure AM principles and practices are incorporated into all phases of MRRP implementation. While the ISP Manager is responsible for scientific monitoring and research results for the Threatened and Endangered (T&E) species and their respective habitats addressed under the BiOp, the AM PM is responsible for ensuring this information is easily accessible to and understood by members of the AM Teams, other agencies, states, tribes, stakeholder groups, and the public. The AM PM oversees the Technical Team activities, is a member of the Management Team, and an ad hoc member of the Bird, Fish, and HC Teams. Other responsibilities include (1) providing AM expertise for the Program, (2) AM coordination amongst the ISP, AM Teams, and MRRIC, and (3) the preparation and distribution of the annual AM Report.

2.3.6.5 Implementation Project Managers (IPMs; Bird PM and Fish PM)

IPMs are responsible for implementing the MRRP habitat creation/restoration projects within the Districts. This includes the assignment of PDT members and necessary work to identify, plan, construct, track, and report accomplishments of each project. A Bird PM and Fish PM generally function as the IPM for each sub-program, although more than one IPM may be engaged if multiple projects are concurrently in planning or engineering and design phases. Bird and Fish PMs identify, plan, construct, track, and report accomplishments of each sub-program as well as progress toward meeting the MRRP goals and objectives (i.e., identifying future work; setting and tracking acquisition priorities; and completing and updating project management plans (PMPs) for sub-programs and sites). The IPMs are responsible for assignment of PDT members as appropriate to achieve goals and strategically position the MRRP for meeting BiOp requirements. The Bird and Fish PMs work closely with the SPgM to assign budgets and tasks for annual design and construction, and develop work plans for sub-program implementation, as well as contributing to the annual Strategic Plan update. The Bird and Fish PMs are members of the Management Team and generally serve as the Agency Leads to the Bird and Fish Teams.

2.3.6.6 Tribal Lead

The Tribal Lead is a member of the HC Team and is responsible for coordinating/communicating MRRP developments with the federally recognized Native American Tribes with historic ties to the Missouri River basin. The Tribal Lead coordinates directly with each affected tribe and ensures that their leadership is aware of issues that might impact tribes. A key responsibility is to communicate concerns expressed by individual tribal nations about specific actions or projects to MRRP management for consideration. The Tribal Lead coordinates and provides feedback to the tribe making the request. All basin tribes are encouraged to have a representative at MRRIC. For those tribes unable to have representation at each MRRIC meeting, the Tribal Lead is to ensure tribal governments receive information discussed at these important stakeholder meetings and that they are aware of pending decision-making opportunities. The Tribal Lead coordinates activities with the NWD, NWO and NWK tribal liaisons.

2.3.6.7 Missouri River Basin Water Management Representative (WM Representative)

The WM Representative serves as the interface between the MRRP and the NWD MRBWMD. A WM Representative (there can be multiple and alternate representatives) is a member of each of the Implementation Teams and the Management Team. The WM Representative is responsible for reporting any issues addressing water management decisions and their potential impact on the program. The WM Representative makes recommendations to the teams on strategies to avoid or minimize take, provides information on water management projections (effects of the AOP for the Missouri River), and provides technical insights into team discussions regarding potential flow management actions.

2.3.6.8 Office of Counsel (OC)

The designated Office of Counsel for the MRRP (currently from NWK) provides guidance and advice on all legal matters related to administration and implementation of the program. OC works closely with the Bird, Fish, and HC Team Leads, Management Team, ESC, and MRRIC as participants in Team meetings as well as on-call advisors. Specific real estate, contracting, and regulatory activities will generally be served by an attorney from the OC in the district where the action officer is assigned.

2.3.7 Overview of MRRIC roles and responsibilities

The Missouri River Recovery Implementation Committee (MRRIC) represents stakeholder interests for the MRRP. As described in WRDA Section 5018 (3) (B) (i), “The Committee (MRRIC) shall provide guidance to the Secretary with respect to the Missouri River recovery and mitigation plan in existence on the date of enactment of

this Act, including recommendations relating to changes to the implementation strategy from the use of adaptive management.” The AM engagement approach laid out in this SAMP should be considered the vehicle for the MRRIC, in collaboration with the USACE, to achieve this objective. In addition, the Charter for the MRRIC includes, as part of the Committee’s purpose and scope [1) a) iii)]: “Provide recommendations and guidance that will include:

1. Recognition of local stakeholders' social and economic, historical and cultural, flood control, irrigation, agriculture, internal drainage, water supply, water quality, navigation, hydropower, thermal power, science, natural resources, conservation, and recreation issues, and any other issues identified by the Committee
2. Identification of impacts to stakeholders
3. Identification of actions that will benefit multiple uses of the river (MRRIC 2014).”

In executing this role, the MRRIC and the agencies each bear responsibilities for Program execution and for effective collaboration and decision making. Adherence to basic principles already outlined and reiterated below will help ensure this occurs. As a practical matter, the MRRIC will continue to rely on WGs, ad hoc Work Groups, and the ISAP to engage at the necessary level of detail with elements of the agencies and the AM Program and provide the full body of the MRRIC with insights and recommendations (Figure 15). The MRRIC relies upon WGs to collaborate on issues through frequent interactions with agency specialists, and provides input to the agencies and the full MRRIC based on those interactions. The full MRRIC weighs in on the most significant issues based upon WG input, and focuses on SP recommendations.

Figure 15 provides an overview of the roles for MRRIC and its key WGs. The schematic shows that the MRRIC would rely upon three WGs to collaborate on issues through frequent interactions with agency specialists and provide input to the agencies and the full Committee based on those interactions. The full Committee would weigh in on the most significant issues based upon the WG input, as well as focus on recommendations for the SP. More details are given in the following sections, elsewhere in the SAMP, and its appendices and attachments.

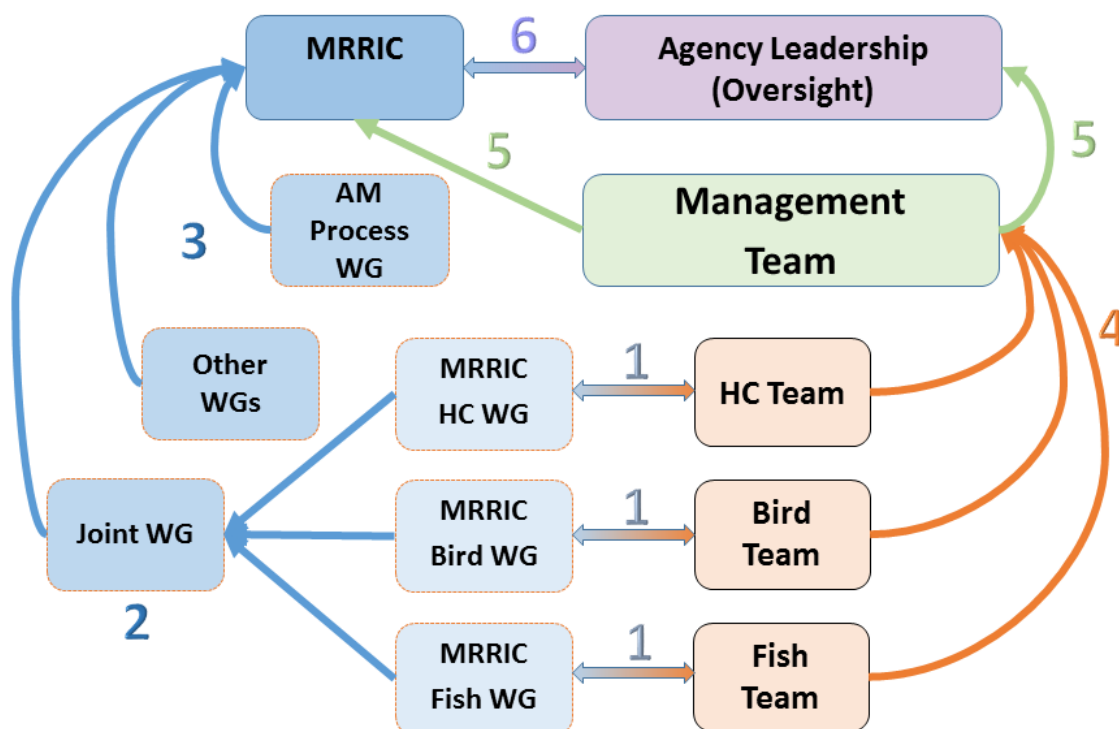


Figure 15. Schematic of MRRIC interactions. Implementation Teams meet (1) and MRRIC WGs hold a Joint WG meeting (2). Joint WG and other WGs develop draft recommendations (3). Team Leads provide input to Management Team (4) and Management Team develops draft SP and other recommendations (5). MRRIC and agency leadership collaborate at plenary meeting (6), and leaders make decisions.

2.3.7.1 MRRP collaborative forum composition, roles, and responsibilities.

The MRRIC Charter (MRRIC 2014 [amended from 2009]) and Operating Procedures and Ground Rules (MRRIC 2018 [amended from 2009]) establish the objectives for MRRIC and its mechanisms for achieving those objectives (see Attachments 1 and 2 of Appendix A). The MRRIC plenary meetings provide the primary forum for collaborative engagement where a consensus recommendation is needed or desired. Other opportunities for collaboration and input to the MRRP are described in later sections of this chapter (see Section 2.3.7.2 through 2.3.7.4 and Section 2.4).

MRRIC advanced and approved an engagement strategy for the development and implementation of an AM Plan for the MRRP (MRRIC 2011). That document outlines a set of principles that remain relevant to the current and future efforts under the MRRP (MRRIC 2011, see Sections 2.3 and 2.4.5). In addition, the agencies have engaged with the AM ad hoc WG to develop a collaborative governance process. Those engagements produced useful input to the process and a draft recommendation to the MRRIC that resulted in a consensus recommendation on governance (see Attachment 5 of Appendix A for related recommendations). The following sections draw from that consensus

recommendation and from a “dry run” of the process in 2017 and 2018 and describe a set of WGs that interact with the agency teams and the process for implementing AM to influence the SP.

2.3.7.2 MRRIC Bird, Fish, and HC WGs

Three permanent WGs (Bird, Fish, and HC) support the MRRIC and agencies by engaging with the agencies as part of the Bird, Fish, and HC Teams, respectively, to inform the program’s strategic direction as it adjusts based on new knowledge. Each Team includes agency staff involved in implementation of the MRRP and its AM Plan as well as MRRIC members of the WGs who meet at defined times throughout the year to engage on important issues.

The main role of the Bird and Fish WGs is to engage around the science and technical issues that relate to the piping plover and pallid sturgeon and underpin the Program. This includes understanding what actions are being implemented for the birds/fish, the status of hypotheses related to the birds/fish, and how the models work and the implications of updated model results. The WGs are responsible for providing comments and feedback to the lead agencies (during meetings with Bird, Fish, and HC Teams and through WG reports), keeping the full MRRIC informed of their comments and feedback, and bringing forth issues to MRRIC that may need a formal recommendation from the full committee. A fundamental product of the engagements for each Team is the identification of priority actions for each species to help the Management Team with development of updates to the SP. While the details of priority actions are developed by the species’ PMs, the WGs contribute through their dialogue as part of the Teams and they provide related feedback to the MRRIC.

The composition of the HC WG and the HC Team are similar to those for the birds and fish. However, the role of the HC Work Group is to understand the technical aspects of AM that relate to human uses of the Missouri River System. This includes understanding how HC’s are being accounted for in AM and understanding the hydrologic, hydraulic, economic, or other models used to predict effects to HCs. Another focus of the HC Team, as warranted, is monitoring and assessment of the effects of MRRP actions on HC interests. The main responsibilities of the HC WG include providing comments/feedback to the Federal agencies (during meetings with the HC Team and possibly during real-time operations), keeping the full MRRIC informed of their comments/feedback, working with the full MRRIC to explore the adequacy of the human consideration monitoring metrics, and bringing forth issues to MRRIC that may need a formal recommendation from the full committee.

Members must be able to commit the time and energy to stay involved, understand the issues, and stay meaningfully engaged in the technical discussions regarding application of science to species needs. Reasonable expectations regarding the level of effort are therefore essential before committing to serve as a WG member. WG members should expect to devote up to a month of their time annually in order to effectively engage with the Teams, stay abreast of developments, prepare reports, and maintain sufficient participation.

WG interactions with the teams are coordinated by the Team Planning Group, consisting of the Facilitator, WG POCs, and the Agency Leads (typically the Implementation PMs for each species and the MRRIC PM/AM PM for the HC Team). These interactions are assisted by a third-party facilitator initially and until such time as the MRRIC and agencies agree facilitation is no longer required. The Planning Group identifies and confirms dates for meetings and calls, develops draft agendas for work Team/WG review and considerations, and assists in other administrative preparations as necessary. The WG meetings with the teams are facilitated, recorded, and summarized by the Facilitation Team. The recording and summary is shared with WG members as well as other interested parties including, but not limited to, the full MRRIC.

The WG POCs and agency lead for each Team are responsible for keeping WG members apprised of activities of the Team. The full WG is expected to meet with the rest of the Team as often as necessary to accomplish the tasks assigned to the team. Generally the WGs/Teams meet two or three times a year in association with the following:

- In October/November – at the Fall Science Meeting – to obtain briefings on the status of monitoring activities, early performance observations, research in-progress reviews, and other noteworthy activities of the team; and to provide input into the activities of the team for the following quarter.
- In February – at the Annual AM Workshop – to participate in discussions of significant science findings, performance of past management action implementations, prioritization of research needs and project implementation proposals, and recommendations for the SP.
- In April/May – after the release of the agencies' draft SP – either for a Joint WG meeting to address issues regarding the SP recommendations, or to review any significant adjustments to plans due to budget changes. Note that this is a Work Group meeting and may not involve the full teams.

In addition to the above meetings, Team calls are typically held in January (to discuss findings in the draft AM Report) and August to discuss activities over the field season and prepare for the Fall Science Meeting). WG meetings are documented by the Facilitation Team, who prepares a summary of the discussions at the meeting, and any issues addressed. Reports from the team meetings are provided to the Management Team for consideration, and contribute to draft changes to the SP by the Management Team. The WGs have the opportunity to share their observations including the range of their perspectives, provide individual or consolidated reports, and draft recommendations, directly with MRRIC in preparation for potential recommendations to the agencies.

To effectively involve MRRIC in the AM program, it is important to establish and maintain a significant level of understanding of, and trust in, the decisions and associated implementation efforts. Full engagement by all MRRIC members in the AM process is not feasible; however, it is essential that opportunities exist for members to stay engaged and share their perspectives. In addition to active participation as members of the WGs, the agencies will afford opportunities for interested MRRIC members to observe key Team meetings without the attendant commitments required of WG members. It is possible that interest and participation during initial implementation is higher than ultimately optimal for efficient WG function but will serve to increase trust in the process. Therefore, early involvement should be accommodated to the extent possible, with a longer-term aim to reduce the group size to an optimum.

The agencies and MRRIC will collaborate to refine the composition and operation of the WGs as program needs change. MRRIC may retain other existing Task Groups or sunset those no longer required, and may establish new Task or Ad Hoc Groups as needed to address specific issues related to the AM program (with consideration for maintaining a total number of subgroups commensurate with the available budget and for the time commitment of members and agency staff).

2.3.7.3 Independent Science Advisory Panel

The MRRP maintains an Independent Science Advisory Panel (ISAP) for independent peer review, advice, and recommendations to support decisions and directions for the program. The Panel (or constituent sub-Panels) are convened, as necessary, to provide independent scientific and socio-economic peer review of work products, or to analyze and interpret data. The Panel composition may be adjusted as needed to accomplish their charge. This structure will allow for flexibility in focusing sub-Panels on specific issues, when warranted, or integration across disciplines by using the full Panel when that is required and when more efficient and effective communication with the agencies and MRRIC is needed.

The Panel or sub-Panels may review the monitoring and assessment results, research proposals, monitoring plans, Strategic Plans, and other relevant materials, or provide expert scientific and socio-economic advice and recommendations to MRRIC, its WGs, and the agencies. Execution of these functions, within the scope of their contract and subject to the availability of funds, is necessary for the proper function of the AM Program and for building and maintenance of trust between the agencies and stakeholders.

The Corps will utilize the Third Party Science Neutral (TPSN) contracted by the U.S. Institute for Environmental Conflict Resolution (USIECR), to manage the Panel, including scientific advisor selection, panel processes, and panel products. The TPSN maintains Panel membership to ensure appropriate expertise is provided, receives tasks from the MRRIC and/or agencies, and ensures their activities are within the mandates and the scope of the SAMP (see Section 2.3.7.4). The TPSN refrains from any reviews and remains neutral on products of the Panel or sub-Panels.

The size and composition of the ISAP and sub-Panels, as well as their role and level of engagement, should be periodically reviewed and updated to ensure maximum benefit to the Program. Presently, the Panel should be comprised of between six to eight science advisors that represent the following expertise or disciplines: River Ecology/Conservation Biology; River Hydrology/Geomorphology; Sturgeon Biology/Ecology; Quantitative Ecology/Statistical Methods; Resource Economy/Sociology; Tribal and Cultural Resources/Native Science Expertise; Least Tern/Piping Plover Expertise. An individual member can fulfill more than one of the aforementioned areas of expertise, and Panel size should be regulated accordingly.

The ISAP is charged with independent science support and technical oversight by providing objective advice on specific topics originating from the agencies and/or MRRIC. In addition to other specific tasks, the ISAP should attend the annual Fall Science Meeting and the AM Workshop and meet with the full MRRIC at least once annually. Interaction with the Panel must be within the scope of their contract, subject to the availability of funds, and must identify specific tasks, products, and timelines. To ensure such interactions meet contractual requirements and are documentable, the following definitions will be used:

- Panel-Initiated Communication. If the Panel considers a topic of sufficient relevance in their role of reviewing and providing independent scientific advice on draft products regarding implementation of the Panel recommendations or MRRIC proposed actions, they may provide written advice or guidance to MRRIC and the

AM Teams. Their advice would be provided through the TPSN to the appropriate WG, MRRIC, or the agencies for consideration.

- **Inform.** In coordination with the appropriate MRRIC WG, the agencies will provide information to the TPSN to assist Panel members in understanding the problem being addressed, the options being considered, and the final decision to be made. The agencies will keep the TPSN informed of the final decisions. The task for the Panel is to review materials as time permits.
- **Discuss and Provide Feedback.** In coordination with the appropriate work WG, the AM Teams or Technical Team may interact directly with the Panel on a “scientist-to-scientist” basis. During meetings (web or face-to-face), the Teams will seek verbal feedback (e.g., clarification questions, initial reactions, and/or a general sense of direction and progress) from Panel members. The Teams will consider the feedback and then apprise the TPSN and MRRIC (or appropriate WG) as to how the feedback was used. Panel member verbal feedback should be considered informal and does not necessarily represent a consensus statement from the Panel. Documentation of the exchange during the calls/meetings will be provided through meeting summaries.
- **Evaluate.** In coordination with the appropriate WG, the AM Teams will interact directly with the ISAP seeking a collective opinion. Any document(s) for review and necessary background information will be shared with the Panel along with a specific review question (or set of questions). Discussion and feedback between the Panel and MRRIC and the relevant AM Team is inherently part of the “evaluate” option. The expected Panel product is a written memo reflecting the collective opinion of all Panel members in response to the review question(s), which will be considered by the AM Teams. The Agency response will be shared in a written memo indicating how the opinion was used/will be used.

Independent advice and reviews provided by the ISAP are scientific, while decision-making and policy interpretations are left to the USACE after consideration of consensus recommendations from MRRIC. The AM Teams, particularly the Technical Team, interact with the Panel on an as-needed basis, but nominally during the Fall Science Meeting and AM Workshop. Requirements of the Panel and procedures for its interactions with the MRRIC and the AM Teams are provided in Attachment 9 of Appendix A.

2.3.7.4 Third Party Science Neutral (TPSN)

The TPSN is responsible for selecting and managing the ISAP, including liaising between the Panel and the MRRIC, the USACE, and USFWS (see Section 2.3.7.3 and Attachment 9 of Appendix A). The TPSN follows guidance from the National Academy of Science (2003) and the Office of Management and Budget’s “Final Information

Quality Bulletin for Peer Review” (2005) when selecting panel members. Above all, the TPSN ensures that the ISAP reflects the needed expertise in an appropriate balance, and that panelists have no conflicts of interest.

MRRIC and/or the USACE work directly with the TPSN, to develop topics and questions to be addressed by the Panel. This includes instructions to the panelists regarding the topic, expected products, task timelines, and how panel deliberations will be conducted. The TPSN facilitates all Panel deliberations and keeps the panelists on track. All communication regarding the topics under consideration between the USACE, MRRIC members, and candidate or selected panelists, is coordinated through the TPSN.

The TPSN ensures full consideration of multiple perspectives on the issues and a structured process that guarantees the integrity of an independent review, avoids bias, and guides communications between Panel members and the USACE, MRRIC, and other interested parties. The TPSN is generally expected to attend the Fall Science Review, the AM Workshop, and any plenary MRRIC meetings. Additional details regarding the TPSN roles and responsibilities is included in Attachment 9 Appendix A.

2.3.7.5 Interactions with MRRIC

Degrees of collaboration between the agencies and MRRIC are based on the Spectrum of Public Participation developed by the International Association of Public Participation (IAP2) to help clarify the role of the public in decision-making processes. MRRIC, with guidance from the USIECR, adapted the Spectrum for their uses and, by consensus, incorporated their version into the Committee's Operating Procedures (MRRIC 2016; amended 2018; See Attachment 2, Appendix A; check latest version at www.mrric.org). These consist of one-way (inform) and two-way communications (with low, medium, and high collaboration). In February 2011, MRRIC approved an engagement approach describing how the agencies would interact with MRRIC in developing and implementing AM strategies for the MRRP. The approach was developed to ensure timely exchange of information and development of products, while providing opportunity for appropriate interaction between MRRIC and the agencies at key stages in the development, implementation, and decision-making involved in the AM process. The engagement with MRRIC on the development of the MRRMP-EIS and this SAMP used this approach, and it remains an effective mechanism for engagement during AM implementation. The intention of the approach is the following:

1. Be understood and trusted by MRRIC members.
2. Provide a satisfactory level of participation in the systematic process for MRRIC members.

3. Provide an opportunity for MRRIC to identify any social, economic, or cultural issues that may result from the proposed action(s).
4. Be implementable for both the agencies and MRRIC.
5. Be focused on resolving scientific uncertainties necessary to inform management decisions.
6. Provide for collaboration that allows the agencies to implement the MRRP in a timely manner.

AM strategies require highly interactive and timely deliberations. To address this requirement, the approach established that engagement is to be conducted primarily through the MRRIC WGs. Agency leads and the AM Teams (Management, Bird, Fish, HC, Technical) interact directly with the WGs through conference calls, webinars, and in-person meetings. Implementation of the approach is expected to work as follows: the WGs identified in Section 2.3.7.2 work closely with and at times as a part of their corresponding agency AM Teams. The primary interactions center on the Fall Science Meeting, the AM Workshop, and the SP development, but the Teams will meet at other times as needed to ensure the necessary collaboration and communication occurs. MRRIC WGs engage with agency personnel on the Teams and reach into the broader MRRIC to solicit input and promote understanding and support for activities and products. WG and Agency briefings will occur at key points, typically as part of normal plenary meetings, to ensure the full MRRIC stays informed.

Communications between the agencies and MRRIC are classified by the level of collaboration (as low, medium, or high). More medium- and high-level collaboration is likely to occur in implementation of the SAMP, especially among the AM Teams and the MRRIC WGs and early in implementation of the Program. The appropriate types of interactions depend on the nature of the issue and the groups involved. These interactions may vary over time as well; e.g., an issue initially treated using low-level collaboration may later require a medium-level of collaboration. Thus, a mechanism to change the designated level or the flexibility to adjust the associated collaboration is needed. A summary of potential interactions follows:

- **Inform**. The AM Bird, Fish, HC and Management Teams will provide information to MRRIC to assist members in understanding the program performance, results of key analyses, alternatives considered, problem being addressed, the status of and predictions for population and system status, and other pertinent information about the Program. Interactions at the Inform level will rely on the WG Representatives as well as e-mail and web meetings to inform the MRRIC. The agencies will inform MRRIC of any Oversight-level decisions regarding program implementation. The Technical Team will provide information to MRRIC and the Panel through the

appropriate WG to assist Panel members in understanding the problem being addressed, the options being considered, and decisions that need to be made.

- Low Collaboration. As the AM Bird, Fish, HC and Management Teams “inform” MRRIC of the above issues during facilitated meetings and plenary meetings of MRRIC, they will also seek feedback from MRRIC. Concerns expressed are taken into consideration prior to making decisions regarding the issues discussed, and the use of the input is addressed at the next Team meeting and the next MRRIC plenary meeting. Input from MRRIC WGs during Team meetings is included in summary reports for those meetings produced by the facilitator.
- Medium Collaboration. The AM Bird, Fish, HC and Management Teams will work directly with their associated MRRIC WGs on monitoring and assessment activities and research for the MRRP. This interaction occurs at the Fall Science Meeting and, Annual AM Workshop, and any other scheduled meetings for this purpose. The Teams will ensure concerns and suggestions are understood, and will try to address those concerns to the extent possible within legal and policy constraints. The WGs then communicate to MRRIC and any appropriate Task or WG describing how their concerns were addressed. MRRIC WG input is reflected in the draft recommendations prepared by the Joint Work Group, and the facilitator shares WG deliberations through meeting minutes, recordings, presentations, or other means.
- High Collaboration. The AM Bird, Fish, HC and Management Teams will work directly with appropriate MRRIC WGs on certain decisions and recommendations, within legal and policy constraints. A high level of collaboration occurs on the development of the SP, new or controversial information, research and project implementation priorities, etc. The Teams, including their member MRRIC WGs, jointly explore potential solutions and seek agreement on critical issues. The Teams’ Agency Leads will elevate any concerns or recommendations to the appropriate agency decision entity, and will provide related briefings to the MRRIC, as warranted. The WGs, in turn, provide their feedback to the full MRRIC and seek agreement (consensus) on draft recommendations for MRRIC’s consideration.

Interactions with MRRIC are intended to fall under the same laws and acts that currently guide the Committee and agencies (e.g., Sec. 5018, FACA, WRDA).

Notwithstanding the cooperative nature of the Program, the lead agencies (USACE and USFWS) have statutory responsibilities that cannot be delegated; the program structure and interactions are intended to promote collaboration and facilitate MRRIC input to decisions, not transfer decision authority. Generally, the recommended interactions provide for the following:

- MRRIC WGs engaging with agency personnel as part of the Bird, Fish and HC Teams to assess the latest scientific data/findings, provide input on monitoring, assessment,

research and implementation issues, and help decide which issues should be elevated to the full Committee

- MRRIC as a whole to be directly informed about the team process by the WG members participating on the teams (rather than solely by agency staff/contractors)
- MRRIC as a whole involved in the AM learning process and in the formation of recommendations for actions, research, monitoring and assessment
- MRRIC members to remain informed of significant findings through attendance at the AM Workshop and other interactions during the year so they can be informed prior to plenary meetings
- Access by MRRIC members to monitoring results and research findings through data-sharing and program reports
- MRRIC as a whole to examine the science process and provide recommendations for the program's direction as reflected in the strategic plan
- MRRIC as a whole to evaluate the AM program performance and make recommendations for changes to improve performance, accountability, etc.

MRRIC typically meets three times per year - subject to available resources and other relevant considerations - to develop recommendations, building on the results of MRRP SP implementation and reports from the Bird, Fish, and HC WGs/Teams. An additional meeting may be conducted by conference call, but would likely be convened only to reach final consensus on a recommendation that MRRIC already reached tentative consensus on during a face-to-face meeting. MRRIC members may also attend the Fall Science Meeting and/or Annual AM Workshop, as well as participate in any of the webinars/calls established to brief MRRIC.

The interaction strategy described above is intended to facilitate development of consensus recommendations on the MRRP, including recommendations on the Strategic Plan in a relatively compressed timeframe. This maximizes the effectiveness of the MRRIC's input to the budget and SP processes. A general meeting schedule with typical agenda items is provided below. The first three are face-to-face plenary meetings; the fourth is by conference call. The timing of each meeting will need to be adjusted periodically for logistical reasons, and may change along with the Program's needs throughout implementation. The collaborative strategy should provide MRRIC the ability to influence the program through their recommendations.

- Meeting #1 (in October/November) which would provide an opportunity to discuss the status of implementation efforts and preliminary information gained from the the prior year's monitoring efforts and discuss other issues as appropriate (e.g., strategic priorities, programmatic considerations)

- Meeting #2 (in mid- to late-March) which would provide an opportunity to engage on key issues related to the program's strategic direction addressed during the AM Workshop, and for MRRIC to begin identifying potential areas for recommendations related to the SP
- Meeting #3 (in late-May) which would provide an opportunity to reach tentative consensus on recommendations related to the Corps' draft SP, hear updates on implementation of the AM activities, and discuss other issues as appropriate (e.g., strategic priorities, programmatic considerations)
- Meeting #4 (in June) which would be by conference call if MRRIC approves the tentative consensus recommendations and approves use of the meeting by conference call approach to approve the consensus recommendations.

2.3.8 Basin states, other Federal agencies, and tribal roles outside the MRRIC collaborative process

Involvement by any Federal Agency, State and Tribe in MRRIC does not change or affect any other authorities relating to these groups. The MRRIC Charter specifically describes the intention to not interfere with these outside processes. The MRRIC charter expressly states:

Participation in the Committee by Tribal entities does not substitute for nor replace federal requirements to consult with Tribal entities pursuant to federal laws and regulations, such as: Executive Order 13175, Tribal Consultation; any federal agency's trust responsibilities to a federally recognized tribe in the Missouri River Basin or a tribe that has historically been on the Missouri River; and/or replace any treaty or right thereof such as: the Portage des Sioux Treaty (July 1815); the Treaty of Ft. Laramie, 11 Stat. 749 (Sept 17, 1851); the Treaty with the Omaha, 10 Stat. 1043 (March 16, 1854); the Treaty of Ft. Laramie, 15 Stat. 635 (April 29, 1868); Title VI-Cheyenne River Sioux Tribe, Lower Brute Sioux Tribe, and State of South Dakota Terrestrial Wildlife Habitat Restoration Act of the Omnibus Consolidated and Emergency Appropriations Act of 1999, PL 105-277, 112 Stat. 2681, 2861-660-670 (October 21, 1988), as amended by Title IV of the Water Resources Development Act of 1999, PL 106-53, 113 Stat 269, 385-397 (August 17, 1999), and as otherwise amended; and any other treaty or right. Cooperation with the federally recognized tribes engaged in this process should be interpreted as "in good faith."

Participation in the Committee by State, Tribal, or Federal entities does not limit their discretion; alter, affect, impair, delegate, or relinquish their statutory or other legal rights and responsibilities, including any right to legal remedies; or otherwise waive their sovereign immunity under applicable law; create any new right to any type of administrative review or create any new right to judicial review or any other right or benefit,

substantive or procedural, enforceable by or against these entities or any other stakeholder participating in the Committee; and affect Tribal reserved water rights, treaty rights, or water rights administered by the Tribes and/or States, including the "Winters' Doctrine", *Winters v United States*, 207 U.S. 564 (1908). If the processes and procedures of the Committee would impede the implementation of any action for which agencies of the States, Tribes, or United States are obligated under law, that agency reserves the right to proceed with fulfilling those obligations in such manners as it may deem appropriate. (MRRIC 2009).

Similarly, the governance of this AM plan cannot impede or interfere with any other right or responsibilities of these groups. Rather the SAMP describes the roles of Agencies, States, and Tribes specifically within the MRRIC framework. MRRIC is designed to be an additional forum for these groups to provide valuable insight on the management and operations of the MRRP. Additionally, the expertise of these groups may be utilized by the various work groups and implementation teams. These new forums for collaboration between USACE and Federal Agencies, States and Tribes provide important avenues for communication and collaboration while protecting any outside processes.

2.3.8.1 States

As previously stated, this governance structure does not change or impede any of the rights and responsibilities of a state.

Historically, it has been the role of the state fish and game agencies to assist in putting projects on the ground. The USACE and USFWS will continue to plan site-specific projects with State input and continue to coordinate with the appropriate state agency on any and all legal requirements for comment, collaboration, certification, permitting, etc. One statutorily protected consultation role of note is the Fish and Wildlife Coordination Act (FWCA). Under the FWCA, USACE is required to coordinate with the state game and fish agencies and the USFWS for site specific projects. USACE will continue to execute the FWCA in accordance with the National MOU between the USFWS and the USACE.

With regard to the regulation of the Missouri River Mainstem Reservoir System, the USACE will continue to provide a draft Annual Operating Plan (AOP) that describes the planned operation of the reservoir system for the coming year under a variety of runoff conditions. States will have the opportunity to provide comments on the draft and final AOP at the public meetings or by providing written comments during the comment period.

If at any time during AM Plan implementation the Basin States or USACE determine the actions proposed to occur are outside of the conditions of the Master Manual, procedures for addressing these situations outlined in the Master Manual will be followed. Those procedures include the Corps consulting with all the Basins States, their designated representatives and/or other interstate organizations consisting of Missouri River Basin State representatives before making any substantive modifications. Additionally, states retain the right to comment or request consultation outside of MRRIC, FWCA, and AOP processes on any issue related to the Management Plan or ongoing AM process via official letter at any time.

2.3.8.2 Federal Agencies

Federal agencies are not counted for purposes of Committee quorum requirements and do not participate in the determination of consensus recommendations, however, agency representatives provide important input on substantive issues where they have jurisdiction or special expertise and are therefore integral to the AM Process. Like states and Tribes, Federal agencies are consulted on site-specific projects when they have special expertise, statutory responsibilities or authorities. The National Park Service, for example, will continue to be involved in assisting the agencies in planning sandbar habitat construction activities in the Missouri River National Recreational River (MRNRR) reaches below Fort Randall and Gavins Point Dams. Federal agency consultation in this capacity should occur early in the project formulation process through interactions and discussions during meetings of the Implementation Teams.

2.3.8.3 Tribes

Participation in MRRIC by tribes does not substitute for or replace the federal requirement to consult with Tribal entities pursuant to federal laws, regulations, executive orders, and treaty and trust obligations, including the following:

Executive Orders:

- EO 11593 Protection and Enhancement of the Cultural Environment
- EO 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
- EO 13006 Locating Federal Facilities on Historic Properties
- EO 13007 Protection of Indian Sacred Sites
- EO 13175 Consultation and Coordination with Indian Tribal Governments
- EO 13287 Preserve America

Federal Laws:

- National Historic Preservation Act (16 U.S.C. §470f et seq) (NHPA)

American Indian Religious Freedom Act (AIRFA), Pub. L. No. 95-341 (codified in part at 42 U.S.C. §1996).

Native American Graves Protection and Repatriation Act (NAGPRA), 18 U.S.C. §1170, 25 U.S.C. §3001 – 3013, implemented through regulations codified at 43 C.F.R. part 10.

Archeological Resources Protection Act, 16 U.S.C.470aa – 470mm, implemented through uniform regulations (identical except for numerical designations)

National Environmental Policy Act (NEPA), 42 U.S.C. 4321 – 4347, implemented through regulations issued by the Council on Environmental Quality codified at 40 C.F.R. parts 1500 – 1508.

Indian Self-Determination Act, 25 U.S.C. §§450 – 450n, 455 – 458e.

Policies:

Department of Defense, American Indian and Alaska Native Policy, 1998

Northwest Division, USACE, Native American Desk Guide, September. 30, 2002

Guidance Letter #57, Indian Sovereignty and Government-to-Government Relations with Indian Tribes

Guide on Consultation and Collaboration with Indian Tribal Governments and the Public Participation of Indigenous Groups and Tribal Members in Environmental Decision Making, prepared by the National Environmental Justice Advisory Council, Indigenous Peoples Subcommittee, a Federal Advisory Group of the EPA

Department of Defense and / or USACE Regulations and Guidelines:

ER 405-1-12 Real Estate Handbook

ER 1105-2-1 Environmental Compliance Program at Corps Projects and Activities

ER 1130-2-433 Collections Management and Curation of Archeological and Historical Data

ER 1130-2-438 Project Construction and Operation Historic Preservation Program

ER and EP 1130-2-540 Cultural Resource Management – Project Operations: Environmental Stewardship Operations and Maintenance Guidance and Procedures

EP 1165-2-1 Digest of Water Policies and Authorities, section 3-12 on E.O. 13007

2.4 AM Decision process, critical engagements, and workflows

2.4.1 Overview of the MRRP AM decision process

The decision process for the MRRP includes the mechanisms by which information about project and program performance, species status, system state, and other knowledge is gathered, evaluated, shared with agency managers, MRRIC, and the public, and used to make improved implementation decisions. The process is constrained by the timing of budget cycles, construction windows, and information availability; by the resources necessary for data processing, QA, analysis, and interpretation; by the need for coordination and communication; and by external factors like regulatory compliance issues.

The process is outlined in diagrams and timelines that identify the needed decision-making steps, who is responsible for those steps, and when they occur. (see Section

2.4.2 – 2.4.6). The process is built around the review of information and application of learning to the development of the SP. The overall process includes several important products and critical engagements that are consistent from year-to-year, while specific steps can vary depending upon the decision under consideration. The decision process should be adjusted as needed to have the following characteristics:

- *Science-Driven.* Decisions are based on the ongoing testing of hypotheses and active development, incorporation, and communication of new decision-relevant information arising from research, monitoring, and assessment efforts.
- *Collaborative.* MRRIC and its WGs are engaged at several points in the process to ensure their access to the latest information and to obtain their input to key decisions.
- *Efficient.* Recommendations and decisions are made as close to the implementation level as possible and elevated to higher levels only when programmatic or policy authority is required.
- *Specific.* The process steps, products, needed engagement and level of decision making are defined explicitly for a range of decisions and vary by decision scope.
- *Comprehensive.* A range of decisions, including ones likely to be rare, are considered in advance in order to reduce programmatic uncertainty and increase efficiency through the development of contingency plans, where warranted.
- *Transparent.* The decision process requires that information is shared in a timely and understandable manner, and MRRIC participates in the process at all levels.

The USACE Civil Works budget process and the AOP for the reservoir system play an important role in defining the basic MRRP decision process (see Section 2.2.2). The basic annual cycle (section 2.4.2) can be subdivided on the basis of three interrelated processes that occur seasonally each year:

1. A “Science Update” process, which occurs annually from October through January, and is the primary means by which scientific information is synthesized, hypotheses are assessed, and the results are communicated, including collaboration across various participants in the governance process (see Section 2.4.3),
2. The “Strategic Plan Update” process (Section 2.4.4), which occurs annually from February to June, and includes the collaboration and decision making that applies the lessons learned from research, implementation and monitoring to adjustments in the Program, and

3. An “Implementation” period from June through September during which much of the construction and monitoring activity occurs.

These are further described in sections 2.4.2 through 2.4.4 of the SAMP. Should knowledge gained from AM indicate the need for new management actions the necessary steps, engagements, and decisions are described (see Section 2.4.5). Variants on the basic process to address different issues are addressed using decision workflow diagrams for different types of decisions (see Section 2.4.6).

2.4.2 Basic Annual AM engagement process

The annual engagement process for the MRRP revolves around science updates and the generation and sharing of information about program performance, then using that information for the development/adjustment of the SP. Figure 16 provides an overview of the process, which recurs each year for the Program. The elements in the figure are discussed further in following sections. The description below outlines the basic process as it relates to the information exchange between the agencies and MRRIC leading to an annual update of the SP. Embedded within are a number of additional decision processes, which are described in the remainder of Chapter 2 and Appendix A, and for which examples are provided in key sections of Chapters 3 through 5. Each process or input between major decision points or events (e.g., draft or final documents, meetings, webinars) is described with an associated colored symbol, and combined into a workflow diagram (Figure 16; see Sections 2.4.2.1 – 2.4.2.4).

2.4.2.1 Annual operations planning cycle



AOP Meetings – Annual public meetings held in October by the USACE around the Missouri River basin to present and receive feedback on the draft AOP for the upcoming calendar year. Public meetings held in April present the final AOP for that year’s operations.



Draft AOP – Draft AOP prepared by the USACE Water Management office annually based on the draft SP



Final AOP – The finalized AOP based on the approved SP and issued by the USACE Water Management office in December of each year for the following calendar year.

2.4.2.2 Monitoring, evaluation, and engagement with the Bird, Fish, and HC Teams



Fall Science Meeting – A Fall science meeting would be held for agency technical staff and MRRIC WGs to be briefed on research and monitoring findings (see Section 2.4.3.2).



Bird, Fish, and Management Team Calls – Conference/webmeetings held throughout the year to review and discuss information, develop recommendations, and plan for and follow up on in-person meetings.



Draft AM Report – Summary of monitoring and assessment results, research, and new information relevant to the MRRP, prepared by the TT.



Annual AM Workshop – Annual meeting where primary exchange of information between scientists and decision makers occurs. Includes close collaboration with MRRIC WGs through AM Team meetings. Focus is on updates to the SP given implications of new knowledge and MRRP progress (see Section 2.4.3.4).



Bird, Fish, HC and Management Team Meetings – Bird, Fish, and HC Teams meet to deliberate on program performance and lessons learned, and to consider and discuss potential adjustments to future program activities, with an emphasis on the FY+2 and strategic (FY+3 and FY+4) program needs.



Workshop Report and Teams Summaries – Includes a summary of workshop discussions and key issues affecting the program's strategic direction. Includes issues from the Bird, Fish, and HC WGs that may warrant draft recommendations for MRRIC.



Final AM Report – The Technical Team integrates input from the independent reviews, AM Workshop discussions, etc., into revisions to the AM Report and submits for publication.

2.4.2.3 SP development



PDT Meetings and IPRs – Internal and inter-agency meetings to discuss issues related to the AM Report and SP. See Appendix A for details.



Draft SP – The draft SP is prepared/updated by the Management Team based on the draft AM Report, input from the Teams at the AM Workshop,

and guidance from senior leadership regarding budget and acquisition constraints and needs.



Final SP – The SP is updated in August or September each year to reflect actual program execution for that year and any additional adjustments to outyears based upon MRRIC recommendations.

2.4.2.4 MRRIC meetings and products



MRRIC Meetings – Three in-person meetings of the full MRRIC are held annually, with a fourth meeting using web and telephone as an option. Team meetings may be held in conjunction with MRRIC plenary meetings.



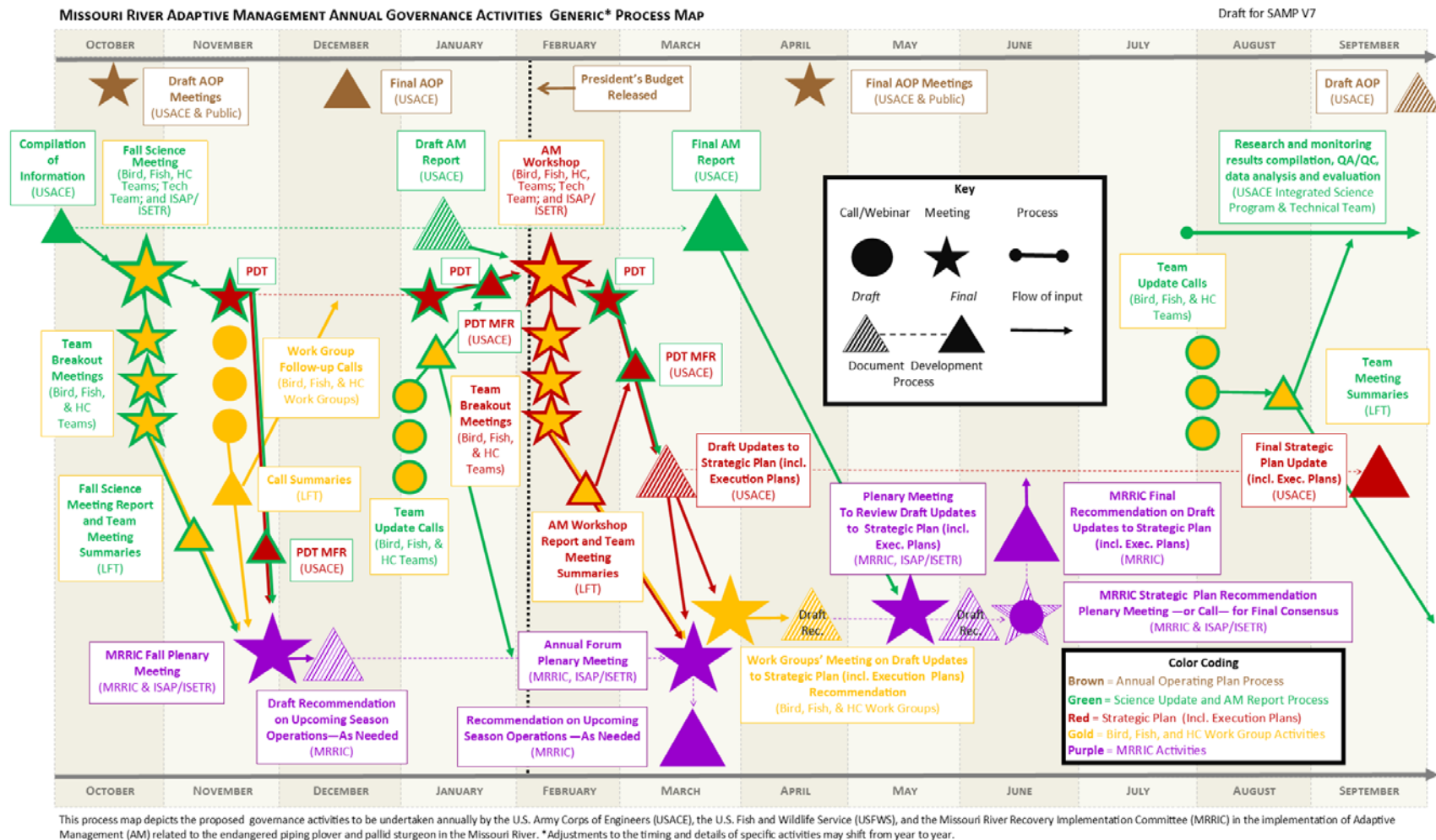
MRRIC Draft Recommendations – The MRRIC may develop draft recommendations on the SP, typically at the May plenary meeting. Recommendations focus on FY+2 needs and strategic direction for the Program (FY+3 and FY+4), but can include adjustments to other years.



MRRIC Recommendations – The MRRIC typically provides final recommendations on the SP during the June plenary of each year. Approval can occur on a MRRIC call.



MRRIC Calls – (Optional) A conference call is scheduled in June for final consensus on recommendations approved at the May MRRIC Plenary.



1

2 Figure 16. Generic depiction of governance activities to be undertaken annually by the USACE, the USFWS, and the MRRIC in the implementation of AM
 3 for the MRRP. Labeled symbols are described above. Additional description of process provided in Sections 2.4.2.1 – 2.4.2.4 and in Appendix A.

2.4.3 Science Update process

The Science Update process (Figure 17) includes a set of activities that begins when system-wide and action-specific monitoring data becomes available each fall and culminates in the annual AM Workshop, which generates input to the SP update process (section 2.4.4). The following represents the order of events as characterized in the 'Generic' Science Update Process Map (Figure 16), intended to guide the process only; deviation in some years will be required for various reasons. Activities associated with the MRRIC collaborative process are emphasized in sections 2.4.3.1 through 2.4.3.3. Related intra- and inter-agency interactions are addressed in more detail in Appendix A (see Attachments A.10 and A.15).

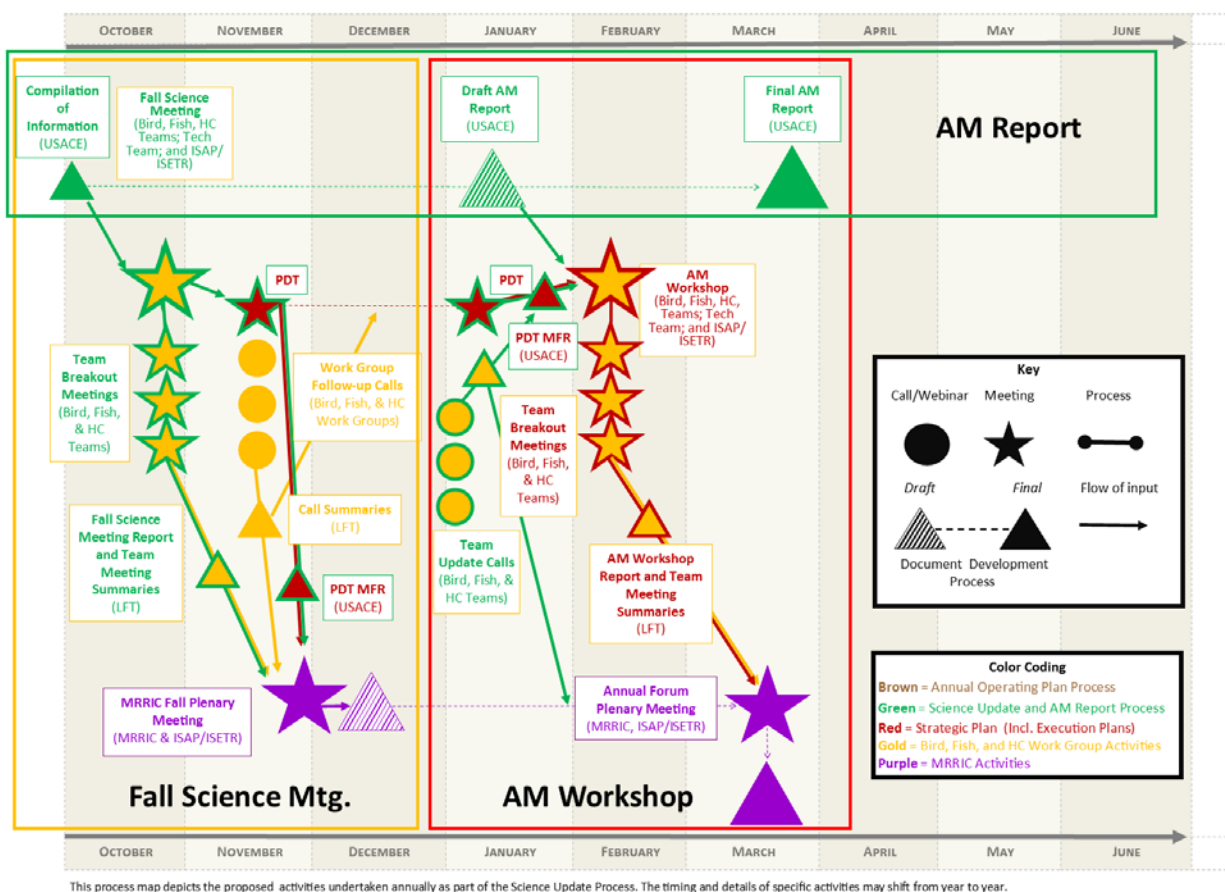


Figure 17. Overview of the science update process.

2.4.3.1 *Schedule of Activities*

An overview of the activities occurring annually as part of the science update process are summarized below.

2.4.3.1.1 *Compilation of Information (September/October)*

Objective: The ISP conducts an In-Progress Review (IPR) of funded research and studies. Agency science and implementation staff compile information on work completed during the prior summer and other information building on the hypotheses being explored in preparation for the Fall Science Meeting.

Structure: At the discretion of the ISP Manager, but intended to reflect consistent organization and formatting within and among major MRRP documents (i.e., SAMP, AM Annual Reports, and Strategic Plans). Typically concluded with an agency IPR.

2.4.3.1.2 *Fall Science Meeting and Team Meetings (October/November)*

Objective: A Fall Science Meeting (FSM; see Section 2.4.3.2) is held by the ISP to review initial observations from the field season, assess ongoing research efforts, identify analytical needs in support of the AM Report and AM workshop, and identify key issues with potential to affect the program's strategic direction. The FSM consists of a set of webinars for technical presentations and a meeting that provides MRRIC WGs with face-to-face opportunities to discuss observations with technical staff involved in the MRRP and implications for the program.

Structure: Typically a two-day webmeeting followed by a face-to-face meeting of the Teams during the Fall MRRIC plenary.

- Birds (and HC) – day one (webmeeting)
- Pallids (and HC) – day two (webmeeting)
- Bird, Fish, and HC Teams – day three (face-to-face)

Products: The following are generally developed and shared with Agencies and MRRIC in preparation for November MRRIC meeting (and to assist the Corps' efforts to develop the draft AM Report).

- A summary of the Workshop presentations and discussion developed by the ISP Manager, including:
 - Outlines of the primary presentations, issues, and outcomes
 - Overview of on-going research and technology development activities
- Separate summaries of the Team meetings developed by the facilitation staff to include such items as:
 - Implications of science on actions in the context of the 5-year strategic plan

- Implications of science on Technical Team work efforts
- Implications of science on potential topics for Independent Panel review

2.4.3.1.3 *Agency PDT Meetings (November)*

Objective: Overseen by the SPgM to discuss results of Fall Science Meeting and implications for the Bird and Fish PDTs, Technical Team taskings, and other program needs. First cut at identifying/updating key issues to be addressed in AM Report and discussed at AM Workshop. Prepare for MRRIC Plenary meeting.

Product: None required. SPgM may prepare a Memorandum For Record (MFR) outlining next steps (e.g., charges to the Bird PDT, Fish PDT, needed analyses by the Tech Team, and any next steps related to HC monitoring and assessment). SPgM determines what information is shared with Agencies and MRRIC in preparation for November MRRIC meeting.

2.4.3.1.4 *Fall Work Group Calls (November)*

Objective: Discuss results of Fall Science Meeting and respective Team meetings, implications for MRRIC, and what to convey to MRRIC at upcoming MRRIC meeting, including possible recommendations for MRRIC consideration.

Product: A summary of each Work Group call is prepared by the Facilitation Team and these are shared with MRRIC and the Agencies in preparation for November MRRIC meeting.

2.4.3.1.5 *MRRIC Fall Plenary (November)*

Objective: One of three regularly scheduled MRRIC meetings, over the course of a year. Focuses on the results of the Fall Science Workshop and implications for the program. MRRIC will review and strive for tentative consensus on any recommendations developed by the WGs.

Products: A meeting summary is prepared by the Facilitation Team and shared with MRRIC for review and final consensus at a future meeting. Tentative recommendations are shared with MRRIC for review and final consensus (either by phone meeting per Operating Procedures or at the March MRRIC Annual Forum Plenary Meeting). Presentations and other materials provided at the meeting are shared with MRRIC and the agencies.

2.4.3.1.6 AM Report (Draft December/January; Final March)

Objective: The Technical Team performs necessary data analysis and synthesis to evaluate action effectiveness and the habitat and species status and needs. The Team conducts any additional analyses as directed by the ISP Manager, and as approved by the SPgM. Results are presented in an annual AM Report. The four primary report objectives are (1) provide an analysis of monitoring data, especially pertaining to performance of actions relative to the targets, objectives and goals of the MRRP; (2) provide a forecast of outcomes of future management scenarios; (3) outline recommendations for managers and stakeholders; and (4) provide a review of the status of the science, including current published and unpublished research results relevant to management.

Product: Draft AM Report is circulated internally among the AM Teams and Corps leadership and is shared with the USFWS in January. Webinar briefings to MRRIC in February. Final AM Report in March.

2.4.3.1.7 Interagency IPR Meeting (January)

Objective: Discuss program activities and performance as reflected in the AM Report, and needs leading up to the AM Workshop and the subsequent draft updates to the Strategic Plan. The meeting will generally include the senior leadership of the agencies, Management Team, Technical Team and other agency staff as needed.

Products: None required except as specified in the PgMP (see Attachment A.10). The SPgM may prepare an MFR summarizing the deliberations and including any next steps. IPR determinations should be shared internally with the Teams and shared (in whole or part) with the MRRIC WG POCs to help prepare for the AM Workshop. Any significant issues affecting the program's compliance should be documented.

2.4.3.1.8 Team Calls (January)

Objective: Planning Group calls are held to develop agendas for the AM Workshop. A focus of the calls should be clear identification of the key issues around which the agendas will be formulated. An additional call(s) may be held to provide an opportunity for the Teams to hear plans for the upcoming AM Workshop, including an outline of the agenda and materials to be shared in preparation for the workshop. The discussions will also include updates on activities occurring since the last Team engagement.

Products: AM Workshop agendas. Summaries of Team calls (if held) are developed by the facilitation staff. These are shared with Agencies and MRRIC in preparation for AM Workshop (and assist the Corps' planning efforts).

2.4.3.1.9 AM Workshop and Team Meetings (January/February)

Objective: A facilitated workshop is held late January or early February of each year (technical presentations led by the ISP) to provide an opportunity for agency staff, contractors, and stakeholders to interact and discuss results of research and monitoring efforts for the previous year (various presentations and the draft AM Report) and any key issues potentially affecting the program's strategic direction. The purpose of the workshop is to promote discussions about program performance and direction, identify program priorities, and formulate risk management strategies.

Structure: The ISP Manager, with assistance from the Facilitator, is responsible for organization of the AM Workshop, and for summarizing and disseminating summary materials. Format will typically consist of a three-day workshop with plenary, concurrent and non-overlapping meetings of the Bird, Fish and HC Teams. May consist of a face-to-face component preceded by a webmeeting.

Products: An overall summary of the Workshop presentations and discussion is developed by the ISP Manager. Separate summaries of the Team meetings are developed by the facilitation staff. Agency Leads prepare an MFR for each Team. All Workshop products are shared with Agencies and MRRIC in preparation for March MRRIC meeting (and assist the Corps' efforts to develop the draft updates to the Strategic Plan).

The key activities and meetings associated with the Science Update Process are described further in the following sections. These must occur each year in time to permit the Management Team to draft the SP and to provide MRRIC the information necessary to review the SP and make recommendations based on science progress prior to the May MRRIC plenary.

2.4.3.2 Fall Science Meeting

2.4.3.2.1 Purpose, scope, and timing

A Fall Science Meeting (FSM) is held annually – typically in October - to provide a regularly scheduled, focused opportunity for the Teams (Technical, Bird, Fish, HC, and Management) to meet with technical personnel engaged in research, studies, or monitoring and assessment under the MRRP in order to discuss technical aspects of the program's science and AM implementation efforts. The FSM may serve as an In-Progress Review (IPR) for the ISP's ongoing research and technology development activities, or the ISP may hold a separate IPR and require a subset of investigators to brief at the FSM. The meeting provides opportunities for field crews to share early

observations regarding system conditions, project performance, and monitoring activities.

The FSM may be conducted using webinars and/or in-person meetings as dictated by needs each year, but normally involves one or two days of webinar presentations by technical staff with subsequent face-to-face meetings of the Bird, Fish and HC Teams to discuss implications of the presentations. Questions arising during the webinars, if not dealt with at the time, are addressed prior to the face-to-face meeting. Adjustments to the meeting format and duration are made annually based on the content.

The FSM is used to initially identify key issues that could affect the program's strategic direction, and that serve as a basis for further investigation and discussion at the AM Workshop. A joint meeting of the MRRIC Bird, Fish and HC WGs will generally be held at the end of the FSM to consider the need to draft any recommendations for MRRIC's consideration. Following the FSM and with input from the Team discussions, the Management Team will identify any non-routine analyses needed to support the upcoming AM workshop. The ISP Manager and Team Planning Groups (WG POCs and lead agency representatives) will coordinate to deliver briefings of the FSM at the next MRRIC meeting.

2.4.3.2.2 *Attendees*

The Fall Science Meeting is organized by the ISP Manager with assistance from the facilitation team. Key personnel and groups involved in collecting and assessing scientific data for the MRRP, or conducting research for the MRRP, or responsible for developing recommendations or making decisions based upon scientific information should attend.

FSM participants include the following:

- The ISP Manager,
- The Lead PI for any research funded by the MRRP,
- Agency Leads and members of the MRRP Fish, Bird and HC Teams,
- Members of the MRRP Technical Team so tasked,
- Members of the MRRP Management Team,
- MRRIC Bird, Fish and HC WG Members
- MRRIC Chair,
- The TPSN, and
- Members of the ISAP.

Those encouraged, but not required, to attend include the following:

- Members of other MRRIC WGs,

- Agency staff involved with monitoring or assessment under the MRRP,
- Other Tribal, Federal or State officials with responsibilities related to project implementation, and
- Agency leadership providing program oversight.

The Fall Science Meeting is open to any member of the MRRIC, who wishes to listen to the technical presentations and discussions among participants. Presentations and opportunities for questions and answers (Q&A) may, at the discretion of the lead agency, be limited to invited attendees in order to adhere to the schedule and achieve meeting objectives.

2.4.3.2.3 Agenda

A draft agenda for the Fall Science Meeting is presented in Attachment A.18. The meeting is usually conducted in two parts: 1) webinars in October to present information, and 2) a face-to-face meeting, usually the Monday of the November MRRIC plenary. The Team planning groups will work with the ISP Manager to develop a detailed agenda each year.

2.4.3.2.4 Process

The ISP Manager notifies participants and attendees of meeting location and dates at least two months in advance. A draft agenda is furnished at least three weeks prior to the meeting; adjustments to the specific order or topic of presentations will, as a practical matter, remain subject to change. Presenters provide full presentations and abstracts or copies of reports or other products at least one week prior to the workshop. Project Management Plans (PMPs) for each study or other research effort provided at the Fall IPR are provided to attendees and should be updated by researchers, as appropriate.

Individual webinar presentations are typically 20-30 minutes (or as set by the ISP Manager), with 5-10 minutes allotted for questions regarding clarification. Detailed discussion will be reserved for the face-to-face meeting, but questions regarding clarification are encouraged. Presentation times can be adjusted to suit specific needs, but opportunities for information should not be unduly limited by such adjustments.

In addition to presentations by researchers and staff addressing specific study efforts, the ISP Manager provides a summary presentation of the Program, including major initiatives, significant findings, and implications of any significant study results. Results of solicitations for research needs, research proposals, or other similar efforts are also presented.

2.4.3.2.5 *Key products*

Presentations and abstracts or other related materials from the Fall Meeting are posted on the MRRP website. The Facilitator will prepare a “Meeting Summary” that outlines the primary presentations, issues, and outcomes and makes this summary available to the agencies and MRRIC. The ISP Manager prepares summary evaluations and recommendations for on-going monitoring, assessment, research and technology development activities.

2.4.3.3 *Annual AM Report*

The AM Report is an important component of the annual science update process for the MRRP and serves as a basis for discussions at the annual AM Workshop, where the agencies and MRRIC consider adjustments to the Strategic Plan based upon program performance, any new information, and the need to manage program resources and risks.

This report is prepared annually for the USACE by the MRRP Technical Team and the draft is shared with the USFWS and MRRIC to inform the strategic planning process. The AM Report documents actions taken, program performance, and knowledge gained, while the Strategic Plan lays out future actions and priorities based upon new knowledge and the state of the science. The AM Report looks back in time and is decidedly science based, while the Strategic Plan overlays the science with policy and value considerations to support decisions about future actions.

The AM Report also fulfills a requirement for the USACE to report to the USFWS on actions taken to avoid jeopardizing the listed species or their habitats, and the effectiveness of those actions relative to program objectives. The USACE submits the final report to the USFWS along with the annual update to the MRRP Strategic Plan and the USFWS provides a written response with their assessment of the USACE’s progress.

The report is structured around the three focus areas for the MRRP: birds, fish, and human considerations. A separate chapter is devoted to each focus area and is supported by relevant appendices. Program objectives, metrics and targets are presented (with any changes highlighted), and the uncertainties affecting program decisions are listed. Status and trends of populations and habitats, actions (including research, monitoring, assessment, collaboration, etc.) undertaken in that year, and discussion of the status of the science and related activities are documented. The Technical Team may be directed to evaluate the implications of alternative actions and/or undertake various analyses to support decision making and present those assessments in the report.

The Technical Team is responsible for preparation of the AM Report, but agency implementation staff and PMs for the sub-programs (ISP, Birds, Fish) play a key role in formulating the information for the report. The SPgM identifies any necessary “non-routine” subjects, studies, analyses, etc., to be addressed in the report by the Technical Team. A draft report is provided to the USACE and shared with the USFWS for review and comment, and to assist with planning efforts for the AM Workshop. An inter-agency IPR is generally held in conjunction with the review; focus is upon compliance, identification of key issues, preparation for the AM Workshop, and preliminary discussions related to the SP update. The Technical Team generally provides webinar presentations of the draft AM Report to the agencies and MRRIC ahead of the AM Workshop. The AM Report is finalized in late March, providing authors opportunity to address agency or external peer review comments and make any refinements based on discussions at the workshop.

2.4.3.4 Annual AM Workshop

2.4.3.4.1 Purpose, scope, and timing

A facilitated workshop is held each year – generally in early February - for MRRIC members and agency technical staff, program managers and senior leaders to discuss results of research and monitoring efforts for the previous year and collaborate on their implications with respect to the program’s strategic direction. The workshop follows the release of the draft AM Report, which serves as a basis for the discussions, and prior to the Management Team’s update of the SP, which is based on workshop outcomes.

Objectives of the AM Workshop include the following:

- *Report out on project and program performance, actions, monitoring and research, and projections for the MRRP;*
- *Discuss implications of findings and emerging issues relative to strategic direction of the MRRP; and*
- *Facilitate interactions necessary for teams and work groups to develop their respective input and products in support of the Strategic Plan update process.*

The AM Workshop is organized around meetings of the Bird, Fish and HC Teams (see section 2.3.3). Status updates on the SP, AOP, and budget are provided in a plenary session, and the key topics identified for the engagement are reviewed. Teams then meet individually to deliberate on the program’s performance, status of the science relative to their particular sub-program’s needs, program risks and management strategies, new technical developments, and future priorities. Teams generally meet in a plenary closing session to report out on their discussions, address topics of overlapping interest, and identify next steps.

2.4.3.4.2 Attendees

Mandatory attendees of the AM Workshop include the following:

- The Facilitator
- The ISP Manager,
- The MRRP SPgM,
- Members of the Fish, Bird and HC Teams,
- Members of the Technical Team tasked with presenting information,
- Members of the Management Team,
- MRRIC Bird, Fish and HC WG Members,
- MRRIC Chair,
- TPSN, and
- Members of the ISAP.

Those encouraged, but not required, to attend include the following:

- Agency leadership at the Oversight level,
- Members of the MRRIC,
- Agency staff involved with monitoring or assessment, and
- Other Tribal, Federal or state officials with responsibilities related to project implementation.

The AM Workshop is open to any member of the MRRIC, other agency or Tribe, or general public who wishes to listen to the technical presentations and discussions among participants. Presentations and opportunities for Q&A will be limited to invited attendees in order to adhere to the schedule. Senior managers from the USACE vertical team, the USFWS, and MRRIC are encouraged to participate.

2.4.3.4.3 Process

The Facilitation Team is responsible for organizing the AM Workshop, and coordinates with the SPgM, ISP Manager, and Implementation Team Planning Groups to set dates and formulate a detailed agenda. Attachment 18 of Appendix A provides a generic agenda for the workshop. Agenda details are on a set of key issues, identified and refined through the FSM/AM Report processes and briefed as part of the pre-workshop webinars on the AM Report. The intent is to maintain focus on the program's strategic direction as guided by the science, rather than on near-term implementation decisions or value-driven program considerations.

The Facilitator notifies participants and attendees of meeting location and dates at least two months in advance. The Technical Team will present the draft AM Report findings in a webinar (or webinar series) at least two weeks prior to the workshop, but preferably prior to engagement of the Planning Groups in discussions regarding the agenda. A

draft agenda is furnished at least two weeks prior to the meeting. The workshop typically spans three days, and includes 1-2 days of face-to-face meetings preceded and followed by brief plenary meetings to provide general guidance and share results.

2.4.3.4.4 Key products

Presentations and abstracts or other related materials from the AM Workshop are compiled by the ISP Manager, shared with MRRIC and the agencies, and posted on the MRRP website. The Facilitation Team prepares a Workshop Report and Team Meeting Summaries that outline the primary presentations, issues, and outcomes and makes these products available to the agencies and MRRIC within two weeks of the meeting. Agency Leads for the Bird, Fish and HC Teams prepare a MFR summarizing significant deliberations, resulting priorities, etc. The Facilitator works with the MRRIC Bird, Fish, and HC WG POCs to identify any potential topics as draft recommendations for MRRIC's consideration. The Team Planning Groups collaborate to identify, develop and deliver presentations summarizing the workshop to the MRRIC at its March plenary meeting. A Joint Bird, Fish, and HC WG webmeeting, typically held immediately following the March MRRIC meeting, is held to prepare a draft recommendation on the Strategic Plan (see next section).

2.4.4 Strategic Plan development and approval

The MRRP employs a rolling, 5-year strategic plan (SP) for implementation of the management actions, research, studies, and associated engagement process needed to meet the MRRP goals and objectives. The SP follows and builds upon the Science Update Process (see Section 2.4.3), and conforms to the constraints of the USACE Civil Works Budget Process (see Section 2.2.3). Annual updates to the SP are focused on the Corps' development of the FY+2 budget submission, which occurs from January to June of each FY, and on risk management of outyear (FY+3 and 4) direction., as shown in Figure 18.

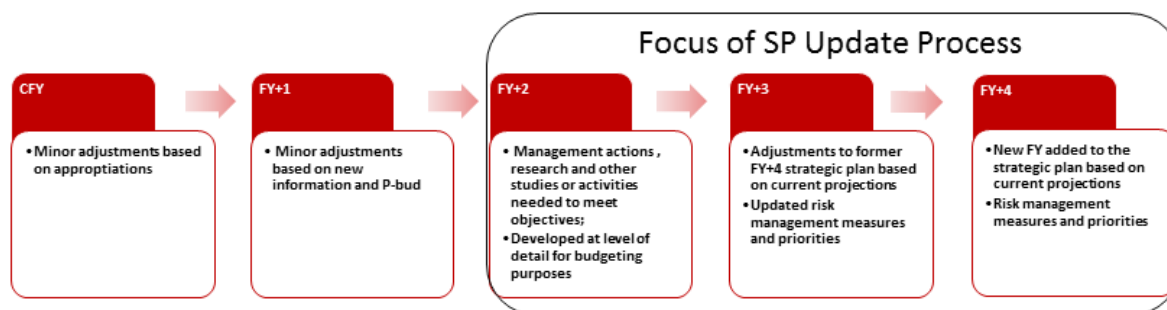


Figure 18. Schematic of the SP showing emphasis for the strategic update process.

While not the focus of the strategic update process, the Corps must also make adjustments to the Current FY (CFY) and the following year (FY+1) to reflect appropriations and the President's Budget (P-Bud). Beginning each FY, the budget appropriation for the CFY occurs between the months of October and March. Following receipt of the appropriation, the Work Plan (WP) for CFY is implemented. The Draft FY+1 WP is finalized concurrently with the release of the FY+1 budget proposal (P-bud). Proposed projects in the FY+1 plan are organized via the Project Work Request (PWR) system, which functions as a database for input of proposed project information. Information on each subprogram/project is compiled for input into the PWR system with all work items entered in the PWR database no later than February 1 of each FY.

A series of important interactions occur annually as part of the SP update process, which begins in earnest with the Annual AM Workshop where the scientific findings and results of data analyses from the Technical Team are assessed in terms of Program implications. The SP process ends when the agencies “finalize” the updated plan in June, following a series of meetings, MRRIC engagements, and an opportunity for MRRIC to provide consensus recommendations on the updates. The associated engagements and products are shown in Figure 19, and discussed further below.

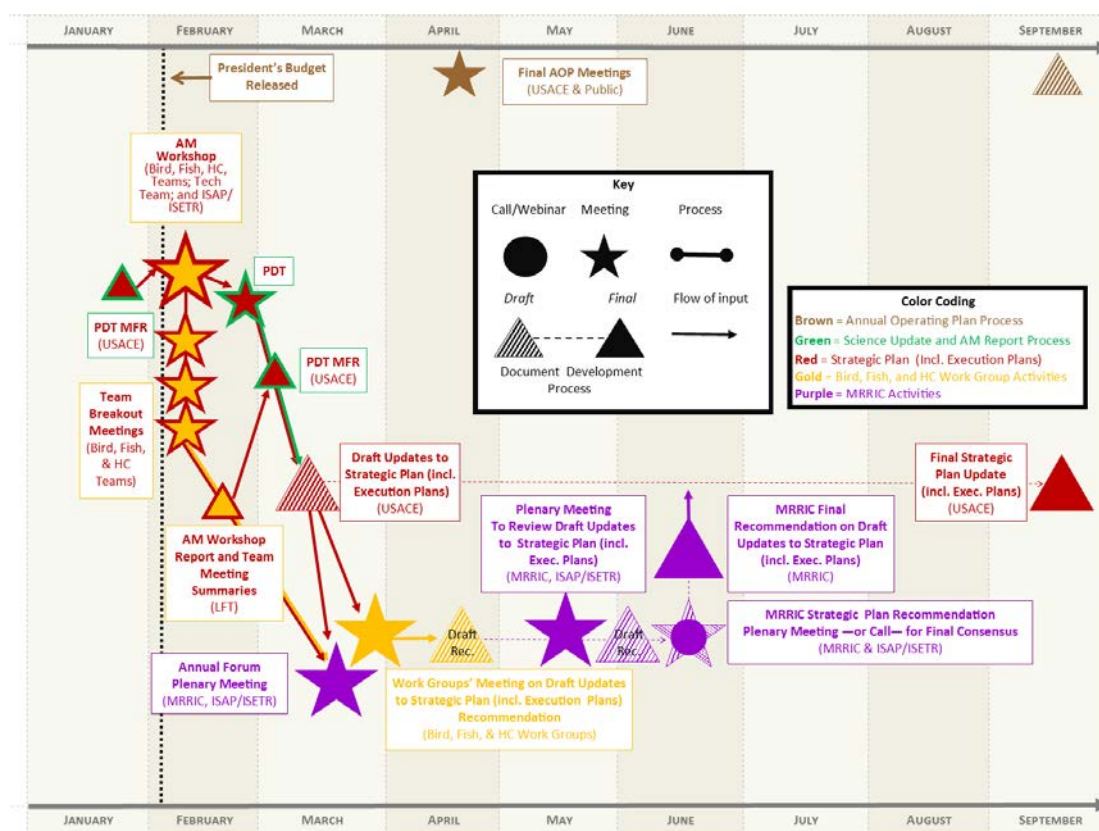


Figure 19. Strategic Plan update process.

2.4.4.1 AM Workshop and Team Meetings (February)

The AM Workshop is the culmination of the Science Update process and the start of the Strategic Planning process. Details of the meeting are described in section 2.4.3.4. Information developed by the Technical Team and presented at the AM Workshop is discussed by the Teams to assess the significance to the program's direction. A set of key issues potentially affecting the program's strategic direction initially identified during the FSM and further refined based on the AM Report are at the heart of the AM Workshop discussions and central to the SP Update process. These issues may present risks to the program, hint at the potential need for significant adjustments, or present opportunities to accelerate progress toward objectives. As such, the Management Team relies upon the Team discussions of these issues to consider program needs and reflect them in the updated SP.

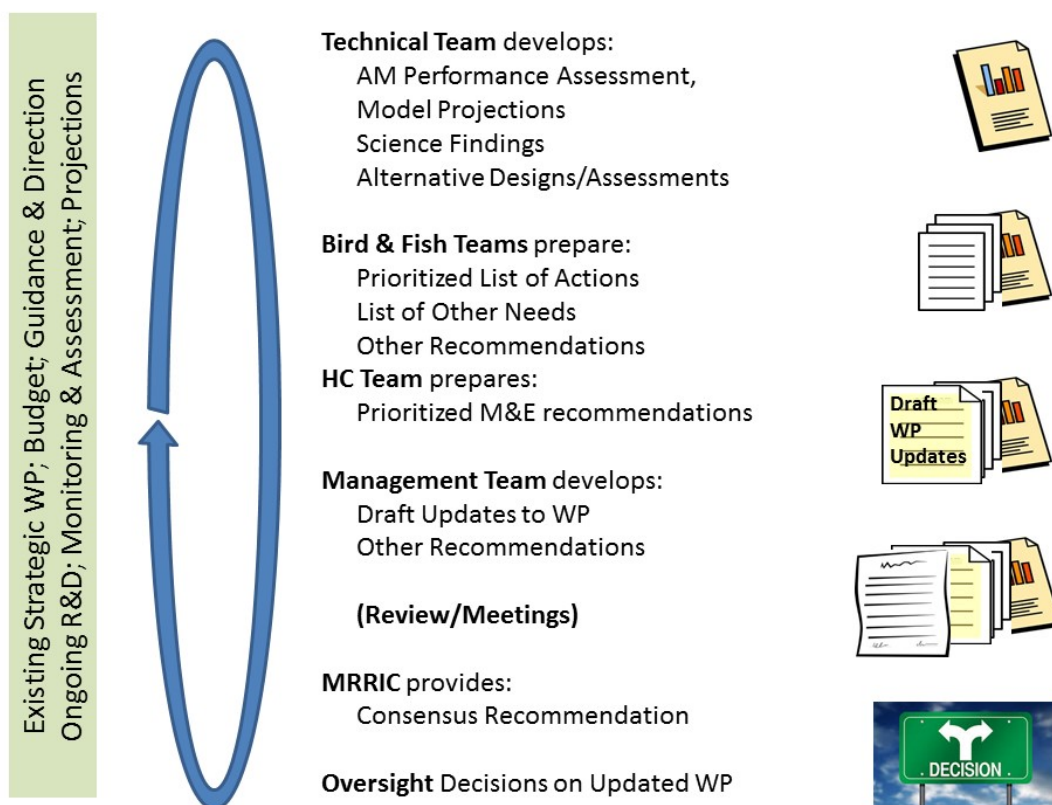


Figure 20. Schematic of interactions and associated recommendations and decisions occurring annually that lead to the updating of the SP.

2.4.4.2 Agency PDT Engagement (February)

Objective: The Agency Leads for the Bird, Fish, and HC Teams convene to discuss implications of the AM Workshop and develop a set of recommendations related to the draft updates to the Strategic Plan for the Management Team. The group will rely upon their respective PDTs to provide any needed analysis, documentation, etc.

Products: Agency Leads/PMs typically each prepare a MFR that provides recommendations regarding to the draft updates to the Strategic Plan. They should include planned and proposed and prioritized implementation, research, monitoring and assessment needs by program year, and present the rationale for any anticipated adjustments to the current SP. The MFRs should address the key issues discussed at the AM Workshop and related analysis. They may describe significant risks and proposed contingencies or other management strategies for those risks. They should reference documents recording the collaboration amongst the Teams, and capture recommendations and decisions for the MRRP AM process. Any MFRs are shared with Management Team to assist in development of the draft updates to the Strategic Plan and with their corresponding WG POCs to assist in preparation of potential draft recommendations MRRIC and presentations at the next plenary meeting.

2.4.4.3 Management Team Engagement (March)

Objective: The Management Team develops the draft Updates to the Strategic Plan (including the Execution Plan) for presentation to agency leadership and the MRRIC based upon input from the Science Update Process and following guidance provided by the ESC regarding resource availability, acquisition strategies, etc. The draft Strategic Plan includes updates to the Current Fiscal Year (CFY) Work Plan (WP) based upon appropriations and presents a draft of the FY+1 Execution Plan based upon the President's Budget. The document describes significant risks and contingencies, records the collaboration amongst the Teams, and captures recommendations and decisions for the MRRP. The Management Team may also make recommendations on issues such as a change in the governance process or an adjustment to targets based on revised models.

Internal Coordination: As part of the SP development process, the Management Team updates/determines key programmatic and project resource needs, including labor (staff and contractors), and materials for both the current and two upcoming FYs. This allows managers and decision-makers to ensure MRRP project and programmatic activities are implemented in the most efficient and effective way. The MRRP resource determination occurs each year during the USACE' financial cycle and is developed in coordination with associated schedules and budgets, in consultation with USACE branch chiefs. The ISP and the Bird, Fish, and HC Teams are responsible for developing a resource needs with prioritizations for their respective efforts, and a draft should be

submitted with their MFR to the Management Team. The Management Team and the ESC are responsible for integrating the resource information provided by the subprogram elements into a programmatic resource needs determination.

A staffing needs estimate is developed for each year concurrently with the resource determinations. The Management Team develops a staffing needs summary for each MRRP subprogram, working with the Bird, Fish, and HC Teams and District branch chiefs. Staffing needs estimates are developed in coordination with the MRRP SP, as well as associated budgets and schedules. Staffing needs estimates serve as a guide for the ESC and senior leadership as resources are allocated each FY. These staffing summaries are dynamic and updated as annual appropriations are finalized and resources are allocated. Staffing needs summaries include provisions for staff turnover, retention, and mentoring as well as a list of those contractors needed and required to assist with MRRP implementation. Additionally, documentation of labor and resource allocation processes includes recognition of existing institutional controls, including P2 and CEFMS, and is used for developing plans to address cross-district labor and resource needs each FY.

Additional detail on the internal coordination and other programmatic requirements can be found in the PgMP (Attachment A.11).

Products: A draft update to the Strategic Plan (including the Execution Plan) provides a multi-year accounting of the Program that:

- 1) Identifies significant study proposals and outlines anticipated program activities and contingencies, including
 - Project implementation
 - Research
 - Monitoring and assessment
 - Governance, collaboration, administration, reporting, etc
- 2) Articulates the rationale for program direction
- 3) Provides a listing (with prioritizations, where appropriate) of major activities and identifies work packages representing opportunities to accelerate program progress toward objectives
- 4) Documents decisions at the Implementation and Management levels and presents recommendations for consideration of the MRRIC and agency leaders on issues requiring Oversight-level decisions
- 5) Highlights programmatic decision-relevant uncertainties that could affect program direction and composition, as well as any appropriate contingency plans or other risk management strategies

The draft Strategic Plan is shared with the Bird, Fish, and HC Teams in written form for review and with the USFWS for discussion at an inter-agency IPR (see below). Following

the IPR and any associated adjustments, the draft SP is shared with MRRIC for initial discussion at the March Annual Forum (possibly via presentation) and so that the Bird, Fish and HC WGs may jointly develop draft recommendations for consideration at the May MRRIC plenary meeting.

2.4.4.4 Interagency IPR Meeting (March)

Objective: The Management Team meets with agency leadership in an IPR during the SP Update period to review proposed updates. The meeting will generally include the senior leadership of the agencies, Management Team, Technical Team and other agency staff as needed. Provides the agencies an opportunity to discuss program progress toward objectives and address any significant issues.

Products: None required except as specified in the PgMP (see Attachment A.10). The SPgM may prepare an MFR summarizing the deliberations and including any next steps. IPR determinations should be shared internally with the Teams and shared (in whole or part) with the MRRIC WG POCs to help prepare a draft recommendation for MRRIC. Any significant issues affecting the program's compliance should be documented and discussed at the Annual Forum.

2.4.4.5 MRRIC Annual Forum Plenary Meeting (March)

Objective: One of three regularly scheduled MRRIC meetings over the course of a year with a focus on understanding the results of the AM Workshop and obtaining an introduction to the draft updates to the Strategic Plan (including the Execution Plan).

Products: Facilitation Team prepares a summary of the meeting and provides copies of all presentations, materials distributed, etc.

- Possible tentative recommendations as needed
- Possible final recommendations (from prior meeting)

The summary is shared with MRRIC for review and final consensus at a future meeting. Tentative recommendations are shared with MRRIC for review and final consensus (either by phone meeting per Operating Procedures or at the May MRRIC Draft Strategic Plan Review Plenary Meeting).

2.4.4.6 Bird, Fish, and HC Work Group Meeting (March/April)

Objective: Discuss results of AM Workshop, review the draft Updates to the Strategic Plan (including the Execution Plan), and strive to develop draft recommendations for MRRIC consideration.

Product: A summary is prepared by the Facilitation Team and shared with MRRIC and the agencies for information. Draft recommendations (if any) are shared with MRRIC for review and final consensus at the May MRRIC meeting (and with the Agencies for their information).

2.4.4.7 MRRIC Draft Strategic Plan Review Meeting (May)

Objective: One of three regularly scheduled MRRIC meetings over the course of a year with a focus on reviewing Work Group recommendations regarding the draft Updates to the Strategic Plan (including Execution Plan).

Products: Facilitation Team prepares a summary of the meeting and provides copies of all presentations, materials distributed, etc. The summary is shared with MRRIC for review and final consensus at a future meeting. Tentative consensus recommendations on the draft updates to the Strategic Plan are shared with MRRIC for review and final consensus (either by phone meeting per Operating Procedures or at the MRRIC Fall Plenary Meeting).

2.4.4.8 Compliance Submittal to USFWS (June) and SP Finalization (September)

The USACE prepares a “Tentative Final Strategic Plan” in June following interactions with MRRIC and any tentative or final consensus recommendations. This is submitted to the USFWS, along with the Final AM Report for that year, in compliance with the requirements of the BiOp. The USFWS reviews the documents and, provides feedback to the USACE, usually in the form of a “Letter of Sufficient Progress”. The SPgM makes final adjustments to the Strategic Plan each September to reflect actual program execution. The Final SP is shared with the USFWS and MRRIC, and any adjustments are explained at the fall MRRIC Plenary. This version of the SP is used as the basis for the annual update the following year.

2.4.5 Consideration of new management actions

2.4.5.1 Triggers for the consideration of new management actions

The EA identified a wide range of management actions that could be utilized to meet the needs of the listed species. The MRRMP-EIS considered those actions relative to program objectives and identified a subset as a first increment to be applied under the framework of the MRRP SAMP. The USACE will implement the identified management actions, monitor their effectiveness, and conduct annual performance evaluations. The AM framework guides decisions regarding the nature of subsequent actions. Should those actions prove ineffective in meeting targets for the listed species, the USACE, in consultation with the USFWS and with MRRIC engagement will determine the

appropriate course of action. That may include continued implementation and monitoring of the selected alternative, adjustments to the actions or to targets, or the introduction of management actions other than those in the ROD.

If knowledge gained through research, implementation and monitoring suggests that actions other than those in the ROD may be required to meet objectives, the USACE would first identify that need as part of the SP Update Process. Following necessary engagement with the USFWS and MRRIC on the SP, the USACE would pursue an investigation of alternatives. Specific steps required would depend upon the circumstances and the scope of additional measures under consideration (e.g., see Section 1.1.6). Planning and budgeting for a change in the scope of actions under the program could take considerable time and involve a high level of collaboration.

At present, there are no programmatic-level triggers for the introduction of new management actions. Species-specific decision criteria can be applied for this purpose but caution is warranted as they may not offer a sufficient basis for that decision when considered in isolation. Contingency plans may be established in the SP to address specific outcomes associated with the key issues and these may have associated decision triggers. Additionally the MRRP should work toward the identification of a more comprehensive suite of metrics and associated decision criteria that would define the circumstances under which a decision to broaden or adjust the scope of actions applied under the Program is triggered.

2.4.5.2 Structured processes for decision making

There will be a need under the SAMP to make a wide range of decisions under uncertainty that have complex implications for endangered species, scientific learning, and for Tribes, states and stakeholders. In general, structuring decision-making processes help increase transparency, efficiency, communication, and accountability. In the implementation of the SAMP, structured decision-making (SDM) processes should be used whenever it is clear that they would add value. In particular, the planning associated with significant adjustments to management actions or the introduction of new management actions lends itself to SDM.

Not all decisions warrant the use of formal decision analysis; indeed, most of the decisions that need to be made on an ongoing basis as part of the SAMP will be technical in nature and will not have significant or complex implications that need to be analyzed in great depth. Many of the day-to-day decision-making concerning Level 1 and (most) Level 2 actions and associated monitoring studies will fall into this category, as will the details of habitat construction designs and associated monitoring. While it is true that structuring even these decisions may often help scientists think carefully about the best

way to approach certain issues, it is not usually necessary (nor always desirable, given the additional effort required) to do so for decisions where uncertainties are low and the consequences of action are uncomplicated.

Sometimes, overall decision-making complexity can be avoided through the use of simple decision rules for situations for which consequences are readily understood or for where the potential for a large negative consequence is low. Some of the decision rules noted in Chapters 3 and 4 serve as examples. Another approach to reduce complexity is to avoid deeper consideration of trade-offs where those consequences are known to be below a pre-defined threshold (e.g., if expected impacts of a decision are thought to be less than a certain amount, then analysis for an issue could be neglected). In some low-stakes cases, the development of solutions to a problem that are robust to external uncertainties may be preferred without need to resort to deeper analysis. Robust solutions can, however, come with their own trade-offs (e.g., higher cost), which might not necessarily make them the best choice, however.

Despite these examples, even seemingly straightforward, technical decisions can suddenly become complex in the context of a large AM plan where unintended consequences could arise with insufficient thought. Decision analysis in its general sense should therefore be considered as "a formulation of common sense for decision problems which are too complex for informal use of common sense." (Keeney 1982, 806). In these cases, the diverse array of decision contexts in the plan suggests an equally diverse range of decision structuring tools should be considered.

Decision structuring is already mandated by the USACE for certain situations. For example, Cost Effectiveness and Incremental Cost Analysis techniques have long been integral components of the USACE's water resources, environmental planning, mitigation of fish and wildlife habitat losses, and ecosystem restoration. These particular techniques are most helpful when there is a wide array of potential solutions, when primary performance is readily quantified, and when secondary considerations (e.g., effects on HC) are minor or can easily be monetized. These techniques may be highly valuable for decisions related to mechanical habitat site selection questions, for example.

Cost Effectiveness (CE) and Incremental Cost Analysis (ICA) may not always be appropriate tools, for example when cost effectiveness is not a driving factor in a decision; when the number of options are small; when the options contain many nuanced issues; and when dialog and engagement are considered a priority. In these cases, other structuring tools, such as decision trees, multiple account evaluation (MAE), and multi-attribute trade-off analysis (MATA) may be preferred.

There are many forms of decision analysis of this type, and numerous tools and methodologies to implement them. Typically, they have in common a more-or-less formal process for working through stages in decision making involving: (1) clarifying the problem definition, (2) identifying issues of importance to people that might be affected by the decision (objectives), (3) developing creative alternative solutions to the problem, (4) estimating consequences of alternatives on objectives, and (5) evaluating the trade-offs thereby exposed. This sequence of steps is sometimes referred to by the acronym PrOACT.

The precise form that an analysis should take is highly dependent on the specifics of a decision context. Some decision contexts will be site-level or involve a much smaller scale of issues than were the case during the development of the MRRMP-EIS. During that process, a consequence table decision analysis format was used to share information on how the direct impacts of habitat construction or hydrological differences might be felt in terms that stakeholders were familiar with, (e.g., in the number of days of boat ramp availability during various seasons.). These proxy metrics have the advantage of being quick to calculate from modeling and help give people a sense of how one alternative might compare relative to another, but they have limitations when they do not fully correlate to more complex implications, particularly in an absolute sense. Later in the DEIS development, more comprehensive economic calculations were performed on a smaller number of alternatives, and more precise information on impacts was learned, though these calculations were intensive and took months and considerable resources to complete.

Moving forward, many of the things learned from both approaches should be reviewed for the suitability (or for their potential to be adapted) in support of ongoing or future planning decisions. In some cases, economic models created or updated for the EIS may be updated relatively easily and, so new planning situations could best be informed by re-using them. In other cases, where this approach might be too onerous, it may be possible to compare the outputs of proxy metrics with economic outputs for the same alternatives undertaken in the Plan in order to create response curves that may helpfully approximate economic impacts.

Economic impacts are not always the best indicators for impacts, however, particularly where further uncertainties are introduced to a situation through the use of assumptions made to calculate them, or when they address issues (e.g., learning as an objective, or issues for which NED and RED were not calculated) that may be problematic to put into meaningful dollar terms. In some contexts, decision makers and stakeholders are able to discuss trade-off questions more easily when impacts are left in more “natural units,” constructed scales or proxy metrics (Keeney and Gregory 2005). Both approaches have

their strengths and weaknesses in different decision contexts, and the two can work in complementary ways.

One example of this concerns the value of learning. Any changes to the management of the river could have complex implications for the research programs associated with Level 1 and Level 2 studies. Consideration should be given to whether and how any given change could compromise the quality of information being gathered for studies; if so, a judgment must be made as to whether the proposed change is worth the negative impacts it might have on information quality (as one among many other things). Formal academic approaches to estimating the value of information in dollar terms are available, but these are problematic to apply in highly complex situations, particularly when other policy objectives are being weighed.

For these reasons, and given the widely varying decision contexts that could arise under the SAMP, the USACE considers it appropriate not to detail a prescriptive process for AM decision making at this time. Rather, working with the Technical and Implementation Teams, efforts will be ongoing in the early stages of AM implementation to explore, perhaps through the use of decision scenarios or archetypes, what options might exist to present the species, learning, and HC trade-offs inherent to various types of tough choices faced by decision makers and stakeholders.

2.4.5.3 Requirements

The introduction of new management measures may require supplemental analysis under NEPA if there are significant new circumstances or significant new information relating to the proposed action or its impacts, even if the action were previously evaluated under the MRRMP-EIS, and potentially the preparation of a new EIS (see Figure 6). The essential components of an EIS are a discussion of the proposal, its environmental impacts, reasonable alternatives to the proposed action and their consequences, mitigation of adverse impacts, and any irreversible commitments of resources.

Management actions beyond those previously evaluated under the MRRMP-EIS would be subjected to the same types and degree of evaluation applied to the MRRMP-EIS. If the new action involves flows, an update to the technical criteria in the Master Manual may be required. Figure 21 is a schematic showing the process to update Master Manual; the requirements are presented in detail in Attachment 9 of Appendix A. Expansion of this section to outline the appropriate and necessary requirements for introduction of new management measures is recommended so those engaged in the MRRP have a reference for the processes.



11

Figure 21. Schematic of the process to update the Master Manual.

2.4.6 Workflows for specific scenarios

The processes for the annual Science Update and the Strategic Plan Update outlined in Sections 2.4.3 and 2.4.4 provide the general framework for any decision made under the MRRP SAMP. Additional details regarding the specific steps for various types of decisions that might be needed are presented in a series of “Workflow Diagrams” in Attachment 20 of Appendix A. Decision workflow examples are provided for the following ten decisions/issues (other decision/issue workflows can be inferred from these examples):

1. Construct habitat with sufficient resources¹.
2. Construct habitat with insufficient resources.
3. Implement a test flow action included in the ROD.
4. Stop or scale back a flow action during implementation.
5. Scale up flow criteria after implementation or add a flow modification action.
6. Scale back the criteria for a flow action after implementation.
7. Move between pallid sturgeon action implementation levels.
8. Change species objectives, targets, or decision criteria.
9. Change monitoring and assessment associated with HCs.
10. Change the AM structure and/or process.

¹ This scenario includes a more detailed description of the process than is provided for other scenarios. Readers are encouraged to read this scenario first; subsequent presentations highlight the differences in the products and decision flow rather than reiterate the details of the basic process.

Many of the workflows are intended to apply generically to decisions regarding habitat and flow actions for birds and/or sturgeon. For example, workflows 1 and 2 could apply to constructing ESH, IRC, or both during a given year, as well as to prioritization of one habitat type over the other if funding or other resources are limiting. The workflows focus on specific decisions and thus do not reflect every activity that would occur in the MRRP during the course of that decision. Most processes take place within the SP update cycle, with multiple decisions under consideration concurrently.

2.5 Important protocols and procedures

This section lists and summarizes a number of activities critical to the program's execution and governance. Protocols or procedures for these activities, as needed, are included as attachments to Appendix A.

Note: Details of some processes in this section remain under development. Additional process descriptions may be identified and descriptions of listed processes and procedures updated and reviewed in future updates to the SAMP.

2.5.1 Procedures for dispute resolution

Given the large number of considerations and decisions to be addressed in executing the MRRP, some disputes may arise. Commitment to the rapid and transparent resolution of disputes/conflicts is required from all parties and clear processes are needed to achieve resolution of those concerns. The approach for resolving conflicts within the MRRP depends on the nature of the conflict (technical or policy consideration) and the parties involved. Resolving all disputes in a way that is agreeable to everyone is unlikely given the diversity of viewpoints within the Basin and the potential for agency missions to conflict. Therefore the purpose of this section should be to help rapidly identify the appropriate path for dispute resolution, while remaining committed to an open, transparent, and collaborative process respective to everyone's roles and responsibilities.

Internal USFWS and USACE dispute resolution processes are outside the scope of this SAMP. These processes should be utilized by agency team members within their respective organizations to resolve disputes that arise internally. Similarly, MRRIC has internal processes for resolving disputes and providing recommendations to the agencies, which are outside the scope of this governance process.

MRRIC Work Groups may elevate disputes within work groups, with other work groups, or with the agencies to the MRRIC body for consideration and if appropriate the formulation of a formal recommendation. When issues arise between agencies and/or MRRIC it is critical to determine what is at issue and which agency has authority over that issue. Agencies are legally prevented from delegating decision making authority to any other group or individual. Decision making authority is delegated to a specific individual in each organization. Once the appropriate decision maker has been identified the issue should be properly briefed and elevated for resolution by that person.

2.5.2 Procedures for adjustments to significant components of the SAMP

Although every effort was made to develop the SAMP with the long-term needs of the program in mind, the need for periodic updates or changes will be needed to adapt the plan as lessons are learned and knowledge improves. This section outlines the procedure for recommending, evaluating, and adopting changes to the SAMP. The specific topics covered herein and the examples provided are not intended to be limiting in any way. Any component of the SAMP is subject to change, and any of the Science Update, Strategic Plan Update or Collaborative processes can be used to initiate a change. The intent is to establish that, whichever process is employed, any proposed change is identified clearly to all parties and transparently deliberated, that decisions to change are agreed upon in advance (or disagreements are resolved as described above), and that the change enhances the likelihood of Program success relative to its fundamental objectives. Changes should be initiated with written notification of the proposed change to all parties, and decisions regarding the issue should be similarly documented and communicated to all parties. Significant adjustments should be identified on the “Addenda and Version Control” page at the front of the SAMP.

2.5.2.1 Procedures for changing the governance of the MRRP AM Program

Proposals for governance changes must originate from a Program Team (i.e., the Bird, Fish, or HC Team or Management Team), a lead agency, or MRRIC. The ISAP, or an entity engaged to provide an external review of the Program for this purpose may also propose adjustments (see Section 2.5.4.4). A proposal should be presented in the form of a white paper that identifies, at a minimum, (a) the current governance situation, (b) the section(s) of the SAMP addressing the structure/process under consideration, (c) the suggested revision(s), (d) a rationale for the change (i.e., a brief summary of the problem, benefit of the proposed change, etc.), and (e) a proposed timetable for its implementation.

Proposals for changes to governance by any entity can be submitted to the Management Team for consideration as part of the SP update process as described in Section 2.4.4. Included are suggestions for adjustments to governance arising from external reviews of

the Program. The Management Team may add their recommendation to any proposal, including suggested adjustments, but must forward the original proposal for consideration and discussion at the next MRRIC meeting, or the following meeting if the next meeting occurs within 15 days of a proposal receipt. MRRIC and the agencies are encouraged to discuss and comment on any proposal as well as changes proposed by the Management Team. Rapid approval of this nature would generally be restricted to minor corrections that are needed quickly or non-controversial adjustments to the composition of one Team. Immediate disapproval would generally occur when a proposal conflicts with policies.

Two other outcomes could (and most commonly would) arise: (1) the proposal could be remanded to a standing or ad hoc Team or Panel for review and input, or (2) the proposal could be returned to the originating entity with suggestions for revision or request for more information. In either of these cases, the revised proposal (with input from the review Team/Panel or submitter's revisions) can be reconsidered and discussed during any MRRIC meeting. MRRIC can make a consensus recommendation regarding proposed governance changes as part of (or separate from) the recommendations they make on the SP updates. The agencies may render a decision on the proposal at any time following the MRRIC meeting in which it is discussed, but are encouraged to wait for a recommendation if one is forthcoming. The agencies will report their decision at the next MRRIC meeting following a decision, and will direct the Management Team to update the SAMP accordingly.

2.5.2.2 Procedures for adjusting objectives, targets, or decision criteria.

As learning progresses under AM, the need to update objectives, targets, decision criteria, or other similar Program benchmarks may become necessary. These are factors that fundamentally guide the Program, relate to ESA compliance, or could impact HCs, so they should be rigorously analyzed and deliberated, including full coordination between the USACE and USFWS and with opportunity for input by the MRRIC. However the ultimate decision making authority to adjust ESA compliance objectives, targets, and metrics remains at the sole discretion of the USFWS.

Recommendations for adjustments to objectives, targets or decision criteria can be initiated by either of the lead agencies, by MRRIC, the Panel, by any of the Program Teams, or by an independent external peer review of the Program. Recommendations should be provided in the form of a white paper outlining (a) the specific objective, target or criterion to be reconsidered, (b) the basis for the proposed change (studies, reports, monitoring results, data, etc.), and (c) a summary of the rationale and benefits of the change.

2.5.2.3 Procedures for elevating and relegating hypotheses

This procedure applies to the management of the broad suite of hypotheses identified in the CEMs, described in the EA reports, and highlighted in various sections of the SAMP. Hypotheses can be elevated from or moved into reserve as information and understanding dictates. The reserve includes those hypotheses (1) below a priority threshold, (2) having no clear mechanism for investigation or testing, and/or (3) outside current USACE authorities.

As learning occurs through the AM cycle, the list of hypotheses may expand or contract beyond the initial set of hypotheses identified in the EA reports. Hypotheses that are implemented and found to not be effective can be moved into the reserve, and hypotheses that show merit based on research or other further analyses, new information, or improved understanding can be elevated into the active hypotheses category. The Technical Team will be charged with an annual hypothesis evaluation and will report the findings of this evaluation at the Annual AM Workshop.

Based on the analyses of the Technical Team, the Bird, Fish and/or HC Team may recommend the elevation of any reserve hypothesis, and may include prioritized studies or actions to address that hypothesis in the SP development process. The Management Team may also recommend elevation of a reserve hypothesis, independently of the Bird/Fish/HC Team recommendations. The process for approving the elevation of reserve hypotheses or relegation of current working hypotheses to the reserve is similar to the process changing species objectives, targets, or decision criteria highlighted in Section 2.5.2.2. Elevation/relegation can also be recommended by MRRIC or agency leadership.

In the event the recommendation is made by the Bird and/or Fish Team and is subsequently supported by the Management Team and approved as part of the SP Process, no further action is required. In the cases where the recommendation is made without concurrence either level, a reevaluation of hypotheses will be performed by the Technical Team and their findings reported and reviewed by the Panel (Note: An exception is made in cases where the hypothesis is relegated to reserve status by policy/authority factors; in those instances the agency makes the determination and reports its rationale at the next MRRIC meeting). The Technical Team's report and the Panel evaluation are submitted to MRRIC and the agencies for review/discussion. Oversight's decision regarding the recommendation is recorded and communicated through a decision document.

2.5.3 Procedure for addressing significant new information

Information derived as a product of the research and monitoring of the MRRP will be subjected to the review processes outlined throughout this SAMP. Review is also needed for the occasional “new information” that originates outside the Program but was not identified and addressed by the Technical Team during its annual review process and is of a nature that it could significantly influence Program direction. The procedure outlined in this section is intended to ensure that the MRRP is using the best available and verifiable science information in informing AM decisions and that it is not subject to change driven by incomplete, unsubstantiated data, or research.

Any concerned party may bring to the MRRP new data or other information on the ecology and behavior of the listed species, resources, and habitat attributes that effect those species including environmental stressors, ecosystem processes that are known or suspected to contribute to the survival and recovery of those species, and HC factors that may affect the listed species or be impacted by efforts to protect the species. That new information may include survey data that contribute to time series; analyses that show linkages among the species, their habitats, and the river ecosystem, including its human uses; interpretation of monitoring data; and model outputs presented with mechanistic explanations for phenomena of conservation concern.

The identifying entity can initiate a review process to assess that new information by submitting to either of the MRRP Science leads for the lead agencies an issue paper that concisely explains the rationale for introducing new science information. This paper does not need to document all available information; the objective is to illustrate the importance of the issue and motivate a more-detailed analysis. The paper should include a description of the information and its source, an explanation of its management relevance, and pertinence in confronting the priority management hypotheses that guide the MRRP SAMP (and may include any non-priority hypotheses that can be linked to the survival and recovery of the listed species or effects of management actions taken under the MRRP). The Science Leads will make an initial, joint determination on whether the new information may have relevance and importance to MRRP decision making. A written evaluation will be provided to the submitter. If the initial determination does not support a detailed evaluation of the issue, the submitter will be given an opportunity to provide additional information.

If the initial determination identifies merit in the issue, the Science Leads will elevate it for consideration by the Technical Team, which will engage in a “joint fact-finding” process and an evaluation of the potential for that information to affect Program decisions. An ad hoc joint, fact-finding team will be established and will include the submitter and one or more members of the Technical Team, depending on the scope of

the new information. The ISP will issue a charter and identify the objectives of the joint, fact-finding effort, which will generally include the compilation and analysis of all available data, including new information and contextual information, to determine if and how the AM process should accommodate the new information.

The fact-finding team in consultation with the Bird Team, Fish Team, and/or HC Team (as appropriate), and in consultation with Panel, will consider whether the new information provided is (or might be) reliable knowledge (constitutes best available science) that warrants consideration in the AM program planning process. Only if so, then the fact-finding team will provide a study plan to the ISP and, after review by the ISP and the Panel, proceed with additional data gathering and/or directed studies to substantiate the phenomenon of concern. The fact-finding team will provide the ISP with monthly status reports (if the effort spans more than 2 months) and will participate in a mid-point review conducted by the ISP to ensure the effort is proceeding toward resolution and is utilizing accepted standards of practice. The fact-finding team will produce a draft report with analysis of the new information, analysis of how the new information relates to decisions and management actions, and a draft recommendation for disposition of the issue. Recommended disposition may include the following.

- Note the issue but take no further action (based on lack of merit, no clear relationship to management actions, etc.).
- Recommend additional study (including identification of additional data or scientific information/analyses required to clarify the issue).
- Elevate the issue to a new action hypothesis to be addressed through the MRRP AM process.

The draft report and all data will be provided to the ISP, which will schedule a review and comment period and formal presentation of the study and findings. Review comments may be provided by the agencies and by the Panel. The fact-finding team will respond to comments and the revised document will be submitted to the Panel for final review and concurrence /comment. (Note: The submitting entity has participated in the evaluation as a member of the fact finding team and therefore will not be engaged for further comment on the final product). If the Panel does not concur, the issue will be sent back to the fact-finding team for further consideration. In the event further consideration does not alter the position of either the fact-finding team or the Panel, or if the submitting entity disagrees with the outcome, the issue may be elevated to the Oversight level for decision making.

2.5.4 Independent external review

The MRRP maintains several established Peer Review Processes to allow for the review of the Program, monitoring and study plans and reports, project designs, and the science program. Assurance that these and other products used for decision making in the SAMP are of the highest quality and meet standards of practice is essential to trust building and program success. The peer review process relies upon good QC and peer review at the district level as well as external product/program review using independent panels selected because of their expertise on the specific subject matter. These panels are convened to do the reviews only and are not on- going or permanent components of the program, with the exception of the Panel.

All Civil Works planning, engineering, and O&M products must undergo review (see EC 1165-2-209; USACE 2010). All products undergo District Quality Control (DQC), and a subset of these undergoes ATR. Smaller subsets of the ATR group undergo IEPR. Peer reviews are critical to high-quality decision and implementation documents.

2.5.4.1 District Quality Control (DQC)

DQC is an internal review process of basic science and engineering work products focused on ensuring the quality requirements of the SAMP are met. DQC consists of quality checks and reviews — routine checks and reviews carried out during the development process by peers (i.e., supervisors, team leaders, other senior personnel) not responsible for the original work — conducted for any science and/or engineering product under the MRRP. Documentation of all DQC activities is required. The NWK and NWO districts will manage the DQC process in accordance with USACE policies.

2.5.4.2 Agency Technical Review (ATR)

ATR is undertaken to “ensure the quality and credibility of the government’s scientific information” and was previously referred to as “Independent Technical Review” (ITR). It is mandatory for all decision and implementation documents and other work products, according to a case-specific, risk-informed decision (see EC 1165-2-209 and 08502-CENWD-RBT on EC 1165-2-209).). Decision documents are planning feasibility/reevaluation studies or other project studies that require NWD/HQUSACE approvals. Implementation documents are generated subsequent to decision documents and lead to the implementation of the selected action. Reviews are conducted by professionals outside of the MRRP districts and not affiliated with the development of the project or product. The required ATR team member disciplines and expertise are described in the Master Review Plan. At the conclusion of the ATR, the team prepares a review report, which is then certified by the NWD.

2.5.4.3 Independent External Peer Review (IEPR) of MRRP Projects

IEPR is the most independent level of review, applied in cases where the risk and magnitude of the proposed project are such that a critical examination by a team outside of the USACE is warranted. IEPR panels are made up of independent, recognized experts in the appropriate disciplines and are selected using the National Academies of Science (NAS) policy for selecting reviewers.

There are two types of IEPRs. Type I IEPR is conducted on decision documents and supporting work products where there are public safety concerns, significant controversy, a high level of complexity or significant economic, environmental, and social effects to the nation. Type II IEPR is conducted on design and construction activities for hurricane and storm risk management and flood risk management projects, as well as other projects where potential hazards pose a significant threat to human life. This applies to new projects as well as major repairs, rehabilitations, replacements or modifications of existing facilities. A third category, Special Case IEPR, is required when a non-Federal interest undertakes a study, design, or implementation of a Federal project, or requests permission to alter a Federal project. The non-Federal interest must make a risk-informed decision on whether to undertake a Type I and/or Type II IEPR, and this decision process and the reviews must be included in the documents submitted for review or approval.

2.5.4.4 Independent External Peer Review of the MRRP

An IEPR of the MRRP should be held after its third and sixth year of operation. Further IEPR needs should be reassessed following the second review. The review should be conducted by an independent entity with related expertise and experience. The scope of the review should be broad, with the aim of (1) identifying overall program performance towards its goals and (2) identifying mechanisms/changes to improve its capacity toward achieving those goals. Included are assessments for the subprograms (birds and fish), as well as for the overall program and its governance. The review should assess the performance of the agencies and of MRRIC, and should make recommendations for the improvement of the Program, its components, and its participants. Reviewers should prepare a report, and an executive summary, to be submitted to the agencies and MRRIC for consideration. Details on the Programmatic IEPR are presented in Attachment 13 of Appendix A.

2.5.4.5 ISP review process

The ISP has a science QA process that includes both internal and external reviews to ensure integrity and independence are maintained in the ISP and its products. Internal review involves technical review by PDTs and technical leads, and managerial review of

products by the ISP Managers and ISP Management Team (MT). External review is conducted on an as-needed basis and involves ISR and peer review by individuals outside of the action and partner agencies.

The MRRP's Panel is an example of an ISR panel that provides advice on specific topics. This group is a neutral group with expertise retained by the MRRP to provide independent and objective guidance to the program. A Panel review could occur at any level, program, project, study, or report. The Panel can comprise up to six science advisors who meet at least annually and are charged with independent science support and technical oversight. Topics originate from the USACE and/or MRRIC. The general disciplines of expertise on the panel include: Aquatic/Riverine Ecologist, River Hydrologist/Geomorphologist, Least Tern/Piping Plover Specialist, Sturgeon Specialist, Quantitative Ecologist/Statistician, and Conservation Biologist. The Panel website is <http://projects.ecr.gov/moriversciencepanel/default.aspx>.

2.5.5 Requirements for research and focused study efforts

The Principal Investigator (PI) for any funded research effort or the lead investigator for any monitoring program or focused study effort will be required to develop and maintain a Project Management Plan (PMP) for the effort. A project management plan (PMP) is a formal, living document used to define requirements and expected outcomes and guide project execution and control. All continuing MRRP projects are required to develop and maintain a PMP (5–10 pages). Yearly updates of the PMP will be due at the Fall Science Meeting for the program (generally occurring in September). However, the ISP Manager should be informed of significant deviations from the PMP at the earliest possible opportunity during the course of the FY. See Attachment 1 of Appendix J for a PMP template.

Each PI or Lead Investigator will also be asked to prepare and maintain a Fact Sheet (see Attachment 23 of Appendix A for a template) and provide quarterly progress reports on products and expenditures.

Investigators undertaking research funded by the MRRP are obligated to participate in two In-Progress Reviews (IPRs) annually. In addition to oral presentations at each IPR, the PI will submit the required documentation of research progress and milestone status shown in Attachment 3 of Appendix J. PIs can elect to have a colleague present at an IPR, but is responsible for ensuring the alternate is sufficiently familiar with the work to answer detailed technical questions regarding the work. Inability to substantially defend a research effort is grounds for termination of funding for the effort.

Technical publications from the MRRP will adhere to the guidelines in Attachment 2 of Appendix J unless required by their agency to use a different set of guidelines and after obtaining approval of the ISP Manager. All data collected and/or used to support analyses shall be furnished to the ISP following the guidelines and procedures outlined in Chapter 6.

2.5.6 Agendas for the Fall Science Meeting and for the Annual AM Workshop

Attachment 18 of Appendix A presents the standing agendas for the indicated meetings/workshops. These agendas can be modified at the discretion of the ISP Manager to include issues, but the meeting/workshop should address all of the topics on the standing agenda.

2.5.7 Guidelines for technical publications

Research reports and findings of monitoring and assessments constitute important products of work under the MRRP. They influence important decisions regarding program implementation. Money, facilities, and talent devoted to research should always result in a formal technical communication of some kind. It is important that reports be published in a timely fashion, be clearly and concisely written, and be technically correct. The content of a report and the manner of presenting data are governed by the objectives of the investigation and the distribution intended. The ISP Manager may prescribe the level of detail of a report prepared for specific needs. Attachment 2 of Appendix J provides guidelines for technical publications of the Program.

2.5.8 Example Fact Sheet

Fact sheets outlining the purpose, approach, products, significant findings, and a point-of-contact for sub-programs, management actions, research efforts, studies, significant analyses, or other activities of the MRRP are recommended as a mechanism for informing MRRIC and stakeholders of program activities. Attachment 23 of Appendix A provides a template and guidelines for developing and posting fact sheets.

2.5.9 Program priorities development process

There are two types of priority setting within the MRRP. The first type is the annual request for appropriations, and this is implemented as part of the Corps' 3-year budget cycle process. For example, prioritization during FY18 will provide planning information for implementation of projects in FY20. The Omaha District (NWO) has the responsibility for requesting the appropriations for the overall program including

resources for both districts (NWO and NWK). Appropriation requests are based on three priorities:

1. *Minimum Compliance:* Projects that ensure that The USACE would be in compliance with the BiOp for the appropriation year. This includes continuing contracts and projects that were awarded in a previous year and the real estate acquisitions to ensure compliance with habitat requirements in out years (i.e., it takes a minimum of two years from acquisition to habitat development on most acquired properties).
2. *Long-term Compliance:* Projects that ensure compliance with the BiOp and the Mitigation Program in the out years, particularly for any BiOp “check-in” years.
3. *Capability:* Projects that ensure program capability (i.e., the amount of work that can be accomplished in both districts in that FY). Appropriation requests rarely align with actual appropriations.

BiOp activities are initially prioritized by the Bird, Fish, and HC Agency Team Leads based on input from their respective teams, analyses by the Technical Team, decision criteria for their priorities, application of programmatic screening and prioritization tools, or whatever means they establish, then elevated to the Management Team for integration into the overall budget, which is reviewed by the ESC, presented to MRRIC for input, and ultimately approved by the NWD Director of Programs.

The second type of priority setting is the development of the SP for implementing the actual appropriation (see Section 2.4.4). At the program-level, priorities for the MRRP are linked to the mission, vision, and scope of the program as well as the BiOp and enabling legislative acts (e.g., WRDA 2007). MRRP priorities may change significantly from one FY to the next because (a) system conditions change, creating both demands (e.g., need to build ESH) and opportunities (e.g., storage for a flow release), and (b) information from research and ecosystem monitoring and assessment may reveal the need for significant shifts in program focus.

2.5.10 Cost management

The MRRP cost management program includes planning, estimating, budgeting, and controlling costs so that program execution and recovery projects can be completed within approved budgets. There are three critical elements associated with MRRP cost management: (1) cost estimating – developing an approximation of the costs of resources needed to complete program management activities of restoration projects; (2) cost budgeting – aggregating the estimated costs of individual activities to establish an annual MRRP cost budget for each FY; and (3) cost control – monitoring the factors that create cost variances and controlling approved changes to the MRRP budget. An

MRRP cost management plan will be prepared and used as an essential component of program execution. See the Program Management Plan (Attachment A.11) for more details.

2.5.10.1 Cost management plan

The MRRP will develop a broad, formal cost management plan; the MRRP SPgM has the responsibility for development and implementation of this plan. The cost management plan will clearly define how MRRP funding will be managed throughout the program's lifecycle. The plan will identify the processes and procedures by which MRRP program and project costs are estimated, measured, and controlled. Additionally the plan will outline the following.

- Who is responsible for management of program and project costs.
- Who has the authority to approve changes to program and project budgets.
- How MRRP costs are quantitatively measured and reported.
- What is the proper format and frequency of financial reports, and to whom they are presented.

2.5.10.2 Cost estimating

An initial estimate of MRRP project costs is developed for each PMP based on the project's Work Breakdown Structure (WBS). Estimates are based on experience with similar projects taking into account site-specific conditions. Cost estimates are further refined and detailed during development of the Project Implementation Reports (PIRs), land acquisition appraisals, or scopes of work for ISP activities. Cost estimates are prepared to the level of the WBS needed by PMs to effectively monitor project budgets and track project execution, as determined by the project schedule.

2.5.10.3 Annual cost budgeting

Annual project budgeting involves allocating the overall cost estimate to individual activities identified in the project WBS. An annual MRRP budget is developed by using the project cost estimate, anticipated research funding needs, and baseline subprogram costs to estimate costs for each subprogram. The SPgM coordinates with the PMs to ensure budgets for each MRRP subprogram and project are reasonable, and to assess risks/impacts and develop contingencies for alternative budget amounts. These individual subprogram budgets are integrated and added to other programmatic costs (cost for Program integration and administration, MRRIC, etc.,) and used to develop an annual program-scale cost budget for the MRRP.

Annual MRRP budget exercises already utilize cost estimating techniques by using three budget scenarios – compliance, long-term compliance, and capability. These budget scenarios allow the Management Team, ESC, and District leadership to estimate costs each FY given the fluctuations in annual appropriations; they also provide transparency to the budget process by clearly indicating what is funded under each scenario.

2.5.10.4 *Cost control*

MRRP programmatic activity costs are the responsibility of the SPgM while the other PMs are responsible for individual restoration project budgets. PMs review biweekly Financial Management Reports to ensure the correct labor charges have been made and all contractor costs are correct. PMs communicate with members of the PDT regarding progress on individual activities throughout the program/project lifecycle and bring any problems to the attention of the SPgM. The SPgM, in turn, alerts the ESC of any budget problems that cannot be resolved by the SPgM. A list of factors that generally cause cost variances is used to inform the SPgM and PMs so that they are aware of potential budget risks. Quantitative cost thresholds are also defined up front and used to identify when corrective action is required (e.g., program/project is over budget). Finally, a list of corrective actions is prepared in advance and used in the event that changes to the budget are needed.

2.5.10.5 *Cost change control approval process*

When an established cost threshold for a specific MRRP project/activity is triggered, the change control process is initiated. The SPgM evaluates the request and makes a determination for changes under <\$50,000>; the ESC considers and approves changes over this amount. Project budgets are adjusted and documented to reflect approved revisions.

2.5.10.6 *Value Management (VM) and Value Engineering (VE)*

A VM/VE study should be conducted for all individual habitat development projects that exceed \$2 million (ER 1110-1-12; USACE 2006). The PM and PDT will work with the District Value Engineering Officer to decide if a cost-effectiveness review or VM/VE study is required. Because a preliminary cost estimate will be completed during the PIR phase for each site, this is when the decision is made regarding VM/VE study need.

The goal of a VM/VE study is to assure that the most cost-effective approach is taken while meeting the project objectives. Study teams should include USACE and Mitigation ACT personnel experienced with the program and seek, to the extent possible, to maximize development and sharing of lessons learned between the two districts. PMs will review all construction contracts to ensure that Contract Clause

52.248-3 “Value Engineering-construction” is included. This contract clause encourages the construction contractor to develop, prepare, and submit VM/VE proposals (i.e., VECs) during the course of habitat development activities. If an event or process is identified during any VM/VE study that is significant enough to warrant a change in any processes outlined in this SAMP, it should be brought to the attention of the SPgM for change management procedures.

PMs will undertake steps to ensure the most cost effective techniques are employed, allowing for the need to implement experimental designs that sometimes call for actions with varying costs so they may be properly evaluated. Management actions should be designed to take advantage of natural river processes as much as practical, following the “Engineering With Nature” principles endorsed by the USACE. For actions at Levels 3 and 4, the PDT will seek, where possible, design standards and criteria based on the lessons learned from those previous projects so as to most cost-effectively meet objectives given site/system/program constraints.

2.5.11 Program safety and health requirements

The Safety and Occupational Health Managers (SOHM) are responsible for the District Safety and Occupational Health Program (SOHP). The SOHM is responsible for planning, organizing, overseeing, and evaluating the SOHP, in conjunction with the PgM. The SOHM reviews the Site Safety and Health Plan (SSHP), if required. The SOHM or staff conducts periodic safety surveys, inspections, evaluations of all work and procedures associated with the project to include operational procedures, programmatic safety and occupational health requirements, environmental hazards that could be encountered, construction, recreational and public protection from safety hazards, and personal protective equipment requirements. The SOHM ensures compliance with all applicable safety regulations and provides support to the PgM/PM for overall safety on the project site. Safety requirements for the MRRP are presented in Attachment 24 of Appendix A.

3 Adaptive Management for Plovers and Terns

This chapter is organized according to the five steps of the AM cycle introduced in Section 1:

1. Assess (Section 3.1), which provides objectives and scope for piping plover and least tern management and summarizes the EA.
2. Plan and Design (Section 3.2), which outlines the bird AM framework, performance metrics, and management conditions, targets, and specifies management actions and associated decision criteria.
3. Monitor (Section 3.3), which summarizes the metrics used for monitoring habitat and species status, action effectiveness, and monitoring to capture outcomes of unusual events.
4. Implement (Section 3.4), which summarizes steps in carrying out management actions.
5. Evaluate (Section 3.5), which summarizes the evaluation of habitat and population status, management conditions and options, key relationships and new information, model updates and validation, and the use of ancillary information and unexpected events.
6. Decide (Section 3.6), which summarizes key management decisions and associated tools including predictive models, and decisions to reevaluate metrics and targets.

Associated appendices include Appendix A (Protocols and procedures for decisions), Appendix B (CEMs), and Appendix G (Monitoring protocols related to the birds).

3.1 Assess

3.1.1 Management objectives and scope for least terns and piping plovers

The fundamental objectives for piping plovers and least terns, specified in the 2018 BiOP, are as follows:

Fundamental Objective. Avoid jeopardizing the continued existence of the piping plover due to the U.S. Army Corps of Engineers actions on the Missouri River.

Fundamental Objective. Avoid jeopardizing the continued existence of the least tern due to the U.S. Army Corps of Engineers actions on the Missouri River.

Sub-objectives for piping plovers are also included in the 2018 BiOp.

Sub-objective 1 (Distribution). Maintain a geographic distribution of plovers in the river and reservoirs in which they currently occur in both the Northern Region (Missouri River from Fort Peck Lake, Montana to Fort Randall Dam, South Dakota, including reservoir shorelines) and Southern Region (Missouri River from Fort Randall Dam, South Dakota to Ponca, Nebraska)¹.

Sub-objective 2 (Population). Maintain a total population number of Missouri River piping plovers that has a 95% probability that at least 50 individuals will persist for at least 50 years within both the Northern and Southern Regions.

Sub-objective 3 (Population Trend). Maintain a stable or increasing long-term trend in population size within both regions.

Sub-objective 4 (Reproduction). Maintain fledgling production of breeding pairs at least sufficient to meet the population growth rate objectives within both regions.

3.1.1.1 Geographic scope

The geographic scope of the SAMP for piping plovers and least terns is the mainstem Missouri River from the upper end of Lake Sakakawea near Williston, ND, to Ponca, NE. Plovers and terns nest in six segments within this geographic area (Table 18; Figure 22):

Table 18. Missouri River bird habitat segments, habitat types, river miles (RM), and segment length.

	Segment	Habitat Type	River Miles (RM)	Length (RM)
Northern Region	Lake Sakakawea	Reservoir shoreline	1568-1389.9	178.1
	Garrison	Emergent sandbars	1389.9-1304	85.9
	Lake Oahe	Reservoir shoreline	1304-1072.3	231.7
Southern Region	Fort Randall	Emergent sandbars	880-845	35
	Lewis and Clark Lake	Reservoir delta sandbars	845-826.7	18.3
	Gavins Point	Emergent sandbars	811.1-754	57.1

¹ These regions correspond with two regions (Northern Rivers and Southern Rivers) of the four identified in the *Draft Revised Recovery Plan for the Northern Great Plains Piping Plover* (USFWS 2016). The Southern Region as referred to in this document, however, references only the Missouri River mainstem components and not the tributaries included in the recovery plan.

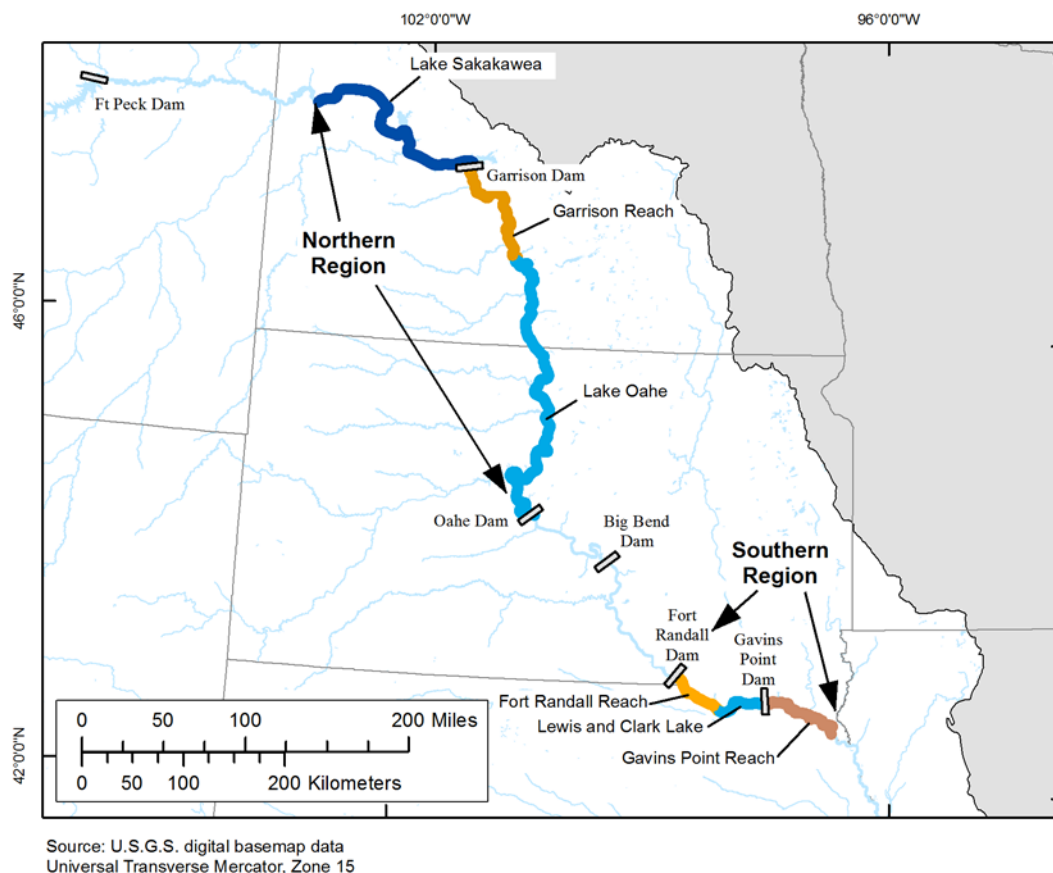


Figure 22. Geographic scope of SAMP for terns and plovers.

Limited nesting also occurs in the Fort Peck reach upstream of Lake Sakakawea, but as very few plovers have been observed on that reach or on Ft. Peck Lake¹, it is not included in the focal areas for plover management.

USACE surveys plover and tern adults in June on all segments from Fort Peck Reservoir, Montana, to Ponca, Nebraska. Lake Sharpe and Lake Francis Case in South Dakota are excluded, as these waterbodies are not designated critical habitat for terns or plovers. Productivity monitoring for tern and plover nests and chicks occurs within the six riverine and reservoir segments in Table 18. The Fort Peck reservoir and Fort Peck riverine segments are excluded from productivity monitoring because the habitat and use by nesting birds is very limited.

The design and operation of Lake Sharpe and Lake Francis Case provides little to no nesting habitat. This gap in habitat availability between Lake Oahe and Fort Randall

¹ Since 1997, 0%–2% of the observed plover population used habitat along Fort Peck Lake or in the reach upstream of Lake Sakakawea. The average was <1% of the plover population.

Reach creates a dispersal barrier. Piping plovers have been observed to have high site fidelity, (i.e., they are likely to return to their previous breeding area), and plovers that disperse are more likely to move within segments or between segments within a region than to return to breed in the other region. Therefore, for planning, modeling, and target-setting purposes, the mainstem breeding areas have been divided into two regions, as indicated in Figure 22. The Northern Region includes Lake Sakakawea, Garrison Reach, and Lake Oahe. The Southern Region includes Fort Randall Reach, Lewis and Clark Lake, and Gavins Point Reach.

The geographic scope reflects the decision-making authority of the USACE. While the federal action described in the MRRMP-EIS includes the Missouri River within the meander belt from Fort Peck Dam, Montana to the confluence with the Mississippi River in St. Louis, Missouri, the USFWS recommends the USACE “prioritize creation and maintenance of habitat within the unchannelized river below Garrison, Fort Randall (including the sediment delta of Lewis and Clark Lake) and Gavins Point Dams” (USFWS 2015).

The effects of nearby subpopulations of piping plovers and least terns on MRMS populations (metapopulation dynamics) are not fully understood, and considered a critical uncertainty within the SAMP (Section 3.1.2.5). Studies underway to measure dispersal between the MRMS and other breeding areas will provide information on metapopulation dynamics. As results become available, the ability to account for and model metapopulation dynamics will be evaluated and developed to the extent possible.

3.1.1.2 Relationship to species recovery

The *Draft Revised Recovery Plan for the Northern Great Plains Piping Plover (Charadrius melodus)*, First Revision (henceforth, Plover Recovery Plan; USFWS, [2016]) identifies four recovery regions (sub-populations) of Northern Great Plains plovers: Prairie Canada, U.S. Alkaline Lakes, Northern Rivers, and Southern Rivers. The mainstem Missouri River comprises the entirety of the Northern Rivers region and a substantial portion of the Southern Rivers region, which also includes the Niobrara, Loup, and Platte Rivers. The Plover Recovery Plan emphasizes the importance of maintaining sufficient habitat in each of the four regions, given the contribution of each region to the overall geographic area and habitat diversity and the limited dispersal observed between regions:

The population should be broadly distributed to reduce the risk of loss of a significant proportion of the population. It is important for the population to be distributed through the range to maximize viability into the future and to reduce the risk of a stochastic event impacting a large proportion of the population. (USFWS 2016)

The plan also identifies the importance of maintaining a diversity of habitat types, including riverine sandbars, and of not relying on human-created, off-river habitats as a means of achieving long-term recovery. In the MRRP planning area, which includes the river and the meander belt, the plover nests nearly exclusively on in-channel islands and along reservoirs. A very high proportion of recorded plover nesting on riverine islands occurs on the Missouri River. Accordingly, to meet the range-wide goal of conserving piping plovers across as much of their historical distribution as possible and in the full breadth of its known habitats, the MRRP should focus on providing in-channel habitat in an extent and condition sufficient to support stable demographic units that can persist in the face of dynamic environmental conditions.

The objectives for the MRRP, as identified above, are to avoid jeopardy to the listed species, rather than to meet requirements for recovery. To the extent that the MRRP can support recovery of the piping plover, it will provide clear benefits to the species and program; however, the MRRP currently has defined targets (Section 3.2.3) that differ from recovery targets, because both the objectives and the methodology for defining targets differ (USFWS 2016). The USFWS has determined that these differences are acceptable and appropriate and do not create a conflict between the Draft Plover Recovery Plan and the MRRP. If, in the course of AM within the MRRP or following finalization of the Plover Recovery Plan, the need to adjust MRRP plover target criteria is identified, that process is defined in Sections 2.5.2.2 and 3.6.5.

The fourth recovery criterion identified in the Plover Recovery Plan is the following:

Criterion 4: Ensure commitments are in place and functioning as anticipated to provide long-term funding, protection, and conservation management activities in essential breeding and wintering grounds. ...

Purpose: To make sure that management commitments necessary for piping plovers' continued persistence are in place and functioning, and will continue to operate after the species is recovered.

In the event the first three recovery criteria are met throughout the range of the Northern Great Plains Piping Plover, the MRRP (and other resource management agencies in the range) will need to demonstrate the commitment to continue providing habitat, population protection, and related management actions. Some requirements may change from the current MRRP objectives, but species recovery will not result in cessation of management for plover and tern habitat on the MRRP.

The Plover Recovery Plan identified reservoirs, channelization of rivers, and modification of river flows; invasive species and vegetation growth; and inadequacy of existing regulatory mechanisms as high threats for both the Northern Rivers and Southern Rivers regions. Population density causing intraspecific aggression,

agricultural development, predation, and human disturbance were identified as high or medium threats to both regions. These stressors overlap strongly with the threats identified in the piping plover EA as explained in Section 3.1.2.

The 5-year review of the Interior Least Tern recommended delisting (USFWS 2013). Delisting requires a conservation plan and post-delisting monitoring plan from cooperating agencies, similar to what is described above for plovers. The MRRMP will also serve as the conservation plan for interior least terns and must therefore demonstrate the ability to continue meeting habitat and population protection needs for least terns.

3.1.2 Key findings from Effects Analysis (EA)

3.1.2.1 Purpose and methods of the EA

An EA was undertaken to address the requirement within the ESA to use the best available science to evaluate the effects of actions proposed by federal agencies on listed species or designated critical habitat. The EA adapted the rigorous approach advocated by Murphy and Weiland (2011). Before the EA began, the problem was formulated with the definition of the proposed action, the area affected, and a conceptual model of the physical and biological relationships relating actions to species outcomes. After problem formulation, the first step in the EA was to collect reliable scientific information, including observations about the stressor(s), the range of stressor conditions, and information on population sizes and trends. The second step included assessment of the data, the use of quantitative models to synthesize existing information, and identification and representation of uncertainties. The third step was to analyze the effect of the actions on the species to determine costs and benefits and identify alternative management approaches.

This section summarizes the EA for plovers and terns as documented in the following reports:

- Summaries of the state of science for the species and their habitats to identify the effects of system operations and actions on species populations and their habitats (Buenau et al., 2015z)
- Conceptual ecological models (CEMs) and hypotheses addressing critical uncertainties (Buenau et al. 2016)
- Quantitative assessments and modeling evaluating the effects of management actions on habitat and population dynamics (Buenau et al. in prep.)

The EA used the information and tools described in these reports to provide an integrated assessment of the effects of management actions on piping plovers and least

tern habitat and populations in the Missouri River. It also documented and synthesized the uncertainties in the assessments. The foundation of the EA is the habitat and population models, which synthesize available information to make predictions, assess management hypotheses, predict outcomes of combinations of management actions under evaluation for the Management Plan, calculate numerical targets, and quantify uncertainties and their impacts on management decisions. These tools will continue to be applied and refined through the AM process.

3.1.2.2 *Conceptual ecological models*

The CEMs for plovers, terns, and their habitat relate drivers (social, political, legal, and economic; climate, geology, and land use) to Missouri River management, hydrology, and habitat. They then relate habitat availability to biotic processes: nesting behavior, predation, food availability, and dispersal. These biotic factors affect survival and reproduction to ultimately determine population size. An overview conceptual model diagram is shown in Figure 23. Complete conceptual models for each species are shown in Appendix B. In the complete models, the estimated importance of each relationship is indicated by the type of arrow, with thick solid lines representing the most important relationships and thin dot-dash lines representing the least important relationships. Importance was determined based on the relative effect of each relationship to the affected factor. Uncertainty is reflected by arrow color. Uncertainty in the CEMs represents lack of knowledge, high natural variability, or both.

The CEMs were initially developed in a set of inter-agency workshops in 2013, then reviewed, revised, and used to develop biological and management hypotheses to be evaluated in the EA.

3.1.2.3 *Quantitative modeling framework*

The quantitative modeling framework includes components for hydrology, riverine and reservoir shoreline habitat, and population viability (Figure 24). These components are briefly described here. Details can be found in Fischenich et al. 2015 and Buenau et al. (2016).

Hydrology and reservoir operations are modeled using HEC Res-Sim, which routes basin runoff through the Missouri River using specified rules for reservoir operations. These rules can be modified to reflect potential changes to reservoir operations, e.g. to release flows capable of creating new sandbar habitat. Currently, the Res-Sim model uses historical runoff and depletions from 1930-2012 as inputs and provides reservoir elevations, dam releases, and river stage at selected locations as outputs. The model uses historical hydrological inputs to cover a range of natural variability in basin runoff. Those inputs are runs through a model of the modern hydrosystem with a consistent set

of operation rules for each 50-year run. Sequences of output with randomly selected initial years are used in the habitat models.

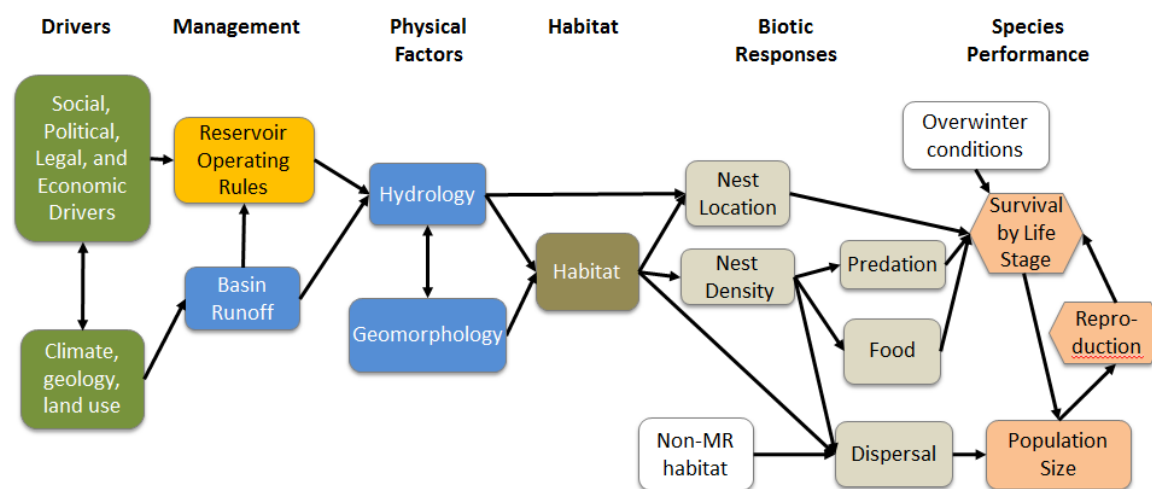


Figure 23. Overview conceptual ecological model (CEM) for plovers (see Appendix B for full set).

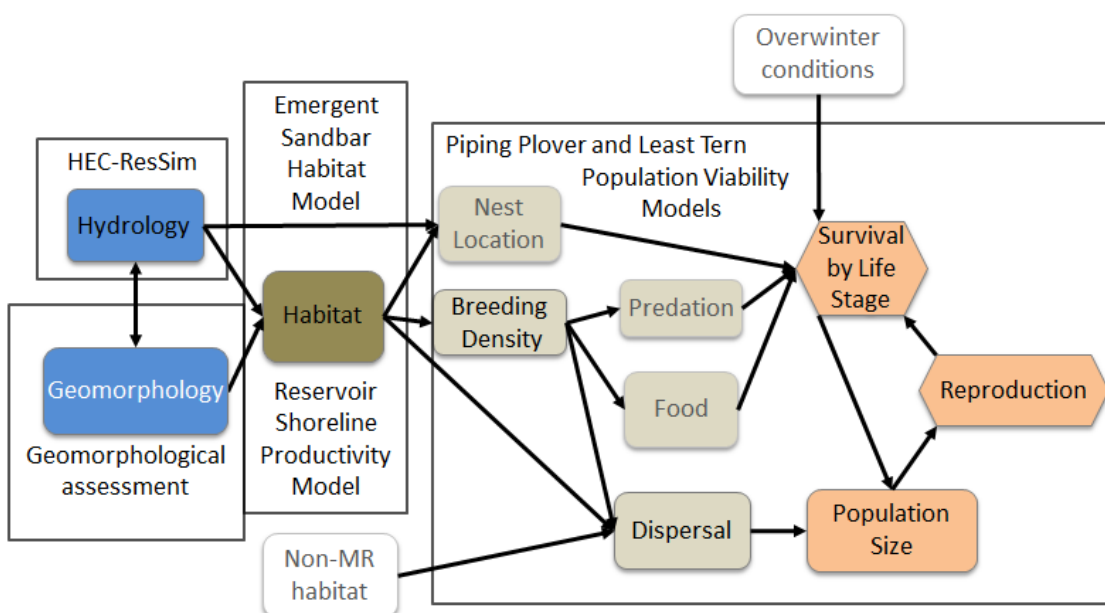


Figure 24. Quantitative model components in relation to conceptual model elements. Elements with black text are represented explicitly in the model; elements with gray text are represented implicitly.

Plover and tern emergent sandbar habitat (ESH) under varying flow conditions is predicted using a model of the change in ESH due to vegetation growth and the deposition and erosion of sandbars as a function of flow and ESH area. At low flows, erosion rates are low. Net erosion is greatest at moderate flows, then, as flows increase, net deposition begins to occur. Erosion rates are higher and occur at higher flows when

the existing ESH area is larger. ESH models were based on a mechanistic understanding of sandbar dynamics and parameterized for each of the three riverine segments individually based upon satellite imagery for all reaches and geomorphic studies for Gavins Point Reach. They use initial ESH area and mean monthly river flows as inputs. Output consists of the standardized acreage of ESH, set to a constant flow for each reach (see Section 3.2.3 for specifications) and available acreage of ESH, adjusted to the maximum July flow in each year, to estimate ESH availability for nesting and brood-rearing.

Reservoir shoreline habitat is modeled indirectly. Fledgling production on reservoir shorelines is modeled as a function of two hydrological metrics: the vertical extent (elevation range) of exposed shoreline that had been inundated for at least 160 days in the past two years, and the increase in reservoir elevation during the nesting season. These metrics predict observed fledgling productivity more effectively than estimates of habitat area, which is challenging to quantify and predict on reservoir shorelines. The reservoir habitat-productivity model uses the daily time series of predicted reservoir elevations and breeding pairs as inputs and outputs the number of fledglings produced.

Plover and tern populations are modeled using species-specific population models. The models account for the number of fledglings produced per pair of adults as a function of population density on riverine habitat and hydrologic change on reservoir habitat. They also include annual survival for life stages (juvenile and adult plovers; juvenile, young adult and older adult terns) and dispersal between river segments and regions. They use the output of available ESH from the habitat models and reservoir shoreline metrics as inputs and produce as outputs fledge ratios (# fledglings/pair of adults), population sizes and population growth rates for each year and segment simulated. The model assumes equal rates of immigration and emigration with other breeding areas.

The habitat and population models include uncertainty about parameter estimates. Hydrological variability is represented by randomly selecting sequences of years in the period of record (1930-2012). The population models also include demographic uncertainty (individually-drawn chances of individuals being born and surviving each year), temporal variability (uncertainty in parameter values from year to year, interpretable as environmental randomness due to factors other than flows) and observation error. For any given scenario, models are run 5,000 times with random variables for each type of uncertainty (Monte Carlo simulations). Results are presented as metrics reflecting the distribution of results, e.g. median and confidence intervals.

3.1.2.4 Effects of management actions on plovers and terns

The management actions evaluated in the EA affect bird populations through several mechanisms: by improving the retention and formation process for habitat, by increasing habitat structure, by increasing availability of existing habitat, or by reducing the mortality of eggs and chicks. The mechanisms have a cascading effect (Figure 25) such that actions that improve habitat structure or availability will, all other factors being equal, also reduce egg/chick mortality and thus improve population metrics. Consequently, if sufficient habitat is available, then less effort will be required on actions to directly improve egg and chick survival to meet objectives. The opposite is also true, such that a lack of habitat requires more intensive population protection.

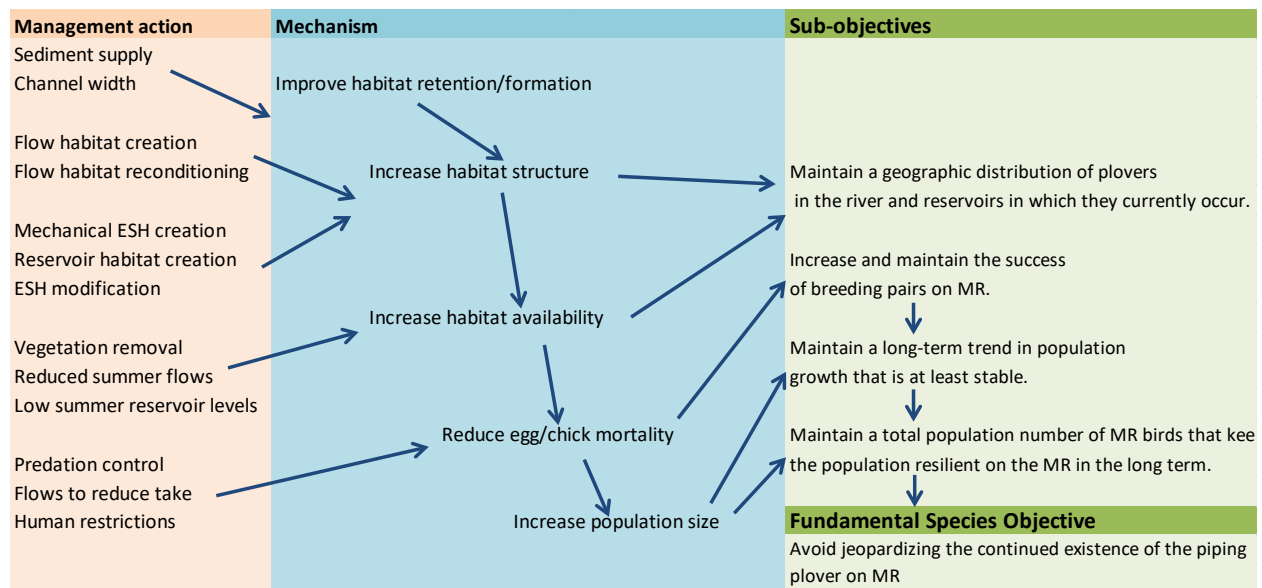


Figure 25. The management actions evaluated in the EA, their mechanisms for affecting habitat and species and consequent effects on the fundamental species objectives and sub-objectives.

A related finding of the EA is that management actions for plovers and terns are highly interdependent: both the opportunities for and effects of a given action depend on how much habitat is available, how dense the breeding bird populations are, and what other actions are taking place (see Section 3.5.4). Decision-makers must take a synthetic approach, considering the status of the system as a whole, the needs of the species, and the management opportunities before choosing a course of action, rather than making separate decisions about whether to implement specific actions (Sections 3.5.3 and 1.1.1 for example). Quantitative models (Section 3.1.2.3) are fundamental to this process, allowing for as many relevant factors to be taken into account as the current state of knowledge allows.

3.1.2.5 Hypotheses and uncertainties

Bird management is made challenging by four sources of uncertainty:

- 1) **Environmental variability:** Future climate and weather cannot be known with certainty. The greatest source of environmental variability for MR birds is basin runoff and resulting system storage and flows, which are major drivers of habitat availability. Local weather, including storms and high temperatures, also affect reproduction and survival. This type of uncertainty is largely irreducible, though advances in modeling can lead to better estimates of the likely distribution of future conditions.
- 2) **Structural uncertainty:** While the fundamental relationship between hydrology, habitat availability and reproductive success is supported by evidence described in the EA, uncertainty remains about the functional form of some relationships. For example: What is the shape of the relationship between flow, ESH area, and sediment transport? What aspects of habitat quality affect fledgling production? What factors best predict reproductive success on reservoirs? How are Missouri River populations affected by metapopulation dynamics? Structural uncertainty can be reduced through research, monitoring, and improvements to models.
- 3) **Parametric uncertainty:** Once the structure of relationships is known, uncertainty remains about their strength. How much sand is eroded or deposited at a particular flow? How much habitat is available at a given river stage? What is the survival rate for birds during their first winter? How strongly does population density affect chick survival? As with structural uncertainty, these uncertainties can be reduced through research and monitoring and incorporated into models. However, they may vary with time and location.
- 4) **Observation uncertainty:** Population and productivity surveys are not 100% accurate. The degree of error and direction of bias can vary by habitat type, conditions and level of effort, and thus tend to differ by location and year. The design and level of effort in a monitoring program can reduce observation error and, in some designs, estimate the error in the survey, which allows for more accurate use of the resulting information.

All types of uncertainty affect the ability to make effective and efficient management decisions, from uncertainty about future conditions (e.g., How much water will be in the system? How many birds will survive and return to breed in specific locations?), to uncertainty about effectiveness of management actions (e.g., How long will created habitat last? How much foraging habitat will be available, and at what quality? How much will predation be reduced by a planned level of control effort?)

While research and monitoring may increase certainty about of system dynamics, long-term trends may decrease that certainty without ongoing or periodic updates. Changes

in climate can change hydrological trends and variability; changes in the sediment budget will affect ESH dynamics. Stressors on the Missouri River, wintering habitat, or nearby breeding areas that would affect productivity, survival, and/or dispersal may also change over time. Ongoing or periodic assessments will be necessary to detect and adjust to changing conditions.

The overarching scientific and management uncertainties for plovers and terns are summarized in the following questions, which AM must seek to address.

Overarching Critical Uncertainties

1. How much habitat is needed to maintain a resilient population of birds and how should it be distributed in space and time?
 - a) How should habitat be quantified and what determines habitat quality?
 - b) What is the relationship between habitat quantity and quality and bird productivity and success on river and reservoir habitat?
 - c) Can the habitat-related factors supporting predation (e.g. nesting density, habitat stability) be managed to reduce mortality of eggs and chicks and limit the need for predator control?
2. How are the Missouri River populations of plovers and terns affected by migratory and metapopulation dynamics?
 - a) How are conditions in overwintering habitats affecting the Missouri River breeding populations over time?
 - b) How do habitat conditions in other breeding areas and dispersal to and from those habitats affect the Missouri River breeding population over time?
3. How will long-term changes in climate and channel morphology affect habitat and species management?
 - a) How will climate affect hydrology including the timing, magnitude, and variability of basin runoff and the frequency, intensity, and duration of extreme events?
 - b) How will sediment dynamics change over time and affect the ability to create and maintain habitat through various means?
4. How can the bird AM program buffer against natural (especially hydrologic) variability and uncertainty for long-term success?
5. How can the bird AM program buffer against institutional and socioeconomic variability and uncertainty for long-term success?

In addition to the overarching critical uncertainties, there are questions about management approaches and specific management actions. Each management action has a testable hypothesis about its mechanism and effectiveness. Table 19 lists these uncertainties and hypotheses.

Table 19. Critical uncertainties related to bird management actions evaluated in the EA and associated management hypotheses.

Management Critical Uncertainties	Actions	Management hypotheses
<p>Creating New Habitat What is the most effective and efficient way of creating habitat within the larger context of management and uses of the Missouri River?</p> <p>a. Are there effective and implementable ways of using flow modification to provide and enhance habitat availability and quality?</p> <p>b. Can habitat be mechanically created in an effective and sustainable manner?</p> <p>c. What are the effects of habitat creation actions on Human Considerations?</p>	Habitat-creating flows	Habitat-creating flows of sufficient magnitude and duration increase the area of nesting/brood rearing habitat and foraging habitat on the river by increasing deposition, assuming sediment is available, thereby increasing fledgling productivity.
	Mechanical habitat creation on river (ESH)	<p>Mechanical habitat creation of ESH in river segments increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.</p> <p>Mechanical habitat creation of sandbars in river segments increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.</p>
	Mechanical habitat creation on reservoir shorelines or islands	<p>Mechanical habitat creation of habitat on reservoir shorelines/islands increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.</p> <p>Mechanical habitat creation of habitat on reservoir shorelines/islands increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.</p>
	Mechanical creation of hydrologically-connected non-sandbar habitat on river segments	<p>Mechanical habitat creation of habitat other than sandbars or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.</p> <p>Mechanical habitat creation of habitat other than sandbars or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.</p>

Maintaining Existing Habitat To what extent can maintaining existing habitat contribute to population objectives compared to creating new habitat? a. Does maintained habitat improve habitat metrics and support production equivalent to new habitat? b. Can flow be used to maintain habitat without increasing net erosion?	Modification or augmentation of existing sandbars	Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation. Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area, which increases food availability and chick survival to fledglings. Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.
	Vegetation removal (spraying/mowing) on river/on reservoir	Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation (by increasing area and by removing cover for predators). Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of chicks to fledglings by increasing food availability. Vegetation removal increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, increasing the number of adults through net immigration from other areas.
	Habitat-conditioning flows	Habitat-conditioning flows are not of sufficient magnitude and duration to create new sandbars, but scour vegetation or deposit new sediment on existing bars, increasing the area of nesting/brood-rearing habitat, thereby increasing fledgling productivity.
Improving Availability of Existing Habitat To what extent can improving the availability of existing habitat through flows contribute to - population objectives compared to creating new habitat?	Reservoir water level management	Declining reservoir water levels between years and/or steady or declining water levels during the nesting season increases the area of suitable nesting/brood rearing and plover foraging habitat on the reservoirs, thereby increasing fledgling productivity.
	Lowered nesting season flows	Lowered nesting season flows increase the area of suitable nesting and brood rearing habitat and foraging habitat on the river, thereby increasing fledgling productivity.
Population Protection To what extent can population protection actions positively contribute to the success of birds on the Missouri River?	Flow management to reduce inundation of nests and chicks	Steady or declining reservoir levels and/or river flows during the nesting season increases survival from egg to chick and chick to fledgling by reducing the risk of nest inundation and chick stranding and by maintaining or increasing foraging habitat.
	Predator removal	Predator removal increases survival of eggs to chicks and chicks to fledglings.
	Nest caging	Nest caging protects plover nests from predators, increasing survival of eggs to chicks, though survival of adults may be negatively affected by cages.
	Human restrictions measures (signs, barriers, education)	Human restriction measures reduce human activity on nesting and foraging habitat, increasing survival both by decreasing direct mortality and indirect effects on survival caused by stress.

3.1.2.6 Implications for AM

Managers on the MR must make decisions without limited knowledge of *what* conditions will occur in the future that will affect both the habitat and species and the ability to manage them, and *how much* those conditions will affect habitat, species, and the effectiveness of management actions. Additional uncertainty remains regarding how effective some management actions are. In comparison to pallid sturgeon, structural uncertainty about bird dynamics—how key elements of the system relate to each other—is relatively low, but the strength, and in some cases form, of those relationships is still uncertain. If these uncertainties are not dealt with explicitly and thoughtfully during the management process, management will be haphazard and inefficient at best, and wasteful and ineffective at worst.

The role of AM for management of terns and plovers is to improve decision making in light of uncertain future system state—an uncertainty that can never fully be resolved—and by improving understanding of how the system functions. The agencies retain discretion and ultimately the decision making authority in determining how to address this uncertainty; the SAMP improves the process, information and understanding surrounding the needed decisions.

The strong role of variable hydrology in driving plover and tern habitat and populations (Buenau et al. 2014) compels a management program to adapt to accommodate droughts and high flows, which affect both the need for action and the ability to act. Simply reacting to these circumstances is not AM. Rather, AM requires that adjustments be made according to the best available science, which is deliberately invested in and improved upon as part of the AM program.

Management decisions for the birds can be improved with learning. Management actions directed towards meeting habitat and bird objectives (passive AM) can add valuable information to ongoing assessments of key processes and relationships if their outcomes are monitored with sufficient and known accuracy. Natural variability broadens the range of conditions for estimating relationships. Opportunities to manage in a way to prioritize learning (active AM) by exploring management options where uncertainty is higher and incorporating experimental design into management planning will accelerate the learning process. For a long-term management program with high resources use, deliberate intent to both learn and use the knowledge gained for improved decision making can lead to significant efficiencies, lowered costs, and improved likelihood of success.

Models integrate learning in the AM process by both projecting the outcomes of different management scenarios and summarizing and quantifying uncertainty. Models can also be used to prioritize information needs and track the benefits of learning over time. Hypotheses about the effects of management actions, developed in the EA (Section 3.1.2.5), are routinely confronted with new information during the AM process to determine the level of support for the hypotheses, revise hypotheses, and develop new ones if warranted.

3.2 Plan and Design

3.2.1 Bird Framework

The key decision-making information and range of decisions for bird AM are illustrated in Figure 26. System status together with the management conditions affecting potential actions provide the information needed to make decisions. That information is interpreted in the context of the current understanding of the system, as synthesized by models, to make decisions. Rather than a dichotomy of continue/adjust, as AM decisions are often portrayed, decisions range from continuing the current activities exactly, to continuing actions with adjustments, to changing which actions are implemented, to adjusting fundamental components of the program. As the breadth and significance of decisions increases, the level of governance and stakeholder engagement increases accordingly.

The variability of the MRMS and the need to balance multiple and, at times, competing species and HC objectives support a toolbox approach to managing for plovers and terns. The approach consists of having multiple flexible management actions and options available to ensure effective management in a context of natural variability and socioeconomic uncertainty. The set of actions in the toolbox and their specifications are determined by the USACE and USFWS in collaboration with MRRIC. As the AM Plan is implemented, learning may result in changes to the bounds and conditions under which actions are implemented, or the addition or removal of management actions. Decisions to make changes are evidence-based; decisions above the implementation level typically involve collaborative processes with MRRIC.

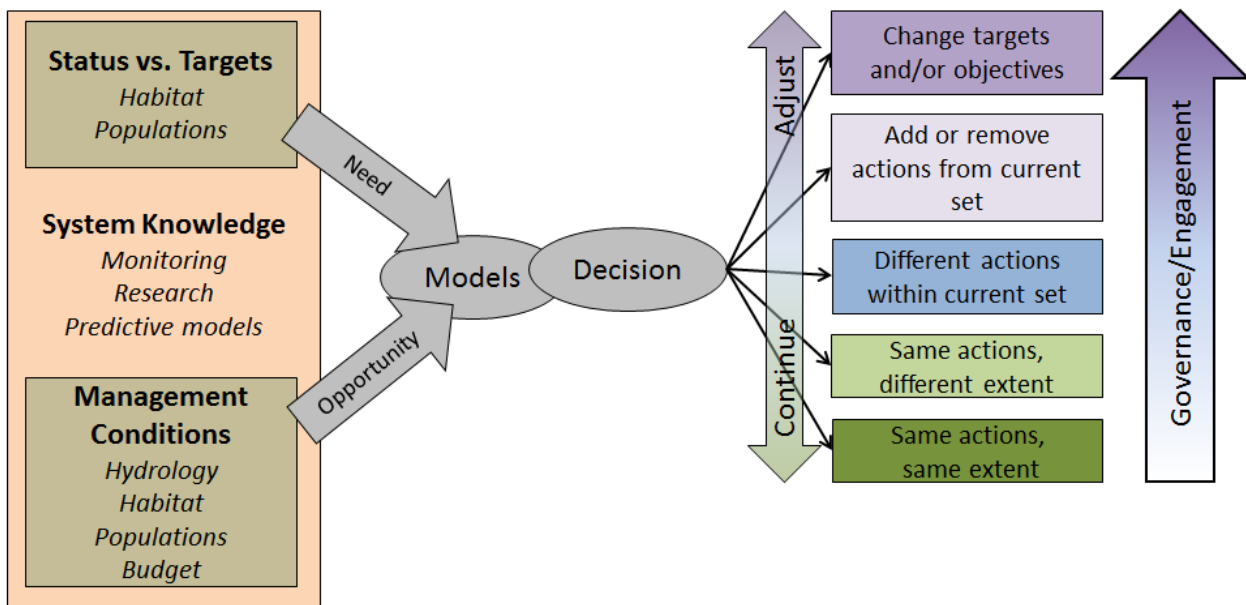


Figure 26. Factors affecting AM decisions for birds and the nature of those decisions

The “toolbox” concept is illustrated in Figure 27. The hypothetical set of actions (A-E) defined in the ROD is available for use. Within that set, several may be selected for use in a specific year (A, C, E), while others are not (B,D). Other actions may have been evaluated in the EIS but are not included in the ROD (F,G), or were not evaluated in the EIS (H,I); actions in either of these categories are not available for immediate implementation. Numbered arrows in Figure 27 indicate the range of AM adjustments that are possible:

1. Reduce the scope (e.g. location, magnitude, duration, timing) of future implementation of an action, most commonly because of the potential for adverse impacts if the action were implemented as currently specified;
2. Increase the scope of future implementation of an action, to improve benefits if adverse impacts are found to not be a concern;
3. Remove an action from future implementation because of insufficient positive effect or unacceptable negative effects;
4. Change how an action is implemented (e.g. techniques and engineering design) without changing the scope;
5. Add an action that was evaluated in the EIS but not part of the ROD, for which the evaluation is still sufficient, requiring a decision document (Section 1.1.6) and, if necessary, adjustments to the Master Manual (Attachment 5);
6. Add an action that was not evaluated in the EIS, requiring additional NEPA analysis (Section 2.2.5). If findings are acceptable, adjustment 5 would be applied next.

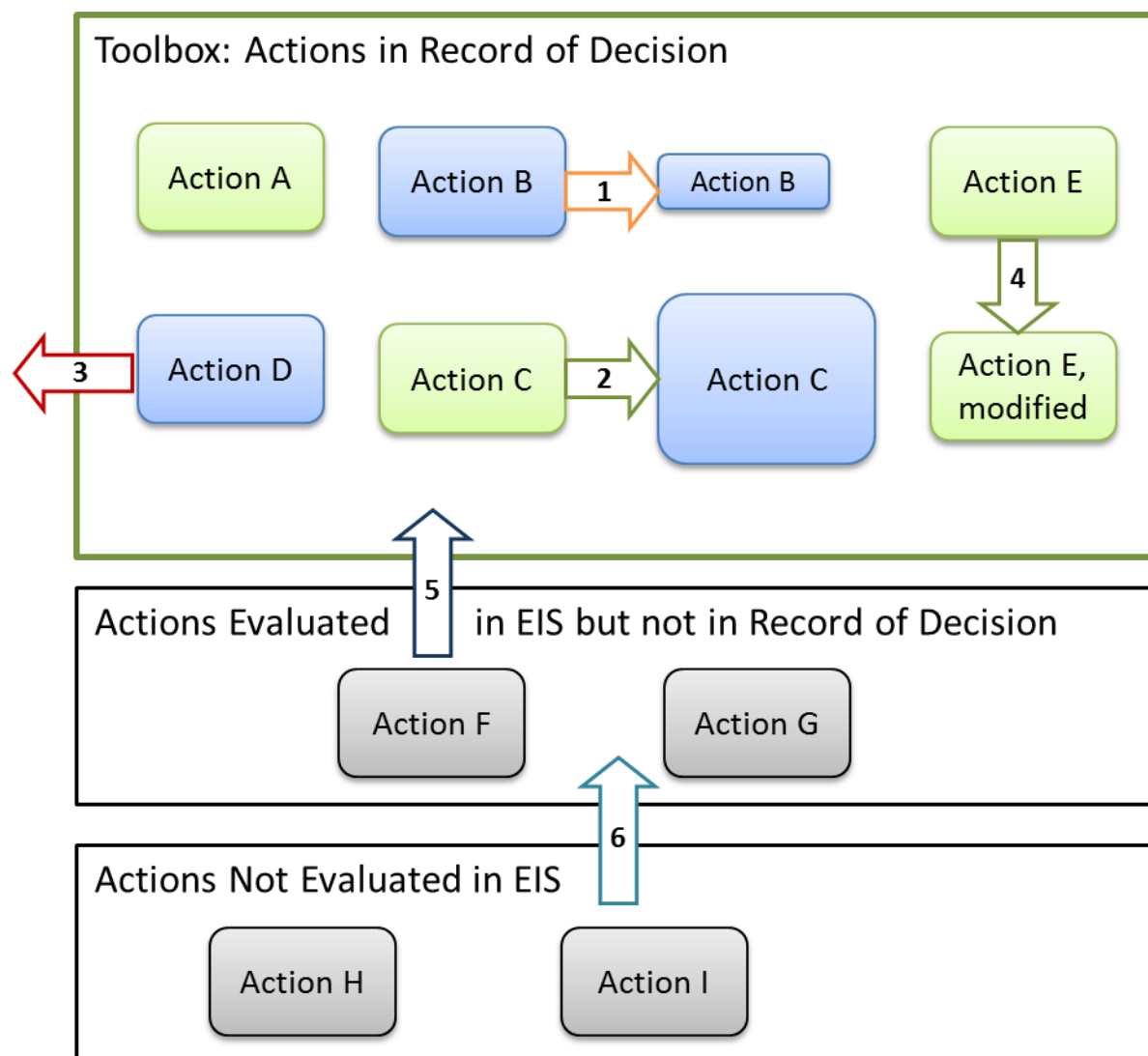


Figure 27. Illustration of "toolbox" concept for AM, indicating action status and a range of potential AM adjustments to actions. Green boxes (A,C,E) indicate actions implemented in a given year; blue boxes (B,D) indicate actions not implemented that year; gray boxes (F-I) indicate actions not currently implementable.

Bird management actions evaluated in the EIS have evidence for their effectiveness based on prior implementation and/or modeling. Other potential management actions were either screened from the EIS alternatives due to uncertainty about their effectiveness relative to impacts, not included in EIS alternatives due to feasibility or authority, not included in the scope of the EA, or identified after alternatives were formulated for the EIS. The AM process includes learning about management actions for which identifiable causal links suggest the potential for species benefits, even if those benefits and any corresponding impacts are not yet understood sufficiently for full implementation. As such, actions not in the ROD with some evidence for effectiveness are identified for research and possible pilot-scale implementation.

The pallid sturgeon AM framework identifies four levels of implementation (Section 4.2.1.1). Research or pilot-scale implementation for birds are analogous to Level 1 and Level 2 actions for pallid sturgeon, respectively. Bird actions included in the ROD will be analogous to Level 4 actions in the sturgeon framework. There are currently no bird analogues to Level 3 actions in the sturgeon framework because ESH targets have been established. Additionally, while Level 1- and Level 2-type actions have been identified for birds, research and implementation timelines have not been defined because of the identified sets of Level 4 actions capable of reaching targets in all EIS action alternatives.

The decision space for an action is bounded by what is effective and what is implementable. An example for a flow action is described graphically in Figure 28). Determination of effectiveness is provided by the EA and subsequent assessments, supplemented by learning from implementation. An action is deemed implementable following collaboration with MRRIC and evaluation in the programmatic EIS or subsequent NEPA analyses to determine the extent to which the action can be used. The overlap of these regions is the usable decision space. If there is no overlap, the action cannot be used unless adjustments to the boundaries are made.

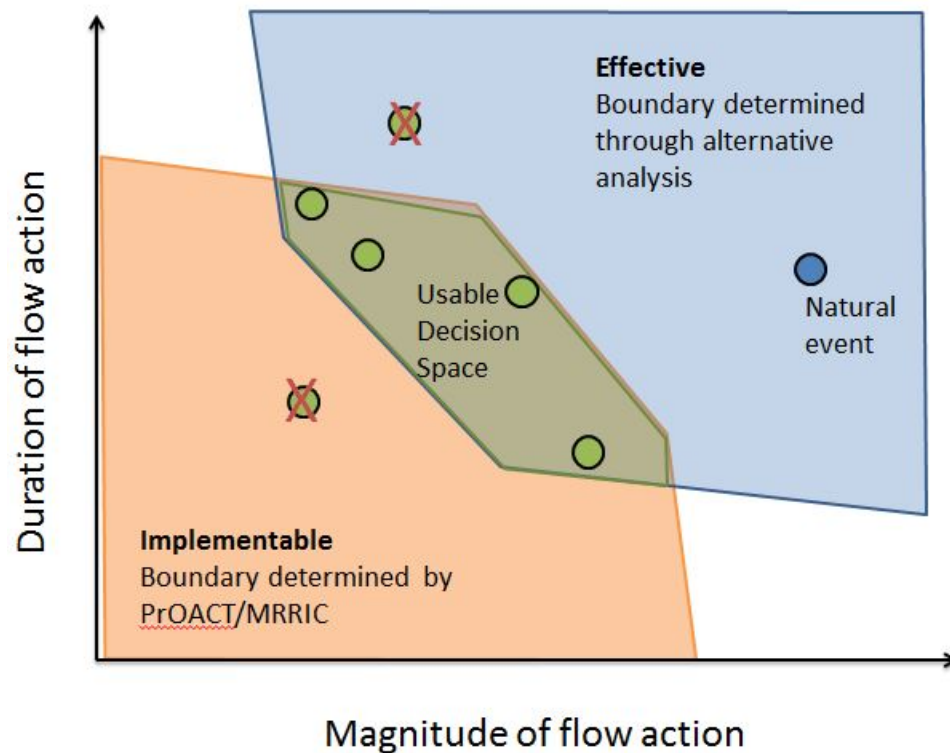


Figure 28. Schematic of decision space using flow management for ESH creation

Actions can be implemented with any combination of parameters that fall within the effective and implementable decision space (green circles.) Depending on circumstances and opportunity, they may be below the upper bounds of what is implementable (e.g. actions implemented at less than their full scope).

Implementation outside the usable decision space (green circles with red X's) is not planned as part of species management as they are expected to either be ineffective or have unacceptable levels of impacts. On occasion, events such as naturally high runoff may lead to reservoir releases outside of the decision space (blue circle.) While not considered an action for habitat or species management, these are important learning opportunities.

The bounds of the implementable and effective regions may be adjusted through AM. If impacts are found to be greater or less than expected, the implementable bound may be adjusted through collaboration with MRRIC (Section 2.4). If effectiveness is found to be greater or less than expected, the effective boundary would be adjusted through the Science Update process (Section 2.4.3). These adjustments may have the effect of increasing, decreasing, or eliminating the usable decision space.

3.2.2 Metrics and management conditions

Habitat and species metrics contain the necessary information to evaluate the overall status of habitat and bird populations on the Missouri River and are directly related to the objectives.

Note: the details of some metrics will depend on decisions about the monitoring program. Some redundancy may be included in the following list; though similar but distinct metrics have benefits for understanding the system, some may not be retained in future versions of the SAMP.

3.2.2.1 Habitat metrics

Emergent sandbar habitat acreage is estimated from satellite imagery acquired during the nesting season. Wet or dry sand with less than 30% vegetation cover is delineated as ESH. The area delineated from imagery will depend upon the flows occurring when the imagery was acquired. To measure ESH in a consistent and meaningful way, the delineated area is adjusted using discharge-area relationships to reflect area available at two different flows:

- 1) **Standardized ESH (acres)** is the area above water if releases were 31.6 kcfs from Gavins Point Dam, 30.5 kcfs from Fort Randall Dam, and 23.9 kcfs from Garrison

Dam¹. Estimating ESH acreage at constant flows each year allows for the detection of changes in sandbar structure due to erosion, deposition, construction, or mechanical modification.

- 2) **Available ESH (acres)** is the area above water during the maximum July release for each reach for the specified year. The acreage available at this flow is used to represent the limiting amount of habitat available during the brood-rearing season, when plover chicks are foraging. It reflects some of the effects of flow management during the nesting season.

Habitat quantification is binary; land cover is classified as ESH or not ESH, with no further distinction as to quality. The AM program will work to develop metrics that determine habitat quality as a function of sandbar form (e.g. elevation, cutbanks), land cover, and landscape characteristics (e.g. channel width, distance to trees) as appropriate. Habitat quality metrics will allow improved estimates of bird productivity and inform planning for habitat construction and modification actions and project design.

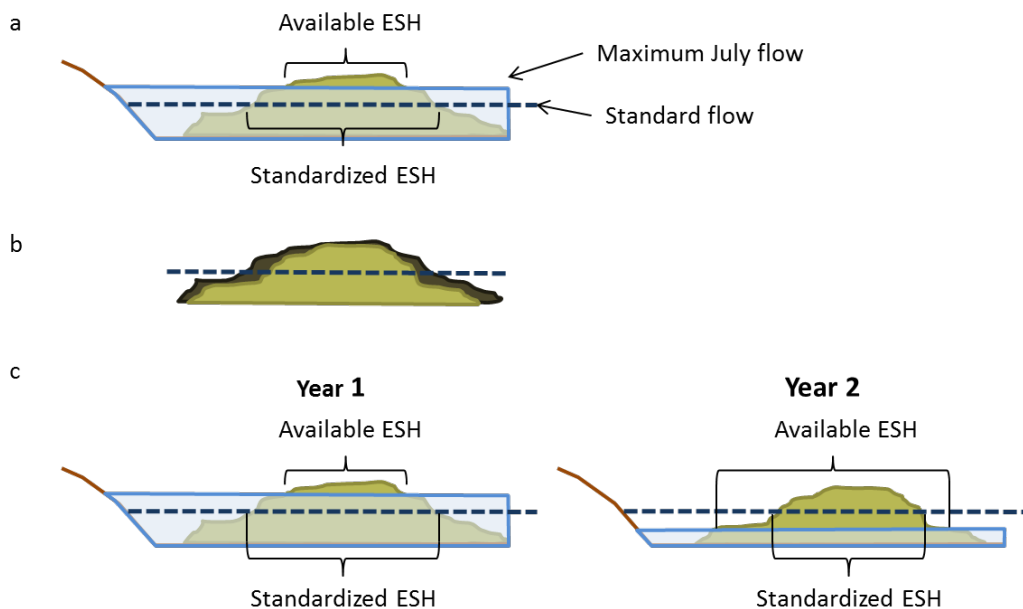


Figure 29. ESH characterization. a) Available ESH is measured at the maximum July flow (blue outline) observed in that year. Standardized ESH is observed at a predetermined flow (dashed line) each year. b) Standardized ESH measures changes in sandbars due to erosion from an earlier year (dark profile) to a later year (light profile). c) Available ESH area may increase from one year to next if flows are lower, even though standardized ESH area decreases from erosion and vegetation growth.

¹ The Gavins Point flow is based on releases from Gavins Point Dam needed to meet downstream flow targets during the July Median, Upper Quartile, and Upper Decile runoff conditions from the Master Manual. The flows for the other segments are based on an average of the July average daily outflows from 1967-2010. The choice of flows is somewhat arbitrary; what matters is that the same flows are used consistently through time and across models and metrics.

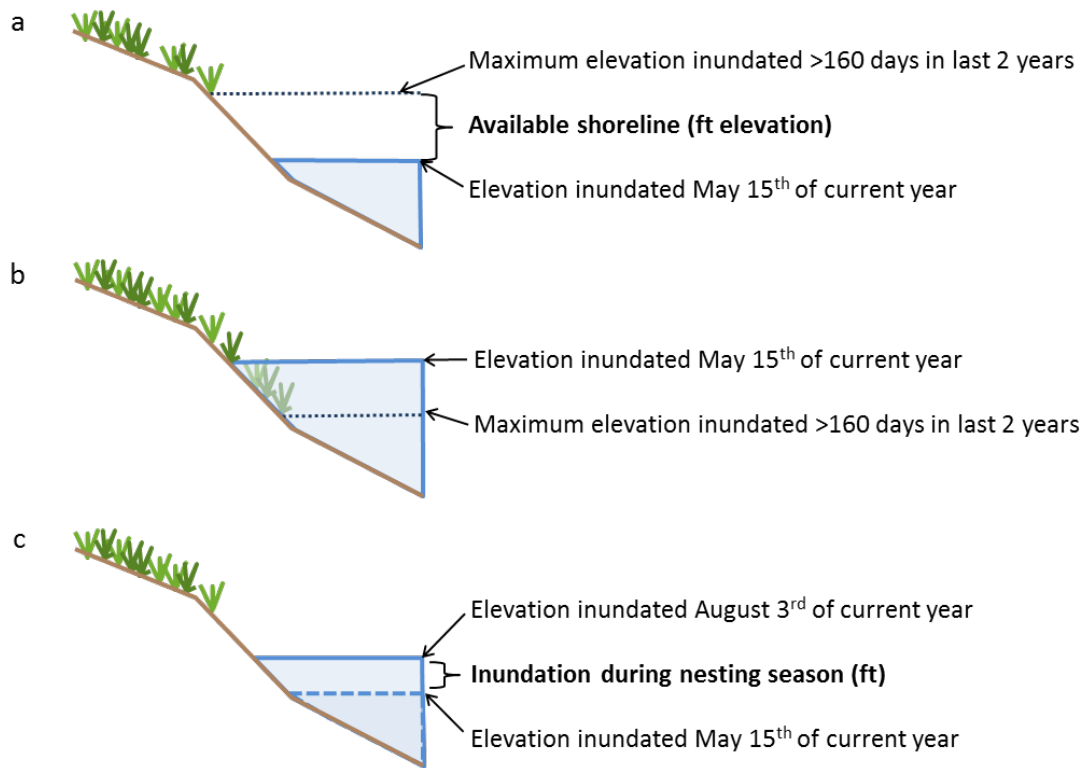


Figure 30. Shoreline habitat characterization. a) Available shoreline is measured as the difference between the maximum elevation inundated >160 days in the previous 2 years (dotted line) and the elevation inundated on May 15th of the current year (solid outline). b) If the elevation inundated on May 15th is higher than the maximum elevation inundated >160 years, the available shoreline metric = 0 ft. c) The inundation metric is the change in elevation between May 15th (dashed line) and August 3rd (solid line) and may be a positive number if water levels increase (shown) or a negative number if water levels decrease (not shown).

The EA found that fledgling productivity on reservoir shoreline habitats was best estimated using two metrics that reflect the change in water elevation along the shoreline between and during nesting seasons:

- 1) **Available shoreline (feet)** is the difference between the maximum shoreline elevation that has been inundated for >160 days during the previous two years and the shoreline elevation inundated on May 15th, the beginning of the current nesting season. If the elevation on May 15th is higher than any elevation that has been inundated >160 days in the previous two years, the metric is zero. This metric estimates the relative amount of shoreline that has been inundated recently and for long enough that it is free of vegetation. Because the shoreline slope varies, this metric does not directly correlate to area¹.
- 2) **Inundation (feet)** is measured as the difference between the minimum and maximum reservoir elevation during the nesting season. The difference is positive or

¹ Habitat area was evaluated as a predictor of reservoir habitat productivity. Not only is habitat area on reservoirs difficult to quantify compared to riverine habitat, area did not predict productivity as well as the metrics defined here.

negative to distinguish between an increase in water levels during the season, which might inundate nests, and a decrease, which typically provides more foraging area.

Available ESH and the two reservoir shoreline metrics were determined during the EA to be the best available predictors of observed fledgling production. Targets have only been specified for ESH, but tracking reservoir habitat metrics enables prediction of bird productivity on reservoirs as part of overall population assessment.

3.2.2.2 *Species metrics*

Population monitoring provides metrics to describe the status of the population and reproductive success:

- 1) **Population size**¹ estimated using one or both of the following techniques:
 - a. **Population size (number of adults)** is the number of adults observed on riverine and reservoir habitat during the nesting season survey.
 - b. **Minimum breeding population estimate (pairs)** is estimated from the daily sum of active nests plus all previously hatched nests plus nests failed during incubation within the previous 5 days. It provides a minimum estimation of pairs as not all nests may be detected.
- 2) **Population growth rate, λ** , is the change in population size between years expressed as a ratio (N_t/N_{t-1}) and indicates whether the population is growing ($\lambda > 1$) or declining ($\lambda < 1$) and to what extent.
- 3) **Fledge ratio** is the number of fledglings observed/(number of breeding adults/2).
- 4) **Population density**² will be estimated as one or both of:
 - a. The number of adult birds/available acres of ESH in a riverine segment.
 - b. The number of breeding pairs/available acres of ESH in a riverine segment.

All metrics are measured and reported at the reach or reservoir scale and aggregated at the region and system scale to provide a thorough understanding of system dynamics. Targets are defined at the region scale (Section 3.2.3).

¹ Decisions yet to be made about the monitoring program will determine if total adult birds can be estimated, or only the breeding population. If the total number is available it will help determine if conditions have reduced the proportion of birds able to breed in a given year.

² Decisions about the most effective means of monitoring population size may determine if only one of these metrics will be used, and which one. As with population size, breeding population density is the primary metric for estimating and tracking the relationship of fledgling production to habitat availability. If the monitoring program allows for the estimation of the total number of birds, total population density would help determine whether conditions are limiting nesting and not just nesting and brood-rearing success. Pending outcomes of monitoring program development, the same metric(s) will be estimated every year.

3.2.2.3 Management Conditions

The following metrics define opportunities and constraints for management actions in a given year. There is some overlap with the habitat and species metrics, but all are listed below to explain their applications.

- 1) **Standardized ESH (acres) and distribution** affect the outcome of flow modification actions. The extent that flows erode or deposit sand is partly a function of existing sandbar area. The effects of nesting season flows on habitat availability also depend on the structure of existing ESH. The location of existing sandbars will determine where new sandbars can be mechanically constructed and whether existing sandbars can be augmented or modified to improve quantity or quality of ESH.
- 2) **Vegetated sandbar area (acres)** determines the potential and extent of vegetation removal as a management action. The age of vegetation affects the methodology for removing vegetation and the outcome. The extent of vegetation on sandbars also affects predation risk, erosion rates, and potential for scour.
- 3) **Storage in reservoirs (million acre-feet) and planned releases (cfs)** determines the potential range of nesting season flows and whether water is available for flow management actions. Higher reservoir releases can affect the ability to construct ESH or manage vegetation.
- 4) **Tributary flows (cfs) and downstream stage (feet)** determine downstream effects of reservoir releases, thus influencing both routine flow management and flow modification actions. Unlike system storage, which changes slowly and relatively predictably, tributary flows and river stage may change abruptly due to precipitation events and thus cannot be forecasted very far in advance.
- 5) **Breeding population density (breeding adults/acre)** influences the need for habitat creation and predation management. If ESH availability is low but populations are small, less additional habitat is needed in the short term than if populations are large. Higher population densities attract predators, increasing proportional impacts on the bird populations.
- 6) **Budget (\$)** determines the extent to which management actions can be implemented. Mechanical habitat construction and modification are most likely to be constrained by budget, but other management, monitoring, and research activities may also be constrained. The budget category also captures the effects of other logistical constraints that might only indirectly affect costs (e.g. contractor availability).

3.2.2.4 Timing

The utility of information for decision making depends upon its availability and timeliness. Hydrological information (system storage, stage) is available on a near-real-time basis. Other information is collected only periodically and model projections may

be needed during the decision-making process. ESH imagery is acquired during the nesting season but must be processed prior to providing acreage estimates. The processing step requires 3-5 months to complete for all reaches; efforts are underway to accelerate this through automation. Population metrics are available in the fall once monitoring data has been compiled and reviewed for quality. Decisions made for upcoming years (Section 2.4.2) are based upon habitat and population information from prior years and projections of future habitat based on various runoff scenarios. Planning, designing and contracting for ESH construction generally requires about two years (e.g. habitat assessments made in FY20 would be used to plan and design in FY21 with construction planned for FY22). Projections can be made using observed and/or predicted flows to estimate ESH availability and other conditions for the upcoming or in-progress season.

3.2.3 Targets

Habitat and demographic targets for piping plovers, as specified by the USFWS (USFWS 2015, Buenau 2015), are described in this section. Because of the greater ESH acreage needs for piping plovers which defend territories for nesting and foraging, compared to colonially-nesting least terns, the USFWS has determined that meeting the plover habitat targets will also fulfill habitat needs for least terns on the Missouri River¹. Therefore habitat targets for least terns have not been specified at this time.

Pending the delisting process for the least tern, conservation plans will be developed for the least tern under an ESA section 7(a)1 consultation process. The plan will include post-delisting management commitments. Should management commitments result in quantitative demographic targets for least terns, they will be added to the SAMP. The USACE monitoring program will continue to monitor and record least tern metrics as per the USFWS post-delisting monitoring plan protocol (in development).

Targets are organized by sub-objective, each of which are necessary to ensure the fundamental objective is met. A description of how the EA models were used to develop targets and related analyses can be found in Buenau (2015). Additional information about how targets will be used in decision making is found in Section 3.6; Section 3.6.5 outlines decision processes for when targets are not met.

Fundamental Objective: Avoid jeopardizing the continued existence of the piping plover due to the USACE actions on the Missouri River.

¹ As terns and plovers do not compete for food or use the same habitat for foraging, there are typically not conflicts between nesting plovers and terns, and they have not been observed to compete for space.

Sub-objective 1 (Distribution): Maintain a geographic distribution of plovers in the river and reservoirs in which they currently occur in both the Northern Region (Missouri River from Fort Peck Lake, Montana to Fort Randall Dam, South Dakota, including reservoir shorelines) and Southern Region (Missouri River from Fort Randall Dam, South Dakota to Ponca, Nebraska)¹.

Means objective: Meet sub-objectives 2, 3, and 4 in both the Northern and Southern regions.

Sub-objective 2 (Population): Maintain a population of Missouri River piping plovers with a modeled 95% probability that at least 50 individuals will persist for at least 50 years in both the Northern and Southern Regions.

Means Objective (ESH): Provide sufficient ESH (in-channel riverine habitat) on the Missouri River to meet the persistence target.

Metric: Number of standardized and available ESH acres measured annually.

Target: From Table 2 in this document:

		Acres of Emergent Sandbar Habitat					
		Northern Region			Southern Region		
		2.5%ile	Median	97.5%ile	2.5%ile	Median	97.5%ile
Standardized ESH Acres		190	450	2160	330	1180	4720
Available ESH Acres Exceeded for Percentage of Years	75%	170	270	555	300	430	720
	50%	420	680	1295	500	740	1550
	25%	960	1920	2670	750	1410	3075
	10%	1965	3000	5165	1125	2240	4945

Timeframe: Median standardized ESH targets (450 acres in the Northern Region; 1180 acres in the Southern Region) must be met for 3 out of 4 years. Median available acres must be met or exceeded for the specified percent of years over a running 12-year interval.

Sub-objective 3 (Population Dynamics): Maintain a stable or increasing long-term trend in population size in both regions.

¹ These regions correspond with two regions (Northern Rivers and Southern Rivers) of the four identified in the *Draft Revised Recovery Plan for the Northern Great Plains Piping Plover* (USFWS 2016). The Southern Region as referred to in this document, however, only refers to the Missouri River mainstem components and not tributaries.

Metric: Population growth rate (λ): the ratio of population size N between the current year and previous year (N_t/N_{t-1}); calculated annually.

Target: $\lambda \geq 1$

Timeframe: The growth rate target must be met as a 3-year running geometric mean¹ calculated as the cube root of the product of the growth rates for each of the three years (i.e. $(\lambda_1 * \lambda_2 * \lambda_3)^{1/3}$).

Sub-objective 4 (Reproduction): Maintain fledgling production by breeding pairs sufficient to meet the population growth rate objectives within both the Northern and Southern Regions on the Missouri River.

Metric: Fledge Ratio: Number of fledglings observed/(number of breeding adults/2), calculated annually.

Target: ≥ 1.14 chicks fledged per breeding pair.

Timeframe: The fledge ratio target must be met as a 3-year running arithmetic mean.

If some or all of the targets are not met over the defined timeframes, a process to determine the cause of the shortfall and identify potential remedies is defined in Section 3.6.5. Note that while the inability of the program to meet targets may lead to reinitiation of Section 7 formal consultation with the USFWS, this occurs at the discretion of the USFWS and after the process described in Section 3.6.5 has been followed.

3.2.3.1 Notes on derivation and application of targets

3.2.3.1.1 How targets were derived

Hydrological, ESH, and plover population models were used to develop ESH targets. The suite of models was run for 50 years with 5,000 replicates for each trial. The trials tested ESH target for each reach to be met by annual construction until an amount of ESH was provided that resulted in meeting the population objective: less than a 5% ($\pm <0.1\%$) risk of dropping below 50 individuals at any point in the 50 years, within either of the two regions. Modeled hydrology based on basin runoff and depletions from the

¹ The 3-year geometric mean is defined as the n^{th} root of the product of n numbers and is the appropriate calculation to describe the average of proportional metrics such as λ . The more familiar arithmetic mean, $(\lambda_1 + \lambda_2 + \lambda_3)/3$ would overestimate the actual population growth over the three-year period.

period of record of 1930-2012 was used under reservoir operating rules evaluated for the MRRMP-EIS Alternative 3, which are in accordance with the 2006 Master Manual. Under this hydrology there is no flow modifications with the purpose of creating ESH. High flows within those operating rules that historically created ESH (e.g. 1975, 1997, 2011) were included and the ESH that is produced contributes to the targets. Fifty-year sequences of modeled reservoir releases over the period of record were used with a randomly selected start year for each model replicate. A full description of the models used is provided in Buenau et al. (2016). The technical basis for ESH target calculations are described more thoroughly in Buenau (2015).

ESH targets have been provided rather than plover population targets. Because of the dynamic nature of both riverine and reservoir habitat, long term (> 10-20 year) population persistence is driven much more strongly by habitat availability than by population size. That is, a relatively large population is unlikely to persist if sufficient habitat is not available in the long run. Smaller populations can persist and grow to larger sizes if sufficient habitat is available most years. With sufficient habitat provided, population viability after 50 years is similar across a range of initial population sizes (Buenau 2015).

This does not indicate that population size is not important for populations in the short term as small population remain more likely to become very small or risk extirpation if faced with several bad years or consistently inadequate habitat. However, a single target population size is difficult, if not impossible, to derive for multi-decadal persistence objectives. If sufficient habitat is provided, population numbers are not expected to become small, and initially small populations should be able to rebound. If populations become small despite sufficient habitat availability, identification of causes for unexpected outcomes (Section 3.5.11) is necessary to determine if other management actions are required to avoid jeopardy to the species. Further explanation and exploration of the use of habitat acres rather than population size is also included in Buenau (2015).

3.2.3.1.2 Role of reservoir habitat and other habitat types

While targets for reservoir shoreline habitat availability have not been specified, plovers nesting on reservoir shorelines are included in the modeling to develop ESH targets. Reservoir conditions and resulting plover productivity on shorelines influence the population viability in the Northern Region and thus the amount of ESH necessary on the Garrison segment to meet viability targets. That is, bird populations on the reservoir count towards meeting the ultimate goal of population persistence. Good nesting conditions on the reservoirs reduce the amount of ESH required to meet population persistence targets.

The current targets assume no significant changes to reservoir operations from the 2006 Master Manual. If reservoir operation rules change in a way that regularly improves nesting conditions on the reservoirs and consequently population viability in the Northern Region, targets should be recalculated to accommodate the changes and give “credit” to management actions that improve reservoir habitat. Conversely, if reservoir operations become more limiting to fledgling production, targets should be recalculated to ensure sufficient riverine habitat is available to support the population.

The habitat targets defined within this document are specifically for in-river ESH. If at some point birds use habitat types other than ESH as defined in this document or reservoir shorelines, and/or management actions involving the creation of other habitat types are broadly implemented (i.e. beyond pilot projects following determination of effectiveness), additional means objectives and associated metrics and targets for Sub-Objective 2 will be developed.

When evaluating demographic metrics (population growth rate and fledge ratio), birds nesting on reservoirs are included. Evaluation of system state (see section 3.5.2) includes calculation of population metrics on both reservoirs and the riverine segments as well as the regions to understand system dynamics and guide management decisions. Good nesting conditions on the reservoirs can offset poor conditions on the river, and vice versa, in order to meet targets.

The status of the populations is evaluated holistically; if populations are doing well and expected to continue to do well even if ESH acreage is below the median target, less focus may be placed on ESH construction. However, it is important to recognize that responses of plover populations to changes in habitat availability may lag in time by one or several years; the lack of an immediately apparent response to ESH availability dropping below target does not indicate targets are inaccurate.

3.2.3.1.3 *Time frame requirements*

Standardized targets are required to be met 3 out of 4 years. This frequency was calculated based on the proportion of time standardized ESH was above target in the model runs used to calculate the target values. A moving window of 12 years is used for available ESH. This allows for calculation of the exceedance probabilities over a meaningful time frame, long enough to accommodate naturally occurring periods of drought and high runoff that affect ESH quantities.

Three-year time frames were specified for the growth rate and fledge ratio parameters. These moving averages allow for brief periods of lowered productivity or population growth (e.g. high-water years that limit or preclude nesting; poor conditions on winter

habitat that reduce overwinter survival and population size). At the same time, they are short enough to be responsive to management actions and provided indication of potential problems in time to intervene. Other time frames could be considered if the 3-year interval is found inadequate for supporting management decisions.

3.2.3.1.4 *Use of fledge ratios to measure productivity*

Fledge ratios are used to measure productivity rather than simple counts of fledglings. Fledgling numbers are valuable information, but must be understood in the context of the number of adult birds nesting on the MRMS. For example, 200 fledglings produced by 200 adults would produce a fledge ratio of 2, which indicates excellent potential for population growth and that habitat is not limiting the population. The same 200 fledglings produced by 600 nesting adults would produce a fledge ratio of 0.67, which is not sufficient to support a stable or growing population and suggests that habitat may be limiting reproductive success. The use of fledge ratios to measure productivity versus measuring nest success and chick survival is a topic of continued discussion. Considerations include accuracy, cost, disturbance and feasibility of monitoring to acquire the necessary information to use one or more of these metrics to sufficiently estimate breeding success on Missouri River habitats.

Fledge ratio targets were derived from the population models. The relationship between the fledge ratio for a given year and λ the following year over a number of model scenarios was used to calculate a fledge ratio that, on average, corresponded with $\lambda = 1$ (a stable population.) Thus the target fledge ratio is an estimate of the fledgling production per pair required to support a stable population. By meeting or exceeding this fledge ratio, the population would be expected to remain stable or grow, respectively, other factors remaining equal. These targets are minimum values; if population density is low, higher values are to be expected and necessary to support a stable or growing population.

Targets for ESH and fledge ratios are dependent upon current system knowledge, as synthesized in the hydrology, habitat, and population models, and upon current conditions including climate, sediment supply, reservoir management practices, and conditions in wintering habitat. As knowledge increases and/or conditions change, the targets described in the SAMP will likely no longer accurately reflect ESH amounts and demographic rates necessary to meet population viability goals. Target values will be updated periodically or following significant changes to models or conditions (see Section 3.6.5)

3.2.3.2 *Incidental Take*

Incidental take consists of harm or harassment to threatened or endangered species that may occur during an otherwise lawful activity that is not the purpose of the activity. In the context of the MRRP, incidental take refers to negative effects upon plover reproduction and survival caused by system operations to serve authorized purposes and implementation of the actions described in the MRRMP-EIS and SAMP. The USFWS generally recognizes that some incidental take is anticipated, but that the USACE will seek to minimize such take. Included in the issuance of a new Biological Opinion, the USFWS will provide an Incidental Take Statement that will include a statement of anticipated incidental take and reasonable and prudent measures, with accompanying terms and conditions, to minimize take. When the statement is available, the SAMP will incorporate the requirements and appropriate considerations related to monitoring and implementation.

3.2.4 **Management Actions**

Management actions for birds serve three general functions: 1) create habitat with construction or flows, 2) improve habitat quality or availability through construction, modification, or flows, or 3) directly protect nests, chicks, and/or adults to improve survival. A set of potential actions for birds was identified and evaluated in the EA. Those actions, and several additional actions identified since the initial EA process, are listed with their associated critical uncertainties and management hypotheses in Table 19. As described in Section 3.2.1, a subset of these actions were evaluated as part of management alternatives in the EIS. Some actions were included in all alternatives, while others were included in only one of the 6 alternatives.

A preferred alternative was identified for the EIS and the selected alternative is described in the ROD. (This process is described in Section 2.2.5). As the set of actions selected for implementation may change during implementation of AM, this document retains the broader set of management actions and associated decision criteria. They are organized into three sections within this document:

- 1) Actions evaluated in the EIS and identified as part of the Preferred Alternative. If included in the ROD they are available for full implementation.
- 2) Actions evaluated in the EIS but not identified as part of the Preferred Alternative. They would not be available for full implementation after the ROD, but may be explored through research and pilot-scale implementation.
- 3) Actions not evaluated in the EIS. They would not be available for full implementation, but may be explored through research and pilot-scale implementation. These actions would typically need supplemental EIS analysis if later chosen for full implementation.

Table 20 summarizes how the bird management actions were addressed in the EIS and how they are organized in this chapter. The following sections describe the actions in more detail. The specific HCs associated with each action are summarized in Chapter 5.

Table 20. Summary of management actions for birds, their primary mechanism, whether they have been evaluated for the MRRMP-EIS and in which alternatives, and whether or not they have been included in the preferred alternative in the EIS. References to the section of this document in which the action can be found are also listed.

Action	Function	Evaluation in EIS	In Preferred Alternative?	Section
Sandbar construction in river channel	Create habitat	Yes; all alternatives	Yes	3.2.4.1
Sandbar augmentation and modification	Create habitat; Improve habitat quality			
Vegetation management	Improve habitat quality			
Flow management to avoid take	Population protection			
Predation management	Population protection			
Human restrictions measures	Population protection			
Habitat-forming flow release (fall)	Create habitat	Yes; Alternative 5	No	3.2.4.2
Habitat-forming flow release (spring)	Create habitat	Yes; Alternative 4, 2*, 6*		
Lowered nesting season flow	Improve habitat availability	Yes; Alternative 2**		
Reservoir habitat creation (shoreline)	Create habitat	No	No	3.2.4.3
Reservoir habitat creation (island)	Create habitat			
Habitat creation connected to river channel	Create habitat			
Reservoir water level management to provide/improve shoreline habitat	Improve habitat availability			

*The spawning cue flows in Alternatives 2 and 6, while not designed to create ESH, may create some ESH in the spring when conducted, depending on magnitude and duration.

**Evaluated based on the flows prescribed in the USFWS 2003 Amended Biological Opinion, not based on outcomes of the Effects Analysis.

3.2.4.1 Actions and Decision Criteria for Full Implementation (Included in Preferred Alternative in the EIS)

Note: Some decision criteria have yet to be specified and will be developed through the collaborative process.

The actions described in this section have been evaluated in the MRRMP-EIS and included in the preferred alternative. If included in the ROD they will be available for program-wide implementation. Actions in this section are analogous to Level 4 actions as described for pallid sturgeon (Section 4.2.1.1).

3.2.4.1.1 Sandbar construction

Definition and function: Sandbar construction creates in-channel ESH using dredges and earth-moving equipment to provide nesting habitat. Sandbars are constructed to the desired condition including foraging habitat at a range of river stages.

Implementation criteria: The predictive ESH model is used to determine how many acres of sandbar habitat per year are needed to have a 75% chance of remaining above the median standardized ESH target for the next 5 years (Strategic Plan horizon). Planning for construction should be undertaken in at least 2 years prior to anticipated shortfalls. If logistics or funding does not allow for all necessary construction, river segments with higher plover population densities and lower fledge ratios and/or population growth rates should receive priority. Planning for construction on Garrison Reach will also consider current and expected conditions and productivity on the reservoirs; a more robust river sub-population may be required to support the northern region population objective if reservoir sub-populations are doing poorly. Model projections help estimate the amount of construction needed. Construction amounts can be adjusted based on habitat quality, fledgling production, and stressors (e.g. predation, human disturbance).

Sandbars are generally constructed in the fall, after all birds have left and before ice forms (September through October or November), but can also be constructed in the spring between ice melt and bird arrival.

ESH construction sites are identified and prioritized to avoid sensitive resources or high likelihood of disturbance and use areas of natural sand accumulation. The nesting history of terns and plovers also helps identify suitable sites. Staging areas must be available nearby, and may incur additional costs. Attachment 6 of Appendix G provides further description of the ESHERS tool, which provides some of the necessary site selection criteria in spatial form.

Constraints: Flows above 35 kcfs during the construction window may preclude construction. Sandbars should be located in areas where flow velocity and resulting erosion are expected to be low; depending on the extent and locations of existing ESH, vegetated bars, and islands, highly suitable sites for new construction may become limiting. Additional practical and regulatory constraints may apply.

Performance metrics: Acreage of standardized and available ESH on constructed sandbars to track total area and sandbar longevity. Additional habitat quality metrics will be developed. Nesting site selection and fledge ratios are used to assess the effectiveness of constructed habitat and its contribution to overall population dynamics. Metrics for nesting vs. foraging habitat and overall habitat quality will developed.

Uncertainties, research and active AM: Previous research and monitoring has provided substantial evidence for the general suitability of constructed sandbars for plover and tern nesting (Buenau et al. 2016). The target amount of ESH needed to support resilient bird populations and the rate it must be created remain uncertain. Improvements in ESH and bird modeling, supported by research and monitoring, will result in more accurate estimates.

While ESH is constructed to a specific acreage, habitat longevity and quality over time is uncertain, both scientifically and because of variable conditions (flow, wind and ice). Efficiency and effectiveness of construction designs and methods can be improved by testing different approaches and assessing performance metrics (Table 21). Annual habitat and bird productivity evaluations incorporate sandbar size, form, and landscape context information. Sandbars deliberately constructed with a range of characteristics will increase learning potential for about optimal project design. Experimental design of sandbars should include adequate monitoring of treated and control sites.

Criteria for adjusting action: *During implementation of construction projects:* adjustments may be required to accommodate unexpected flow conditions. Contingency plans should be included with sandbar design to accommodate changes to conditions. *After implementation of projects:* Results from annual habitat evaluations and experimental design of construction will help determine best practices for sandbar location and design. These results, along with observations and recommendations from the Bird Team, Technical Team, or implementation staff will be captured in annual reporting and used to inform future project design. *Programmatic adjustments:* If the rate of habitat construction needed to meet targets estimated by the model is not producing the desired results, there may be bias in the model and/or flows are consistently in more or less erosive ranges than expected. If effective adjustments to the models aren't available, adjustments to the criteria for determining how much to implement may be needed.

Table 21. Potential questions and study summaries for ESH construction research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty: What is the most effective and efficient way of creating habitat within the larger context of management and uses of the Missouri River?			
Associated Hypotheses: Mechanical habitat creation increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability. Mechanical habitat creation increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.			
How large should sandbars be? Are single large sandbars or several small more effective?	Construction of one large and one or more small sandbars during the same year, controlling for as many landscape and location factors as possible.	ESH area, foraging habitat and nesting habitat area, # adults, # fledglings.	Assess effect of sandbar area on productivity with historical sandbars; control for age, vegetation, landscape features.
What ratio of nesting to foraging habitat is necessary to support successful productivity?	Construction of sandbars of similar size but different nesting/foraging habitat ratios during the same year.	ESH area, foraging habitat and nesting habitat area, # adults, # fledglings.	Assess historical sandbar edge/area and other metrics and site selection/fledgling production.
Where should sandbars be constructed relative to other sandbars used for nesting?	Construct new sandbars of similar size and design during the same year at a range of distances from sandbars currently used for nesting.	Site fidelity, adult and nest density, movement between sites, probability of human disturbance.	Assess use of historical sandbars relative to distance from other sites used for nesting.
Where should constructed sandbars be located relative to landscape features?	Construct new sandbars of similar size and design during the same year at different distances from key landscape features, including distance to trees, width of river, distance from the dam.	ESH area, # adults, # fledglings, predation rates, probability of human disturbance.	Assess use of historical sandbars relative to distance from landscape features.
Is adequate substrate currently available for creating sandbars? Does enough coarse material remain to support creation of new habitat? Does enough fine nutrient-rich material exist to create adequate foraging habitat?	Assess sediment samples throughout river reaches; compare to any samples or assessments taken prior to the 2011 flood. If possible, manipulate sediment composition on constructed sandbars.	ESH area, foraging habitat and nesting habitat area, # adults, # fledglings, forage quality (prey surveys).	
What ESH construction techniques are most cost-effective? What techniques can be used independent of flow magnitude? What construction strategies are most resilient?	Assess ESH developed using alternative construction methods (e.g. hydraulic dredging, mechanical dredging, placement of structures to trap sediments), including alternative containment/stabilization materials and designs.	Cost per unit area of standardized ESH; maximum annual production levels; erosion rates; range of implementable flows	

Decision and collaboration level: The Management Team allocates resources to ESH construction, based upon needs outlined by the Bird Team (including the Bird Work Group) and the balance of other MRRP needs. The implementation staff decides the specific location, methodology, and design of construction activities based on best practices, and the assigned PM manages contracts and monitoring. MRRIC is informed by the Bird Work Group and through the Strategic Plan. See Section 2.4.4.

3.2.4.1.2 *Sandbar augmentation and modification*

Definition and function: Existing sandbars can be augmented or modified to increase ESH area and elevation and/or improve substrate or the quantity and quality of foraging habitat across a range of likely river stages. Modifications may include reshaping to increase edge/area ratios and reduce slopes or cutbanks. Augmentation or modification may be combined with vegetation removal.

Implementation criteria: Augmentation and modification may be used when practical to extend the life of existing sandbars or improve fledgling production. Sites with sufficient nesting area but low quantity or quality of foraging area, or those with lower site selection or fledge ratios than expected, may be suitable for modification. Preferable ratios of nesting area to foraging area will be determined. Modification of existing sandbars may be contraindicated if predation, human activity or other persistent or recurring disturbances have been observed at the site.

Constraints: Constraints on modification or augmentation are similar to those for sandbar construction, though cost-effectiveness per acre may differ depending on fixed costs of the project (e.g. staging). . Implementation is most practical when sandbars are of moderate age. Reshaping highly degraded sandbars may be less effective for overall habitat creation than building new sandbars.

Performance metrics: Acreage of standardized and available ESH on constructed sandbars over time is used to track total area and sandbar longevity. Habitat quality metrics (TBD), nesting site selection and fledge ratios are used to assess the effectiveness of constructed habitat and its contribution to overall population dynamics.

Uncertainties, research and active AM: Little information exists on suitability of modified habitat relative to newly-created sandbars. Before-after-control-impact experiments with sandbars of similar size and shape would provide evidence for effectiveness. Comparisons of bird use of and productivity on modified sandbars compared to constructed or flow-created sandbars, using multivariate analysis to control for sandbar size, age, and other factors, can be used to test the effectiveness of

modified sandbars and/or particular designs of modified sandbars. Examples of sandbar modification studies are listed in Table 22.

Table 22. Potential questions and study summaries for sandbar augmentation and, modification research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty: To what extent can maintaining existing habitat contribute to population objectives compared to creating new habitat?			
Associated Hypotheses: Augmentation/reshaping of existing sandbars increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability. Augmentation/reshaping of existing sandbars increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.			
How does sandbar modification influence use of sandbars by nesting plovers and fledgling productivity? Under what conditions should sandbars be modified?	Modify selected sandbars and compare with unmodified sandbars of similar characteristics; use before-after-control-impact study design.	ESH acres; nesting and foraging habitat; elevation profiles; bird use and fledgling production.	Once general effects of modification have been studied, effects in conjunction with vegetation modification should be evaluated.
What ratio of nesting to foraging habitat is necessary to support optimal productivity?	Modify selected sandbars and compare with unmodified sandbars of similar characteristics; use before-after-control-impact study design.	ESH area, foraging habitat and nesting habitat area, # adults, # fledglings.	Assess historical sandbar ratios of nesting to foraging habitat and other metrics and site selection/fledgling production.
What designs for modification of sandbars are effective?	Compare modification techniques on otherwise similar sandbars; use before-after-control-impact design.	ESH area, foraging habitat and nesting habitat area, # adults, # fledglings.	Once general effects of modification design have been studied, effects in conjunction with vegetation modification should be evaluated.
Does modified ESH have higher predation risks than new construction?	Measure predation rates on modified sandbars and similar new sandbars.	Predation observations; fledge ratios	May overlap with studies for vegetation modification

Criteria for adjusting action: *During implementation:* same as ESH construction.

After implementation: adjustments may be needed if modifications do not last. If performance metrics do not respond as expected, then either modification methods were not well-designed or sufficient in magnitude, location is unsuitable (e.g. especially vulnerable to erosion due to proximity to thalweg) or unusual flows adversely affected the habitat form. If modified sandbars are less-used or less productive than newly constructed bars or predation increases, and problems cannot be corrected, the overall effectiveness of modification as a tool for habitat management should be reevaluated. Cost-effectiveness should be considered to determine value of continuing modifications

(e.g. do large amounts of moderate quality modified habitat produce as many birds as small amounts of high quality newly-constructed habitat for the same or lesser cost.)

Decision and collaboration level: Same as ESH construction.

3.2.4.1.3 *Vegetation management*

Definition and function: Vegetation management includes any non-flow means of reducing or preventing vegetation growth on sandbars to improve ESH area and quality and reduce predation. Spraying post-emergent herbicides in the fall, aerially or via land-based equipment, is an effective means of reducing vegetation cover. Mowing may be used on established vegetation, but removal or burning of standing biomass will generally be required if treated habitat is to attract nesting birds, though mowing may be enough to limit predator cover.

Implementation criteria: Vegetation management should be implemented whenever possible on early vegetation growth, before woody vegetation such as cottonwoods and willows become established. Larger areas may be treated more effectively and quickly through aerial applications.

Constraints: The extent of sandbar area that can be gained through vegetation control is limited to the amount of vegetated area in early successional states. Vegetation control may not be implementable if flows are too high during the fall, though higher flows of sufficient duration may also remove vegetation or limit growth. Limits on the use of herbicides might restrict application in certain locations.

Performance metrics: Area of standardized ESH and reduction in vegetated area; bird nesting use and fledging success on vegetation-managed habitat.

Uncertainties, research, and active AM: A recent before-after-control-impact study suggests that spraying is effective at reducing the establishment of emergent vegetation, but additional evidence regarding habitat quality and bird use and productivity is necessary. Experimental spraying, mowing, and burning of *Phragmites* on sandbars in the Lewis and Clark Lake delta is underway to evaluate the ability to remove predator cover. Comparisons of bird use and productivity on vegetation-managed sandbars compared to constructed or flow-created sandbars, using multivariate analysis to control for sandbar size, age, and other factors, can be used to test the effectiveness of vegetation management and/or particular methodologies. Additional research questions are described in Table 23.

Criteria for adjusting action: *After implementation:* if vegetation-managed sandbars are not used for nesting at levels comparable to newly created sandbars, and/or fledgling production is not comparable, use of methodologies should be reevaluated. Cost-effectiveness should be considered to determine value of continuing management (e.g. do large amounts of moderate quality vegetation-managed habitat produce as many birds as small amounts of high quality newly-constructed habitat for the same or lesser cost.)

Table 23. Questions and study summaries for vegetation management research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty: To what extent can maintaining existing habitat contribute to population objectives compared to creating new habitat?			
Associated Hypotheses: Vegetation removal increases survival of eggs to chicks and chicks to fledglings by reducing predation (by increasing nesting/brood-rearing area and by removing cover for predators). Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of chicks to fledglings by increasing food availability. Vegetation removal increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.			
Does spraying vegetation reduce the amount of vegetation on sandbars to provide for suitable nesting habitat?	Spraying of test sites with before-after-control-impact design (some studies already conducted/underway). Age, successional stage, and species of vegetation must be taken into account.	Transects and imagery assessments of vegetation before and after treatment and relative to control sites; bird use and productivity at treated vs. control sites; predation rates.	Once understanding of effects of vegetation modification, may experiment in conjunction with sandbar augmentation.
Can Phragmites and other wetland vegetation be successfully removed from sandbars in the Lewis and Clark Lake delta?	Spraying, mowing, and burning of wetland vegetation on Lewis and Clark Lake sandbars (study underway). Age, successional stage, and species of vegetation must be taken into account.	Transects and imagery assessments of vegetation before and after treatment and relative to control sites; bird use and productivity at treated vs. control sites; predation rates.	
What are the successional dynamics/revegetation rates of sandbars following flow creation, mechanical creation, or vegetation management action? Are they different between habitats created by different methods? How have these activities influenced the seed source for revegetation?	Treatment of test sites on habitat previously created, modified, and/or treated through different means.	Transects and imagery assessments of vegetation following the management action annually. Take core samples to measure seed bank.	
What are the direct or indirect effects on invertebrate prey base for piping plovers from vegetation control, either through the loss of vegetation or effects of herbicides on	Spraying of test sites with before-after-control-impact design.	Measure invert abundance along transects and organic nutrient content, Transects and imagery assessments of vegetation before and after treatment and relative to control sites; bird use and	

Question	Study Summary	Metrics	Related studies
prey (if any). How does the effect on prey base affect productivity?		productivity at treated vs. control sites. Measure for residual herbicide.	
How does vegetation (species, density, distribution, etc.) affect erosion rates for ESH and what are the tradeoffs between erosion and productivity?	Assess bars with different vegetation conditions using a BACI study design.	Erosion rate and productivity as a function of vegetation type, density, distribution, location on the bar, and age.	Constructed bars with vegetation used to assess construction strategy or design.
Does vegetation-controlled ESH have higher predation risks than new construction?	Measure predation rates on modified sandbars and similar new sandbars.	Predation observations; fledge ratios	May overlap with sandbar modification studies.

Decision and collaboration level: The Management Team decides on the budget available for vegetation management as well as construction, as informed by the Technical and Bird Teams. Implementation staff decide on location, methodology, design and contracting based upon identified best practices. MRRIC is engaged through team meetings associated with the science update process (section 2.4) and informed through plenary meetings and the Strategic Plan updates.

3.2.4.1.4 *Flow management to avoid inundation of nests or chicks*

Definition and function: The magnitude of releases needed to support authorized purposes are determined and established prior to the nesting season so that birds will nest at high enough elevations to reduce the risk of inundating nests. Once birds have initiated nesting, reservoir releases are managed to minimize nest inundation or chick stranding by using a steady release/flow-to-target release strategy. This approach recognizes that tributary inflows below Gavins Point Dam typically decrease over the summer, potentially requiring increases in releases from Gavins Point in order to meet downstream navigation targets. Such increases can inundate nests at low elevations or inundate entire sandbars, leading to mortality of pre-fledged chicks. By setting releases somewhat higher than necessary to meet navigation targets at the beginning of the nesting season, later increases can be avoided.

Implementation criteria: Steady releases are set in May based upon forecasts and navigation expectations. Increases in flow above the elevation of known nests are avoided to the extent possible. Short-term reductions in releases from Gavins Point Dam may be used in cases of high discharge from downstream tributaries, to reduce flood risk; if reductions are short enough that birds do not initiate nests at lower elevations, releases can be returned to higher levels once downstream flood risks have passed with low risk of take. Once eggs have hatched, releases can be increased

gradually as needed to meet navigation targets. The initial steady release is set in anticipation of reduced tributary flows later in the summer to limit the necessary increase. The range of flexibility for flows depends upon the sandbar elevation profiles relative to target releases and resulting river stage. Releases may also be adjusted to avoid having low-elevation sandbars just above the river stage that attract nesting birds but are likely to be inundated.

Constraints: Releases from Gavins Point are also managed to meet flood control, navigation, and water supply needs.

Performance metrics: Releases (cfs) during nesting season (including slope and direction of changes), number of nests inundated, chick mortality, fledge ratios.

Uncertainties, research, and active AM: The effectiveness of flows to avoid inundation of nests or chicks is assessed by observations during the nesting season, but nest detection is not perfect and loss of chicks is difficult to attribute to specific causes. Flow management during the nesting season may also cause sub-lethal stress by inundating foraging habitat or decreasing forage quality. Erosion rates may be affected when flow is varied to meet downstream targets. Targeted research may be required to determine lethal and sublethal effects of nesting season flow management and effectiveness of steps to reduce those effects (Table 24). Inundation risk is difficult to model beyond the current season given current capabilities; information on sandbar and nest elevation, together with model refinements, would improve predictions.

Criteria for adjusting action: *During implementation:* flows are adjusted in response to downstream flood control targets and navigation using information from productivity monitoring on nest elevations and at-risk nests, in balance with meeting other authorized purposes. *After implementation:* Effects of flow management on egg/chick mortality and outcomes of research may be used to adjust implementation rules, with consideration of HC effects. This may require adjustments to the Master Manual.

Decision and collaboration level: These flows are routinely implemented by Water Management. Changes to operations needed to address unusual circumstances will be made by Water Management following guidelines in the Master Manual. Systematic changes must be approved by MRBWMD at the Oversight level.

Table 24. Potential questions and study summaries for research and active AM regarding flow management to reduce take.

Question	Study Summary	Metrics	Related studies
Management Uncertainty: To what extent can population protection actions positively contribute to the success of birds on the Missouri River?			
Associated Hypotheses: Steady or declining river flows during the nesting season increases survival from egg to chick and chick to fledgling by reducing the risk of nest inundation and chick stranding and by maintaining or increasing foraging habitat.			
What are the predicted effects of different magnitudes, durations, timing and frequencies of flows to reduce take on ESH, species, and HC metrics?	Modeling studies to assess a range of flow options; should be repeated following significant new information for ESH, population, and/or HC models as needed.	ESH acres (standard and available); fledgling production; population size; HC metrics (TBD)	
How do flow increases in July/August affect breeding success directly by flooding nests or by stranding chicks?	Additional focused monitoring of effects of flow increases during nesting season; if possible, explore range of flow increases when navigation requirements allow.	Nest success; egg loss; chick mortality.	Assessments of flow variability effects on nest success and chick mortality within normal operations (detection of chick mortality and ability to associate with cause is low with historical monitoring).
How do flow increases in July/August affect breeding success indirectly (starvation, etc.)?	Additional focused monitoring of effects of flow increases during nesting season; if possible, explore range of flow increases when navigation requirements allow.	Forage habitat; prey density and diversity; chick growth and weight.	Assessments of flow variability effects on forage habitat availability within normal operations currently or historically.
What are the effects of nesting season flow changes on erosion of ESH?	Additional focused monitoring of effects of flow increases during nesting season; if possible, explore range of flow increases when navigation requirements allow.	ESH acres; nesting and foraging habitat metrics; elevation profiles.	Assessments of flow variability effects on ESH area and nesting/foraging habitat within normal operations. Geomorphic assessments and monitoring of stage/area relationships.
What are the effects of flows to reduce take on HC metrics?	See Chapter 5		

3.2.4.1.5 Predation management

Definition and function: Predation management includes nest caging for plovers and predator removal to reduce mortality of eggs, nests and adults and increase fledge ratios. Nest caging is not suitable for terns.

Implementation criteria: Plover nest caging should be initiated when the density of both plovers and terns increase (thresholds TBD) or when predation begins to be observed. The presence and extent of vegetation, connectivity to shore, proximity to

trees, and other factors that increase predation risk should be considered when determining the need for predation management.

Constraints: Effectiveness is primarily linked to the ability to detect nests (for caging) and to detect and remove predators. Predation rates are typically lower and management less necessary when bird population densities are low (habitat is relatively abundant); thus benefits gained from management are primarily observed when densities are high. Caging of plover nests can result in small increases in mortality for adult plovers though cage design can minimize this effect.

Performance metrics: Predation observations (it may not be possible to estimate rates); number of predators removed; nesting success and fledgling production on sandbars with predation management.

Uncertainties and opportunities to improve management decisions: A relationship between population density and predation has not been quantified, nor have thresholds been identified due to limited data. Causes of nest loss and chick mortality are not always known, and mortality may be undetected, especially for new nests and chicks near fledging. Some data exists for effectiveness of nest caging and predator control and effects of cages on adult mortality, but most data has been collected on other habitat types (e.g. alkali wetlands, ocean beaches) rather than the MR and high uncertainty remains about effectiveness. Enhanced monitoring or research to detect predation, quantify density-predation relationships, and identify other risk factors at the local or landscape scale as well as experimental design of management practices would aid in measuring effectiveness and predicting population impacts (Table 24). The use of cameras to detect predators has been studied and may provide useful data.

Criteria for adjusting action: *During implementation:* observations of high density nesting and/or predation trigger initiation of or increases in management during the nesting season. *After implementation:* Experimental design of management practices and/or sufficiently intensive monitoring should be used to assess effectiveness of predation management and identify adjustments.

Decision and collaboration level: Implementation staff decide on amount and locations as informed by the Technical Team, Bird Team, and ongoing monitoring during the season.

Table 25. Questions and study summaries for predation control research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty: To what extent can population protection actions positively contribute to the success of birds on the Missouri River?			
Associated Hypotheses: Predation removal increases survival of eggs to chicks and chicks to fledglings.			
At what acreage and nest density does predation have significant population effects?	Increase monitoring at study sites to improve detection of predation (may be able to use cameras).	Presence/absence of predators and predator evidence. Percent of nests lost to predation through the field season relative to ESH area and nesting density.	
What are the predominant predators? Do they vary spatially? Does predation decrease as the field season progresses (as other species initiate nests or predators tend to their own young)? Does this decline then allow for adequate productivity rates to support a growing population? Does it vary predictably year to year?	Evaluate presence/absence of predators and predator evidence and the rates of predation on nests and chicks throughout the field season. Identify predominant predators. Assess predator type spatially along the river corridor.	Presence/absence of predators and predator evidence. Percent of nests lost to predation through the field season and year over year. Shifts in predator composition with space and time.	
Can we successfully implement predation management actions? Under what conditions (if any) can predation management be successful?	Implement predation control program measured against similar habitat areas with no predation control	Successful nests, # of fledglings compared to similar non-treated areas	If predation management is successful - determine the factors that created success

3.2.4.1.6 Human restrictions measures

Definition and function: Human restrictions measures include signs and symbolic fences, as well as education, to restrict people from entering nesting areas. These measures are intended to reduce stress on and mortality of eggs, chicks, and adults caused by people, vehicles, and pets.

Implementation criteria: Generally implemented for all sandbars where nesting is observed. Not always used on isolated areas of reservoir shoreline with low human activity.

Constraints: Human restriction measures require low effort and resources to implement, but require enforcement by other agencies. In the absence of sufficient enforcement, restriction measures may be ignored or destroyed.

Performance metrics: Evidence of nest/chick loss attributable to human activity (detection rates may be low); evidence of human presence on sandbars; nesting and brood-rearing success on sandbars with human restriction measures in place.

Uncertainties, research, and active AM: As with predation, the effects of human activity are not fully known as not all nests are detected and not all cause of egg/chick loss can be accurately identified. Mortality rates are typically localized and less than other causes of mortality. Adverse, especially sublethal, effects of human disturbance (stress, impacts on foraging) are difficult to quantify. Thus the contributions of the action to fledgling productivity and population dynamics are difficult to estimate and predict.

Criteria for adjusting action: *During implementation:* observations of problematic human activity indicate increased need for enforcement during the nesting season. *After implementation:* Experimental design of management practices and/or more intensive monitoring should be used to assess effectiveness of human restrictions measures and adjust as necessary.

Table 26. Questions and study summaries for human restrictions measures research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty To what extent can population protection actions positively contribute to the success of birds on the Missouri River?			
Associated Hypotheses Human restriction measures reduce human activity on nesting and foraging habitat, increasing survival both by decreasing direct mortality and indirect effects on survival caused by stress.			
What level of human activity occurs on sandbars with and without signs? How often do lethal impacts occur?	Observation of control and treated sites, particularly during weekends/holidays, to observe effectiveness of signing or other restriction measures.	Evidence of human activity. Number/percent of nests lost to human impacts through the field season relative to sandbar location and management activities.	Monitoring/cameras to detect predation may also increase detection of human activity.
Are there alternative measures of reducing human activity in nesting areas that are more effective?	Observation of sites with alternative restriction measures, particularly during weekends/holidays, to observe effectiveness of signing or other restriction measures.	Evidence of human activity. Number/percent of nests lost to human impacts through the field season relative to sandbar location and management activities.	

Decision and collaboration level: Restriction measures are implemented by default; the Bird Team and implementation staff make any necessary decisions on locations and methods.

3.2.4.2 *Actions for Research and Pilot-Scale Implementation (Evaluated in the MRRMP-EIS)*

Actions described in this section were evaluated in the EA and as part of the alternatives in the EIS. They were found to have beneficial effects for plovers, but were not included in the preferred alternative. If it is determined after the ROD that there is need for these management actions, steps will be taken prior to implementation. The steps may include additional NEPA processes if the EIS analyses no longer suffice. Additional decision documents and changes to the Master Manual may also be required before full implementation. (Section 1.1.6).

Uncertainty remains about the effectiveness of actions in this section. The AM process may take advantage of events occurring within typical system operations (e.g. high or low releases following the current Master Manual) to study about the potential effects of flow modifications. These studies can be done without any bird-specific management action being conducted. The research and pilot-scale implementation (e.g. flow tests) described in this section are similar to Level 1 and Level 2 actions for pallid sturgeon (Section 4.2.1.1). However, unlike for sturgeon, timelines have not been established for implementation of these studies or actions. Timelines were not required by the USFWS as the set of actions in the preferred alternative have been determined during the EIS process as able to meet piping plover targets. Pilot projects or flow tests may be implemented using site-specific NEPA processes or within the scope of the water management rules in place following the ROD.

Changes made to the set of bird actions included in the selected alternative as identified in the ROD could result in changes to this section of the Plan.

3.2.4.2.1 *Habitat-forming flow release*

Definition and function: Releases exceeding 30kcfs from Garrison Dam, 40kcfs from Ft. Randall Dam, and 50kcfs from Gavins Point Dam are expected to deposit more sand than they erode, increasing the amount of standardized ESH. The amount of ESH created depends on the magnitude and duration of the flow release and the area of sandbar present prior to the release (ambient ESH).

Implementation criteria: *If selected as a management action for full implementation:* Habitat-forming flow releases evaluated in the EIS were the following:

- A spring release initiated on April 1st consisting of a 60 kcfs release from Gavins Point and Fort Randall dams and 42.5 kcfs from Garrison dam for a 5.5 week duration. System storage must be greater than 42 MAF.
- A fall release initiated on October 17th consisting of a 60 kcfs release from Gavins Point and Fort Randall dams and 42.5 kcfs from Garrison dam for a 5.5 week duration. The service level must be greater than 35 kcfs.

Implementation may include releases of lesser magnitude or duration than as specified, but will not exceed these magnitudes or durations without a formal process to change the flow definitions (See Attachment 6).

If implemented as a flow test: Criteria for any potential implementation as a test flow (including requirements prior to testing and conditions under which it would not be tested) have not yet been determined. As with other actions, flow tests would be included in the Strategic Plan and thus identified during the AM cycle at least a year prior to implementation.

Constraints: *(If selected as a management action for full implementation)* Habitat-forming flows will not be used more frequently than once every 4 years, nor within 4 years of any naturally-occurring flow that created 250 acres or more of standardized ESH. They will not be used when system storage is less than 42MAF for a spring release or the service level is less than 35 kcfs for a fall release. If releases from Gavins Point combined with downstream tributary flows exceed flood thresholds (71kcfs at Omaha, 82kcfs at Nebraska City, or 126kcfs at Kansas City), releases are decreased by 5 kcfs increments until downstream flow criteria are met or the release falls below 45 kcfs, at which point it is terminated.

Performance metrics: Standardized ESH acreage before and after the flow release measures the effectiveness of the releases. Sandbar elevation profiles should be surveyed to measure created ESH available across a range of typical nesting season flows. Nesting bird densities and fledge ratios are used to assess the quality of flow-created habitat and its contribution to overall population dynamics. Metrics for nesting and foraging habitat and overall habitat quality have not been used historically but will be developed under the AM Plan. Flow releases may result in more habitat on reservoirs the following season; reservoir habitat metrics and bird productivity should also be assessed as an outcome of habitat-forming flows.

Uncertainties, research, and active AM: The amount of habitat created by any specific combination of flow magnitude and duration is variable and depends upon the distribution of pre-existing sandbars and sediment supply, among other factors. The longevity of created ESH is dependent upon subsequent flows, which are unknown but

can be statistically represented. Habitat quality and long-term availability will also depend upon the elevation of sandbars created by the flow; current predictive capacities are limited in this respect. Each implementation, therefore, will provide valuable information for model development and/or validation, which will help refine future implementation decisions Table 27.

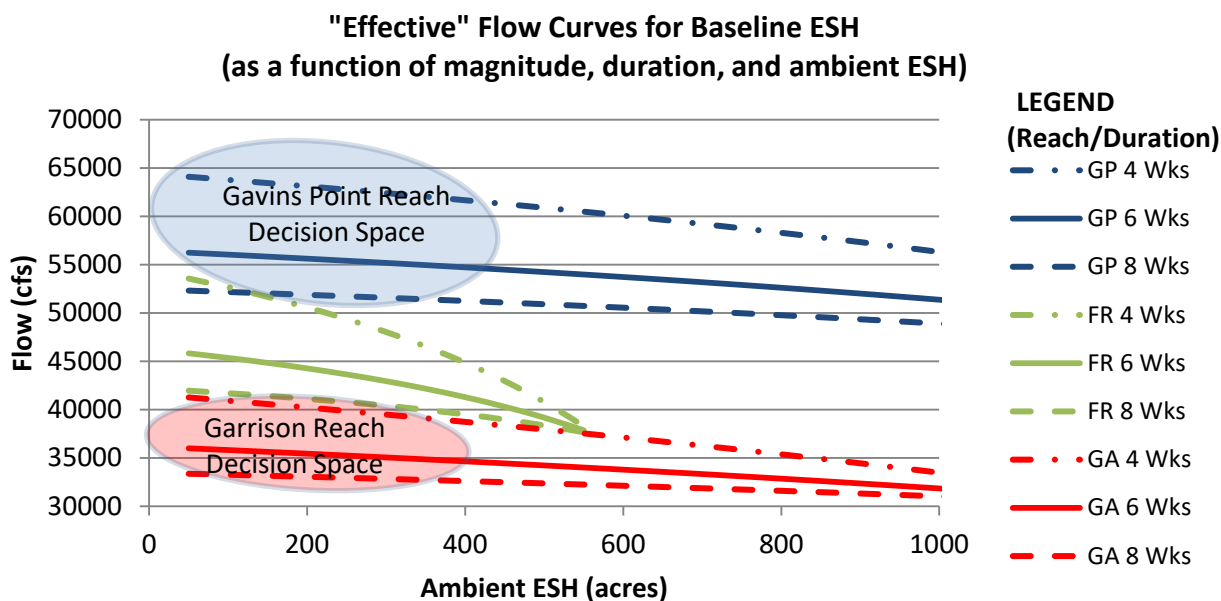


Figure 31. Anticipated range of “effective” combinations of flow and duration that meet standardized acreage targets given initial ambient ESH, with presumed “decision space” shown for Gavins Point and Garrison reaches.

Learning can be enhanced by a) monitoring sandbar evolution during “natural” flow events, b) implementing flow actions included in the ROD when the necessary conditions exist, and c) implementing a range of flow magnitudes, duration, and timing. Monitoring of key HC metrics will validate/improve existing relations between habitat creation flows and impacts to interior drainage and flood risk concerns. Further discussion can be found in Section 3.5.7.

Table 27. Potential questions and study summaries for habitat-creating flow research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty Are there effective and implementable ways of using flow management to improve habitat availability and quality? What are the effects of habitat creation actions on Human Considerations?			
Associated Hypotheses Habitat-creating flows of sufficient magnitude and duration increase the area of nesting/brood rearing habitat and foraging habitat on the river by increasing deposition, assuming sediment is available, thereby increasing fledgling productivity.			
What are the predicted effects of different magnitudes, durations, timing and frequencies of habitat-forming flows on ESH, species, and HC metrics?	Modeling studies to assess a range of flow options; should be repeated following significant new information for ESH, population, and/or HC models as needed.	ESH acres; fledgling production; population size; HC metrics (TBD)	
What is the relationship between proposed habitat-creating flows and ESH area created?	Implement flows when conditions permit; explore effects of different initial conditions and flow parameters; track evolution of habitat.	ESH acres; nesting and foraging habitat; elevation profiles; bird use and fledgling production.	Geomorphic assessments of flow variability effects on ESH within normal operations.
What are the effects of habitat forming flow implementation on HC metrics?	See Chapter 5		
How will changes to sediment supply and channel morphology (including aggradation/degradation) alter the effects of flow releases on ESH deposition?	Conduct a numerical modeling study to assess the effects of decreasing sediment supply, coarsening of sediment gradation and lowering of bed profile on ESH/flow relationships. Validate model study results using trends from monitoring over time.	"Effectiveness" of flows (magnitude and duration) in creating ESH (acres) as measured by departure from current response curves.	Geomorphic investigations of sandbars in the Garrison and/or Gavins reaches.

Criteria for adjusting actions: *During implementation*, if combined releases plus tributary flows exceed flood thresholds (71kcfs at Omaha, 82kcfs at Nebraska City, or 126kcfs at Kansas City), releases are decreased by 5 kcfs increments until downstream flow criteria are met or the release falls below 45 kcfs, at which point it is terminated. *After implementation*, monitored impacts will be compared with the level of acceptable impact determined in coordination with MRRIC. If results fall outside the acceptable range, adjustment to the action specification (i.e. the "decision space") may be made to avoid or reduce risks in the future. Benefits from the action will also be compared with expected outcomes; possible adjustments will be noted if the observed benefits deviate significantly from projected values. However, given the complex nature of the system, any adjustments should be made with the best possible understanding of *why* the deviation occurred, the expected range of natural variation and the likelihood of re-occurrence. E.g. an extreme hydrological event during implementation may not allow a realistic assessment of action effectiveness and impacts. The tolerance for unusual outcomes and the ability to repeat actions despite them will be different for actions with

unexpectedly high HC impacts versus those with unexpectedly low ESH creation, as repeating instances of the latter carries lower risk.

Decision and collaboration level: For flows within the decision space of the ROD, the Bird Team can suggest a flow action as a management option for Management Team consideration. Should the Management Team suggest a flow action, implementation must be approved by MRBWMD, who informs MRRIC of intent, monitors for impacts and reviews after-action assessment with MRRIC. If the Management Team decides the decision space for flows needs to change based on evaluations from the Technical Team or Bird Team recommendations, Oversight must approve the proposed changes after consultation with the MRBWMD and MRRIC.

3.2.4.2.2 *Lowered nesting season flow*

Definition and function: The availability of ESH during the nesting season (~May 15-August 15) depends on flows. Lowered flows expose more ESH and may also reduce overall erosion, depending upon other releases. Lowered nesting season flows are limited to Fort Randall and Gavins Point dams. If water is held back, lowered nesting season flows reduce nesting habitat availability in the reservoirs relative to if flows had not been reduced.

Implementation criteria: *As implemented according to the 2006 Master Manual:* Opportunity to provide low summer flows exists under the current Master Manual, dependent primarily on system storage level and the status and location of commercial navigation on the river. Plate VI – 1 in the Master Manual shows the service level related to system water supply. If the water supply is such that water must be evacuated from the system low summer flows would not be likely during the nesting season. However during droughts when water conservation is a priority and service level is less than full service low summer flows are likely.

Section 7-13.1.1 of the Master Manual describes the manner in which day-to-day regulation of the system to support navigation will be accomplished. Anticipated traffic or the absence of traffic at the control points will have a bearing on the selection of the control point for providing the service level. After selection of the control point, System releases are adjusted so that in combination with anticipated tributary flows they will meet the target flow at the control point. This affords an opportunity to provide low

summer flows if navigation traffic is below Omaha so the control point is Nebraska City or Kansas City and enough tributary flow is present to allow for low summer flows.¹

If implemented specifically for increasing ESH availability: If available ESH has been below percent exceedance targets over the period of evaluation, the ability of reduced flows to increase the likelihood of meeting targets should be evaluated. Similarly, if standardized ESH area is below the median target and the ability to create new habitat through flows or construction in the near future is projected to be limited (e.g. insufficient system storage or budget), lowered summer flows should be given additional consideration as they can increase the longevity of existing habitat by reducing erosion and/or allow for habitat-creating flows in the fall. If the standardized ESH area is very low, benefits of lowered nesting flows are less and may not be worth impacts to reservoir habitat and/or HC.

Bird population densities should be high enough to limit reproductive success (e.g. Figure 39) for reduced flows to be beneficial. As reduced flows in the southern reaches affect habitat in the northern reservoirs (Sakakawea and Oahe), consideration should also be given to habitat and population trends in the reservoirs, with lower flows a higher priority when the southern region is less likely to meet habitat and/or population targets than the northern region. Model evaluation of habitat availability and expected population density should be used to assess benefits prior to implementing flows.

Constraints: The ability to lower releases from Gavins Point Dam during the nesting season depends on basin hydrologic conditions including inflows downstream of Gavins Point Dam. Lowered releases from Garrison Dam have not yet been investigated; additional constraints might apply.

Performance metrics: Standardized and available ESH during lowered releases measures their effectiveness on habitat availability. Standardized ESH measurements in the year following the flow are used to assess any net effects on erosion. Reservoir habitat metrics must also be evaluated to measure the tradeoff between downstream ESH and reservoir shoreline habitat. Fledgling production in both river and reservoir segments should be evaluated to determine net effects of lowered flows.

¹ The years 2007 and 2008 provide an example of water conservation and high downstream flows coupled with missing navigation targets in the Sioux City and Omaha reaches produced very low releases from Gavins Point during the bird nesting season. Releases ranged from 10.5 kcfs to 21.5 kcfs in 2007 and 13.1 kcfs to 22.8 kcfs in 2008. For comparison purposes the average release from Gavins Point since the system filled in 1967 ranges from 28.5 kcfs to 36.6 kcfs during the bird nesting season.

Uncertainties, research, and active AM: The estimated relationship between flow/stage and ESH availability is uncertain; this relationship varies with time and location and thus requires periodic re-evaluation, particularly following high flow events. Imagery acquisition, LiDAR and/or elevation surveys during lowered flows provide additional information about flow/area relationships and sediment dynamics at lower flows. Implementation of a range of reduced flows under different conditions would accelerate learning. Additional studies (Table 28) can also reduce uncertainty.

Table 28. Questions and study summaries for lowered nesting-season flow research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty To what extent can improving the availability of existing habitat through flows contribute to -population objectives compared to creating new habitat?			
Associated Hypotheses Reduced summer flows increase the area of suitable nesting and brood rearing habitat and foraging habitat on the river, thereby increasing fledgling productivity.			
What are the predicted effects of different magnitudes, durations, timing and frequencies of lowered nesting-season flows on ESH, species, and HC metrics?	Modeling studies to assess a range of flow options; should be repeated following significant new information for ESH, population, and/or HC models as needed.	ESH acres (standard and available); fledgling production; population size; HC metrics (TBD)	
What is the relationship between lowered nesting season flows, nesting and foraging habitat, and fledgling production?	Implement varied flows when conditions permit; explore effects of different initial conditions and flow magnitude and duration.	ESH acres; nesting and foraging habitat; bird use and fledgling production.	Assessments of flow variability effects on ESH area and fledgling production within normal operations. Geomorphic assessments and monitoring of stage/area relationships.
What are the effects of lowered nesting season flows on HC metrics?	TBD: See Chapter 5		
How will changes to channel morphology (including aggradation and degradation) alter the effects of nesting season flows on habitat availability?	Numerical modeling study to assess the effects of decreasing sediment supply, coarsening of sediment and lowering of bed profile on ESH elevations. Validate using trends from monitoring over time.	Exposure of ESH (acres) at low discharge values and trends therein.	Geomorphic investigations of sandbars in the Garrison and/or Gavins reaches.

Criteria for adjusting action: Actions are implemented within a range of acceptable risks (of high adverse impacts, low benefits, or both). If results fall outside the acceptable range, adjustment to the action specification (i.e. the “decision space”) may be made to avoid or reduce risks in the future. Similar adjustments might be made if the observed benefits deviate significantly from projected values. However, given the

complex nature of the system, any adjustments should be made with the best possible understanding of *why* the deviation occurred and the likelihood of re-occurrence. E.g. an extreme hydrological event during implementation may skew many outcomes and not give a realistic assessment of action effectiveness and impacts. The tolerance for unusual outcomes and the ability to repeat actions despite them will be different for actions with unexpectedly high HC impacts versus those with unexpectedly low ESH creation, as repeating instances of the latter carries lower risk.

Currently, lowered flows in summer can be implemented when other requirements such as navigation do not need to be met or when runoff is very low as described above. These modifications are constrained by other authorized purposes and not focused on optimal effects for bird nesting. In the case that lowered summer flows are determined to be both effective and necessary for more regular implementation or implementation triggered by ESH or bird population conditions, a supplemental EIS would be prepared if not already covered by the MRRMP/EIS, and the process for changing the Master Manual technical criteria would be exercised, if required (see Attachment 6 of Appendix A).

Decision and collaboration level: For flows within the decision space, the Management Team recommendation to implement must be approved by MRBWMD, who informs MRRIC of intent, monitors for impacts, and reviews the after-action assessment with MRRIC. If the Management Team decides the decision space for flows needs to change based on recommendations from the Technical Team, Oversight must approve the proposed changes after consultation with the MRBWMD and MRRIC.

3.2.4.3 *Actions for Research and Pilot-Scale Implementation (Not Evaluated in the MRRMP-EIS)*

Actions described in this section were identified in the EA or the ProACT process as potential management actions but were not evaluated as part of the alternatives in the EIS. Additional evidence for the effectiveness of these actions from research and/or field testing is required to determine whether full-scale implementation should be considered. The research activities and pilot-scale implementation described in this section are similar to Level 1 and Level 2 actions for pallid sturgeon (Section 4.2.1.1).

Pilot projects or tests may be implemented using site-specific NEPA processes or within the scope of water management rules following the ROD. If evidence for action effectiveness supports broader implementation, supplemental programmatic NEPA coverage will likely be required prior to full-scale implementation. New actions that may be added during the course of the AM process would be added to this section.

3.2.4.3.1 *Non-sandbar habitat creation or modification*

Definition and function: The USFWS has determined that created habitat other than sandbars must be hydrologically connected, i.e. it regularly comes into contact with the mainstem river or reservoirs, in order to contribute to bird objectives for the MRRP. Projects must fall within the USACE' management authority. Habitat types that have been proposed include:

- Habitat on reservoir shorelines: habitat that is created, modified, or maintained to improve physical characteristics (slope or substrate), reduce or remove vegetation growth and reduce predation (e.g. through fencing); may be employed at different elevations to provide habitat when reservoirs are filling.
- Created islands in reservoirs: habitat not attached to the shoreline. In some locations such as small side bays water control measures may be considered to provide habitat less subject to inundation during the nesting season.
- Areas connected to the river but not in the channel (e.g. backwaters): sandy areas with limited vegetation that provide foraging habitat for plover chicks. Such habitat would be subject to fluctuating water levels but flow velocities may be lower, limiting erosion or supporting deposition.
- ESH located in areas not currently managed for sandbar habitat: potential is very limited in channelized portions of the river but some habitat could potentially be formed in association with sturgeon habitat projects.

Hydrologically disconnected habitat (e.g. sandpits separated from the river) is not included in this category. Most non-sandbar habitat types are conceived as providing habitat that is either available when most other habitat is not (e.g. during high water) or may persist longer than ESH due to less exposure to erosive flows. These habitats would require ongoing and possibly extensive habitat maintenance and predation management in the absence of natural processes, especially for floodplain-attached habitat. Each type of non-sandbar habitat identified now or in the future will be evaluated for effectiveness separately.

Implementation criteria: Criteria to implement pilot projects and to implement at broader scales under development will be incorporated as addenda to the SAMP.

Constraints: Habitat must be hydrologically connected to the mainstem Missouri River and provide wet sand foraging habitat accessible to plover chicks hatched at the site. Some sandy areas on the floodplain that least terns have used for nesting will not be suitable for piping plovers due to lack of wet sand foraging habitat. Property ownership and access may limit capabilities to construct/maintain habitat. Suitable topography and substrate must be available, or costs may increase considerably.

Performance metrics: Area of suitable habitat (as defined by ESH habitat criteria of suitable substrate and <30% vegetation cover) area of foraging habitat, number of birds nesting at the site, fledge ratios, predation observations.

Uncertainties, research, and active AM: Data on nesting and brood-rearing success, site selection, and site fidelity on habitat other than sandbars and reservoir shorelines is extremely limited due to the absence of such habitat on the Missouri River. A few sites outside of the ESH-managed segments on the Missouri River have been used for nesting by terns, but not by plovers. Some data exists for hydrologically disconnected habitat on the Central Platte River, but differences in substrate type, groundwater, creation of sites, and the general lack of in-channel habitat in that section of the Platte River limit the ability to consider those sites as analogous to potential alternative habitat creation on the Missouri River. Monitoring data is more limited on the Lower Platte and precludes comparative analysis. The numerical plover and habitat models can be revised to include alternative habitat types, though analyses will be limited by the lack of empirical data.

Feasibility studies will be required prior to pilot implementation; a study on the feasibility of created reservoir habitat was previously conducted and estimated low benefit. Pilot-scale projects would need to be evaluated over multiple years to understand habitat suitability, and plover nest site selection and site fidelity over time and relative to a range of potential conditions on the river (e.g. when ESH or reservoir shoreline habitat is abundant vs. when it is scarce.)

Information from projects not implemented by the MRRP may be used to address this management uncertainty if sufficient information is collected. At minimum, site area, number of nesting adults, and number of fledglings produced at a site, using the same metrics and definitions as for the MRRP monitoring, is necessary to evaluate action effectiveness. Information on additional management actions (i.e. predator control, vegetation management) including treatment type, level of effort, and/or area treated is also required. Observations of predation rates, nest success rates, dispersal, and site fidelity are useful and will be included in action effectiveness assessments if available. Example studies to assess non-sandbar habitat are listed in Table 29.

Criteria for adjusting action: The process to move from research to pilot projects and from pilot projects to broader or full-scale implementation depends on the nature of the action and the extent to which it was studied as part of the MRRMP-EIS. Section 1.1.6 provides an overview of the considerations involved. Actions not evaluated in the EIS would require NEPA coverage. Acceptance of new actions outside the ROD would follow a high level of collaboration among the agencies and the MRRIC (Section 2.4).

Table 29. Questions and study summaries for non-sandbar habitat creation research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty To what extent can non-sandbar habitat creation actions contribute to the success of birds on the Missouri River?			
Associated Hypotheses Non-sandbar habitat creation contributes to the fledgling production and population growth on the Missouri River by providing additional habitat and habitat that may be available at times when ESH and/or reservoir shoreline habitat is not available.			
Non-intervention research studies (Level 1)			
Is <non-sandbar habitat type> creation feasible?	Assessment of site availability, access and suitability, construction requirements and costs; maintenance requirements and costs	Number, location and area of suitable sites; costs	
Are there analogous sites or conditions that provide evidence for the effectiveness of a habitat type?	Assessment of evidence from MRMS and other plover breeding areas	Area of suitable habitat; site selection; site fidelity; adult numbers; breeding bird density; number of fledglings and fledge ratio	
What are the site, region, and population-scale effects predicted by models for a range of habitat creation locations and levels?	Modeling studies using data if available; expert opinion if not (with results indicating the impact of using expert opinion vs. relying solely on existing data)	Fledgling production, number and proportion of birds nesting at alternative habitats, response of population size and viability metrics to number of sites and area of alternative habitat	
Pilot projects and/or field experimentation (Level 2)			
Does a pilot project provide habitat and support fledgling production similar to sandbar or reservoir shoreline habitat in the same region?	Pilot-scale implementation of one or a small number of sites; additional monitoring of sites and nearby sandbar/reservoir shoreline habitat may be required to assess effectiveness; banding to assess site fidelity and dispersal	Area of suitable habitat; site selection; site fidelity; adult numbers; breeding bird density; number of fledglings and fledge ratio; return rates	

Decision and collaboration level: The Management Team allocates budget and other resources to research and pilot-scale implementation activities, based upon recommendations of the Bird Team and the balance of other MRRP needs including pallid sturgeon management activities. Implementation staff decides upon the sites, methodology, and design of construction activities based on best practices and manages contracts and monitoring.

3.2.4.3.2 Reservoir water level management to provide shoreline habitat or

reduce take on shorelines

Definition and function: Stable or declining reservoir levels during the nesting season can reduce or prevent nest inundation and provide additional foraging habitat (Section 3.2.2.1). Changes in reservoir elevation between years provides nesting habitat. Manipulations to releases to improve reservoir habitat metrics would be expected to improve performance metrics for the reservoirs.

Implementation criteria: Reservoirs are not currently managed to provide plover habitat or manage nest inundation. Opportunities to manage releases for populations nesting on shorelines while meeting other reservoir management requirements may be identified and specified if learning during AM determines that such management would provide sufficient net benefits toward meeting bird objectives in the Northern Region.

Constraints: Maintaining reservoir levels in the optimal storage range and releasing water at rates necessary to support authorized purposes and limit nest/chick take in riverine reaches are currently prioritized over managing for reservoir habitat. Depending on ESH availability and elevation, releases may reduce habitat availability or inundate nests. Overall population effects of reservoir management depend upon the relative population size and productivity of birds nesting on reservoir shorelines vs. reaches and between the Northern and Southern regions.

Performance metrics: Available shoreline and inundation; plover population size, fledgling counts, and fledge ratio on reservoir shorelines. Effects on ESH and fledgling production on riverine segments should also be evaluated.

Uncertainties, research, and active AM: While the general effects of reservoir water elevation changes on plover productivity can be estimated from, the ability and opportunity to manage for desirable reservoir shoreline habitat metrics while meeting other requirements and having a net positive effect on plovers is uncertain. Limited modeling conducted to date has shown small positive effects for birds of “unbalancing” reservoirs to improve shoreline habitat availability; additional modeling to explore different potential management rules would be necessary before test actions could be specifically defined. Monitoring of plovers nesting on reservoirs tends to be less accurate than on river reaches due to the length of the shoreline that must be surveyed. The ability to understand the effects of shoreline habitat availability on nesting plovers during normal operations is affected by the precision and accuracy of that monitoring.

Table 30. Questions and study summaries for reservoir water level management research and active AM.

Question	Study Summary	Metrics	Related studies
Management Uncertainty To what extent can improving the availability of existing habitat through flows contribute to -population objectives compared to creating new habitat?			
Associated Hypotheses Declining reservoir water levels between years and/or steady or declining water levels during the nesting season increases the area of suitable nesting/brood rearing and plover foraging habitat on the reservoirs, thereby increasing fledgling productivity.			
Non-intervention research studies (Level 1)			
Are there options for managing reservoir water levels for shoreline habitat and take reduction that provide net positive benefits to birds and acceptable HC impacts?	Modeling studies to determine potential for managing water levels to improve reservoir habitat; effects on plover productivity (riverine and reservoir) and reservoir use; effects on HC metrics	Reservoir shoreline habitat availability and inundation, ESH availability, plover adult # and fledge ratio, HC metrics TBD	Interactions with modeling for habitat-forming flows, as they also affect reservoir elevations compared to routine operations.
How do plovers respond (site use, dispersal, and fledgling production) to changes in water elevations on reservoir shorelines?	Monitoring, potentially with increased effort as needed to ensure sufficient statistical power to detect effects, banding to monitor site fidelity and dispersal to other segments or non-MR nesting areas	Reservoir shoreline habitat availability and inundation, ESH availability, plover adult # and fledge ratio, site fidelity and dispersal	Dispersal/metapopulation studies could inform assessment of site selection, fidelity, and dispersal.
Pilot projects and/or field experimentation (Level 2)			
Does management of reservoir water elevations improve plover nesting on the reservoir and net positive benefits to the population?	Modification of releases within operational flexibility; TBD	Reservoir shoreline habitat availability and inundation, ESH availability, plover adult # and fledge ratio, HC metrics TBD	Flow modifications for other purposes may affect reservoir shoreline habitat; ensure sufficient monitoring on reservoirs to detect effects

Criteria for adjusting action: *To move from research to pilot projects:* To be determined during AM implementation. *To move from pilot projects to broader or full-scale implementation:* To be determined during AM implementation.

Decision and collaboration level: Management Team recommendations to implement test releases must be approved by MRBWMD, who informs MRRIC of intent, monitors for impacts and reviews after-action assessment with MRRIC. If the Management Team decides the action should be elevated from test releases to broader applications, Oversight must approve the proposed changes after consultation with the MRBWMD and MRRIC.

3.2.5 Effects of Pallid Sturgeon Actions on Terns and Plovers

Actions for pallid sturgeon generally only affect birds if they modify reservoir operations. Channel reconfiguration or sediment augmentation activities are separated

geographically from the areas where the vast majority of plovers and terns nest, and propagation has no mechanism to affect bird habitat or populations. The effects of all proposed actions (including those not in the Preferred Alternative) are summarized in Table 31.

Changes to reservoir operations in the Upper Missouri River (Fort Peck Dam to headwaters of Lake Sakakawea) for pallid sturgeon would affect shoreline nesting habitat on Lake Sakakawea. The degree of the effects would be dependent on releases from Garrison Dam; adjustments to Garrison releases to accommodate differences in inflow may in turn affect birds nesting in Garrison Reach or Lake Oahe. A drawdown in Lake Sakakawea has the potential to affect habitat availability for plovers, but the long-term effects would depend on the extent of the drawdown and the topography of the shoreline. The same volume of water would create larger fluctuations in the elevation of a drawn-down reservoir. The effects of any proposed action of this type could be evaluated with modeling.

Flow modifications for pallid sturgeon in the Lower Missouri River (Fort Randall or Gavins Point Dam) would have direct effects on ESH availability in the Gavins Point Reach and could have indirect effects on habitat availability on reservoir shorelines. Spawning cues could create ESH, though not necessarily as efficiently as habitat-forming flows. Flows of lower peak magnitudes may cause net erosion of ESH rather than deposition. The second pulse of the spawning cue would occur during the nesting season and could inundate nests initiated prior to the release. As birds may be able to renest after the peak of the flow release, overall effects on productivity are uncertain. As empirical evidence for bird responses to flow patterns such as these is not available, the ability to estimate effects of this action through modeling are constrained and uncertainty is high.

Actions for pallid sturgeon create few conflicts or additional constraints (aside from budget allocation) on bird management actions. Storage used for a spawning cue flow would be unavailable for a specific ESH-creating flow modification. Any lowered summer flow for fish, as with those designed for birds, could result in held-back water that would need to be released in the fall; if releases exceed ~35kcs from Gavins Point they may preclude or interfere with ESH creation, modification, or vegetation removal activities (fall releases of sufficient magnitude or duration may create ESH).

Table 31. Effects of pallid sturgeon management actions on piping plovers and least terns

Action	In Pref. Alt.?	Geographic overlap*	Direct effect on bird habitat	Direct effect on bird reproduction or survival	Constraints on bird actions (other than budget)	Uncertainty
Alter Flow Regime at Fort Peck	No	Yes, Lake Sakakawea, downstream depending on Sakakawea releases	Positive or negative effects on reservoir shorelines, depending on Lake Sakakawea releases	Depends on relative releases between Fort Peck and Sakakawea, more likely to reduce risk of nest inundation on shoreline	No	Medium
Temperature Control, Fort Peck	No	No	No	No	No	Low
Sediment Augmentation at Fort Peck	No	No	No	No	No	Low
Passage at Intake	Yes	No	No	No	No	Low
Upper Basin Propagation	Yes	No	No	No	No	Low
Drawdown Lake Sakakawea	No	Yes, Lake Sakakawea	Decrease in overall shoreline availability, but sufficient habitat may remain, depending on topography and population size. Increase to extent of inundation when reservoir fills.	No	No	Medium
Alter Flow Regime at Gavins Point, spawning cue	No, but potential for flow test after 9 years	Yes, Gavins Point, Lake Sakakawea, Lake Oahe	Spawning cues of sufficient length and duration create ESH. Lower pulses may erode ESH. Above-normal releases provide additional reservoir shoreline habitat.	Rises beginning in mid-late May may inundate nests. Birds may be able to renest after peak of pulse, depending on timing and subsequent releases	Use of storage could limit ability to implement flow modifications specifically to create ESH	High
Alter Flow Regime at Gavins Point, low summer flows	No	Yes, Gavins Point, Lake Sakakawea, Lake Oahe	Decreased flows in summer increase availability of existing ESH. Decreased releases from Gavins may result in inundation of nests on reservoir shorelines.	Low flows may increase foraging habitat availability and improve chick survival; if releases must be increased, nests or chicks may be inundated.	If water stored during low flows is released in the fall at discharges >35 kcfs, ESH construction, modification, or vegetation removal may be impeded	Medium

Action	In Pref. Alt.?	Geographic overlap*	Direct effect on bird habitat	Direct effect on bird reproduction or survival	Constraints on bird actions (other than budget)	Uncertainty
Temperature management, Fort Randall	No	Yes, Fort Randall Reach and Gavins Point Reach	No	Might improve prey availability/quality for plovers or terns	No	Medium
Interception and Rearing Complexes	Yes	No	Limited evidence of opportunistic use of existing sturgeon habitat projects for nesting by terns	Possible positive impact if birds nest in areas associated with IRCs	No	Medium
Spawning Habitat	Yes	No	No	No	No	Low
Propagation Lower River	Yes	Yes	No	No	No	Low

3.3 Monitoring

Monitoring of habitat, species performance, action effectiveness and unusual events, is necessary to adaptively manage plovers and terns (Figure 32). Monitoring tracks performance metrics relative to targets and identifies needs for changes to management. It also provides some of the information needed to develop and maintain accurate models (e.g. fledgling production relative to habitat availability; changes in ESH availability as a function of river flow). Monitoring must be flexible and responsive to ensure timely and consistent data collection in a highly variable system. As habitat and populations on the Missouri River can change rapidly, monitoring for performance metrics must occur annually. Information needs that are not addressed through the monitoring program may need to be addressed through focused research.

The following priorities have been suggested for ESH and bird monitoring. Monitoring should:

1. Provide information to continue advancing the habitat and population models for decision support;
2. Provide information for the evaluation of action effectiveness, including the population response;
3. Track the habitat and population performance metrics annually to determine whether targets are being met;
4. Provide information for assessing incidental take;
5. Be cost effective and practical to implement; and

6. Be comparable with previous monitoring programs to the extent possible while meeting objectives 1-5.

Using and advancing the models requires the ability to:

4. Estimate population size, change, and density
5. Estimate fledgling productivity by habitat condition
6. Estimate survival and dispersal
7. Quantify management action effects and incidental take
8. Estimate observation error

All of the information listed above varies spatially and temporally and so requires ongoing monitoring across river and reservoir segments to estimate sufficiently. Limited monitoring can provide useful monitoring but introduces the risk of error in determining compliance or selecting management actions that is detrimental to program success.

USACE surveys plover and tern adults in June on all segments from Fort Peck Reservoir, Montana, to Ponca, Nebraska. Lake Sharpe and Lake Francis Case in South Dakota are excluded, as these waterbodies are not designated critical habitat for terns or plovers. Productivity monitoring for tern and plover nests and chicks occurs within the six riverine and reservoir segments in Table 18. The Fort Peck reservoir and Fort Peck riverine segments are excluded from productivity monitoring because the habitat and use by nesting birds is very limited.

Information needs for action effectiveness and model development may also be addressed through limited-scope research projects, but some information, such as survival or dispersal data requires multiple years of data collection to estimate parameters and additional years to improve accuracy. Including such monitoring annually may provide sufficient value over shorter-term research to justify the associated expenses. Tradeoffs between cost effectiveness and information breadth and quality can be quantitatively evaluated to support monitoring decisions. Initial and ongoing analyses of the statistical power of a monitoring program and the value of information provided will assist with decisions about how to allocate resources to monitoring and other needs.

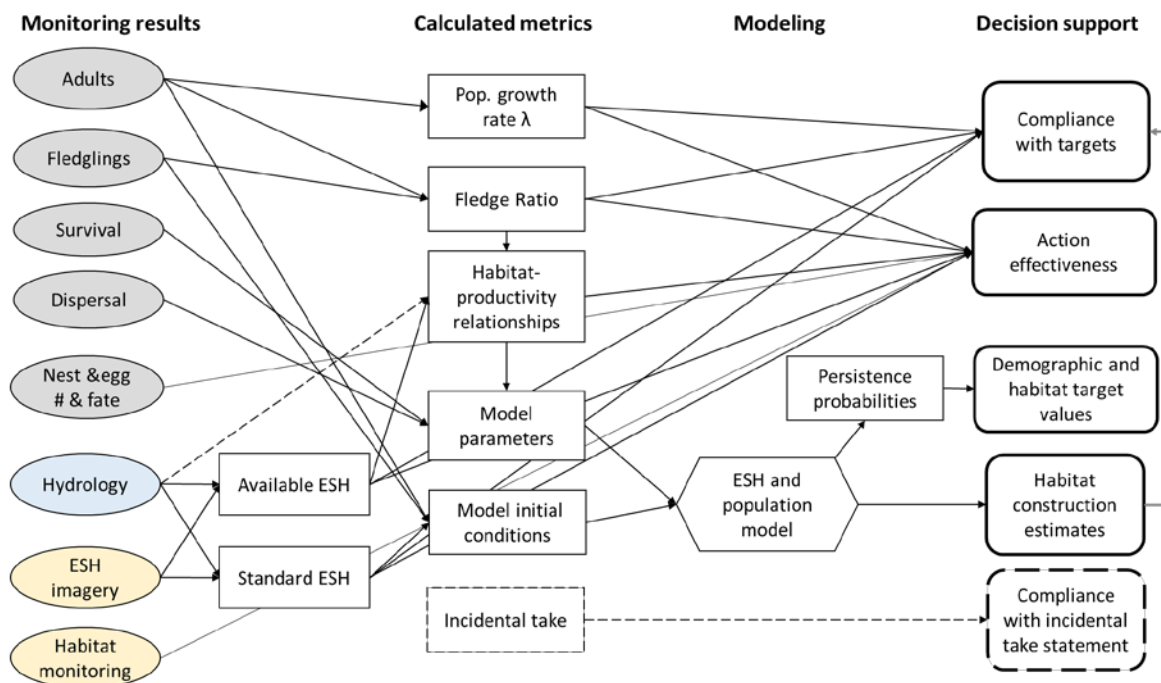


Figure 32. Conceptual diagram of how current or potentially monitored metrics support decisions. Dashed lines indicate information or relationships yet to be developed. Processing of raw data is necessary to arrive at the information in the “Monitoring” column but not all details are shown here. Additional information may be needed for monitoring effectiveness of actions.

3.3.1 Status of revised monitoring programs

The bird habitat and population monitoring programs are currently in revision. The existing habitat monitoring program and tern and plover monitoring program (TPMP) have been in place since 2006 and 1993, respectively, and collect the information necessary to evaluate compliance and provide some information for modeling and action effectiveness assessment. They also estimated incidental take as per the 2003 BiOp. While these programs meet the baseline AM monitoring needs, there is room for improvement in accuracy, error estimation, types of metrics provided, and efficiency.

The revised programs are being developed with input from USGS (e.g. Shaffer et al. 2013), quantitative model assessments, and consideration of new or improved methods or technologies. The monitoring program also must meet any requirements established in the Incidental Take Statement (ITS) which will accompany the 2018 BiOp. As the ITS was not yet available as of the writing of this version of the SAMP in April 2018, the revised monitoring plan has not been finalized. Several options and other considerations are being evaluated with respect to statistical design, cost, and the value of information.

Considerations involved with revising monitoring plans include:

- 1) What is the importance of measuring survival and what would the necessary level of effort be?
- 2) What is the importance of measuring dispersal and what would the necessary level of effort be?
- 3) Counting adults and fledglings is required for determining compliance with targets, but how accurate does that count need to be and what is the necessary level of effort?
- 4) Must nests be counted and fated? At what level of effort?
- 5) Can the ESH quantification process be improved and what are the benefits of improving it?
- 6) Can a metric for ESH quality be developed to improve predictive capabilities and monitoring decisions?

The options are summarized below and described more thoroughly in the Appendix. A more thorough development of monitoring protocols is pending receipt the ITS, as additional protocol development requires knowledge of any constraints or specific requirements the ITS may include. The geographic scope of monitoring will remain the same, though spatial sampling designs may change.

As the existing program measures the required performance metrics and covers the scope of the action area, the AM plan can be implemented prior to the revised monitoring programs being finalized and initiated. As changes to monitoring programs can complicate the application and interpretation of data, the intent is to ensure the revisions are well-developed and thoroughly assessed prior to implementation. This is most true for the population monitoring program for which changes to protocols alters application of the results and comparability across years. Some aspects of the habitat monitoring are being updated as they are developed, because once imagery is collected, it can be re-analyzed and quantified retrospectively if further changes are made.

It is anticipated that the revised monitoring program will increase accuracy and, ideally, allow for estimation of observation error such that estimates can be adjusted and/or interpreted accordingly. This may affect compliance rates as well as management action planning. It is not anticipated, however, that changes to monitoring will fundamentally change program objectives or target criteria, or alter the types of management actions being used.

3.3.2 Monitoring of hydrology and habitat metrics

Hydrological metrics (reservoir releases and pool elevations for Lake Sakakawea, Lake Oahe, Lake Francis Case and Lewis and Clark Lake; flow at Sioux City) are monitored and reported daily by USACE Water Management and provide information for

estimating reservoir habitat availability, estimating ESH metrics, determining inundation risks and providing historical inputs to use in ESH model validation.

ESH is monitored by acquiring satellite imagery of all riverine habitat during the nesting season. Imagery is classified to land cover type, which can then be used to estimate area of ESH (dry and wet sand with less than 30% vegetation cover) and vegetated sandbar. These estimates are adjusted to standardized and maximum July flows for quantification of standardized and available habitat. Ideally, multiple acquisitions are made, including in May during nest initiation and in July during peak chick numbers, to more accurately estimate metrics.

ESH accounting (standard and available estimates) has been limited to estimating habitat quantity rather than quality. Aside from percent vegetation, no other habitat characteristics are considered in the quantification. Work initiated in the EA to develop a protocol for estimating quality of habitat based upon land cover and landscape features at relevant scales will be evaluated for use in AM. Quality assessments would allow for more accurate predictions of bird population dynamics and better allocation of resources to habitat management. As ESH is quantified with satellite imagery and archived, it can be retroactively reassessed if improvements are made in the quantification and quality assessment protocols.

Periodic assessments of channel form using LiDAR and bathymetric surveys are fundamental for determining discharge-area relationships needed to accurately estimate standardized and available ESH and to predict the effects of planned flow releases on habitat availability. Assessments of sediment load should also be conducted. While annual collection of this data is likely unnecessary, significant changes to channel form warrants additional data collection. This may be considered periodic monitoring rather than research, in order to regularly update the ESH discharge-area models and provide information for improving the ESH dynamics model.

Reservoir habitat is not currently monitored beyond hydrological metrics. Research on metrics for reservoir habitat beyond the hydrological metrics described above would help determine if different or additional metrics should be used to quantify reservoir habitat for predicting bird productivity.

3.3.3 Existing program for monitoring of population metrics and associated challenges

USACE annually monitors population and productivity for piping plover and least tern, as well as loss of adults, eggs and/or chicks due to USACE operation of the dams. From 1993-present, monitoring has followed the Least Tern and Piping Plover Monitoring

Program (TPMP) protocol (USACE 2009b; 2017a). Monitoring begins in late April, as the first piping plovers arrive in the Missouri River basin, and continues through the end of August, when the last birds depart for the wintering grounds. All suitable habitat on the river segments and reservoirs is surveyed weekly for nests and chicks during the breeding season (see Appendix G.1 for a description of survey segments).

Data for nest site locations, nest status, chick abundance, fledge counts, and current site conditions are uploaded daily into the USACE web-based data management system. These data are then available on a near real-time basis to reservoir regulators, USFWS personnel, and other involved agencies. Weekly coordination is undertaken between USACE field biologists, Water Management, and USFWS to determine operational strategies to protect tern and plover nests and chicks. Monitoring personnel are trained by USACE biologists in least tern and piping plover biology and survey techniques to ensure the capture of consistent and quality data and to ensure compliance with ESA permit restrictions (Appendix G.2.2).

Under the TPMP, an adult census of both species on the six reservoir and river segments is conducted to estimate population size and growth rate, fledge ratios, and population density. The census attempts to completely count all adult least terns and piping plovers observed during the third week in June, assuming that both of the species are settled on the breeding grounds by that time. There are limitations in trying to accurately count all adult birds on the system, however, due to movement of adult birds, so the adult count is augmented on sites where the number of adults counted is less than two times the number of active nests and broods. The timing of the adult count – the third week in June – also raises some concerns. The USGS in their analysis of the USACE Tern and Plover Monitoring Program (Shaffer et al. 2013) found that peak adult numbers varied by species, by segment and by year, yet that variability is not currently factored into the adult census methodology.

Fledgling counts are required for estimating fledge ratios and density-productivity relationships. Juvenile monitoring generally has higher detection and accuracy than adult monitoring (Shaffer et al. 2013), as chicks can be more easily observed and attributed to specific sites prior to fledging, but requires repeated visits to determine whether chicks survive to fledge.

The USACE method of estimating fledglings combines counts of actual fledglings (chicks able to fly) and assumed fledglings (plover chicks observed in the 21-24 day age group and tern chicks observed in the 16-20 day age group, but not observed as fledglings). However, with a 7-10 day return interval for monitoring, some chicks are never observed. In addition, it is difficult to ascertain whether the fledglings observed at a site

are chicks that just fledged, fledglings previously observed on site, or chicks that fledged elsewhere and are using the site as a stopover area.

While not a performance metric, nests and broods have also been monitored to avoid and account for take in coordination with MRBWMD. Monitoring of nests and broods provides partial information as to the degree of predation, human impacts, and other causes of egg/chick mortality and improves accuracy of fledgling counts. Causes of mortality cannot always be determined and nest detection can be low, particularly for failed nests. Accurately determining nest fate relies on the ability of the crew to find the nest and revisit it frequently enough to determine the outcome, as well as the type and extent of evidence remaining at the nest. The USGS analysis of the monitoring program identified problems related to the ability to find nests and determine nest fate, including the late start of the monitoring program (typically mid-May), the frequency of nest visits (typically 7 – 10 days), and the ability to detect nests at any given site (Shaffer et al. 2013). The monitoring program needs to be flexible enough to adapt to changes in habitat availability and increase crew size accordingly in order to more effectively survey sites and reduce the return interval, and to begin early enough to observe all nest timing.

Accuracy of the TPMP varies depending on habitat area that must be surveyed, population density, habitat type and age, and experience of monitoring crews. Thus accuracy can vary by year and by segment, and with the exception of Shaffer et al. 2013, has not been quantified. The monitoring program must be robust to changes in budget or staffing availability, or prioritized such that a base level of monitoring can always be performed at an adequate level. Fluctuations in level of effort and quality of monitoring, such as may occur when funding, equipment or personnel resources are limited, affect both near-term decision making and longer-term assessment of trends and hypothesis assessment. The predictive habitat and population models are being used to assess the effects of estimated monitoring error and bias on assessment of population objectives and on management decisions. They will also be used to assess proposed changes to the monitoring program to evaluate robustness to changing habitat conditions and funding/staff availability.

Periodic review of the monitoring program will occur to assess adequacy. If necessary, improvements should be made while keeping in mind that changes to protocols affects the ability to compare data collected before and after the changes are made. Similarly, if methods of collecting information more quickly or cost-effectively become available, they should be explored, but potential impacts to assessment caused by changes to monitoring protocols should be taken into account before changes are made.

3.3.4 Options for changing the population monitoring program

Changes to the population monitoring program were originally proposed by Shaffer et al. (2013), focusing on spatial subsampling in order to improve accuracy and generate observation error estimates for each reach each year. More recent discussions with USGS staff provided updated additional recommendations on monitoring. A preliminary assessment of monitoring design options by Porter et al. (2017) evaluated four potential monitoring designs stemming from USGS advice:

Option 1: *the current TPMP protocol, as described in the TPMP handbook.*

Option 2: *changes to the current TPMP protocols to include probabilistic sampling within segments, as described and recommended in Shaffer et al. (2013). Chicks are also banded and tracked to estimated detection probabilities to adjust raw counts of fledging-aged chicks.*

Option 3: *A “hybrid” of Options 1 and 2, including the core elements of the existing TPMP program augmented with targeted searches in selected segments. Chicks are also banded and tracked to estimated detection probabilities to adjust raw counts of fledging-aged chicks.*

Option 4: *USGS proposed monitoring employing full banding and mark-resight methodology only.*

Options 2 and 4 are described in more detail in Appendix G.

The preliminary assessment of these monitoring options identified existing information gaps and evaluated any impediments to a full analysis. Initial focus has been on three well-studied segments—Gavin Point (GVP), Garrison River Reach (GRR), and Lake Sakakawea (SAK) only. The assessment evaluated each option for its ability to relate to the MRRP bird objectives (distribution, population abundance, population trend, and reproduction.) It also looks at the effectiveness of each monitoring option for measuring adult survival, chick survival, and adult dispersal; management effectiveness; cost effectiveness and ability to relate to legacy monitoring data. Completing the assessments will require guidance on required levels of precision, which can be informed by model analyses.

In summary, the preliminary assessment concluded the following:

- Sub-objective 1 (maintain the geographic distribution) is met by meeting sub-objectives 2, 3, and 4 of the AMP and no additional specialized monitoring is required.

- Sub-objective 2 (maintain population) is evaluated through a model external to this survey effort for abundance and productivity, and is based on the amount of emergent sandbar habitat available under the assumption that habitat is a limiting resource for these populations.
- Sub-objective 3 (maintain a stable/increasing population trend) requires estimates of abundance in each year or estimates of population growth directly. The population growth rate (λ) is found as the ratio of population size N between the current year and previous year calculated annually. The current TPMP (Option 1) protocol's count of adults may suffer from bias as outlined in Shaffer et al. (2013). It must also be assumed that while the current TPMP is imperfect and only an index to the population size, that the growth in the index is comparable to the growth in the population as a whole. Therefore population growth may be estimated using the current TPMP protocol (Option 1). Options 2 and 3 are able to provide estimates of the minimum breeding population based on nest counts, and if a correction factor is available these can be extrapolated to estimate the total breeding population. Option 4 will provide an estimate of adult abundance on each segment, but this estimate may include non-breeders who are also present at the study area
- Sub-objective 4 (maintain fledgling production) requires direct estimates of productivity which Option 1 appears to provide; however both the numerator and denominator suffer from biases (see Shaffer et al. 2013) and the combined effect of the two biases is difficult to predict. Both Options 2 and 3 spend considerable effort on a subset of the map-units to obtain (hopefully) nearly unbiased estimates of productivity. Option 4 provides estimates of productivity through the banding and resighting of chicks. Options 2, 3 and 4 also provide estimates of uncertainty for productivity.

The path forward for developing sampling designs for the monitoring program includes 1) revisiting the priorities for the monitoring program to ensure that the USACE and USFWS are in agreement, 2) Applying any requirements or constraints included in the ITS, 3) completing the evaluation and cost estimates for monitoring options, and 4) applying results from the modeling assessment to determine the level of effort needed to meet the level of precision in observation determined to be necessary. The resulting monitoring plan may require further adjustments as level of effort and budgets for pallid sturgeon monitoring and other programs are considered in a programmatic context.

3.3.5 Additional species monitoring

Depending on the final design of the monitoring program, additional information may be needed about species demographics, dispersal, and/or habitat use. Supplemental monitoring programs, research, or collaboration with other programs could be used to

supply the needed information. The MRRP can benefit from cooperation with other programs that mark and/or resight birds in wintering habitat and other breeding areas.

3.3.6 Action effectiveness monitoring and research

Action effectiveness monitoring addresses three primary questions:

- 1) Implementation: Was the project implemented as designed?
- 2) Habitat: Did habitat conditions respond as expected?
- 3) Biological: Did site selection, productivity, and survival by birds respond as expected?

This monitoring occurs during and after implementation and can needs vary considerably depending on the type of action. Implementation monitoring is relatively straightforward, but the effects of an action on habitat and biological responses may be difficult to discern if multiple actions are affecting a site simultaneously. Action effectiveness may require multiple years of monitoring for individual actions. Systematic actions such as flow modifications require monitoring data on a different scale than site-specific actions, which may only require information from a small number of sandbars.

In some cases, action effectiveness can be assessed using information from the routine habitat or species monitoring; in other cases it may require specific studies. The need for separate studies or additions to routine monitoring will be better understood once the species monitoring program is revised. The amount and strength of evidence needed varies by the question being asked; showing that an action in general does or does not work effectively needs a higher standard of evidence and more statistical design than monitoring to adaptively manage individual implementations, such as a constructed ESH project.

Details of action effectiveness monitoring are in development. As an example, questions and data, methods, and/or tools for monitoring vegetation management are listed in

Table 32.

Table 32. Action effectiveness monitoring needs for vegetation management actions.

Action effectiveness questions	Data/Methods/Tools required
Does it reduce vegetation? Is vegetation becoming resistant?	Imagery analysis--broad but imprecise Ground monitoring (transects, BACI design*)--limited scale but more accurate, measures higher vegetation cover
Does it maintain/restore ESH quantity?	Imagery analysis
Does it maintain quality?	Habitat quality metrics TBD
Does it reduce predation?	Nest fate data, predation control data, camera study
Do birds use treated sites?	Bird presence and nest data on treated vs. untreated polygons and sandbars
Does it increase fledgling production?	Productivity survey data (if multiple actions confounding, may need controlled experiment)

* See line intercept protocol Attachment #4, Appendix G

Other information needs may include:

- Habitat-forming flow releases: imagery and delineation of habitat availability directly after flow release (especially for fall flow releases); elevation surveys to determine elevation profiles of created sandbars; field surveys to track evolution of created sandbars.
- Lowered nesting season flow releases: ensure habitat quantification captures availability during release; assessment of ESH area before and after flow and after fall evacuations of extra storage to evaluate effects on erosion.
- Sandbar augmentation and modification: elevation surveys and other field observations to evaluate effectiveness, longevity, and evolution of modifications, comparison of wet to dry sand ratio pre and post modification.
- Predation management/human restrictions: Focused monitoring (e.g. increased use of cameras) of selected locations where actions are implemented, in contrast with controls, to detect effects of actions on nest success.

The value of potential studies can be addressed by estimating the cost savings provided by reduced uncertainty and improved accuracy in predictive models used to calculate habitat and other management needs. Uncertainty compels managers to manage in ways that hedge against worst-case scenarios; more accurate and precise estimates of likely outcomes leads to more efficient management.

3.4 Implementation

Implementation of management actions for the birds is generally described in the preceding sections. Some evaluations may be ongoing during implementation, as described in the following section.

3.5 Evaluation

The Evaluation step is primarily conducted by the Technical Team, which coordinates with the Bird Team and implementation staff to obtain information and identify analytical needs. The Technical Team's analyses begin as monitoring data becomes available in fall. The Fall Science Meeting is the venue to review initial outcomes of the previous year's management actions, monitoring, and research, and to identify specific analytical topics of interest to the Management Team and Bird Team. The Technical Team conducts routine annual analyses as described in this section, assesses topics identified as priorities by the other teams, and presents results in the Draft AM Report. As illustrated in Figure 16 the Draft AM Report is reviewed in the AM Workshop, revised, and released as a final draft in the spring. The annual AM Report process is the primary means for developing and communicating the technical information for the MRRP, but additional evaluation tasks may arise at other points in the year for topics needing immediate assessment or for longer-term assessments that cannot or do not need to be completed during the annual cycle. Annual analyses include evaluation of status and conditions, hypothesis evaluations, and model projections, updates and validation. The process allows for inclusion of ancillary information and assessment of unexpected outcomes.

3.5.1 Evaluation of habitat status relative to targets

ESH targets are expressed as a quantity of standardized ESH, to be met 3 out of 4 years, and as a distribution over time of available ESH, as described by the proportion of the most recent 12 years in which available ESH should exceed specified acreages. Both standardized and available ESH are specified by median and 95% confidence intervals. The medians provide the target requirements, but the confidence interval allows for variability around that goal driven by the uncertainty in future flows and variability in species response. Species-habitat dynamics are not perfectly known, so more or less ESH than the median estimate may be needed to meet demographic targets. Observed

acres that fall outside the confidence interval should result in more intensive changes to action plans than acres that fall within the confidence interval. There are four possible outcomes when comparing observed ESH to targets, each suggesting a course of action:

- 1) The acreage is below the lower confidence bound. It is very unlikely that populations have enough ESH to meet objectives and the pace of habitat creation must increase.
- 2) The acreage is below the median and above the lower confidence bound. While it is possible that population dynamics will meet objectives, habitat creation is recommended.
- 3) The acreage is above the median and below the upper confidence bound. In this case, it is possible but not certain that more habitat is available than necessary to meet population objectives. Habitat should be maintained with new habitat creation focused on ensuring acreage does not drop below the median.
- 4) The acreage is above the upper confidence bound. It is very likely there is more habitat than is necessary to maintain the desired species status. Habitat creation is not needed, though existing ESH should be maintained.

Available habitat is evaluated over 12 years to accommodate natural variability in flows. Exceedance statistics take time to respond to change in management practices due to the longer time frame. The upper exceedance criterion (10% exceedance) may only be met following flows high enough to create habitat.

ESH targets are defined and evaluated for the Northern and Southern Region (Table 33). In Figure 33 and Figure 34 ESH data from 2006-2017 are compared to the ESH targets. The Southern Region results are shown as an example; the same process would be used to evaluate results from the Northern Region. Available ESH can also be usefully summarized in table form (Table 33).

Table 33. Target and observed available habitat exceedance years and acreages (2006-2017). Targets are met if the observed acres exceeded are greater than the median target acres, within each row, for each region. Likewise, when targets are met, the observed number of years will be equal to or greater than the target years. Shaded cells indicate the target is met.

Northern Region				Southern Region			
Target exceedance (years)	Observed exceedance (years)	Median target acres	Observed acres exceeded	Target exceedance (years)	Observed exceedance (years)	Median target acres	Observed acres exceeded
9 (75%)	11	270	707	9 (75%)	10	440	618
6 (50%)	9	690	1460	6 (50%)	8	750	2165
3 (25%)	4	1920	2874	3 (25%)	8	1410	4695
1.2 (10%)	1	3110	4042	1.2 (10%)	5	2240	8065

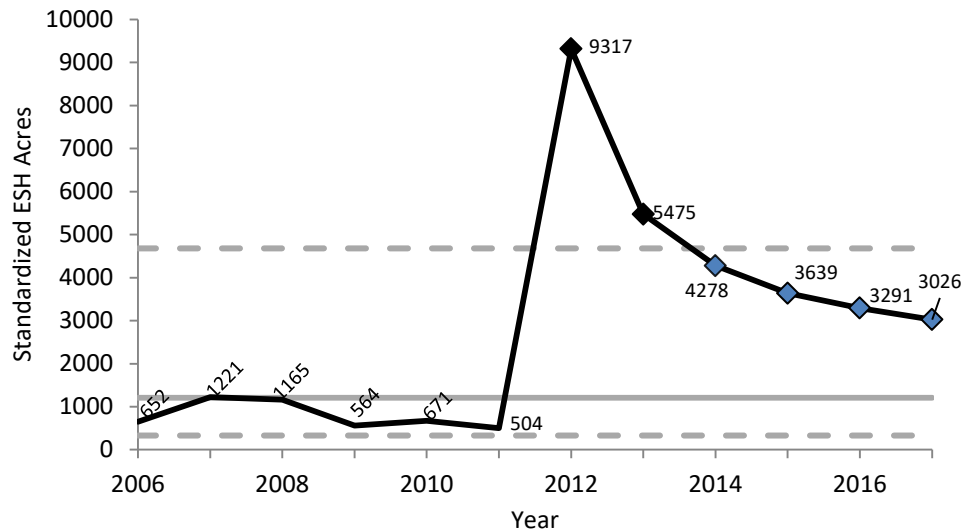


Figure 33. Observed standardized ESH (black line) from 2006-2017 relative to targets (median, solid gray line; 95% confidence interval, dashed lines) for the Southern region. Black symbols indicate years when targets were met; blue symbols indicate years that the time frame of 3 out of 4 years exceeding the median target is met.

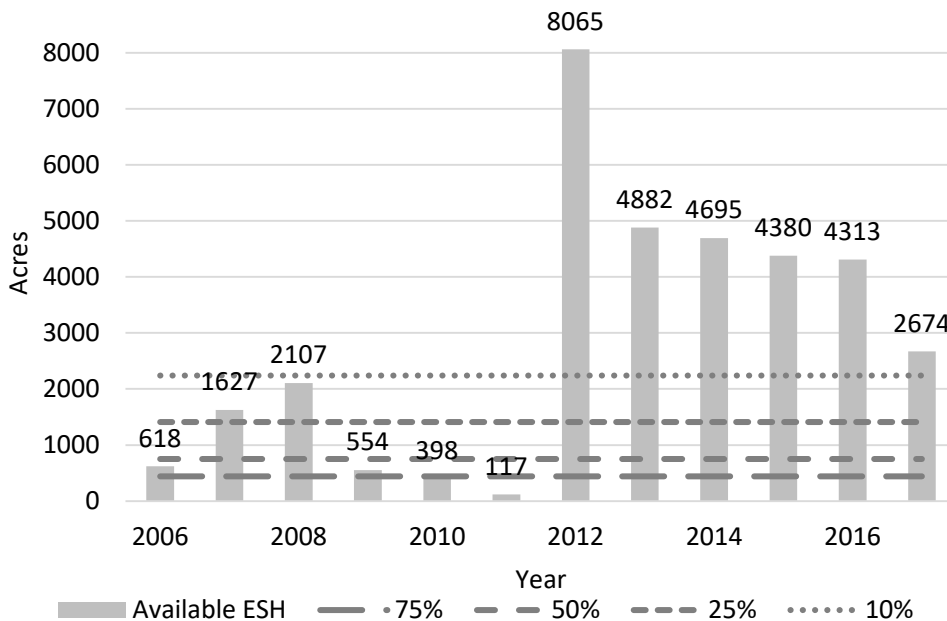


Figure 34. Observed exceedance of available ESH (blue) from 2006-2017 relative to target exceeded acreages for the Southern region. Lines indicate the 75%, 50%, 25% and 10% exceedance criteria specified in the targets.

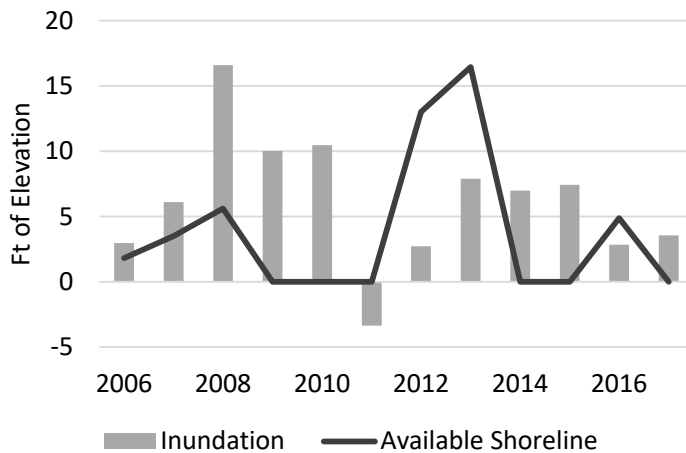


Figure 35. Metrics of available shoreline (lines, high values are good), inundation during the nesting season (columns, low values are good).

While targets are only established for ESH, tracking reservoir metrics is useful for understanding bird population dynamics on reservoirs and how they are affected by management decisions. Figure 36a shows reservoir habitat metrics by year for 1993-2017 for Lake Sakakawea. Figure 36b shows the relationship between reservoir shoreline habitat metrics and whether or not plover fledge ratios meet their target. Patterns in reservoir shoreline water elevations and resulting fledgling production vary between the two reservoirs, as Lake Sakakawea is more affected by inundation during the nesting season and Lake Oahe by changes in water elevation between years.

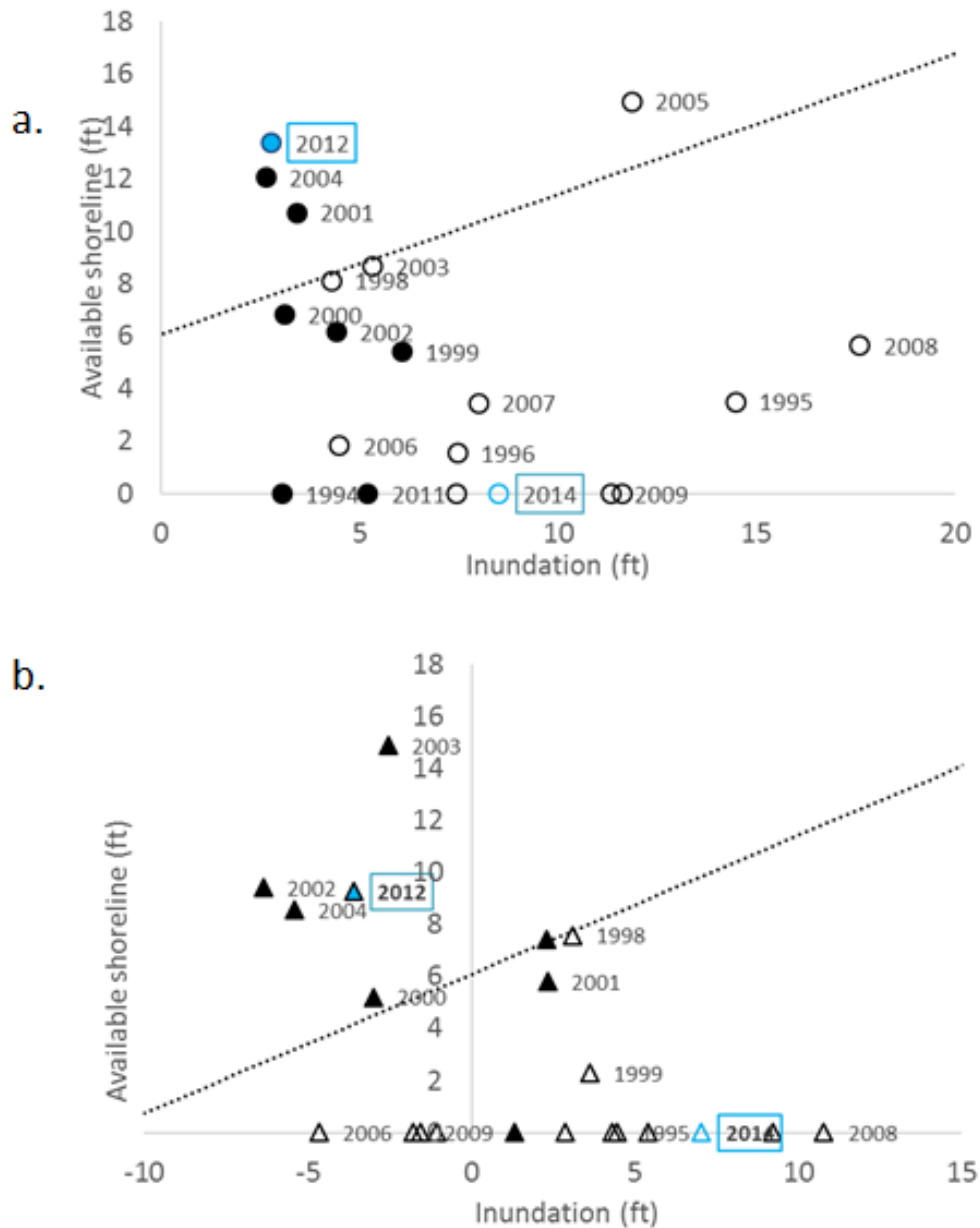


Figure 36. The relationship between reservoir habitat metrics (available shoreline and inundation) and whether the fledge ratio target of 1.14 is met (filled shapes) or not met (unfilled shapes) for a) Lake Sakakawea and b) Lake Oahe for 1993-2014. Recent years are highlighted in blue (fledge ratios were not estimated on reservoirs in 2013). Note that some labels have been omitted for legibility. The dotted line indicates combinations of the two metrics predicted by the model to meet the fledge ratio targets; data points above and to the left of the line are expected to meet the targets and data points below and to the right of the line are not.

3.5.2 Evaluation of population status relative to targets and objectives

The population sub-objectives for birds require that the MRRP 1) maintain the geographic distribution of plovers, 2) maintain a resilient population, 3) maintain population growth that is at least stable, and 4) maintain the success of breeding pair

levels that support population growth. Rather than a quantitative target of a number of adults, criteria were set for long-term population persistence (low quasi-extinction risk). Persistence is supported by population growth rates that are at least stable over time and fledge ratios that allow the population to be at least stable, given current survival estimates. Therefore assessment of population status requires assessment of observed fledgling production, trends in population size over time and assessment of population resiliency under current and proposed management conditions through modeling.

3.5.2.1 Evaluation of fledge ratio and population growth rate

It is most straightforward to evaluate sub-objectives 3 (growth rate) and 4 (fledge ratio) by directly comparing observed rates and running averages with targets (Figure 37). Adjustments may be made to account for variability in estimated observation error, in order to compare population sizes from year to year to calculate growth rate. Adjustments may also account for differential detection of adults and fledglings to more accurately calculate fledge ratios.

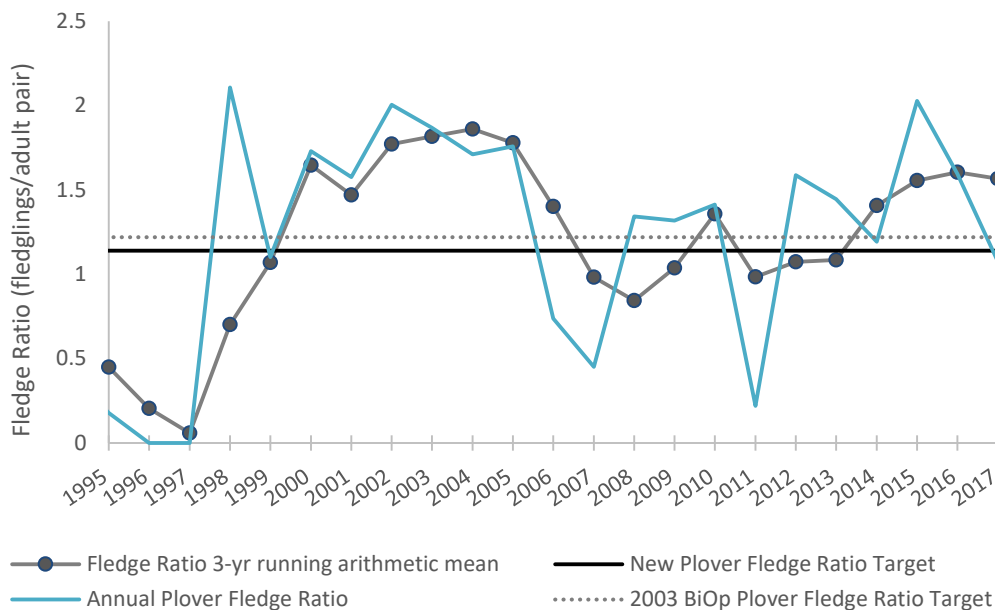


Figure 37. Plover annual fledge ratios (blue) and 3-year running average fledge ratio (gray) for the Southern Region from population monitoring 1998-2017. Horizontal lines indicate targets.

Inter-annual variability in population sizes, growth rates, and fledge ratios is to be expected in any population, particularly birds nesting in naturally variable habitat. In some cases, a single-year deviation below target values is an early sign of a downward trend that could result in failure to meet objectives, while in others it represents natural

variability in an otherwise stable or growing population. Assessment of species status needs to be able to recognize early signs of population decline while not causing overreaction to natural variability. Thus assessment of species status include assessment of the most recent year but also a measure of the metric over a 3-year running geometric mean (for population growth rate) or arithmetic mean (for fledge ratio). Longer-term trends are also informative. These metrics should be interpreted in the context of overall habitat and species status and trends, scientific understanding, and ancillary information.

3.5.2.2 *Evaluation of population trajectory and resilience*

Population resiliency can be assessed through model projections over a 50-year time frame, based on current conditions and management practices, to estimate whether the population under the specified conditions is expected to meet the persistence criteria (remain above the quasi-extinction threshold of 50 adults in each region in more than 95% of model replicates). It is challenging, however, to realistically project current management conditions over a 50-year time frame, and such assumptions of management consistency do not reflect ongoing AM that would be expected to improve management outcomes over time.

An alternative is to model a scenario in which the persistence criteria are just met, and evaluate the current and near-future (5-10 year) population status against those projections. The greater the overlap between the target and projected future population distributions, the greater the likelihood that targets will be met without “over managing” the system. For example, population projections beginning in Year 1, with enough habitat availability to meet ESH targets, provide a distribution of population sizes that should be met in the next five years in order to be on track for long-term viability (e.g. Figure 38). This approach acknowledges that population trajectories are more important than single-year population status (e.g. a small, but growing, population with abundant habitat is more likely to persist than a larger population with limited habitat in the long run) and that there are time lags in population response to changes in available habitat.

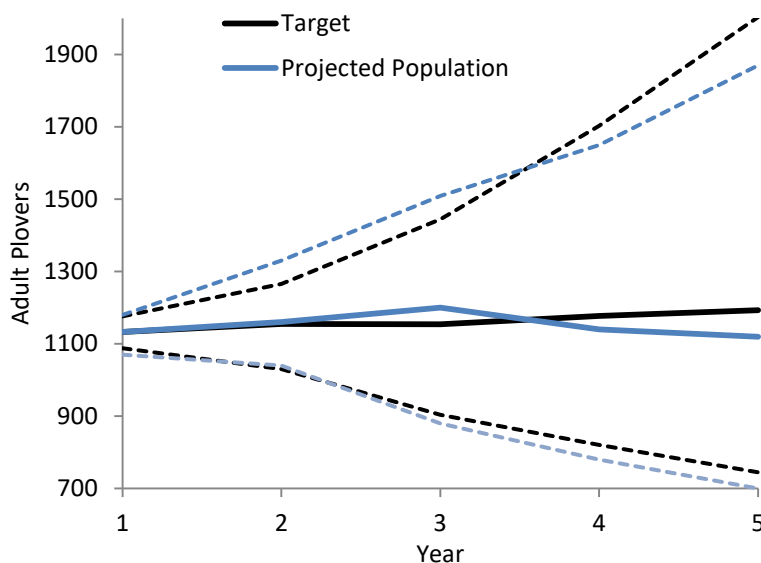


Figure 38. Hypothetical comparison of projected population sizes under a management scenario (blue lines) with a population trajectory that meets the target (black line). Solid lines are median values of 5,000 model replicates; dashed lines are 95% confidence intervals.

3.5.2.3 Accounting for metapopulation and non-breeding habitat dynamics

The Missouri River tern and plover populations are not closed; birds fledged or previously breeding in other areas may breed on the Missouri River, and vice versa. All plovers and terns breeding on the MRMS winter elsewhere. Conditions during migration and at wintering habitats affect individual bird condition, annual survival and dispersal, and thus affect MRMS population dynamics. It is important to distinguish these effects from effects of MRMS management actions. The net flux of birds to and from the MRMS and other breeding areas can also influence population densities and trends, including the population growth metric.

By examining the status and trends of fledge ratios, population size, and growth rates, growth rates that are not in pace with fledge ratios—suggesting changes in survival or dispersal—can be identified and potentially attributed to changes on or off the Missouri River. Ancillary information (e.g. knowledge of conditions and demographics in other habitats) also benefits this assessment but may not be available. Explanations for discrepancies can be taken into account for management planning. For example, long-term changes to wintering habitats may require adjustments to target criteria or objectives.

Metapopulation modeling will incorporate information about dispersal to and from other breeding areas, and population dynamics in those areas, as it becomes available in order to improve management decisions. However, it is expected that this data may

remain limited, especially off-river population dynamics. Dispersal rates may be highly variable and challenging to predict; the value of this information is yet to be determined.

3.5.3 Overall Evaluation of Status and Management Needs

A holistic assessment of the status and trends of bird populations relative to habitat supports management decisions. ESH targets provide guidelines for a resilient population in the long term; the needs of the population in a given year depend on population size relative to habitat availability (population density) and population trends.

A matrix summarizing the status and needs of plovers and ESH (Table 34) provides a heuristic for assessing and communicating the current habitat and species status and recommended overall pathway of management (e.g. continue, increase, or decrease current rates of habitat creation; corresponding rates of habitat maintenance may also be indicated) resulting from that status. To meet objectives, populations must be growing or stable (first two rows of table) and above the lower bound of the ESH targets (second through fourth columns). Outside of that range the population may be on track to meet objectives, unlikely to meet objectives, or potentially in reversal (was meeting objectives but no longer is).

The status-and-needs matrix makes several important assumptions for simplification:

- Plover populations grow or decline based on population density (the number of adults/acre), according to the best available science about density dependence in plover populations. That is, growing populations are at low densities (first row of matrix), declining populations are at high densities (third row) and stable populations (second row) are at moderate, equilibrium densities. ESH acreage targets are built upon those assumptions. If density dependence is substantially different than that estimated when calculating ESH targets, unexpected outcomes may occur. This possibility is noted twice in the matrix: a population growing when ESH is less than the lower bound of the habitat targets is either quite small (low density) or the population can grow at higher densities than expected. Similarly, a population declining when ESH is above the upper bound of target acreage is either very large (high density) or density dependence is higher than expected. Such possibilities may occur within other cells in the matrix as well. When evaluating status, a check of recently observed productivity related to density should be made to ensure population dynamics are within the bounds of this assumption. If there is a deviation over multiple years, then management decisions need to account for a possible bias and ESH targets may need to be re-evaluated.

Population Status	Emergent Sandbar Habitat Status			
	Acreage < Lower Bound	Lower Bound < Acreage < Median	Median < Acreage < Upper Bound	Upper Bound < Acreage
GROWING POPULATION FR and λ > target	On track to meet objectives <i>Status:</i> Small population OR density dependence less than expected <i>Need:</i> Continue pace of habitat creation	Meeting objectives <i>Status:</i> Moderate population, not habitat limited <i>Need:</i> Continue habitat creation at current or slower pace	Meeting objectives <i>Status:</i> Moderate to large population, not habitat limited <i>Need:</i> Maintain existing acreage and quality	Exceeding objectives <i>Status:</i> More birds and much more habitat than needed <i>Need:</i> Maintain habitat quality
STABLE POPULATION FR and $\lambda \approx$ target	Unlikely to meet objectives <i>Status:</i> Small to moderate population, becoming habitat limited <i>Need:</i> Increase rate of habitat creation	Meeting objectives <i>Status:</i> Moderate population, habitat may become limiting <i>Need:</i> Continue pace of habitat creation	Meeting objectives <i>Status:</i> Moderate to large population <i>Need:</i> Maintain existing acreage and quality	Exceeding objectives <i>Status:</i> More birds and more habitat than needed <i>Need:</i> Maintain habitat quality
DECLINING POPULATION FR and λ < target	Will not meet objectives <i>Status:</i> Small to large population, very habitat limited <i>Need:</i> Rapidly increase rate of habitat creation	Unlikely to meet objectives <i>Status:</i> Moderate to large population, habitat limited <i>Need:</i> Increase pace of habitat creation	Potential reversal <i>Status:</i> Large population returning towards equilibrium <i>Need:</i> Continue pace of habitat creation and maintain habitat	Reversal <i>Status:</i> Large population returning towards equilibrium OR density dependence much higher than expected <i>Need:</i> Maintain habitat quality, consider maintaining acreage

Table 34. Status-and-needs matrix for ESH and birds. The population status and habitat action needs depend on whether the population is growing, stable, or declining based on growth rate (λ) and fledge ratio (FR) and the ESH acreage relative to targets. Bold text indicates the status relative to the targets. The cell color summarizes the status and needs: dark green = objectives are being met and current management (habitat creation rates) should continue; light green = management objectives are exceeded and management can be reduced; yellow = species may be on or near the path to meet objectives, but management increases may be necessary; orange = objectives are not being met and unlikely to be met and management must increase; red = objectives will definitely not be met and strong increases in management must occur.

Intentionally Left Blank

- The relationship between growth rate (λ) and fledge ratio (FR) is roughly consistent over time. This is only true as long as survival and emigration/immigration are also consistent over time (annual variability is expected, but the distribution of rates is expected to be stationary). If overwinter survival declines, emigration increases, or immigration increases, the calculated equilibrium fledge ratio may not support equilibrium population growth. The reverse is also true. If such variations occur, the population status would not fit in a single row of the matrix. In those cases, fledge ratio should determine where the status of the species lies, as that is most directly affected by MR management actions (i.e. management actions primarily address reproductive success, and cannot address conditions of overwinter habitat, which affect survival, or conditions in other breeding areas, which affect dispersal).
- Growth rate and fledge ratios are generally in sync. In reality, there is usually a time lag for changes in fledge ratio to be reflected in changes in population size, particularly when reversals occur. A declining population that has begun to grow again may have fledge ratios above equilibrium but growth rates below equilibrium for a year or two until the increase in fledglings is reflected in the population size. The same is true for growing populations that begin to decline.

See Section 3.5.11 (unexpected outcomes) for more discussion of handling observations that fall outside habitat or population dynamics as they are currently understood.

As long as the simplifying assumptions are taken into account, the status-and-needs matrix provides a shortcut for determining which path of action should be taken with a holistic understanding of both habitat and species status and trends. It also can be used to summarize and illustrate species status over time (Figure 39). Use of the matrix does not replace more detailed technical analysis and interpretation of habitat and population trends and forecasts. Quantitative modeling and assessment informs which action should take place. At a minimum, the acreage required to achieve or maintain habitat goals with a desired level of confidence is needed prior to making decisions. If targets are not being met, the process and decision criteria to ensure shortfalls are corrected are described in Section 3.6.5.

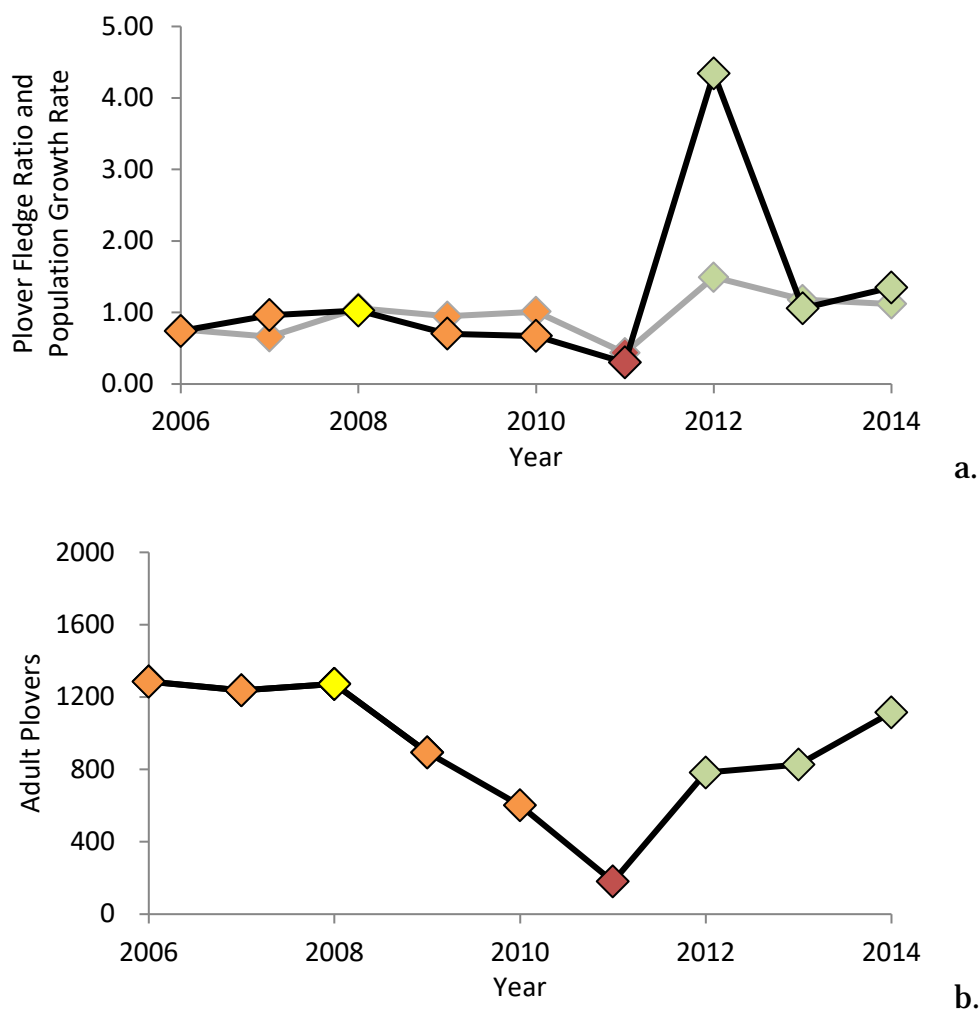


Figure 39. Evaluation of status over time for a) plover fledge ratio (gray lines) and population growth rate (black lines) and b) plover population size. Symbol color indicates status relative to status and needs matrix (see Table 34 for definitions.)

3.5.4 Evaluation of management conditions

The evaluation of management conditions is the other half of the foundation for decisions, providing the necessary information on what actions are possible. Management conditions define the constraints on actions in a given year (Table 35). Management conditions of standardized acres, vegetated habitat, and population density determine whether habitat creation, vegetation removal, and predator control, respectively, would be effective and how much benefit would likely be gained (Section 3.2.2.3). Information on storage and tributary flows determines whether flow modification actions are feasible, their expected effectiveness, and opportunity for ESH construction or maintenance. Budget and logistics determine the capacity for most non-flow actions. Constraints related to storage, flows, and budget must be determined in

Habitat-creating flow	Most effective when combined acreage is low		Storage > 42 for spring release; > 35 SL for fall release	Incorporated into operating plan dependent upon runoff conditions	Flow less than 71 kcfs at Omaha, 82 kcfs at Nebraska City, or 126 kcfs at Kansas City	Most needed when density is moderate to high
Lowered nesting season flow	Moderate ESH acreage		If water must be evacuated, low flows are unlikely	Low flows more likely when below full service	Accommodate water supply and navigation needs	Use at moderate to high population densities

3.5.5 Incorporation of new information

Research that is conducted over the course of the year is summarized in the annual AM report. MRRP-funded research will typically be reported upon in the Fall Science Meeting. Relevant non-MRRP research findings will also be discussed in the AM Report, with consideration given to the level of QA/QC and peer-review or related evaluations such findings have undergone and to the design and strength of studies (For example, a study conducted over a single year with a small sample size would generally not be given as much weight as a multi-year study with larger sample sizes, particularly if the results of the studies are contradictory. For an example of a weight-of-evidence approach, see Diefenderfer et al. 2016.)

Occasionally, new information might become available that has the potential to significantly alter some aspect of management under the MRRP and which is not captured in the annual AM science process. This may be a matter of timing or because the information was not identified by the Technical or Bird Teams. Such information would be vetted and addressed through the process described in Section 6.2.5. Important insights emanating from the vetting process would be incorporated into the AM process in the same way as other monitoring and assessment results.

3.5.6 Evaluation of key relationships and science questions

Beyond determining system status, monitoring and research provides information for evaluating the critical uncertainties and management hypotheses (Section 3.1.2.5, Table 19). The assessment of evidence for hypotheses will be revisited annually to incorporate any new findings. The level of support for management hypotheses, as evaluated by the Technical Team should then be considered by the Bird Team when determining priorities for SP updates.

In addition to the critical uncertainties and management hypotheses, the physical and biological relationships underlying the conceptual and numerical models will be evaluated regularly. For example, the hypothesis that plover fledgling production is a function of habitat availability and population density underlies the model predictions, objectives and targets, and habitat-based management actions. New monitoring data collected each year adds information for routine analyses, following the EA (Buenau et al. 2014); e.g. Figure 40, and indicates where in the estimated density-productivity function the system currently falls. Updated analyses are reported annually and results are applied to ongoing modeling (see Section 3.5.7). Most analyses can be done quickly and consistently across years using established scripts in statistical software (e.g. R), though these approaches should be evaluated periodically and may need adjustments if monitoring protocols change.

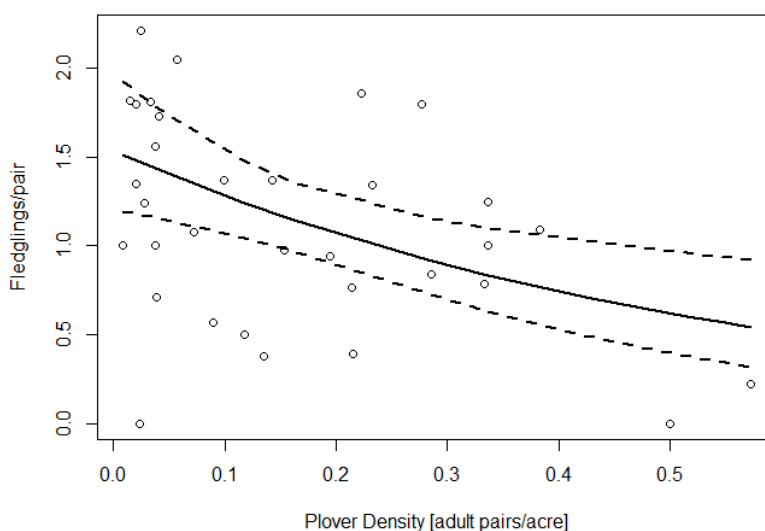


Figure 40. Example of an evaluation of key relationships. Results of best-fit model relating plover density to fledge ratio in annual assessment of density dependence in plover population. Points indicate fledge ratios in individual reaches and years, solid line is median prediction of the statistical model, dashed lines are 95% confidence intervals.

For questions that can be addressed quantitatively, the degree of uncertainty can be quantified and used to track the learning process as new information is added. New understanding may allow questions to be refined, or answered conclusively enough that they need no longer be evaluated as frequently. The potential for long-term change in system drivers suggests that hypotheses should be confirmed or re-confirmed over longer time periods. Additional science questions and management hypotheses may also be identified if new situations arise.

3.5.7 Evaluation of action effectiveness

The effects of management actions, particularly those with high uncertainty, can be assessed by predicting outcomes, monitoring the effects of action implementation, and then evaluating predicted vs. observed effects. Evaluation occurs at multiple levels, as described with examples below. Prior to implementation, the physical and biological characteristics are estimated during the Strategic Plan development process and, as applicable, during planning and design for the specific project. For population protection actions, only biological responses may be relevant. Action effectiveness monitoring, along with annual monitoring, occurs during and after implementation as described in Section 3.3.6, with the intent of answering questions about implementation, physical, and biological effectiveness, such as the following examples:

- 4) Implementation: was the project implemented as designed?
 - a) ESH construction: was the project completed in the construction window and built to specifications? Does the sandbar persist for the expected amount of time?
 - b) Flow action: was the flow implemented as planned? If it was modified, what were the impacts on the resulting physical changes?
 - c) Predation management: did actions successfully remove predators?
- 5) Habitat: did habitat conditions respond as expected? Examples:
 - a) ESH construction: was the expected amount of ESH created and did it persist for the expected amount of time? Were vegetation and erosion rates as expected?
 - b) Flow action: did the flow provide as much habitat structure or availability as intended?
- 6) Biological: did site selection, productivity, and potentially survival by birds respond as expected?
 - a) ESH construction: do nesting birds select the project sandbar at rates at least similar to naturally created sandbars of similar age¹? Is bird productivity on the project sandbar as expected within the range of natural variability? Is predation at or below typical rates?
 - b) Flow action: Does site selection by nesting birds respond to the flow action as expected? Does bird productivity change as expected? Is predation at or below typical rates?
 - c) Predation management: Were fewer nests lost to predation than expected, or as compared to sites without management?

The evaluation step seeks to compare the effects of specific actions with average/expected or target performance and use those findings to determine how successful an action was, how it could be improved, and what lessons from

1

implementation could be applied during future implementation. Action effectiveness evaluation is challenged by the lack of true controls in many cases and by interactions between effects of different actions. Spatial and temporal variability can also make comparisons challenging. Managed sites may need to be compared with a broader range of sites across a range of time, while accounting for multiple actions that may be occurring at a location. For example, a constructed sandbar may also be managed for vegetation and predation, the effects of which all combine to influence bird productivity on the sandbar. Habitat actions in particular require multiple years of evaluation to understand effectiveness over a site's life span. To the extent that annual monitoring data can be applied to action effectiveness monitoring, rather than supplementary monitoring, monitoring coverage can be improved while minimizing costs.

To minimize the confounding effects of multiple actions, actions can be implemented within an experimental framework. Doing so allows more direct comparison of treated and control sites, and potentially before/after monitoring. Such an evaluation is more straightforward, but is less necessary for well-established hypotheses.

3.5.8 Evaluation of cross-program effects

Any observed effects of pallid sturgeon actions on birds, positive or negative, will be noted in the Science Update process. The anticipated effects of pallid sturgeon actions on birds (Table 31) are hypotheses that can be evaluated like the management hypotheses for bird actions. Biologically significant effects that increase or reduce the likelihood of meeting demographic or ESH targets may indicate that programmatic decision criteria and/or tradeoff assessments (see Section 2.2.2) should be reviewed to ensure they reflect new understanding of synergistic or negative interactions.

Similarly, effects of reservoir operations or other activities not specifically tied to bird or pallid sturgeon management should be noted and evaluated as part of the ongoing EA.

3.5.9 Model updates and validation

A primary mechanism for capturing and applying learning is incorporating relevant information collected during the previous year into the models. Information sources include a) assessments based on monitoring data updated on an annual basis (e.g. habitat-productivity analyses, Section 3.5.6), b) information from research studies or short-term additional monitoring (e.g. geomorphic assessments following atypical flows) and c) information from external studies deemed to be of sufficient quality and relevance.

Routine updates based on monitoring data are straightforward. This data is formatted consistently and can reuse processing procedures and statistical methods and code. These assessments should be evaluated periodically to ensure they reflect up-to-date understanding and methodologies. Changes to the monitoring program or data management system may require changes to procedures. Updated model parameters are and is documented in the annual report.

Incorporation of information from research studies (including those not funded by the Corps) or collected with new methodologies is more challenging. Case-by-case decisions must be made regarding whether newly collected information should replace or be combined with previous information. Considerations include the design and strength of the study and Bayesian and/or weight of evidence approaches may be appropriate.

These evaluations will be conducted by the Technical Team, who may consult with the Bird Team and/or Management Team about the use of additional information and will report on the effects of the changes being made on management decisions.

Information may support structural changes to the models—adding new mechanisms or changing the scale. These changes require additional time to develop, code, and test. Comparison of old and new model results (using the same parameters) will be reported, to provide understanding of the consequences of the changes to model structure and function and the decisions informed by modeling.

Model validation procedures test model accuracy and precision by comparing model predictions with observations that were not used to parameterize the model. For example, adult counts were used to predict fledglings/pair/acre relationships for the plover model but not to predict population growth rates themselves within the model. Predicted and observed population growth rates can be compared as a form of model validation. Multiple levels of validation are useful for assessing model accuracy and identifying where error occurs:

- Comparison of observed and predicted standardized and available ESH, using actual flows (tests ESH model accuracy)
- Comparison of observed and predicted standardized and available ESH, using modeled flows (tests ability to predict future ESH dynamics, when flows are unknown, given model accuracy and distributions of modeled flows)
- Comparison of observed and predicted fledge ratios and population sizes, using observed ESH (tests accuracy of population models alone)
- Comparison of observed and predicted fledge ratios and population sizes, using predicted ESH (tests overall ability of model suite to predict population dynamics)

An example of model validation for the 2nd and 4th types of comparison, using data from 2005 to 2014, is shown in Figure 41. Model accuracy will vary depending on the time frame used; consistent time frames (e.g. 5 years) should be used for reporting and should be decision-relevant.

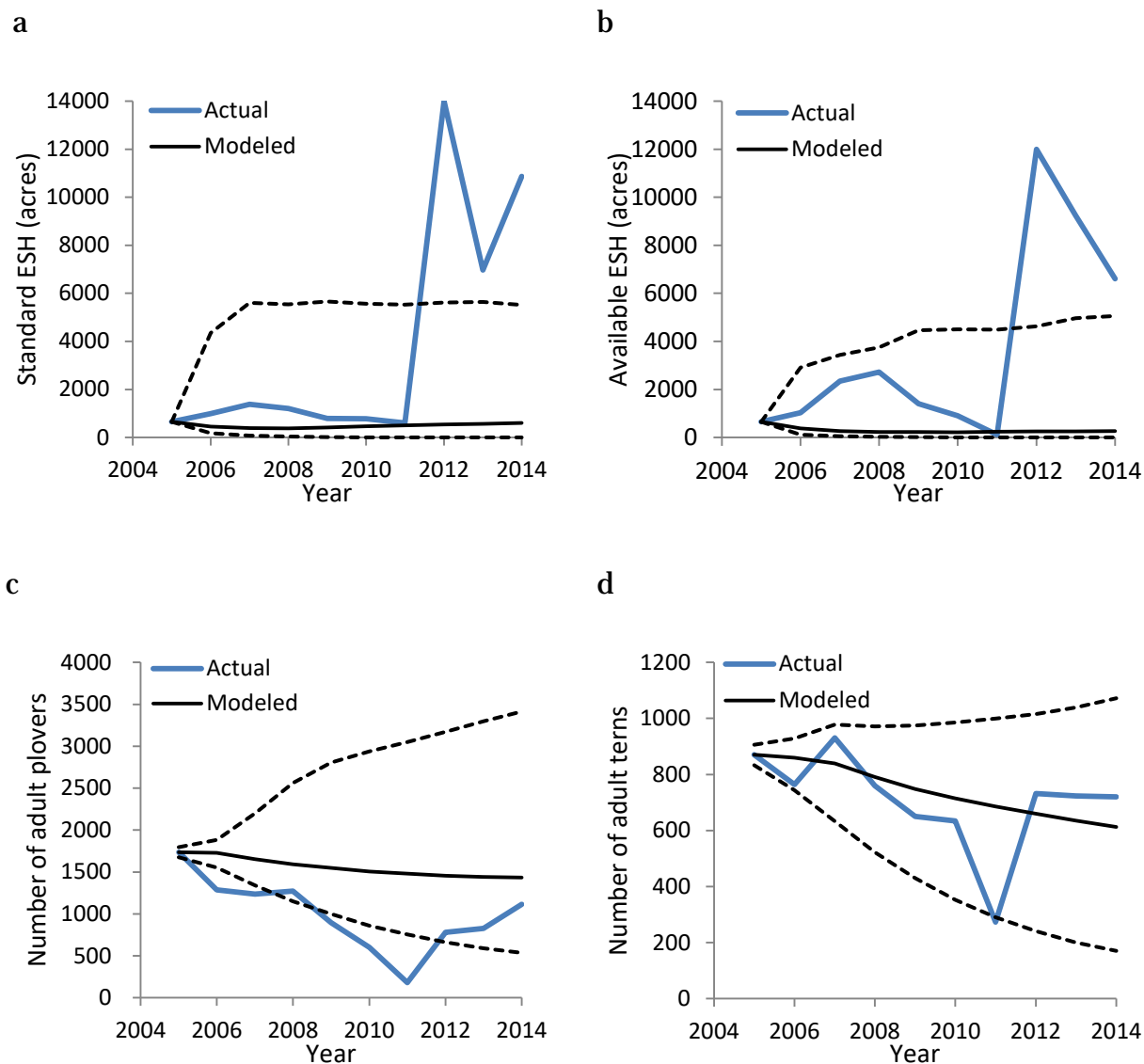


Figure 41. Example of model validation for 2005-2013 for a) standard ESH and b) available ESH modeled using predicted flows (validation type 2 above) and c) plover adults and d) tern adults using predicted ESH (validation type 4 above). Solid black lines indicate the median prediction of 5,000 model replicates; dashed black lines indicate the 95% confidence interval. Thick blue lines are observations.

Model accuracy can be statistically assessed by identifying the percentile of the model distribution at which the observed value falls. Results near the 50th percentile indicate high accuracy, while results near the 0th or 100th percentile indicate low accuracy. Percentile cutoffs could be applied to these results if desired. If monitoring accuracy is known, it should be taken into account when validating the model.

Results from model validation may be used to interpret projections, adjust management decisions (to accommodate systematic over- or under-prediction) and to identify information and model development priorities.

3.5.10 Ancillary information

Additional information that is qualitative or site-specific also reflects learning and should be captured and synthesized. Examples of ancillary information include: observations about habitat quality on individual sandbars that could be addressed with management actions; local events such as storms that negatively impact bird survival and overall performance; observations of birds nesting in unusual locations; or patterns of ESH erosion. They also include implementation-specific learning about methodologies and their benefits and drawbacks that can be used directly to improve future implementation. Such information will be reported along with monitoring data in annual reports, or summarized and cited if captured in project-specific reporting. Other information sources can be included if appropriately vetted (see section 6.2.5).

Such information can be used to adjust management actions, help explain patterns in monitoring data (e.g. multiple local factors could result in unusually high or low productivity in a reach), and identify questions and hypotheses for future research and assessment. The quality of ancillary information will vary and may be subject to bias due to how factors are observed (e.g. a lack of observations during bad weather when fieldwork cannot be conducted) and should be assessed when data is collected and/or compiled. To the extent that these observations can be quantified and standardized, learning will benefit. Ancillary observations may indicate the need for more systematic monitoring of factors not previously monitored.

3.5.11 Unexpected outcomes

Unexpected outcomes occur when observed habitat or population dynamics fall outside of the range of behavior predicted by the models or otherwise anticipated from the understanding of the system. Examples include: ESH eroding or depositing much more or less than predicted given flows that occurred; bird populations continuing to grow when habitat is limited and population density is high, or conversely populations that

are declining despite an excess of suitable habitat. Unexpected outcomes have several possible explanations:

1. Error in mechanisms of the models and/or foundational hypotheses: key driving factors are not represented, or represented in a functionally incorrect way that cannot predict observed dynamics.
2. Error in parameterization of models: the models have the correct mechanisms, but were parameterized in ways that cannot predict observed dynamics—i.e. the parameters are wrong or do not adequately cover the range of potential inputs.
3. A combination of mechanistic and parameterization error.
4. Unusual events or environmental conditions that fall outside the range of historical observation and model functions.

These errors have several possible sources:

- Insufficient or poor quality data were available for testing hypotheses and parameterizing models;
- Data were analyzed incorrectly;
- Fundamental processes have changed and older data used to test hypotheses and parameterize models no longer reflect conditions (e.g. climate-driven changes in hydrology; long-term changes to sediment budget; changes to bird survival because of migration or winter conditions, or disease, or other factors not captured in the models);
- Some combination of the above.

No model is completely accurate. Models used in this AM process explicitly incorporate and project uncertainty. Minor to moderate deviations of observations from projected outcomes are expected—adherence of real populations to median population projections would be highly unlikely. The degree of deviation, as calculated through the model validation process, and the direction of error are of more concern. Large deviations, particularly biased ones (consistently higher or lower), should trigger assessments of why such error occurs.

If an explanation for error cannot be found or corrected, consistent biases in model projections should be identified so that management decisions can respond accordingly. For example, if population projections are biased high compared to observations, more conservative actions (i.e. higher rates of habitat construction) should be considered to compensate until models can be improved. Meanwhile, model validation and associated analyses can be used to identify areas of critical uncertainty and potential error that need to be addressed through research or enhanced monitoring.

3.6 Decisions and planning contingencies

Routine decisions for plover and tern management include when to act, how to act, how much of an action to implement, and how to conduct research and monitoring. These decisions must be made in a programmatic context, incorporating pallid sturgeon management needs and human considerations. They are also made within the current planning context: i.e., which actions are available for use under the ROD. This section includes decisions which have been identified as part of the Preferred Alternative as well as actions that have been evaluated but not included in the Preferred Alternative.

The following sections, as well as the descriptions of actions in Section 3.2.4 provide guidelines for management action implementation. Decision criteria provide a roadmap; however, the Missouri River system is too complex and variable to pre-specify every contingency in an effective and efficient manner. Predictive models support the evaluation and selection of management options; their use in this context is described below. Models cannot account for all available information and situational constraints. Judgment and current scientific understanding must be applied when using decision criteria.

As described in Sections 3.5.2 and 3.5.3, decision-making relies upon the identification of management needs and management opportunities for the next 5 years. This information determines the scope of decisions to be made.

3.6.1 Decision making process

The annual decision-making process is described in full in Section 2.4, with a summary focused on bird management provided here.

Following the evaluation phase and the release of the Draft Annual AM Report, the Bird Team meets to develop a list of priorities for updating the multi-year Strategic Plan. Activities for the current FY are already set, and budget has been established for FY+1. The Bird Team may identify adjustments to the plans for FY+1 and FY+2, but their focus is general planning, including estimates of budget needs, for FY+3 and FY+4.

Using information provided from the Technical Team, the Bird Team discusses needed management actions, science, and any other activities, and their levels of effort. While aware of the competing uses of resources, the Bird Team focuses on identifying plover and tern needs. In this way, they identify the optimal pathway(s) to meeting bird objectives, allowing the Management Team to make the decisions needed to balance programmatic needs. The Bird Team would typically identify at least one suite of actions expected to be effective (based on model projections) and identify key dependencies so

that the Management Team can consider available options when updating the Strategic Plan. They may assign priorities to actions to facilitate the Management Team's decisions if the full suite is not possible with available resources.

The Management Team uses the strategies developed by the Bird, Fish and HC Teams to allocate resources. If flow modifications outside of routine operations are being considered, the Management Team may make recommendations and MRBWMD decides upon reservoir operations with consideration of those recommendations. The updated Strategic Plan is then released, reviewed, and finalized according to the process identified in Section 2.4.4.

Some decisions must be made in near real-time rather than during the annual cycle. Activities such as vegetation and predator control need to be responsive to conditions on the river; while they are anticipated and planned for in advance, details of their implementation will be made by implementation staff during the construction or nesting seasons. Real-time decisions regarding flow modifications are made by MRBWMD.

3.6.2 Information for making decisions

The Annual AM Report includes descriptions of the habitat and species status (Section 3.5.3) and management conditions (Section 3.5.4) which provide a starting point for strategic planning. The report also includes updated assessments of management action effectiveness and model projections.

3.6.2.1 Model projections of management options

Depending on the set of available management actions, there may be more than one means of meeting bird objectives and targets, including different actions or different implementation of actions in time or space. Predictive models can help to determine the optimal combination and intensity of each management action. Incremental benefits of additional management actions or increased effort can be compared with the incremental costs and impacts. In cases where available management options are not expected to meet targets, models can also be used to estimate the future impact of shortfalls. This information can be used at the programmatic level to estimate future resource needs and priorities. Once a set of management options has been identified, the predictive models are used to project the expected distribution of habitat and population metrics for each management option and a "do nothing" baseline comparison. These projections indicate which option comes closest to the target trajectory.

As the models produce a distribution of outcomes, the results used to estimate management needs depend upon the level(s) of certainty desired. For example, in estimating ESH construction rates, the 25th percentile of projected standardized ESH acres can be used. These estimates, rather than the median, increase the likelihood of meeting the criteria of exceeding the target 3 out of 4 years, as the target would be exceeded in 75% of model projections. Other options may be used to hedge against varying levels of risk.

A simple example is illustrated in Figure 42 of management options used to meet the standardized ESH target for the 25th percentile model results. The example includes two management actions, ESH construction and vegetation management, both alone and combined, compared with doing nothing. The mean likelihood of complying with target criteria over the five-year timeframe can also be estimated for each option (Table 36). This information can be used to easily compare and communicate expected outcomes of management options and support decisions. Several iterations of modeling management options may be necessary to fine-tune management options or adjust to resource constraints. Options for contingencies (e.g. construction not occurring as planned because flows are above the cutoff for implementation) may also be tested to ensure sufficient flexibility is encompassed within the Strategic Plan.

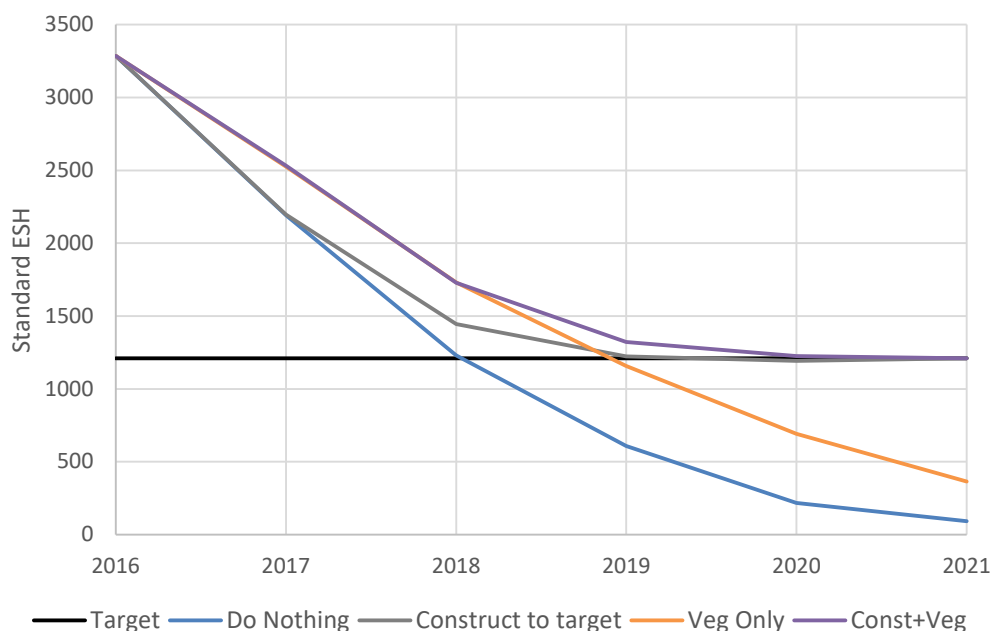


Figure 42. Example model projections of standard ESH acres for three management options using ESH construction only vegetation management only, or both combined, relative to doing nothing. Projections are the 25th percentile of model results.

Table 36. Example five-year mean compliance rates for standard ESH, plover fledge ratio, and plover population growth rate. Results are coded by color according to quintile: the top 20% is dark green, the lowest 20% is red, the middle 20% is yellow, etc.

Scenario	Standard ESH		Plover Fledge Ratio		Plover Pop. Growth Rate	
	Northern	Southern	Northern	Southern	Northern	Southern
Do nothing	49%	42%	19%	28%	22%	42%
Veg. management	63%	68%	28%	47%	28%	56%
Optimal construct	89%	83%	40%	53%	32%	58%
Optimal construct + veg. mgt.	91%	86%	41%	61%	32%	63%

3.6.3 Management action decisions

Most decisions about which actions to implement, when, where, and how are multi-factor decisions. While quantitative criteria can be developed (e.g. how much ESH to create to have a specified likelihood of meeting the target, according to the models), most decisions cannot be simplified to single criteria or triggers. In this section we outline the considerations for implementing management actions. This section focuses on actions in the Preferred Alternative of the MRRMP-EIS. Questions for actions not included in the Preferred Alternative can be found in Appendix A. The considerations are given as a series of questions that should be answered prior to making a decision. Quantitative criteria and tools to weight multiple factors can be developed if deemed useful by managers.

3.6.3.1 Decisions about constructing habitat

Mechanical construction requires decisions of how much to build within each reach, when, and at what specific locations.

- *How much ESH is needed to meet targets in each reach?* Habitat targets are specified separately for the north and south regions (Garrison in the north and Fort Randall and Gavins Point in the south), so the ESH needed for each region can be estimated. These estimates take into account planned vegetation management or other habitat modifications.
- *Is there a greater need for ESH in one region than the other to meet ESH targets?* ESH acreage relative to targets may vary considerably between the Northern and Southern region, so it may be necessary to focus in one region over the other.

- *What is the population status in each region?* Assessments of population density, fledge ratios, and population growth rates within each region should be assessed to determine if ESH needs are greater or lesser than the estimated amount (because populations are performing worse or better than expected, respectively.) Population status may also indicate that one region should receive more construction effort. Demographic targets are prioritized over meeting ESH targets.
- *Are there constraints that limit ESH construction in any reach in the next 1-5 years?* Construction activities for the current FY are already contracted during the decision making cycle; if it appears that construction may not be possible, additional construction should be planned for future years to compensate. Logistical considerations may result in construction that is suboptimal from a target perspective but still beneficial.

The numerical models can be used to predict the expected outcome of different construction strategies as illustrated above. The agencies may agree to accept the risk of constructing to a level less than target in a given year (due to budget constraints, for example), or to build more than needed to meet targets as a hedge against the risk that conditions in that or future years might limit availability. Such strategies, however, may be more costly over longer time periods.

Decision and collaboration level: The Bird Team identifies the amount of ESH needed and may provide general input on location. Implementation staff decides where to construct ESH and coordinates with states, tribes, and other agencies.

3.6.3.2 *Decisions about modifying existing habitat and vegetation removal*

Deciding to modify existing habitat (sandbar augmentation/modification and/or vegetation management) is largely a case-by-case decision based upon observations at individual sandbars. Augmentation of sandbars may be considered when construction is needed but suitable sites for new bars are not available or practical. Augmentation and reshaping activities will generally need advance planning similar to that for construction; vegetation control may be possible on shorter time frames, depending on methodology.

- *Is early-successional vegetation present and above water after the breeding season ends?* Vegetation removal is more efficient at early successional stages, so in most cases removal is warranted to preserve the useful lifetime of ESH.
- *Are there constraints on the use of vegetation removal techniques at a location?* Regulations or HCs may affect the use of vegetation removal at some sites.
- *Is foraging habitat limiting on sandbars that have suitable nesting habitat?* Consider reshaping to provide more foraging habitat.

- *Can low-elevation sandbars be built up to provide nesting habitat that is less vulnerable to inundation?* Consider augmentation to increase vertical profile of the sandbar to reduce inundation risk.
- *Has predation or human activity been prevalent on a sandbar, impacting bird productivity?* Consider *not* maintaining habitat that may be attractive to nesting birds but results in high mortality due to recurring disturbances. Vegetation removal may reduce risk from some predators, but not all.

Decision and collaboration level: The Bird Team identifies the need for and scope of augmentation activities with input from implementation and monitoring staff.

Implementation staff decides on location, methodology, design and contracting.

Decisions about predation management

Deciding to implement predation management is largely a case-by-case decision based upon history and observations at individual sandbars and landscape characteristics, though overall population density allows a rough estimation of the risk of predation and value of management.

- *Has predation been observed on a sandbar/segment in the past?* Some predators may return frequently to sites where they have previously found prey.
- *Is there evidence for predation occurring during this nesting season?* Animal sign and evidence at nests indicates predation, but may be too late at specific sites as individual predators can cause widespread nest or chick loss in short periods of time.
- *Is the population density above thresholds where predation is more likely?* High nesting densities facilitate predation; the densities at which predation increases significantly likely vary depending on other conditions.
- *Do landscape features (vegetation cover, nearby trees) support predators?* Vegetation, especially in later successional stages, provides cover and perches that attract a variety of predators.
- *Is the sandbar attached to shore in the anticipated range of flows during the nesting season?* Direct access to land increases access to a broader range of predators.

Decision and collaboration level: The Technical Team's projection of population densities for the upcoming season informs the need to plan predation control and/or nest caging. Implementation staff identify needs based on observations during productivity monitoring.

3.6.4 Decisions related to experiments and research activities

Opportunities for experimental implementation of management actions can be exercised to develop more productive, efficient, and cost-effective means of achieving the bird objectives. Learning can be accelerated by implementing an action in different ways (e.g. testing and monitoring of different sandbar designs or predation management methodologies, with controls as appropriate) or implementing actions to broaden the available data, allowing for more definitive hypothesis testing (e.g. implementing across a range of effort levels.) This may include *not* implementing an action that may be otherwise recommended if the information to be gained is sufficiently important. Partial implementation, e.g. of predation or vegetation management, provides controls for comparison and hypothesis testing. Decisions about experimental design and research implementation are based on the following considerations:

- *What data gaps need to be addressed? What hypotheses require more evidence?* Regular evaluation of evidence for management hypotheses will identify the need for research and the specific questions that should be addressed.
- *What is the expected value of the information?* Learning resulting in greater gains in the efficiency and effectiveness of management should be prioritized. Modeling can help quantify potential benefits of science activities.
- *Are there additional benefits to experimental implementation?* Experimental implementation may help answer other science questions, enable other research, or provide HC benefits.
- *Does the experimental design increase the likelihood or magnitude of HC impacts?* The potential for impacts not normally associated with an action, or an increase of known impacts, should be evaluated and additional monitoring/analysis, if needed, identified in advance.
- *Are there conflicts or constraints that may preclude completion of the experiment?* For multi-year experiments, the ability to complete the project should be considered along with tradeoffs with other activities. Some studies may conflict with other actions or research.
- *What additional monitoring will be necessary, for how long, and for what cost?* In some cases, it may be possible to assess the outcome of experimental actions with the existing monitoring program; in other cases more focused and/or intensive monitoring or monitoring of additional factors may be required, possibly for multiple years.

Other research activities not directly connected to management actions (e.g. studies of habitat selection, dispersal, etc.) should receive similar consideration:

- *What data gaps need to be addressed? What hypotheses require more evidence?* Regular evaluation science questions and biological hypotheses will provide the information necessary to identify the need for research and the specific questions that should be addressed.
- *What is the expected value of the information?* Learning resulting in greater gains in the efficiency and effectiveness of management should be prioritized. This may include basic science that improves the predictive models. Modeling can help quantify potential benefits of science activities.
- *Are there conflicts or confounding factors that may interfere with research or limit application of findings?* Not all factors can be anticipated, but planned management actions or reservoir releases may affect the ability to perform research, to carry out the full length of the intended study, or to interpret the results.

Identified experimental and research actions will be prioritized based upon these criteria and balanced with other management and research needs for funding and implementation.

Decision and collaboration level: Collaboration on research and experimental management actions will vary depending on the nature of the activity. Collaboration on research activities will generally be through an annual needs elicitation (to which the MRRIC may respond), the Fall Science Meeting and the Annual AM Workshop. Decisions regarding which studies to fund will lie with the ISP Manager, subject to the R&D budget provided in the Program. The Management Team proposes the R&D budget in the draft Strategic Plan, but that figure is subject to approval and appropriations. Collaboration on experimental implementation of management actions would generally be consistent with any other implementation of that management action (see specific action descriptions for examples) and go through the Strategic Plan process. Decisions would generally be made by the Management Team with input from the Technical, Bird, Fish and HC Teams, with consideration of any MRRIC recommendations. Decisions involving flows would be made by the MRBWMD.

3.6.5 Decision criteria for when targets are not met

The definition of targets in Section 3.2.3 includes the quantitative criteria and time frames for meeting targets. There are a number of reasons that the program could fail to meet targets over the specified time frames. Steps to solve the problem are associated with each potential reason. The AM process is forward-looking and will attempt to anticipate and remedy shortfalls before they occur with the use of predictive modeling and adjustments to management actions in the Strategic Plan. In the case that problems are not anticipated, or remedies cannot readily be implemented under existing program

operation, constraints, or priorities, the criteria described below outlines decisions or decision processes that need to occur. These decision criteria do not pre-specify the outcomes of decisions, only that the decision process be initiated with sufficient time to address the problem with adjustments to the Strategic Plan or the SAMP. While the process may determine that no adjustments will be made, the decision criteria ensure that relevant information is taken into account and the decision was made at the correct level(s).

The diagnostic process would be initially conducted by the Technical Team to identify current or anticipated problems and their causes to the extent possible based on monitoring and other program information; the Bird Team would review the diagnosis and identify solutions to be approved by the Management Team or elevated to the Oversight level. Generally, the Oversight level is responsible for deciding whether or not to remove constraints on action implementation, add actions, or change objectives or target criteria based on policy decisions (e.g. as opposed to updating target values based on model updates). Some changes would require additional NEPA analysis and/or formal consultation with the USFWS (Section 2.4.5). Changes to implementation processes or criteria for existing actions within established constraints, or certain other science-based adjustments may not require Oversight approval.

Figure 43 illustrates diagnostic questions for determining why targets are not being met and steps to take to remedy the problem. Problems are listed starting with questions based on scientific understanding, followed by questions about program design and risk tolerance. There may be more than one problem at any given time, but it may be necessary to correct some problems before addressing others (e.g. must be able to fully implement habitat creation guidelines before determining if the creation criteria are sufficient.) Each question and associated recommendation are described in more detail below Figure 43.

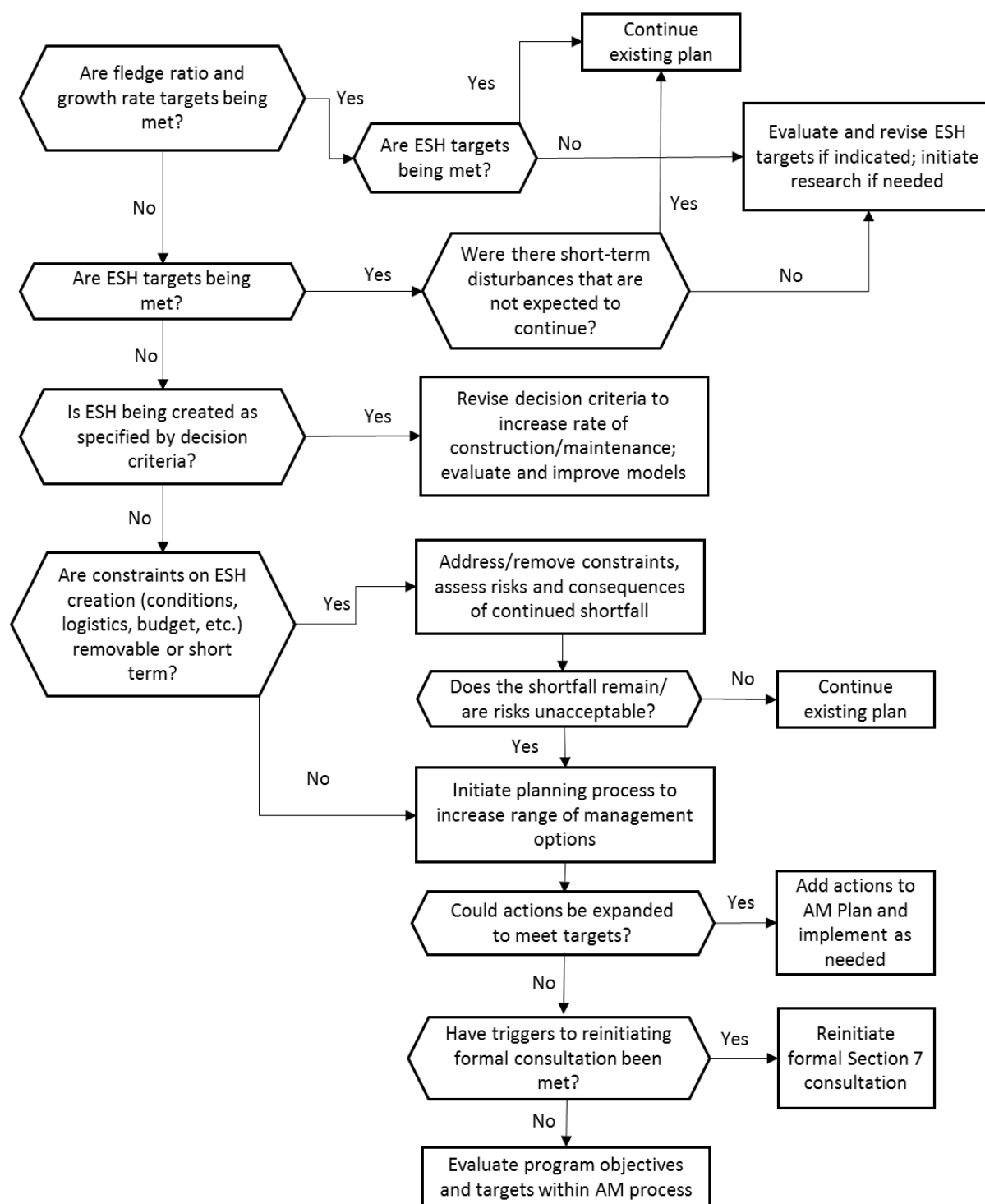


Figure 43. Diagnostic decision tree for a) determining why bird targets are not being met, and b) identifying recommended corrective actions.

1. *Are fledge ratio and growth rate targets being met?*
 - a. *Criteria:* Fledge ratio growth and population growth time frames as specified in targets (3-year arithmetic and geometric means, respectively).
 - b. *If yes*, the existing program is sufficient and should be continued. However, it is also possible that demographic targets are being met but ESH targets are not. If this occurs over multiple years (to account for time lags in population responses) then ESH targets may be higher than they need to be and should be assessed and revised if appropriate. **Action: continue program, revise ESH targets if information suggests they are higher than needed to meet demographic targets.**
 - c. *If no*, continue to question 2.
2. *Are ESH targets being met?*
 - a. *Criteria:* Median standard ESH target is met 3 out of 4 years; available ESH target meeting exceedance criteria over 12-year time frame.
 - b. *If yes:* ESH targets may not be high enough. Either data was insufficient when targets were set, or conditions have changed. Targets should be updated with current information; if information is not available, additional research or monitoring to improve targets should be identified. It is also possible that unusual circumstances (disturbances) lowered demographic rates despite sufficient habitat. If circumstances are identified and not expected to persist, ESH targets may be retained. **Action: evaluate controlling factors, disturbances, and ESH targets; revise ESH targets if the shortfall is not caused by short-term disturbances, initiate additional research if needed to inform models and target calculations.**
 - c. *If no:* continue to question 3.
3. *Is ESH being created as specified by decision criteria and model estimates?*
 - a. *Criteria:* Meeting habitat creation guidance for 4 out of 5 years (construction rates estimated by model to have 75% probability of meeting targets; criteria for implementing flow actions if available).
 - b. *If yes:* Habitat creation criteria are structured to provide sufficient habitat to meet targets given uncertainty in geomorphological understanding and future flows. If habitat is insufficient in the long term after levels of habitat creation specified by the criteria have been met or exceeded, then the models have bias and/or assumptions about the hydrograph are incorrect (e.g. flows are in the highly erosive range more often than in the past due to changes in management, basin runoff, or changes in channel morphology and sediment budgets.) Construction estimates can be adjusted to accommodate bias/uncertainty until models can be improved. **Action: Adjust habitat creation criteria to accelerate construction.**

Evaluate models for sources of bias in habitat estimates; if found, initiate additional research if needed to improve models.

- c. *If no:* continue to question 4.
- 4. *Are constraints on ESH creation (conditions, logistics, budget, etc) removable or short-term?*
 - a. *Criteria:* Constraints are short-term if not expected to occur more than 1 out of 5 years
 - b. *If yes:* Constraints and/or conflicts are not allowing the current set of actions to be conducted to the necessary extent. If constraints can be removed by changes to practices, water management, regulations, or changes in priority, than the problem may be resolvable without changes to the set of actions available for use. Other limitations may be known to be limited in term and not expected to recur. **Action: Remove constraints and assess risks and consequences of continued shortfall by any combination of remaining or anticipated future constraints.** Continue to Question 5.
 - c. *If no:* continue to Question 6.
- 5. *Do shortfalls remain/are risks unacceptable?*
 - a. *Criteria:* Risk acceptability varies over time, by interest group, and circumstantially. The MRRP will seek to identify (and periodically update) appropriate criteria through the AM process.
 - b. *If yes:* The current set and definitions of management actions is not sufficient to meet targets. A broader scope of existing actions and/or the addition of new actions will be necessary to meet objectives. **Action: Initiate planning process to increase range of management options (see sections 2.4.5 and 3.6.6)**
 - c. *If no:* continue to question 6.
- 6. *Can the set of, or specifications for, actions be expanded to meet targets?*
 - a. Results of tradeoff analysis and NEPA processes (as appropriate) indicate actions may be added or expanded in scope
 - b. *Criteria:* Specific criteria not identified at present.
 - c. *If yes:* add actions to AM Plan, develop necessary decision criteria, and implement as needed and appropriate
 - d. *If no:* continue to Question 7
- 7. *Have conditions for reinitiating formal consultation been met?*
 - a. *Criteria:* Formal consultation may be reinitiated if “new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion”

(USFWS 1996)¹. That is, the proposed action evaluated by the Biological Opinion included the current targets and associated decision criteria; if not met, the USFWS must determine whether the previous consultation is still sufficient.

- b. *If yes:* Action: reinitiate formal consultation under Section 7 of the ESA.**
- c. *If no:* Action: revisit program objectives and targets within Oversight Level with support from the Bird Team and Technical Team.**

3.6.6 Decisions to add, change, or remove management actions

Decisions to change how actions are implemented or to add new actions can be triggered by a) new evidence for action effectiveness, b) new evidence indicating expected impacts that precluded an action are sufficiently unlikely, c) regulatory changes that allow additional/broader actions or d) evidence that targets cannot be met with existing actions, thus requiring consideration of expanding the set of available actions.

The decision to add actions is supported by tradeoff analysis, balancing evidence for action effectiveness and for HC impacts and benefits (see Section 2.4.5.2). Cost-effectiveness should also be considered, though the toolbox approach described in Section 3.2.1 includes maintaining a range of management actions for use, even less efficient ones, for when the most cost-effective options may not be implementable.

If targets cannot be met using actions in the ROD and no additional constraints upon their use can be reduced or removed, addition of actions outside of the ROD should be considered before evaluating targets or reinitiating formal Section 7 consultation (Figure 43). This process also requires trade-off analyses or other structured decision techniques (Section 2.4.5.2).

Criteria for changing individual actions are included in Section 2.4. The process for adding actions, particularly flow management actions, is described in Section 2.4.5. Actions may also be adjusted during implementation, though they may only be increased in magnitude during implementation to the extent that the action was defined within the programmatic EIS or site-specific assessments. Increase in action specifications for future uses outside of what has previously been analyzed in the EIS would require additional analysis and a decision document before implementation.

¹ This criteria for reinitiating formal consultation is most relevant to failure to meet targets. There are three additional criteria listed in Section 3.6.7.3.

Decisions to stop an action during implementation can be triggered by approaching identified HC thresholds (see Chapter 5) or indications that an action is no longer effective or needed. Decisions to reduce the scope of an action or not use it in the future may occur if there is sufficient weight of evidence that an action is not effective or following an evaluation of HC impacts (see Chapter 5). The decision to remove an action from future consideration requires cost-benefit determinations under a variety of scenarios that weigh the use of the action against other alternatives. Low cost, low impact actions may be retained even if less effective than other actions, as they may be useful in cases where resources or conditions do not allow more effective action.

3.6.7 Decisions to change metrics and targets

The process to change metrics and targets depends on the type of change required. Updates to metrics and target values, following the same criteria, are science-based and expected to keep pace with learning through regular updates. Changes to target criteria and or objectives are largely based on policy, risk tolerance, and values and expected to be infrequent. These processes and the information or events that trigger them are described below.

3.6.7.1 Updates of habitat and fledge ratio targets

Target values (acres of ESH, fledge ratios, population growth rates) are developed using the ESH and population models and, consequently, reflect the current level of quantitative understanding. With time, the models will be updated to reflect learning and provide more accurate estimates of habitat and population dynamics, habitat requirements, and population persistence. Most changes to the population model or the habitat or hydrological models would affect calculated ESH targets. Periodically, ESH targets will be revised to reflect updated information—i.e. every 3-5 years for incremental changes or more frequently if there are major updates or revisions to models. ESH targets should be recalculated often enough to allow learning to improve management outcomes, but not so frequently as to hinder reasonable planning and assessment processes. These updates can correspond with broader periodic programmatic reviews. Large increases in information—for example, completion of a research study that allows for significant model improvements—may justify interim updates, pending agreement at appropriate decision levels. Decisions follow the process outlined in Section 2.4.2.

Similarly, learning about demographics, particularly survival rates, would likely indicate that the fledge ratio target would need to be updated. This value should be also periodically updated. Interim updates may be warranted following significant science findings.

It is important to note that these updates are to the quantitative value of the targets for the existing target criteria, not changes to the criteria themselves. These changes are informed by the data available, are not policy- or value-based, and are expected to occur more frequently than changes to the criteria themselves.

To update target values, the Technical Team provides the new estimates to the Bird Team, who in turn identify the adjustment in the Strategic Plan updates. The Management Team informs the Oversight level of the change and resulting changes to the Strategic Plan. This update does not require Oversight approval. If either the Bird Team or the Management Team declines to update the targets, or identifies an updated value that differs from the recommendation of the Technical Team, the original proposal is presented at the next MRRIC meeting along with the basis for the deviation (see the discussion in Section 2.5.2.2). Agency leadership may consider this information and render a final decision regarding the targets. The MRRIC may make a recommendation regarding the adjusted value.

3.6.7.2 Revisions to metrics

Learning may also support changes to how habitat or populations are measured in the context of objectives. This includes how productivity (fledge ratio) or habitat is defined. Changes to metrics may be necessary if the assumptions underlying the metrics are no longer accurate, or if the monitoring program is unable to capture the metric sufficiently and cannot feasibly be improved. As with the quantitative values of targets, this does not necessarily reflect a change in the criteria themselves. The Technical Team and Bird Team, individually or together, may recommend a change to metrics to be decided upon at the Management Team level, who also inform the Oversight level. As with target values, disagreements about the course of action regarding metrics go through a collaborative process that includes MRRIC.

3.6.7.3 Revisions to objectives and target criteria

The species objectives and target criteria, unlike their numerical values, are policy decisions based upon agreements of acceptable levels of risk, priorities, and regulations. These decisions can be informed by modeling and other scientific information (such as metapopulation dynamics), but are fundamentally values-based decisions made at the Oversight level. Objectives and targets should be reviewed periodically or if risk tolerance, management priorities, and/or regulations change significantly. The following target criteria are subject to this level of decision:

- 1) Population persistence criteria: the quasi-extinction threshold, probability of quasi-extinction, and time frame. Higher quasi-extinction thresholds, lower probabilities,

and longer time frames reduce risk to the population and increase management requirements (see Buenau [2015] for examples). Lower thresholds, higher probabilities, and shorter time frames increase risk to the population and reduce management requirements.

- 2) Time frames for meeting targets: the definition of the targets allows them to be missed on occasion as long as targets are met in most years (e.g. 3-year running averages for demographic targets.) This allows for short-term disturbances (e.g. high flow years that limit nesting) to occur as natural variability. They allow for limited shortfalls in management but not persistent limitations. Changing the frequency that targets must be met will change the level of risk to the population.
- 3) Confidence bounds: upper and lower confidence bounds trigger larger adjustments to management activities when habitat acreage falls outside rather than within them. These bounds are probability-based but fundamentally a decision based on risk tolerance, and can be adjusted. The lower bound indicates what likelihood of failure to meet population objectives must be met before more intensive habitat creation needs to occur (potentially at higher cost and/or pre-emption of other priority activities.) Increases to the lower bound reduce the risk of failure to meet objectives, while increasing costs and other impacts. The upper bound indicates the point at which too much habitat is being created relative to what is likely needed, and the costs or other impacts are higher than necessary. Lowering that bound places high value on keeping costs and impacts low, with increased risk of not meeting population objectives.

Changes to objectives are more fundamental and may be triggered by regulatory or other policy changes (e.g., to USACE authorities) or broad changes in scientific understanding, e.g. how the Missouri River subpopulations of plovers relate to the larger population. They may also require adjustment to reflect any driving factors outside of USACE control that limit the ability to manage the Missouri River subpopulations, such as factors affecting survival or physical condition when birds are using winter habitat.

An inability to meet targets may trigger re-evaluation of target criteria and objectives (Section 3.6.5). However this step should be taken only after other solutions have been attempted and if it has been determined that no adjustments to the program could be made that would meet the targets. Changes to objectives or target criteria may require reinitiation of formal consultation.

4 Adaptive Management of Pallid Sturgeon in the Missouri River

This chapter is organized according to the steps of the AM cycle introduced in Section 1.1.5:

1. Assess (Section 4.1), which provides goals and objectives for pallid sturgeon, and also summarizes the EA (Jacobson et al. 2015b, 2016a, 2016b; 2016c; DeLonay et al. 2016b);
2. Plan and Design (Section 4.2), which summarizes metrics and decision criteria for Level 1 and Level 2 components, and describes the design and evaluation of Level 3 actions, building on the detailed description of action effectiveness monitoring in Appendix E, and incorporating much of the material from the Lower Missouri River Pallid Sturgeon Framework, Targets and Decision Criteria (USFWS and USACE 2015, USFWS 2015a, USFWS 2016c);
3. Implement (Section 4.3) describes the current schedule for implementation of Level 1, 2 and 3 actions (this schedule will be further revised over time);
4. Monitor (Section 4.4), which summarizes the metrics used for monitoring each Level 2 and 3 action currently under consideration;
5. Evaluate (Section 4.5), which summarizes the evaluation approaches used for each Level 2 and 3 action; and
6. Decide (Section 4.6), which summarizes the decision criteria for each Level 2 and 3 actions.

This chapter is associated with several appendices:

- A. Appendix C contains details of the design of Level 1 science and Level 2 in-river actions.
- B. Appendix D describes the protocol to be used for population monitoring, and the structure of the population model that's closely associated with the population monitoring.
- C. Appendix E describes, in detail, the effectiveness monitoring designs for actions listed in Section 4.2.

- D. Appendix F contains detailed cost estimates for Level 1 and Level 2 science components, and the criteria used to prioritize those components.

Relative to birds, there is a greater level of uncertainty about the most appropriate management actions to maintain and recover pallid sturgeon populations in the Missouri River. Therefore, the approach described in this chapter involves a greater investment in research to reduce critical uncertainties that affect management decisions, and in rigorous monitoring of well designed pilot actions (Level 2) to evaluate their effectiveness.

4.1 Assess

4.1.1 Goals and management objectives for pallid sturgeon

In 2013, the USFWS (written com., September 12, 2013 [Draft Species Objectives, p. 1]) developed the following fundamental objective for pallid sturgeon in the Missouri River:

Fundamental Objective: Avoid jeopardizing the continued existence of the pallid sturgeon from the U.S. Army Corps of Engineers actions on the Missouri River.

The USFWS notes that this objective is consistent with species recovery goals (U.S. Fish and Wildlife Service, 2014) but specific to Missouri River management actions.

In 2013, the USFWS also proposed the following two sub-objectives (both measurable), which must be attained to ultimately achieve the stated “fundamental objective”. The intent of the sub-objectives is to provide direction in the short term, provide objectives meaningful for AM, and focus efforts on the desired short term outcomes while keeping the fundamental objective in mind. Although attaining a self-sustaining population is the desired outcome of the Revised Pallid Sturgeon Recovery Plan (USFWS 2014), described below under sub-objective 2, we may be decades away from such an objective being very meaningful. If natural recruitment were achieved in 10 years, it could take 20 to 30 years before progress toward the self-sustaining population objective could be assessed. Modeling can give projections and insights into the probability of achieving the fundamental objective under proposed and implemented actions. The two sub-objectives provide guidance for the actions, monitoring and research required to support the fundamental objective over the longer term. Figure 44 provides a summary of the goals, objectives, metrics and targets for pallid sturgeon in the SAMP.

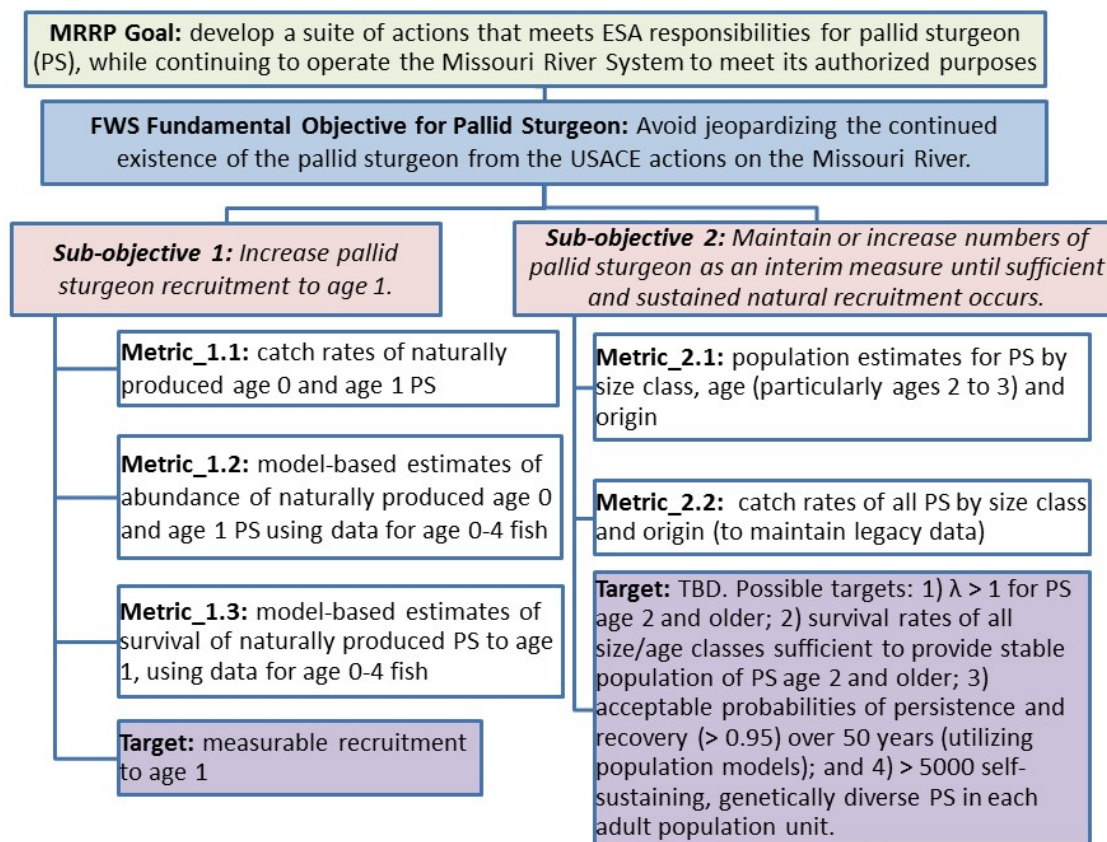


Figure 44. Hierarchy of goals, objectives, metrics and targets for pallid sturgeon. TBD = To Be Determined. The goal of the AM Plan is described in more detail in Section 1.1.3 of this plan.

Sub-objective 1: Increase pallid sturgeon recruitment to age-1.

Metrics: Age-0 pallid sturgeon are rare and difficult to monitor, so inferences on their abundance and survival for sub-objective 1 must be inferred from multiple metrics, some measured in the field, and others estimated from models (Figure 44). The primary metric is catch rates of age 0 and age-1, naturally produced pallid sturgeon; secondary metrics include model-based estimates of (a) abundance of age 0 and age-1 pallid sturgeon, and (b) the survival of naturally produced fish to age-1. These model-based estimates will rely on catch rates or abundance estimates of naturally-produced pallid sturgeon aged 0, 1, 2, 3 and 4, depending on the final form of Pallid Sturgeon Population Assessment Program (PSPAP), which is currently going through a revision process.

Target: TBD. The short-term target is to demonstrate measurable recruitment to age-1, and hopefully increasing levels of recruitment over time. Recruitment to age-1 has not been confirmed in the Upper Missouri River for many years despite evidence of

successful spawning (USACE Biological Assessment 2017, pg. 134-136; Jacobson et al. 2016a). In the Lower Missouri River, monitoring data suggest that some recruitment to age-1 has occurred (USACE Biological Assessment 2017, pg. 136-137; Jacobson et al. 2016a). As described above under “Metrics”, multiple methods are required to estimate recruitment to age-1. Until 2015, there had been no documented captures of genetically identified, wild-spawned pallid sturgeon free embryos, larvae, or YOY in the lower river (U.S. Fish and Wildlife Service, 2014). Recent data indicate that limited recruitment is happening in the Lower Missouri River, but not at a level sufficient to maintain the population (U.S. Fish and Wildlife Service, 2014; Jacobson et al. 2016a). Multiple factors can potentially be limiting recruitment (see Appendix B, Figures B.9, B.10 and B.11).

The long-term target for recruitment (i.e. necessary levels and frequency of recruitment over time) will be informed by the EA (Jacobson et al., 2016a) and the collaborative population model (Section 4.1.2.3 and Appendix D of this plan), following the necessary monitoring, model validation, and supporting research. Defining the long term target is not critical in the near-term as the immediate priority is to establish measurable recruitment. Possible targets could include a modeled egg to age-1 survival rate sufficient to result in growth and sustainable population size.

Sub-objective 2: Maintain or increase numbers of pallid sturgeon as an interim measure until sufficient and sustained natural recruitment occurs.

Metric: Population estimates for pallid sturgeon for all size and age classes by origin (i.e., wild, hatchery, unknown), particularly for ages 2 to 3 to assess recent trends in recruitment; catch rates of all pallid sturgeon by size class and origin (to maintain legacy data). Age classes will be estimated as an output metric of the population model that will be validated through recaptures of tagged fish. There are challenges in quantifying a population size for age 2-3 year old pallid sturgeon as there is a lot of overlap in the lengths of fish aged 2 to 5 years. Further work is required to refine population metrics, which may include estimating a population size for a subset of the length frequency distribution. Proportional Size Distribution (the proportion of CPUE in different size classes; Guy et al. 2007) is a useful proxy metric for age distribution, but is also dependent on the gear used to catch fish.

Target: TBD. Possible targets could include: (1) positive population growth rates (i.e., $\lambda > 1$) of pallid sturgeon age 2 and older; (2) estimated survival rates of all size/age classes sufficient to provide a stable population of pallid sturgeon age 2 and older; and (3) acceptable probabilities of persistence and recovery over a 50 to 100 year time frame (utilizing population models). For example, the Lower Missouri Framework

(USFWS and USACE 2015) described two preliminary decision criteria for halting population augmentation: 1) when population monitoring demonstrates a self-sustaining, genetically diverse population in excess of 5000 adult fish in each management unit; and 2) when the threat of extirpation is less than 5 percent in 50 years. New targets may be introduced through the Range-wide Stocking and Augmentation Plan (U.S. Fish and Wildlife Service, in revision) or other documents developed by the USFWS Pallid Sturgeon Conservation Propagation and Stocking Program. The criteria recommended in USFWS and USACE (2015) are similar to those in the Revised Recovery Plan for the Pallid Sturgeon for reclassifying pallid sturgeon from endangered to threatened status (USFWS 2014, pg. 54):

“Pallid Sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria are sufficiently addressed such that a self-sustaining genetically diverse population of 5,000 adult Pallid Sturgeon is realized and maintained within each management unit for 2 generations (20-30 years). In this context, a self-sustaining population is described as a spawning population that results in sufficient recruitment of naturally-produced Pallid Sturgeon into the adult population at levels necessary to maintain a genetically diverse wild adult population in the absence of artificial population augmentation. Metrics suggested to define a minimally sufficient population would include incremental relative stock density of stock-to-quality-sized naturally produced fish (Shuman et al. 2006) being 50-85 over each 5-year sampling period, catch-per-unit-effort data indicative of a stable or increasing population, and survival rates of naturally produced juvenile Pallid Sturgeon (age 2+) equal to or exceeding those of the adults (see Justification for Population Criteria below [in USFWS 2014] for details). Additionally, in this context a genetically diverse population is defined as one in which the effective population size (N_e) is sufficient to maintain adaptive genetic variability into the foreseeable future ($N_e \geq 500$), conserve localized adaptations, and preserve rare alleles.”

In addition to the fundamental objective and associated sub-objectives, there are a set of proposed actions to be implemented on the Missouri River, which are the means of achieving the fundamental objectives and sub-objectives. The timelines for these actions serve as a backstop to ensure that the rate of implementation of management actions on the Missouri River is not hindered by an inability to learn from applied science efforts. In effect, they define necessary levels of implementation at a point in time for each hypothesis, and must be met unless the learning from applied science efforts demonstrates that the in-river actions associated with that hypothesis are unnecessary.

The 2018 Biological Opinion (USFWS 2018, pages 109-119) describes primary and secondary metrics, as well as decision criteria, for evaluating if Incidental Take has been

exceeded. These metrics include apparent survival, abundance, condition, growth rate and reproductive cycling.

4.1.1.1 *Geographic scopes of the Effects Analysis, MRRP-EIS and this AM Plan*

Scope of the EA. The geographic scope of the Pallid Sturgeon EA was larger than the scope of the MRRP-EIS and this AM Plan. The area considered in the EA included the Upper Missouri River mainstem from Fort Peck Dam to the headwaters of Lake Sakakawea, the Yellowstone River upstream of the confluence with the Upper Missouri River for an unspecified distance, the Lower Missouri River mainstem from Gavins Point Dam to confluence with the Mississippi River at St. Louis, tributaries used by pallid sturgeon, and an unspecified distance downstream in the Mississippi River (Figure 45). The distance downstream in the Mississippi River is unspecified because presently available information (2015) is ambiguous about the extent to which Missouri and Mississippi river populations mix through migrations and dispersal. Recent information suggests that adult pallid sturgeon originating in the Missouri River are frequently found in the middle and upper Mississippi River (Porecca et al. 2015).

This geographic scope was constrained in part by the decision-making authority of the USACE and in part by present understanding of the geographic distribution of pallid sturgeon. Literature and ongoing research from outside this defined area was utilized where it helped to inform hypotheses evaluated in the EA. The reservoirs and inter-reservoir reaches (from Lake Sakakawea to Lewis and Clark Lake) were excluded from the effects analysis based on the assumption that these habitats are unlikely to support reproductive populations of pallid sturgeon. The upper half (A) of Figure 47 shows the area that is the main focus of research into potential management actions to recover the pallid sturgeon population in the Upper Missouri River.

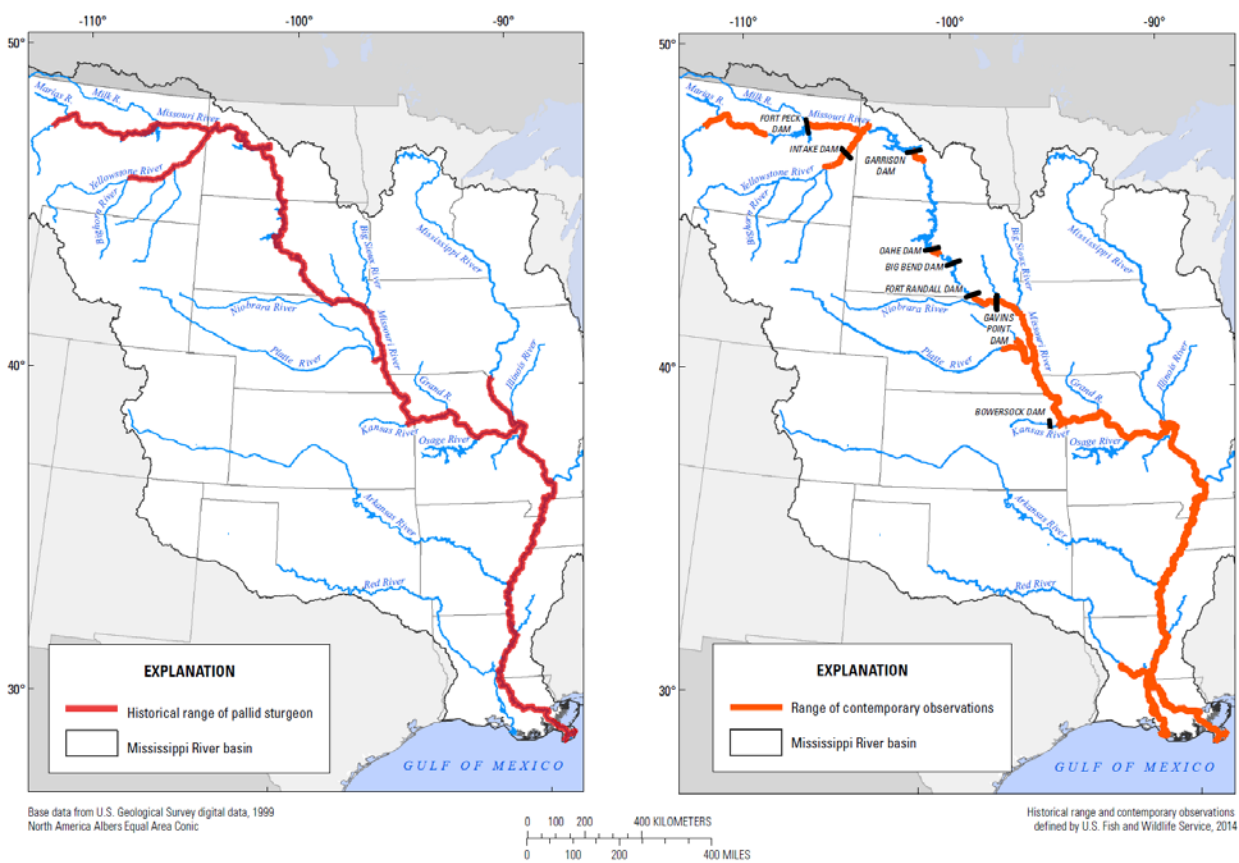


Figure 45. Historical range and present-day occupancy of the pallid sturgeon and scope of the Missouri River included in the EA. Present day occupancy shown on the right side map includes the stretch of the river above Gavins Point Dam and below Fort Randall Dam, which is not included in the defined area of the Lower Missouri River. Pallid sturgeon may be found in reservoirs but do not prefer these habitats. Source: Figure 2 in Jacobson et al. 2016a

Scope of the MRRMP-EIS. Management of Missouri River pallid sturgeon has historically occurred over four Recovery Priority Management Areas or RPMAs, and is now organized around four Management Units (described in section D.1.3 of Appendix D, and Figure D.1, and shown in the upper right panel of Figure 46). The area upriver of Fort Peck Reservoir (former RPMA 1) is outside of the geographic scope of the MRRP. Figure 46 shows the geographic scope of the MRRP (and this AM Plan), which includes:

- the Upper Missouri River below Fort Peck Lake to Lake Sakakawea (sampling segments 1-4, Great Plains Recovery Planning Management Unit or RPMU);
- the Yellowstone River from Intake Dam at Intake, Montana to its confluence with the Missouri River (also in the Great Plains RPMU);
- the unchannelized Missouri River from Fort Randall Dam, SD, to the headwaters of Lewis and Clark Lake (segments 5 (Great Plains) and 6 (Central Lowlands RPMU); and
- the portion of the Lower Missouri River from Gavins Point Dam to the confluence of the Missouri and Mississippi Rivers (segments 7-10 (Central Lowlands RPMU), segments 13 and 14, Interior Highlands RPMU).

Figure 47 provides more a more detailed illustration of the geographic scope of the MRRP in the Upper and Lower Missouri River. The habitat and population attributes of the four management units are described in more detail in the 2018 Biological Opinion (USFWS 2018, pages 37-38, 40-45).

The Yellowstone River is the only tributary included in the geographic scope of the MRRP-EIS, due to its importance to pallids in RPMA #2, and the effects of the Intake Dam. The Platte River has been utilized by pallid sturgeon and information from the Platte River is relevant to an understanding of pallid sturgeon populations in the Lower Missouri River, but the Platte River is not within the geographic scope of the MRRP and the SAMP. As occurred during the EA, literature and ongoing research from outside the geographic area defined for the MRRMP-EIS (e.g., upstream of Fort Peck Dam) may be utilized where it helps to inform the evaluation of hypotheses and potential management actions.

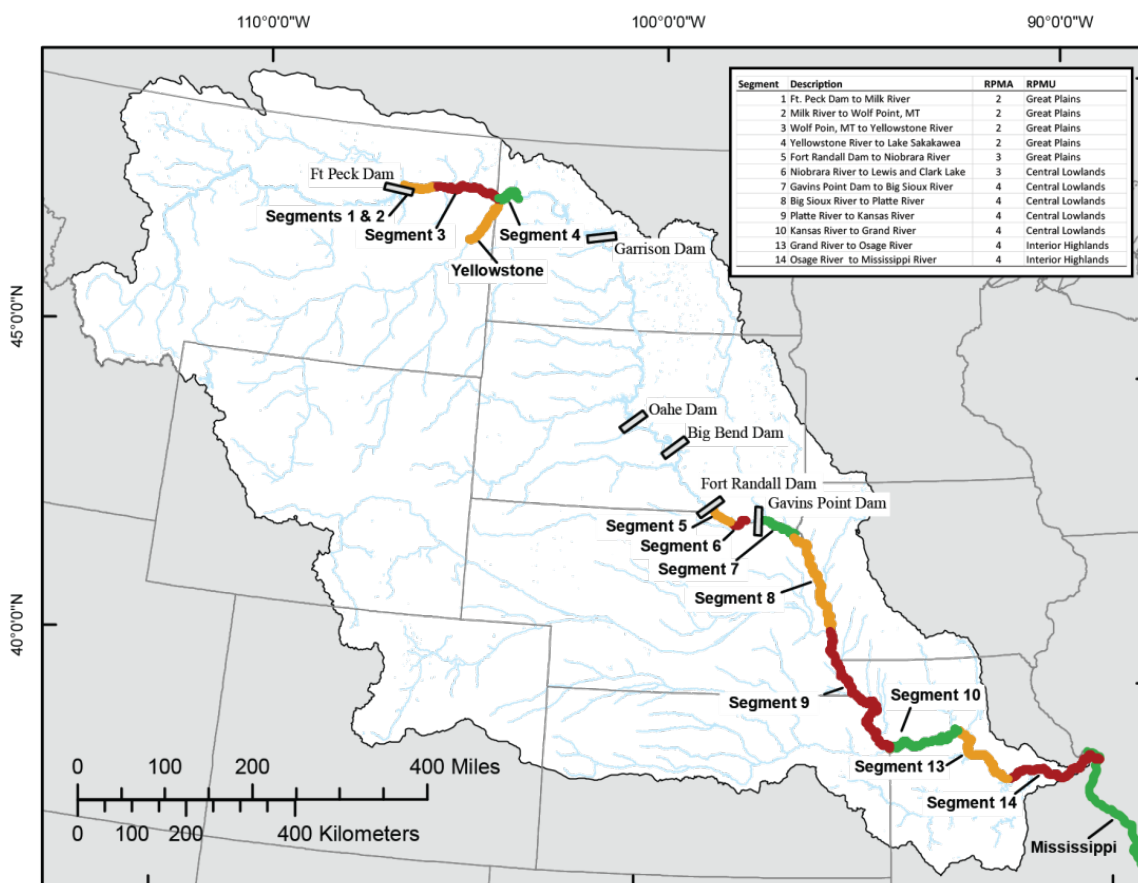
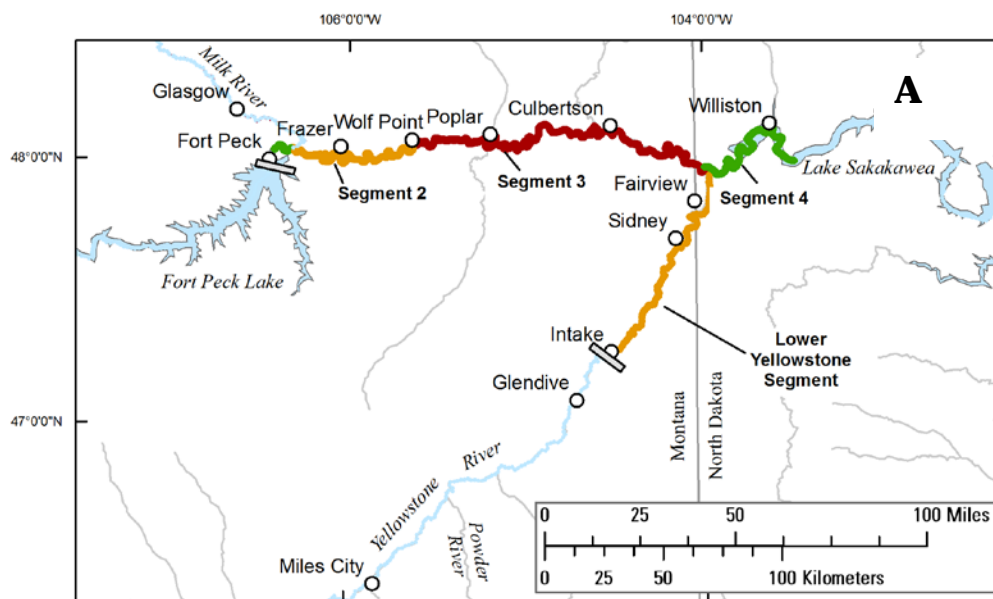
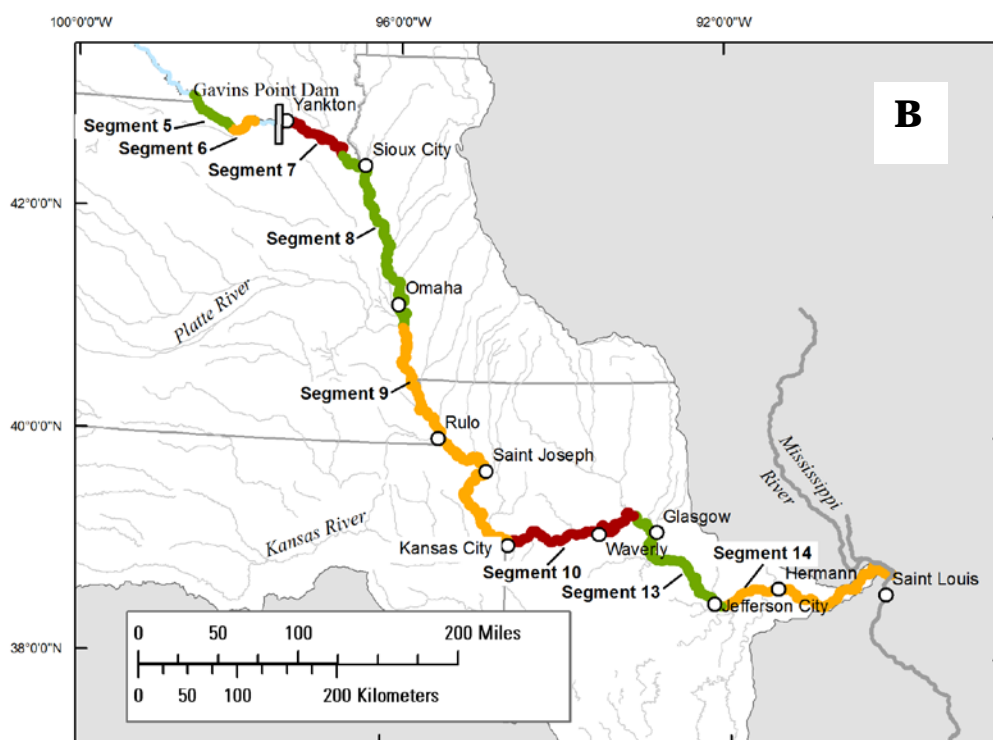


Figure 46 Location map for the Missouri River basin, showing dams and sampling segments (colored river sections). Inset table shows recovery-priority management areas (RPMAs) and recovery priority management units (RPMUs).



Source: U.S.G.S. digital basemap data
Universal Transverse Mercator, Zone 15



Source: U.S.G.S. digital basemap data
Universal Transverse Mercator, Zone 15

Figure 47. Map of the upper (A) and lower (B) river complex, showing the Yellowstone and Missouri Rivers, major tributaries, reservoirs, and river segments. The color-coding represents the delineation of each segment.

4.1.2 Key findings from Effects Analysis and more recent work

4.1.2.1 Purpose and methods of the EA

The concept of an EA is rooted in the requirement within the ESA to evaluate the effects of actions proposed by federal agencies on listed species or designated critical habitat, using the best available science. Murphy and Weiland (2011) advocated for a rigorous approach to EA that consists of three primary steps carried out once the problem has been formulated with the definition of the proposed action, the area affected, and a conceptual model of the physical and biological relationships relating actions to species outcomes. The first step is to collect reliable scientific information, including observations about the stressor and the range of stressor conditions and information on population sizes and trends. The second step includes assessment of the data, including using quantitative models to integrate existing information and identifying and representing uncertainties. The third step is to analyze the effect of the actions on the species to determine costs and benefits and identify alternatives.

This section summarizes the completed Phase 1 of the EA process and documented in Jacobson et al. (2016a) and Fischenich (in review). The primary and relevant products of the EA are summarized in the following reports and models:

- Summaries of existing data/information reflecting the state of science for the species and their habitats to identify the effects of system operations and actions on species populations and their habitats (Jacobson et al., 2015a)
- Conceptual Ecological Models (CEMs) to guide quantitative models (Jacobson et al., 2015b)
- Hypotheses addressing critical uncertainties (Jacobson et al., 2016b)
- Quantitative models for forecasting the effect of different alternatives on species performance. Modeled processes include reservoir operations and hydraulic conditions (Fischenich, in review), habitat availability (Fischenich et al. 2014, in revision), and species demographics (Appendix D of this Plan)

The EA provides an integrated assessment of the potential benefits of management actions for pallid sturgeon in the Missouri River, and documents uncertainties in that assessment. As the models presented in the EA are improved they will become focal points for data assimilation, hypothesis generation, experimental design, and evaluation of management actions. These models are intended to eventually be used to make projections of habitat availability and population responses under different combinations of actions, and to develop species/habitat targets under the MRRMP. The

EA is an on-going process that can be used to further refine strategies to address the uncertainties and hypotheses identified as part of the EA. To date, this process has involved the EA team, independent scientists on the ISAP and ISETR, as well as representatives from MRRIC and its committees. The EA process can be used to address various forms of “new information”, including both unexpected results derived from science efforts within the AM program, as well as novel findings from outside the program (see sections 2.5.3 and 6.2.5). Syntheses of new information could lead to changes in existing hypotheses, the retrieval of hypotheses from the hypothesis reserve (Figure 48) or the addition of new hypotheses.

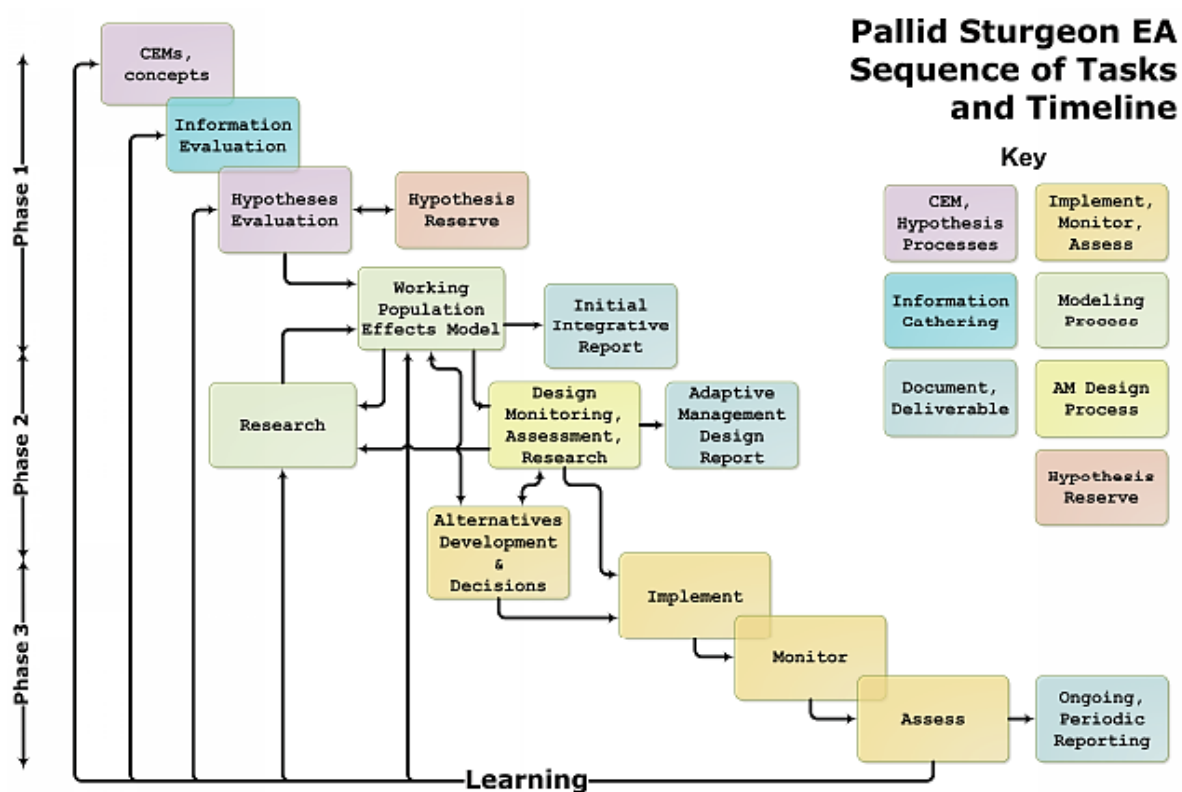


Figure 48. Phases 1, 2, and 3 envisioned for the EA process (Jacobson et al., 2016a).

4.1.2.2 Overall conceptual model

Conceptual ecological models (CEMs) illustrate population dynamics at the population level, and show the linkage between management actions, ecological factors, and biological responses (Jacobson et al. 2015b). The generalized population-level conceptual model in Figure 49 was adapted from Figure 3 in Jacobson et al. 2016c. This conceptual model demonstrates the conditions, processes, and potential management actions that affect survival at critical life-stage transitions. In Figure 49, squares

represent different life-stages with arrows in the direction of development. Life-stage transitions are influenced by the survival probability (diamonds) and the conditions, processes, and management actions influencing survival (ovals and icons). The conceptualized river in the middle of the graphic demonstrates the use of the river mainstem or its tributaries during different life-stages (Wildhaber et al. 2007).

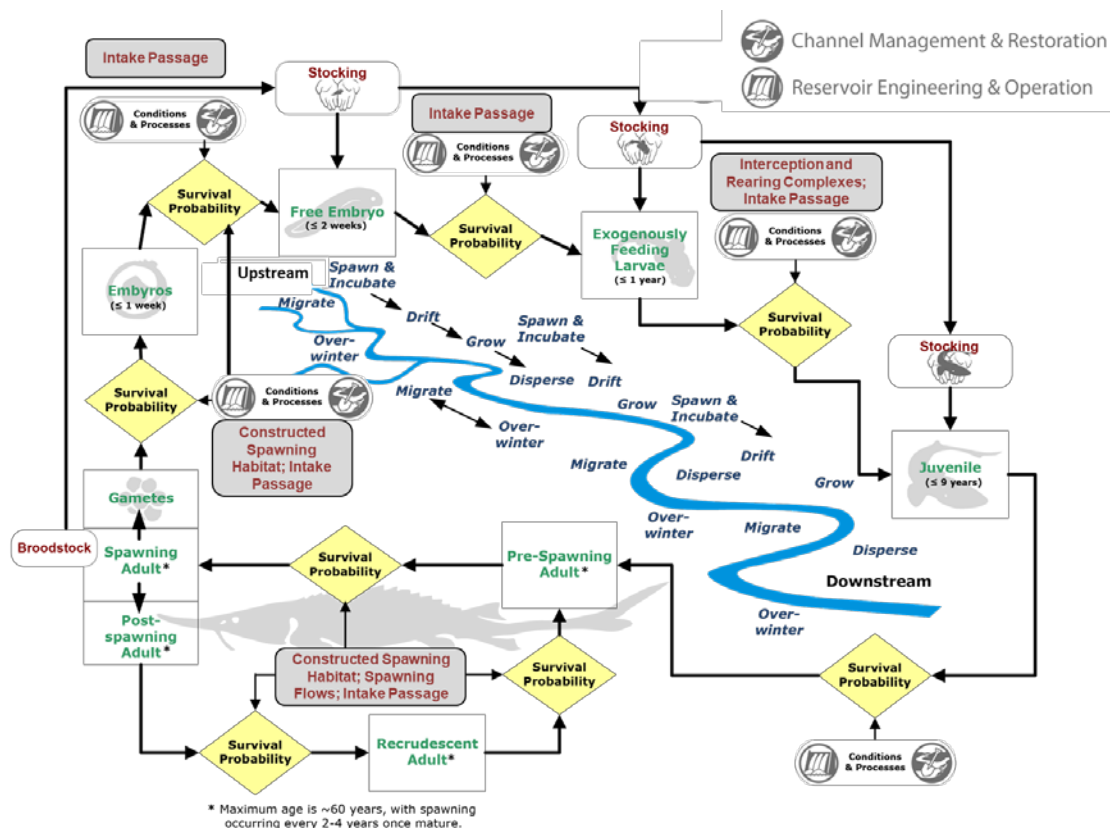


Figure 49. Generalized population-level CEM showing life stages, geographic context of pallid sturgeon reproductive cycle, and management actions being considered in the upper and lower Missouri River (and described in Section 4.2). Fingerlings and yearlings less than 1 year old fit into the “exogenously feeding larvae” life stage.

The two classes of management actions represented in the figure are channel management and restoration, and reservoir engineering and operations. Channel management and restoration options include channel reconfiguration, interception and rearing complexes, spawning habitat creation, bank stabilization and in-river structures to alter velocities or flow paths. Reservoir engineering and operations include operating rules (e.g., flow pulses, drawdown), passage structures, and structures or actions to improve water quality (e.g., temperature, sediment, oxygen).

Life-stage component CEMs were developed by Jacobson et al. (2015b) to illustrate the driver-stressor relationships influencing survival of that life-stage transition. These life-stage transition survival probabilities correspond to the diamonds in Figure 49. Survival at each life history stage is a function of the conditions and processes which occur during that stage, which in turn are potentially affected by different management actions. Figure 49 also shows potential stocking activities (which historically have included stocking at free embryo, exogenously feeding larvae / fingerlings / younger yearlings (all < 1 year old), and juveniles / older yearlings) and broodstock collection of spawning adults.

Figure 50 is an example of a life-stage component CEM. Each pair of columns, from left to right can be considered a cause-effect linkage, with the final rightmost column being the ultimate biotic response (Jacobson et al. 2015b). The classes of factors that were considered include (from left to right in Figure 50): anthropogenic or geologic independent drivers, management and restoration activities, primary ecological factors, secondary ecological factors, primary biotic responses, and ultimately the secondary biotic response of survival of that life-stage (yellow diamond). The conceptual model uses a hierarchical structure of factors, whereby bounding boxes represent broad descriptions of ecosystem factors and are common across all component CEMs, and the colored boxes within each column are more specific factors which may vary depending on the life-stage and location of the component CEM. Hypothetical relationships between the factors were explicitly mapped out in a workshop process involving experts in pallid sturgeon biology and Missouri River processes. Participants at these workshops characterized each relationship by its relative importance and uncertainty. The relative importance ranking used line weight used in Figure 50 (solid, dashed, and dotted lines, where solid represented the highest relative importance), and the uncertainty ranking used line color (black—least uncertainty, blue—moderate uncertainty, and red—most uncertainty). These hypothetical relationships provide the basis for the global hypotheses for the EA (Section 1.4.2).

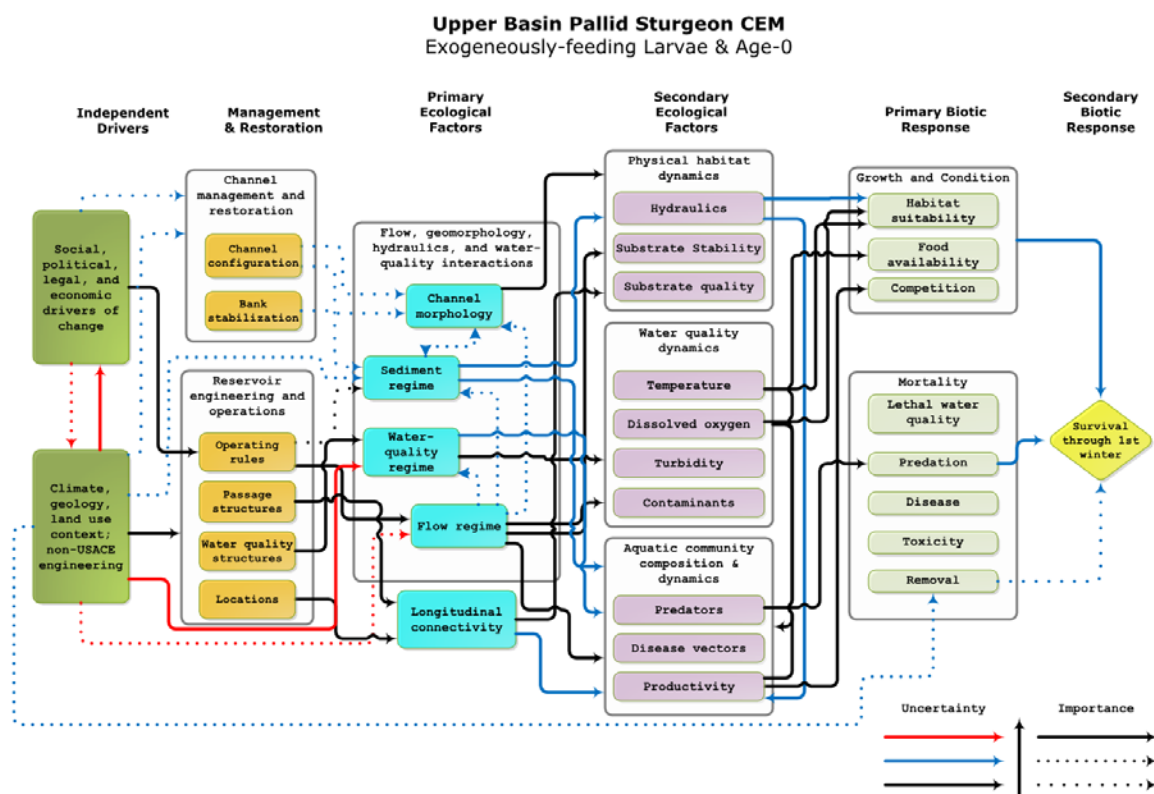


Figure 50. Example of a life-stage component CEM showing the cause-effect linkages leading to survival to the next life-stage (Jacobson et al. 2015b).

4.1.2.3 Collaborative population dynamics model

The collaborative pallid sturgeon population model (Jacobson et al. 2016a; Appendix D, section D.4.3) serves as a central tool to organize, assimilate, and evaluate information on Missouri River pallid sturgeon populations. The primary purpose of the model is to evaluate the population-level effect of management actions and provide metrics (e.g., population viability, abundance) that link to fundamental objectives for pallid sturgeon. The description of the model presented here is a snapshot of the current state of the model, which has expanded in scope since the EA was developed. The models are the quantitative statement of hypotheses. Expressing hypotheses in a quantitative form reveals where the most critical uncertainties exist in our understanding of functional relationships (i.e., uncertainties in key inputs to decisions), which helps to prioritize data collection and small-scale experiments. The models also provide a mechanism for extrapolating observed changes at specific life-history stages (from field data) to their long term population consequences, and propagating the inherent uncertainties in life-stage specific survival probabilities (the diamonds in Figure 49). The structure of the model mimics the structure of the revised population assessment program, as described in Appendix D. This will provide benefits in both directions: essential empirical data for

model calibration, testing and application; and use of the model to design the most cost-effective data collection procedures, explore alternative hypotheses, and evaluate the long term consequences of current and proposed actions for fundamental and sub-objectives.

The development of the stage-based collaborative model has several advantages over previous age-structured models (e.g., Reynolds and Tyre 2011, Steffensen et al. 2013a, Wildhaber et al. 2015). First, the collaborative model explicitly models all life-stages. Specifically, there are several early life history stages that participants believed required their own conceptual ecological models, including gametes, embryos, free embryos, exogenously feeding larvae, and age-0 fish. The collaborative population model faithfully represents the work of the participants who developed the component CEMs. Second, the collaborative model has a flexible model structure template to model several populations (i.e., upper river, lower river, and sub-populations if identified) at varying spatial resolutions. Previous models were constrained to either the Upper or Lower Rivers with most effort in the Lower River and a strong bias towards the Lower River population (Jacobson et al. 2015b). Finally, the development of the collaborative model occurred through a transparent process involving input from potential users using open-source software with public-domain source code and open accessibility to an online version. This tool will evolve and be modified to meet the AM process needs and the community of scientists engaged in understanding pallid sturgeon population dynamics.

The geographic extent of the current model is limited to segments of the lower and upper Missouri River (Figure 45). These two parts of the Missouri are subdivided into bends representing the spatial grain of the population model. River bends are defined as three continuous habitats (channel cross-over, inside bend, outside bend) and vary in number and size from the Lower to Upper River¹. Bends are used as a spatial organization for the model, to accommodate movement of fish among bends in the model, and because bends are the sampling units for the Pallid Sturgeon Population Assessment Program (PSPAP). The current temporal extent (duration of model runs) is user defined and can be up to 50 years with a monthly time step.

The model requires basin-specific demographic rates and values (e.g., survival, fecundity, sex ratio) and values for state variables (e.g., number of hatchery fish, number of natural fish) to simulate population dynamics. Uncertainty is associated with most of these inputs, though the number of stocked fish is known precisely. Inputs are derived from literature and from experts within the basins. The population model is

¹ Lower: 317 bends, in river km, mean=4, min=0.2, max=19; in river mi mean=2.5, min=0.1, max=11.8;

Upper: 157 bends, in river km, mean=2.3, min=0.6, max=8; in river mi mean=1.4, min=0.4, max=5;

initialized by drawing demographic values and rates from distributions. Next, state values (i.e., number of hatchery or natural origin fish) are drawn from distributions. Age structure is then initialized given the abundance and demographic rates drawn. For example, if 4000 natural origin fish were stochastically selected, those fish are then allocated to an age class given their cumulative probability of surviving, yielding the typical exponential decay in number of fish with age. Model initialization makes an assumption of population equilibrium as in past modeling studies (Steffensen et al. 2013), which basin experts agreed was reasonable. This assumption takes into account the fact that, even in the absence of recruitment, population declines are expected to be relatively small for a long-lived fish with high sub-adult and adult survival.

Current model implementation outputs the origin and fate of individual fish (i.e., natural, hatchery, mortality) for each time step over the years simulated. When multiple stochastic replicates are simulated, values can then be post-processed to forecast values like pseudo-extinction probabilities. Additional post-processing includes a function to simulate a robust design capture-recapture program so that the model can be used to inform population monitoring designs (discussed in section 4.4 and Appendix D).

The ultimate objective for the population model is to evaluate management actions propagated through the pathways described in the CEMs. There are many gaps in biological understanding linking primary and secondary biotic responses. Current model implementation accepts demographic rates; however, direct effects of primary biotic responses are uncertain or unknown. These uncertainties and unknowns aside, the model framework development is focused at further development of the capacity to evaluate primary biotic responses in two approaches. The first approach modifies the demographic rate distributions as a function of a primary biotic response. For example, the current model represents demographic rates in terms of a baseline survival rate, the uncertainty in that survival rate, and potential changes in the survival rate as a function of other factors (e.g., amount of food available for exogenously feeding larvae in interception and rearing habitat). The mathematical form of these functions is described in Appendix D, section B.4.3.3.

Sensitivity analyses of parameters in the collaborative population dynamics model confirmed that early life-stage survival values were the most uncertain and have the most leverage on population dynamics. Further, the EA team used the model to explore how the persistence of pallid sturgeon in the Missouri River varied with different levels of stocking. Parameter estimates generated from the modeling included estimates of early life-stage survival rates needed to sustain a population under current stocking rates. These numbers provide benchmarks to evaluate stocking and ongoing refinement of survival rates. The early life-stage survival rates also represent a key parameter

uncertainty in the model (gamete, embryo, free embryo, exogenously feeding larvae, age-0) because there are limited data on these probabilities. Another source of uncertainty is the spatial dynamics including flow cues as a trigger for movement and flow modifications for drift of free embryos. An additional complicating factor (not included in the model) is hybridization between pallid sturgeon and shovelnose sturgeon (Jacobson et al. 2016a), albeit hypothesized genetic consequences on population demography are not well understood. The model's structure and proposed applications are closely aligned with the proposed revisions to monitoring of pallid sturgeon populations, as described in Appendix D.

4.1.2.4 *Initially modeled hypotheses, and process for examining new information and additional hypotheses*

The filtering approach used to determine the 21 hypotheses that were the focus of conceptual and quantitative modeling (Upper River - Table 37, Lower River –Table 38) was a stepwise process starting with the implicit hypotheses from the component CEMs. A series of workshops were used to filter these hypotheses, link these hypotheses to management actions, and determine if these actions were within the USACE authority and jurisdiction (Jacobson et al. 2016b).

Jacobson et al. 2016b defined several categories of hypotheses (Table 1 in their report). *Global* hypotheses are a set of possible, biologically important hypotheses, relevant to population dynamics that are derived from the CEMs (see Appendix B). These implicit hypotheses are depicted by the arrows between cells in the CEM. These were filtered by the EA team to a set of 40 *candidate dominant* hypotheses that were identified by experts as being important in pallid sturgeon population dynamics. Through a series of workshops and a modified Delphi process, this list was filtered to 23 *working dominant* hypotheses based on input from experts (Jacobson et al. 2016b). This list is meant to include plausible, most biologically relevant hypotheses without regard to specific management or mitigation actions. These working dominant hypotheses were then linked to management actions resulting as many as 176 potential linkages, but when consolidated across life-stages led to 53 hypotheses. The list was further reduced through an expert survey to a list to 30 *working management* hypotheses. Finally, the set of working management hypotheses was filtered by the USACE MRRP for actions that were within the agency's authority and jurisdiction resulting in the 21 initially modeled hypotheses selected for modeling in Phase 1 of the EA.

As learning occurs through the AM cycle, the list of hypotheses may expand and contract beyond the initially modeled hypotheses. In anticipation of this, a hypotheses reserve will explicitly manage the broad suite of hypotheses developed through the EA and highlighted in the CEM. Using this concept, hypotheses can be brought forward or

moved back into reserve as information and understanding directs. The hypotheses reserve concept includes: 1) hypotheses that are not deemed important to investigate at this time; 2) have high uncertainty and require further investigation; and/or 3) are outside USACE authority (see Jacobson et al. 2016b for examples).

The annual AM process described in Chapter 2 will bring forth new findings that lead to adjustments, additions or rejections of the existing set of hypotheses. In addition, the new information process (described in Section 2.5.3) provides a mechanism for bringing forward new information that is analyzed by a technical team in a “joint fact finding” process. This analysis could lead to hypotheses being brought forward from the list of reserve hypotheses, or new action hypotheses being formulated, which would then be included in the SAMP, and further considered by the Technical Team and Management Team.

The new information process is well illustrated by efforts completed for the issue of declining fish condition, which involved the following steps:

- A problem with fish condition was observed by biologists with the Nebraska Game and Parks Commission (NGPC) during efforts at broodstock collection in the Lower Missouri River in the spring of 2015. NGPC biologists submitted an issue paper to the USFWS and USACOE in January 2016.
- The NGPC evidence on this issue was then reviewed by the Chief of the Threatened and Endangered Species Section of USACE and the Missouri River Coordinator of the USFWS. They agreed that this issue merited further investigation, and developed a charter (Bonneau and Kruse 2016) for a joint fact-finding team (coordinated by the EA team for pallid sturgeon) to investigate the fish condition issue. The charter for the investigation (Bonneau and Kruse 2016) involves a detailed review of the evidence that pallid sturgeon are in poor or declining condition (including patterns across space, time, size, age and wild vs. hatchery fish), the potential for negative effects on reproduction and survival, the likely causes of observed patterns that have potential impacts on reproduction and survival, and the recommended next steps (including both science efforts and potential remedial actions).
- A joint fact-finding team conducted a 6-month investigation into the problem, following the terms of reference of the charter. The draft report of joint fact-finding team (Randall et al. 2016) confirmed the existence of the pattern of declining condition from 2012 to 2015, found variable levels of fish condition in the same locations, and observed a higher percentage of fish in low condition

within the Lower River (particularly in the section of river between Omaha and Kansas City). The draft report proposed various hypotheses to explain the observed patterns, including reduced carrying capacity, changes in the amount of suitable habitat following the 2011 flood, changes in prey base, intraspecific and interspecific competition, and changes in fitness. Randall et al. (2016) recommended a systematic evaluation of these alternative hypotheses in the SAMP through such activities as continued monitoring of movement and non-lethal measures of fish health across contrasting regions and fish histories; research on diet, bioenergetics, food webs and habitat changes to test alternative hypotheses; necropsies of stored carcasses, and (possibly, following a reduction in the number of possible hypotheses) carefully designed and monitored changes in propagation strategies and/or other management actions.

- The ISAP reviewed the draft report of Randall et al. (2016), and made various recommendations (webinar September 29, 2017), including applying different methods of analysis to assess whether the apparent decline in condition might be an artifact of an increasingly older population and the particular methods of analysis that were employed in Randall et al. (2016).
- Subsequent work by the EA Team used four different approaches to analyzing the data, and confirmed declines in fish condition in the Lower River, but not in the Upper River (Randall et al. 2017). The draft report of Randall et al. (2016) was revised, subjected to internal and external peer review, and published in 2017 as a USGS technical report (Randall et al. 2017).
- As part of the USACE-USFWS consultation on the Biological Assessment, and further discussions with the Technical Team, it was agreed to elevate concerns about pallid sturgeon condition to a new Big Question (see USACE 2018). Similar to the other pallid sturgeon Big Questions, the proposed Lower River BQ 7 incorporates multiple hypotheses. Unlike the other Big Questions, BQ 7 is not tightly linked to specific management actions, which is reflective of the greater uncertainties that presently exist surrounding the origins of the declining fish condition. Implementation of BQ 7 is an elevation of several hypotheses that were originally developed in the Effects Analysis in conceptual ecological models (Jacobson et al. 2016c) and listed in table 2 of Jacobson et al. (2016b). These hypotheses were subsequently refined as developed in Randall et al (2017).
- The statement of BQ 7 is: *Are there combinations of management actions (flow alteration, channel re-configuration, population augmentation, water quality management, or management of other fish species) which could improve the*

condition of pallid sturgeon within key segments of the Lower Missouri River, resulting in population stability or growth? The nine hypotheses encompassed by BQ 7 are listed in Table 44. They are potentially complimentary (i.e. not mutually exclusive) explanations of the decline in fish condition within certain segments of the Lower Missouri River. Generally, the hypotheses fall into three categories that relate declining adult condition to: pallid sturgeon health (disease, contaminants), ecosystem productivity (including primary, secondary productivity, predation, competition), and habitat changes (increased energetic demands). Presently, BQ 7 has been proposed only for the Lower River but it is possible that emerging information on carrying capacity of the Upper River could result in a parallel Upper River Big Question related to fish condition.

- Candidate research activities to assess the relative likelihood of the nine hypotheses proposed in Randall et al. (2017) were discussed by the Fish Team at an AM workshop in February 2018, and are being considered for inclusion in the MRRP Strategic Plan and the Independent Science Program. USACE has yet to develop a set of Level 1 research activities to better understand the fish condition problem.

Beyond the 21 EA hypotheses, there may be additional factors affecting pallid sturgeon recovery which will need to be considered in developing management actions and experimental designs (e.g., fitness of pallid sturgeon, hybridization of pallid sturgeon and shovelnose sturgeon; climate change (USFWS 2016)), but for which clear linkages to USACE authority and jurisdiction are lacking. When developing designs for management actions within USACE authority and jurisdiction, it is very important to anticipate the influence of these additional factors on the potential effectiveness of management actions, and the ability to evaluate action effectiveness. Genetics information from field sampling will be informative on which genotypes appear to be surviving better than others. Spawning habitats should be designed to reduce (not increase) hybridization of pallid and shovelnose sturgeon. Trends in hybridization over time should be tracked, so that they don't confound field and model based estimates of the effects of various management actions. Finally, higher year to year variability in flows due to climate change (USACE 2016) could create more variation in catch per unit effort estimates of age-0 fish, making it more difficult to detect the effects of IRCs. It is vitally important for information on pallid sturgeon to be shared and communicated (throughout their range, regardless of who collects these data), as data outside of the scope of the MRRP may still have implications for actions within USACE authority and jurisdiction (see section 6.3 Data Management).

4.1.2.5 EA findings, critical uncertainties, potential actions and decision trees

The key findings and potential routing for each of the initially modeled hypotheses are summarized in Table 37 (Upper Missouri River) and Table 38 (Lower Missouri River). Fundamental information gaps (high uncertainty) compromise the ability to quantify many of the hypotheses of pallid sturgeon population dynamics. For some of the 21 hypotheses, the available information is from theoretical deduction, inferences from sparse empirical datasets, or expert opinion. The degree of uncertainty and risk associated with each hypothesis (risks to both pallid sturgeon and human considerations) will guide the level and sequence of experimentation (i.e., Level 1 vs Level 2, see Table 39). Hypotheses with the highest levels of uncertainty and risk will first be explored through research, mesocosm experiments, opportunistic field experiments or gradient studies. Specific management actions can be taken for hypotheses with less uncertainty and risk, from limited implementation as field-scale experiments (Level 2) to full field implementation (Level 3). This process of hypothesis routing is further developed into Level 1, 2, and 3 actions in Section 4.2. Regardless of the information gaps, key outputs from the EA were conceptual models and hypothesized functional relationships that could help assess the effects of management actions on pallid sturgeon life-stage survival.

The population model developed in the EA can be used to assess sensitivity of life-stage specific demographic rates, assess some hypotheses related to stocking decisions, and explore a limited number of management scenarios. However, information gaps prevent linkage of flow and channel reconfiguration actions directly to population responses.

Aside from the population dynamics model described in Section 4.1.2.3, two other types of models were developed for the EA to evaluate hypotheses. These included one-dimensional advection/dispersion models to assess drift dynamics of free embryos (Fischenich, in review), and 2-dimensional hydrodynamic models for functional habitat assessments to provide an understanding of how the availability of functional habitat varies jointly with flow regime and channel reconfigurations. Models are available for both the upper and lower river. These models will be used to assess the effects of management actions on the survival of drifting free-embryos in the upper river, and for assessing the effects of flow and channel-reconfigurations on interception and habitat availability in the lower river.

Table 37. Findings from Effects Analysis for Upper Missouri River hypotheses.

Action Location	Action	Number	Management Hypothesis	Findings	Potential Routing
Upper Missouri River	Alter Flow Regime at Fort Peck	1	Naturalized flow releases at Fort Peck will result in increased productivity through increased hydrologic connections with low-lying land and flood plains in the spring, and decreased velocities and bioenergetic demands on exogenously feeding larvae and juveniles during low flows in summer and fall.	Theoretical support but inadequate data to model and forecast population response	Research on bioenergetics, hydrodynamic models, comparative field experiments
		2	Attractant flow releases at Fort Peck will result in increased reproductive success through increased aggregation and spawning success of adults.	Theoretical support, inference from other sturgeon species, but inadequate data to model and forecast population response	Research, monitor responses to events, possible pulsed flow experiment
		3	Reduction of main stem Missouri River flows from Fort Peck Dam during free-embryo dispersal will decrease main stem velocities and drift distance, thereby decreasing mortality by decreasing numbers of free embryos transported into headwaters of Lake Sakakawea.	Potential effective action, subject to contingent information	Research to resolve anoxia, use of Yellowstone, interstitial hiding, retarded drift
	Temperature Control, Fort Peck	4	Warmer flow releases at Fort Peck Dam will increase system productivity and food resource availability, thereby increasing growth and condition of exogenously feeding larvae and juveniles.	Theoretical support but inadequate data to model and forecast.	Research on bioenergetics, hydrodynamic models, comparative field experiment
		5	Warmer flow releases from Fort Peck Dam will increase growth rates, shorten drift distance, and decrease mortality by decreasing free embryos transported into headwaters of Lake Sakakawea.	Potential effective action, subject to contingent information	Research to resolve anoxia, use of Yellowstone, interstitial hiding, retarded drift

	Sediment Augmentation , Fort Peck	6	Installing sediment bypass at Fort Peck will increase and naturalize turbidity levels, resulting in decreased predation on embryos, free embryos, and exogenously feeding larvae.	Theoretical support, but laboratory data equivocal; no specific models	Research on predation of eggs, embryos, free embryos
Yellowstone River	Passage at Intake	7	Fish passage at Intake Diversion Dam on the Yellowstone River will allow access to additional functional spawning sites, increasing spawning success and effective drift distance, and decreasing downstream mortality of free embryos and exogenously feeding larvae.	Potential effective action, subject to contingent information	Implementation proposed, but delayed due to legal actions. Complement with robust monitoring and evaluation
Upper Missouri and Yellowstone	Upper River Propagation	8	Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.	Potential effective action, subject to hatchery capacities	Implemented, validate with monitoring, assessment. Research on optimization
		9	Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.	Theoretical support, no specific data, models to forecast for pallids	Research on linking parentage and population viability
Lake Sakakawea	Drawdown, Lake Sakakawea	10	Drawdown of Lake Sakakawea will increase effective drift distance, decreasing downstream mortality of free embryos and exogenously feeding larvae.	Potential effective action, subject to contingent information.	Research to resolve anoxia, use of Yellowstone, interstitial hiding, retarded drift

Table 38. Findings from Effects Analysis for Lower Missouri River hypotheses.

Action Location	Action	Number	Management Hypothesis	Findings	Potential Routing
Lower Missouri River	Alter Flow Regime at Gavins Point	11	Spring flow pulses from Gavins Point will provide aggregation and spawning cues for reproductive pallid sturgeon, resulting in increased spawning success.	Theoretical support, inference from other sturgeon species, but inadequate data to model and forecast population response	Research, monitor responses to events, possible pulsed flow experiment
		12	Naturalized flows from Gavins Point dam will increase productivity and food availability for age-0 pallid sturgeon through improved connectivity with channel-margin habitats and low-lying floodplain lands, increased primary and secondary production, and increased growth, condition, and survival of exogenously feeding larvae and juveniles.	Theoretical support, inference from hydrodynamic models, but data inadequate to model, forecast population response	Research on bioenergetics, comparative field experiments, possible pulse flow experiment.
		13	Naturalized flows from Gavins Point Dam will decrease energetic requirements of age-0 pallid sturgeon through decreased velocities, resulting in increased growth, condition, and survival for exogenously feeding larvae and juveniles.	Theoretical support, inference from hydrodynamic models, but data inadequate to model, forecast population response	Research on bioenergetics, comparative field experiments, possible pulse flow experiment.
		14	Decreased flows in late May and June from Gavins Point Dam will result in decreased velocities and dispersal distance, resulting in increased survival of pallid sturgeon free embryos.	Theoretical support, inference from hydrodynamic models, but data are equivocal as limiting factor and population response	Research into drift dynamics
	Temperature management, Gavins Point	15	Increased temperatures in May from Gavins Point will provide aggregation and spawning cues for reproductive pallid sturgeon.	Theoretical support, inference from other sturgeon species, data equivocal about magnitude of change, population response	Research, monitor responses to events

Action Location	Action	Number	Management Hypothesis	Findings	Potential Routing
Lower Missouri River	Channel Reconfiguration	16	Channel reconfiguration to increase quality and availability of spawning habitat will increase successful fertilization, incubation, and hatch of pallid sturgeon.	Theoretical support, support from other sturgeon, and hydrodynamic models, but data are equivocal as limiting factor and population response	Research in spawning dynamics, comparative field experiment
		17	Channel reconfiguration to increase food-producing habitats will increase growth and survival of age-0 pallid sturgeon, through increased channel complexity and improved bioenergetic conditions to increase prey density (invertebrates and native prey fish).	Theoretical support, inference from hydrodynamic models, but data are equivocal as limiting factor and population response	Implemented in part, comparative field experiment, validate with monitoring, assessment
		18	Channel reconfiguration to increase availability and quality of foraging habitat will increase survival of age-0 pallid sturgeon, through increased channel complexity and minimized resting and foraging bioenergetic requirements.	Theoretical support, inference from hydrodynamic models, but data are equivocal as limiting factor and population response	Implemented in part, comparative field experiment, validate with monitoring, assessment
		19	Reconfiguration of the channel to promote interception of drifting free embryos from the thalweg and transport to supportive channel-marginal habitats will increase survival of free embryos to exogenously feeding age-0.	Theoretical support, inference from hydrodynamic models, but data are equivocal as limiting factor and population response	Implemented in part, validate with monitoring, assessment, comparative field experiments
	Propagation Lower River	20	Improved stocking strategies by optimizing stocked size classes will improve age-0 to age-1 survival of hatchery-origin pallid sturgeon.	Potential effective action, subject to hatchery capacities.	Implemented, validate with monitoring, assessment. Research on optimization
		21	Improved stocking strategies by optimizing genetic diversity will improve population viability for pallid sturgeon.	Theoretical support, no specific data, models to forecast population response	Implemented, validate with monitoring, assessment. Research on linking parentage and population viability

Potential management actions were also identified and include flow management, temperature management, sediment augmentation, passage at Intake Dam, propagation, stocking, and the construction of interception and rearing complexes (IRCs), spawning habitat, and food and foraging habitat. These actions were selected using a scientific filter (do they benefit the species?), a human considerations filter (are impacts acceptable?), and a feasibility filter (can actions be feasibly implemented?). Further filtering of management actions occurred through the MRRMP process, as described in Chapter 2 of the EIS).

Key outcomes and uncertainties from the EA can be conceptualized in a decision tree framework that highlights the possible management actions or additional hypotheses and monitoring (Jacobson et al. 2016a), which can assist the *evaluate* and *decide* stages of the AM process (Sections 4.5 and 4.6 of this plan). Decision trees are shown below for the Upper Missouri and Yellowstone rivers (Figure 51) and for the Lower Missouri River (Figure 52). The decision trees illustrated in Figure 51 and Figure 52 follow the same format and graphical representation. Key uncertainties related to a subset of the key hypotheses being evaluated in the SAMP are depicted by yellow diamonds and potential actions are depicted by blue boxes. The initial uncertainty, posed as a question, is listed in the top-left corner. The yes/no answer to this question is connected by arrows which either lead to another uncertainty (question) or a potential action. The directionality of subsequent decisions follows the life-stages in sequence, which would be the most systematic approach to understanding recruitment failure. Useful information can be generated outside of the sequence as well. For example, using age-0 shovelnose sturgeon as a surrogate species may generate insights about food limitations of pallid sturgeon and allow for an emphasis on other hypotheses. Appendix F contains decision trees with added detail and explanation, which accommodate all of the hypotheses considered in the EA, as well as recent advances in understanding. These detailed decision trees are an important input to the prioritization of Level 1 and Level 2 science activities (Table 39), also described in Appendix F.

The Upper Missouri-Yellowstone rivers decision tree (Figure 51) focuses on hypotheses related to drift and dispersal. The effects of fragmentation are clearest, and the available drift/dispersal distance and hypothesized inhospitable headwaters of Lake Sakakawea pose a distinct constraint on recruitment. The ability to overcome these constraints has bearings on the efficacy of potential management actions including flow management, temperature management, and drawdown of Lake Sakakawea at Garrison Dam. The first uncertainty is whether sediments in the headwaters of Lake Sakakawea are anoxic and lethal to developing embryos. If this is confirmed, then the next uncertainties are whether pallid sturgeon are able to migrate and spawn in the Yellowstone River and whether spawning occurs >500 km upstream (an approximation of required drift

distance). If pallid sturgeon do not migrate a sufficient distance up the Yellowstone River, then the uncertainty is whether retarded drift (interstitial hiding and other mechanisms) occurs. If it occurs, then potential actions include flow management (attractant flows for adults, low flows to slow rate of movement of embryos), temperature management (increased temperature to increase development rates), and drawdown of Lake Sakakawea (or other, as yet unidentified, means of addressing the anoxia). If pallid sturgeon choose to spawn primarily in the lower Yellowstone River then recruitment failure appears likely, as there is not sufficient drift distance before Lake Sakakawea. If pallid sturgeon migrate to the Yellowstone River but do not spawn at a distance far enough upstream from Lake Sakakawea, the uncertainty is again whether retarded drift (interstitial hiding) occurs. The potential action is drawdown of Lake Sakakawea (or otherwise addressing anoxic headwater conditions). Finally, if pallid sturgeon are attracted to migrate up the Yellowstone River, are able to pass Intake Diversion Dam in sufficient numbers, and are attracted to migrate and spawn far enough upstream in the Yellowstone River watershed, potential recruitment may occur and other management actions may be unnecessary. The level of drawdown of Lake Sakakawea contemplated in Figure 51 has not been determined. It would need to be sufficient to provide a biological benefit in terms of drift distance, while still being consistent with authorized purposes. A much larger drawdown of Lake Sakakawea would provide greater drift distance but would not be consistent with current operations. Taking advantage of natural variations in water conditions (e.g., a series of low water years in which reservoir levels naturally decline) could be very informative for determining the survival of free embryos under conditions with greater drift distance.

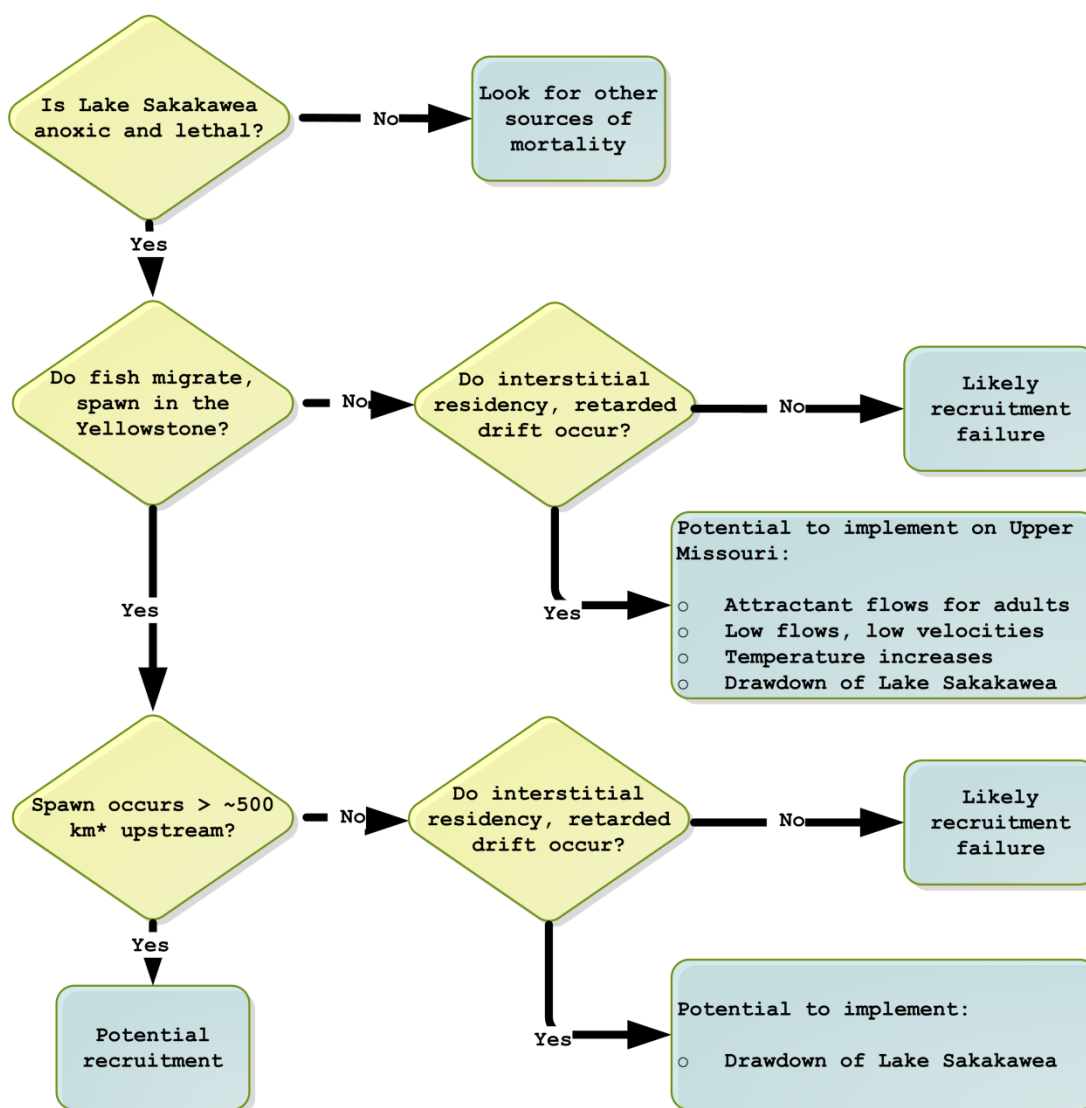
Figure 51 shows a complex set of alternative future scenarios. Focusing research studies and AM experiments on key decision nodes (i.e., the diamonds in Figure 51) can simplify the decision process by rejecting some hypotheses and thereby eliminating certain branches on the decision tree. Such advances help to clarify that some actions are very unlikely to be successful, which helps to focus management attention on the remaining actions with potential benefit, and reduces the number of possible future scenarios. Learning is not instantaneous. Various forms of variability (e.g., year to year variations in flows, temperatures and reproductive spawners; spatial and temporal variability in the distribution of free embryos within each year) require multiple years of observations to separate the signal from the noise, and draw reliable conclusions. Therefore, though information from pallid sturgeon studies will be analyzed and reported annually, major decisions on actions are likely to proceed based on several years of accumulated and carefully confirmed findings.

Interstitial hiding was a hypothesis that emerged through the expert opinion process. Prior to the summer of 2015, immediate drift was also never observed directly in pallid

sturgeon; immediate drift was inferred but not documented. USGS studies have provided good evidence regarding drift rates, and further studies are planned (Patrick J. Braaten, USGS, pers. comm.). Emerging evidence suggests that pallid and shovelnose embryos are not retained within the substrate, in contrast to lake sturgeon (Delonay et al. 2015 conference presentation). However, these results have not yet been peer reviewed and published. Until these USGS studies have been peer reviewed and published, the interstitial hiding hypothesis is retained in the SAMP, given somewhat less emphasis, and enhanced with the idea of retarded drift to encompass myriad other factors that could also affect net dispersal rates. Passage at Intake will result in approximately 400 km of drift (less than the rough guideline of 500 km in Figure 51), so the degree of retarded drift is important. These issues are discussed further in section 4.2.5.2 with respect to Intake Dam.

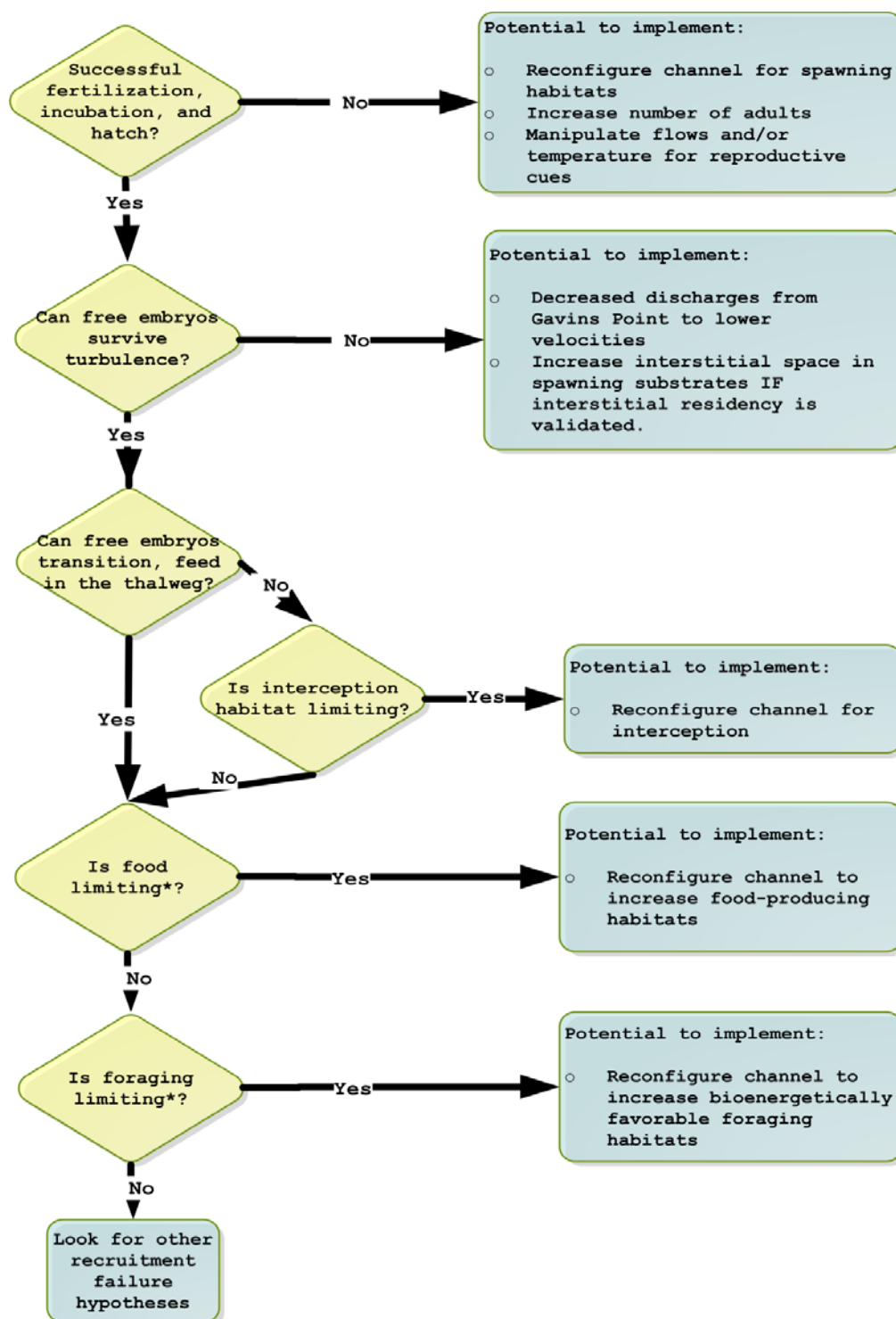
In June and July 2016, a large group of collaborating agencies and scientists conducted the Missouri River Pallid Sturgeon Free Embryo Drift Study, which is described here: <https://www2.usgs.gov/blogs/csrp/>. The study involved dye-studies to test assumptions in hydraulic models, the release of nearly 700,000 free embryos 2 miles downstream of the Milk River, and detailed monitoring of the movement and dispersal of these free embryos, guided by advection-dispersion models that were recalibrated based on the dye studies. The results of this experiment will yield insights on the proportion of free embryos that are able to find suitable rearing habitat and avoid the anoxic zones at the upper end of Lake Sakakawea, and provide improved tools for predicting the rate of movement and dispersion of both water and free embryos. This information is critical to determining the required dispersal distance for free embryos, and addressing key decision nodes in Figure 51.

Legal challenges to passage at Intake Dam have led to delays in its implementation. These delays have caused the USFWS and USACE to raise the priority of Level 1 research and potential Level 2 tests of altered flows at Fort Peck (actions shown at upper right of Figure 51, see USACE 2018). Altered flows could include higher flows in late April to attract spawners, higher flows in June to cue spawning, and lower flows in July and August to maximize the developmental time of free embryos (for more information, see section 3.4.1 of the MRRP Science and Adaptive Management Technical Team 2018). In 2018 the Corps will work with the Service and MRRIC to review previous information generated since the EA to formulate test flows from Ft Peck. The potential benefits and costs of flow actions at Ft Peck will be analyzed through a NEPA process beginning in 2019 if such analysis is warranted.



* 500 km distance upstream is a coarse guideline because it would provide about 9 days for drift and development under purely passive drift assumptions.

Figure 51. Diagram of a decision tree for addressing contingent information for drift and dispersal related management actions in the Upper Missouri and Yellowstone rivers. In this diagram, drawdown of Lake Sakakawea (lower right) is to a level consistent with authorized purposes. The diamond in the upper left refers to the headwaters of Lake Sakakawea. Information exists to partially answer some of the questions in the diamonds, as discussed in the text. A more detailed decision tree, including other actions such as population augmentation, is contained in Appendix F (Figure F2). Source: Jacobson et al. 2016a.



* Note that a habitat type may be limiting at one point in time and not at another. For example, food-producing habitat may not be limiting at low population numbers but may become limiting as population size increases.

Figure 52. Diagram of a decision tree addressing contingent information in the Lower Missouri River. Modified from Jacobson et al. 2016a.

For the Lower Missouri River decision tree (Figure 52), uncertainties center around how pallid sturgeon use the Lower Missouri River, tributaries, and the Mississippi River. This has bearing on the efficacy of potential management actions including flow and temperature management (Gavins Point Dam); manipulating spawning substrates to increase aggregation, reduce hybridization and improve reproductive success; and channel reconfiguration to construct foraging and food habitat and interception and rearing complexes. The first uncertainty is whether fertilization, incubation, and hatch can be demonstrated. If this cannot be established, potential actions include flow and temperature management from Gavins Point Dam for reproductive cues, channel reconfiguration for spawning habitat, and increased stocking to generate more adults. If successful fertilization, incubation, and hatch can be demonstrated, then the next uncertainty is whether velocities and turbulence are lethal to drifting free embryos. If velocities and turbulence are lethal to drifting free embryos, then potential actions are flow management (decreased discharge), and manipulating spawning substrates to allow greater access of free embryos to interstitial spaces. If free embryos can survive turbulence, then the next uncertainty is whether free embryos being transported in the thalweg will starve unless they can settle into supportive, channel-margin habitats, or if instead they can transition to first feeding, find food, and grow to the point where they are mobile enough to seek habitats on their own. If free embryos cannot transition or settle into supportive habitats, IRCs could be constructed. If IRCs are not limiting, and free embryos can transition or feed in the thalweg, the uncertainty is whether food is limiting. If food is not limiting, then other recruitment failure hypotheses need to be considered. If food is limiting, foraging and food habitat could be achieved through channel reconfiguration. Completing science studies in parallel rather than in sequence can accelerate the learning process about the different diamonds in each decision tree.

In addition to the Effects Analysis, the 2018 Biological Opinion (USFWS 2018, pages 55-60) provides a summary of components of system operations that are likely to adversely affect pallid sturgeon, including altered flows, temperatures, sediment regime and turbidity.

4.2 Plan and Design

4.2.1 Pallid sturgeon framework

On November 2, 2015, the USFWS provided the USACE with a Planning Aid Letter (USFWS 2015a) confirming support for a document called “Lower Missouri River Pallid Sturgeon Framework, Targets and Decision Criteria” (USFWS and USACE 2015). This document provides guidance for actions to be included in the Missouri River Recovery Management Plan Environmental Impact Statement (MRRMP-EIS), and its structure

has been used to guide the section of this AM Plan dealing with actions to be implemented in the Lower Missouri River (section 4.2.6). Though an equivalent document has not yet been generated for the Upper Missouri River, we have applied a similar structure to discussions of actions to be implemented in the Upper Missouri River (section 4.2.5). Chapter 2 of the MRRMP-EIS provides guidance on the rationale for including some actions in the alternatives to be analyzed (for both the Upper and Lower Missouri River), while excluding others.

Since the AMP is intended to provide the means of evaluating the effectiveness of actions described in the MRRMP-EIS, and the Pallid Sturgeon Framework (USFWS and USACE 2015) describes those actions, the Framework is a foundational document. Key principles underpinning the Framework are as follows (extracted from USFWS and USACE 2015):

- Given the lingering uncertainties regarding the effects of management actions implemented for pallid sturgeon, a strategy reliant upon a progressive AM program is the most effective way to manage risks to the pallid sturgeon.
- The Framework is expected to accelerate the identification of recruitment bottlenecks, resulting in a more strategic and focused implementation of appropriate management actions. This approach has the added benefit of minimizing impacts to stakeholders and avoiding unnecessary implementation costs.
- The artificial propagation program would be continued throughout the Framework's implementation as guided by the USFWS Range-wide Stocking and Augmentation Plan (US Fish and Wildlife Service, in revision), and improvements to that program related to genetic concerns, disease, stocking size, etc., would be pursued consistent with that plan.
- Implementation of management actions at Level 2 or Level 3 (described below) for each hypothesis would be required within a specified timeframe, provided the hypotheses associated with the action are not rejected by that time.
- At any time during the Framework's implementation, it may become apparent that: 1) a particular action is not needed, 2) a proposed action requires modification to be effective, or 3) that some new action not previously evaluated is required.

4.2.1.1 *The four levels of the framework*

The Framework consists of four levels of activity, as described in Table 39: research (Level 1); in-river testing (Level 2); scaled implementation (Level 3); and implementation at the ultimate scale required (Level 4). The lower river refers to the mainstem Missouri River downstream of Gavins Point Dam, including the influences (to the extent they are relevant) of upstream reservoirs like Fort Randall and Lewis and Clark Lake, influences of major tributaries, and some portion of the Middle Mississippi

River. While originally developed for the Lower Missouri, the concepts are equally applicable to the Upper Missouri.

As information is developed from Level 1 and 2 studies or through monitoring of effectiveness of management actions, the Framework's decision criteria will be used to determine when and what action should follow. Decisions might include:

- a) accepting that the scientific information supports the hypothesized action and:
 1. moving to the next most important science question pending for each big question; or
 2. moving to implementation of higher-level (i.e. Level 2, 3 or 4) actions;
- b) determining that the scientific information does not support the hypothesized action and:
 1. refining the hypothesis and continuing scientific investigations; or
 2. rejecting the hypothesis and promoting an alternative hypothesis that better explains observed information.
- c) to begin implementing at Level 3 because a time limit for a hypothesized action has been reached and results remain equivocal (studies at Levels 1 and 2 might continue concurrently)

Table 39. Pallid sturgeon framework for the lower Missouri River (same as Table 6)

Level 1: Research	Population Level Biological Response IS NOT Expected	Studies without changes to the system (Laboratory studies or field studies under ambient conditions)
Level 2: In-river Testing		Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.
Level 3: Scaled Implementation	Population Level Biological Response IS Expected	In terms of reproduction, numbers, or distribution, initial implementation should occur at a level sufficient to expect a meaningful population response progressing to implementation at levels which result in improvements in the population. The range of actions within this level is not expected to achieve full success (i.e. Level 4).
Level 4: Ultimate Required Scale of Implementation		Implementation to the ultimate level required to remove as a limiting factor.

Level 1 and 2 studies are directly tied to those uncertainties and management hypotheses highlighted in the EA that, if resolved, could significantly affect the implementation of management actions. They can continue concurrently with Level 3 efforts (to better understand cause-effect mechanisms), but are generally intended to

inform future actions at Level 3. Although Level 2 studies have learning as a primary objective, they can also provide measurable and meaningful benefits to pallid sturgeon populations and, in such cases, would be counted toward targets in the same manner as Level 3 actions. Criteria for accepting or rejecting specific hypotheses, for assessing the results of scaled experiments, and for moving from Level 1 to Level 2 or Level 2 to Level 3 actions are described in section 4.2.4.

Chapter 2 of the MRRMP-EIS provides the rationale for which actions are currently included or excluded from Level 3 implementation in the EIS. Actions excluded from Level 3 implementation may still be the focus of investigations at Levels 1 and 2.

4.2.1.2 Current status of actions, relative priority of Level 1 investigations, and overview of decision criteria

Table 40 shows the current status of actions under consideration for both the Upper and Lower Missouri River, in terms of the 4-level framework in Table 39, based on the EA, the MRRMP-EIS and the Lower Missouri River Framework. Figure 53 illustrates the links among actions and research with the underlying big questions and management hypotheses underpinning the pallid sturgeon recruitment sub-objective of MRRP. In addition, Table 40 shows the relative priority of Level 1 investigations. As illustrated in Figure 27 and discussed in section 3.2.1 (Bird Framework), an action may change in scope, be removed from consideration, or be added as a potential action even though it was not part of the EIS or part of the Selected Alternative (with the required review processes).

Figure 54 provides an overview of the decision criteria for moving actions from Level 1 through Levels 2, 3 and 4, as well as for abandoning or revising certain actions. Decision criteria guide the Technical and Implementation Teams when evaluating monitoring and other information and in developing recommendations for consideration by the agencies. Appendix C provides a detailed listing of all Level 1 and 2 science components and associated decision criteria. For those science components prioritized for the first five years after the ROD, decision criteria are summarized in Table 43 for the Upper Missouri and Table 44 for the Lower Missouri.

The descriptions of experimental designs for actions in Section 4.2.5 (Upper Missouri) and Section 4.2.6 (Lower Missouri) are based on the actions in the MRRMP-EIS. It is possible that actions at Levels 2 to 4, which are not addressed in the MRRMP-EIS, are currently planned for investigation at Level 1. Investigations at Level 1, if favorable, might ultimately lead to implementation of actions at Level 2 or Level 3. If such Level 2 or Level 3 actions are determined to be outside the scope of the MRRMP-EIS then a supplemental NEPA process may be required before implementation (section 2.2.5).

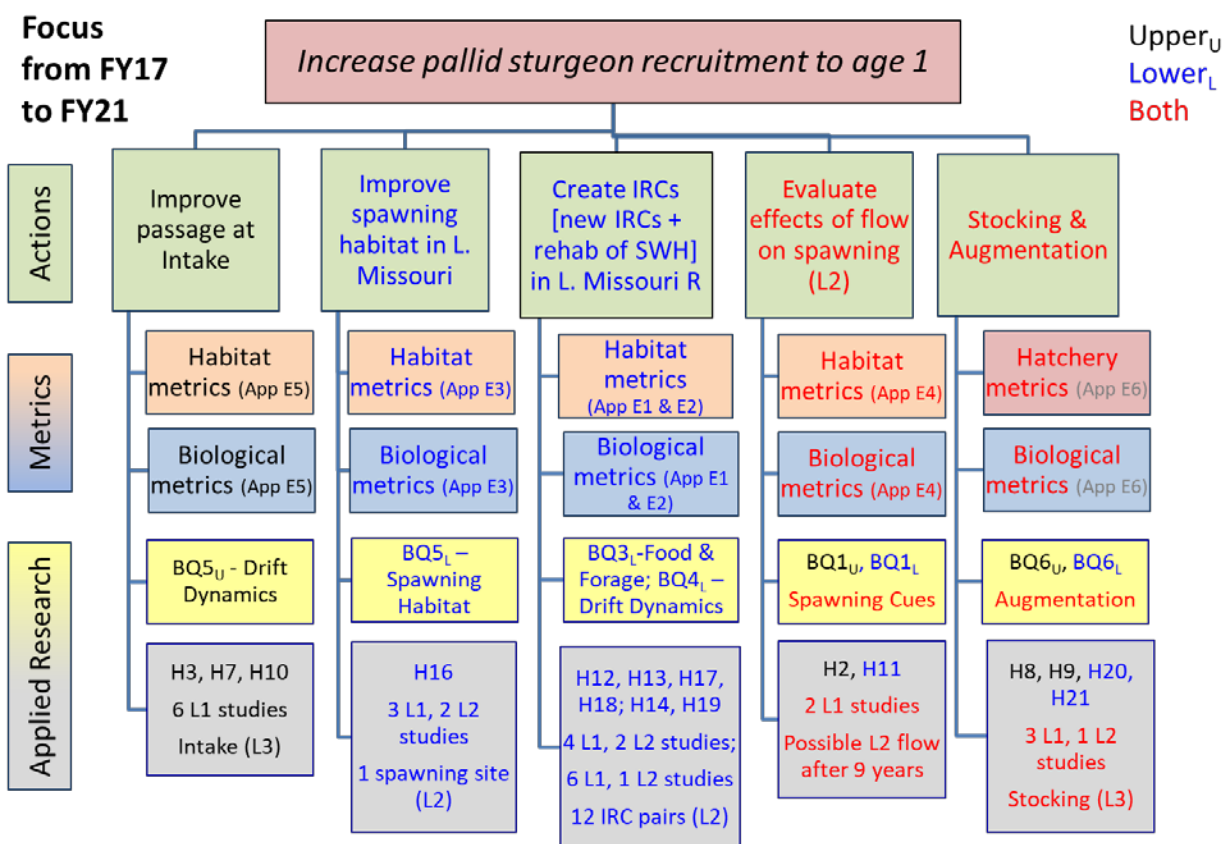


Figure 53 Overview of the links among management actions, big questions, management hypotheses, and the applied research studies (described in Appendix C) being used to inform action implementation in the upper and lower rivers. Habitat and biological metrics for evaluating effectiveness of actions are described in Appendix E. Items applicable to both Upper and Lower Missouri are shown in **red**, those only applicable to Upper Missouri in **black**, and only applicable to Lower Missouri in **blue**.

Table 40 Current status of actions under consideration for both the Upper and Lower Missouri River, and relative priority of investigations at each level.¹ Details of the formulation of alternatives and the rationale for decisions on these alternatives can be found in the Final MRRMP-EIS.

Action location	Action	Current level of implementation and relative priority			Comments
		Level 1	Level 2	Level 3	
Upper Missouri River	Alter Flow Regime at Fort Peck	High	Depends on results of Level 1		Continue to investigate biological benefits with better information on interstitial residency and movement rates of embryos at Level 1. Not currently included in Preferred Alternative, but one possible outcome of research studies and AM experiments, as shown in the decision tree for the Upper Missouri (see Figure 51). Priority of Level 1 research has advanced from Low to High due to concerns about implementation of fish passage at Intake as a result of legal challenges. See USACE 2018.
	Temperature Control, Fort Peck	Low	Depends on results of Level 1		Continue to investigate biological benefits at Level 1. Not currently included in Preferred Alternative, but one possible outcome of research studies and AM experiments, as shown in the decision tree for the Upper Missouri (see Figure 51).
	Sediment Augmentation at Fort Peck	Low	Depends on results of Level 1		Continue to investigate at Level 1. Not currently included in Preferred Alternative.
Yellowstone River	Passage at Intake	High	High	High	This action and associated evaluations of effectiveness have been determined to be a high priority by the USFWS in coordination with the USACE and Reclamation for the Upper Missouri ² . Legal challenges have delayed implementation of this action for an unknown amount of time.
	Upper River Propagation	High	High	High	Included in Preferred Alternative. The Recovery Team and participating federal

¹ Detailed alternative formulation and decision rationale will be included with the release of the Draft EIS in December 2016

² For further information please see the Final EIS and ROD for the Lower Yellowstone Intake Diversion Dam Fish Passage Project (USBOR and USACE 2016a, 2016b)

Action location	Action	Current level of implementation and relative priority			Comments
		Level 1	Level 2	Level 3	
Upper Missouri and Yellowstone					agencies are considering several potential changes to the propagation program, with a strong focus on the genetics of stocked fish. A revised Range-wide Stocking and Augmentation Plan is expected from the USFWS in 2018, and could lead to decreases in the number of fish stocked. The Stocking and Augmentation Plan may lead to the development of effectiveness monitoring designs (to be added to Appendix E6 of the AMP). The report on fish condition (Randall et al. 2018) may lead to additional hypotheses concerning propagation.
Lake Sakakawea	Drawdown, Lake Sakakawea	Low	Depends on results of Level 1		Continue to investigate biological benefits with better information on interstitial residency and movement rates of embryos at Level 1. Not currently included in Preferred Alternative, but one possible outcome of research studies and AM experiments (see Figure 51).
Lower Missouri River	Alter Flow Regime at Gavins Point	Medium-High	Medium-High after 9-year period post-ROD, depending on results of Level 1 studies	Medium-High after 9-year period post-ROD, depending on results of Level 1 and Level 2 studies	Spawning cue flows will be a high priority Level 1 investigation. Naturalization of the flow regime at Gavins Point will be a medium priority Level 1 investigation. Included in Preferred Alternative as a test flow that may be implemented following 9 years of study post-ROD (see Figure 52 and section 4.2.6.4.1).
	Temperature management, Fort Randall	Low	Depends on results of Level 1		Not currently included in Preferred Alternative, but one possible outcome of research studies and AM experiments (see Figure 52).
	Channel Reconfiguration	High	High	High	Construction of habitat to support early life history survival (e.g., Interception and Rearing Complexes, Spawning Habitats) is included in the Lower Missouri Framework. Included in Preferred Alternative.
	Propagation Lower River	High	High	High	As described above for the Upper Missouri River. Included in Preferred Alternative.

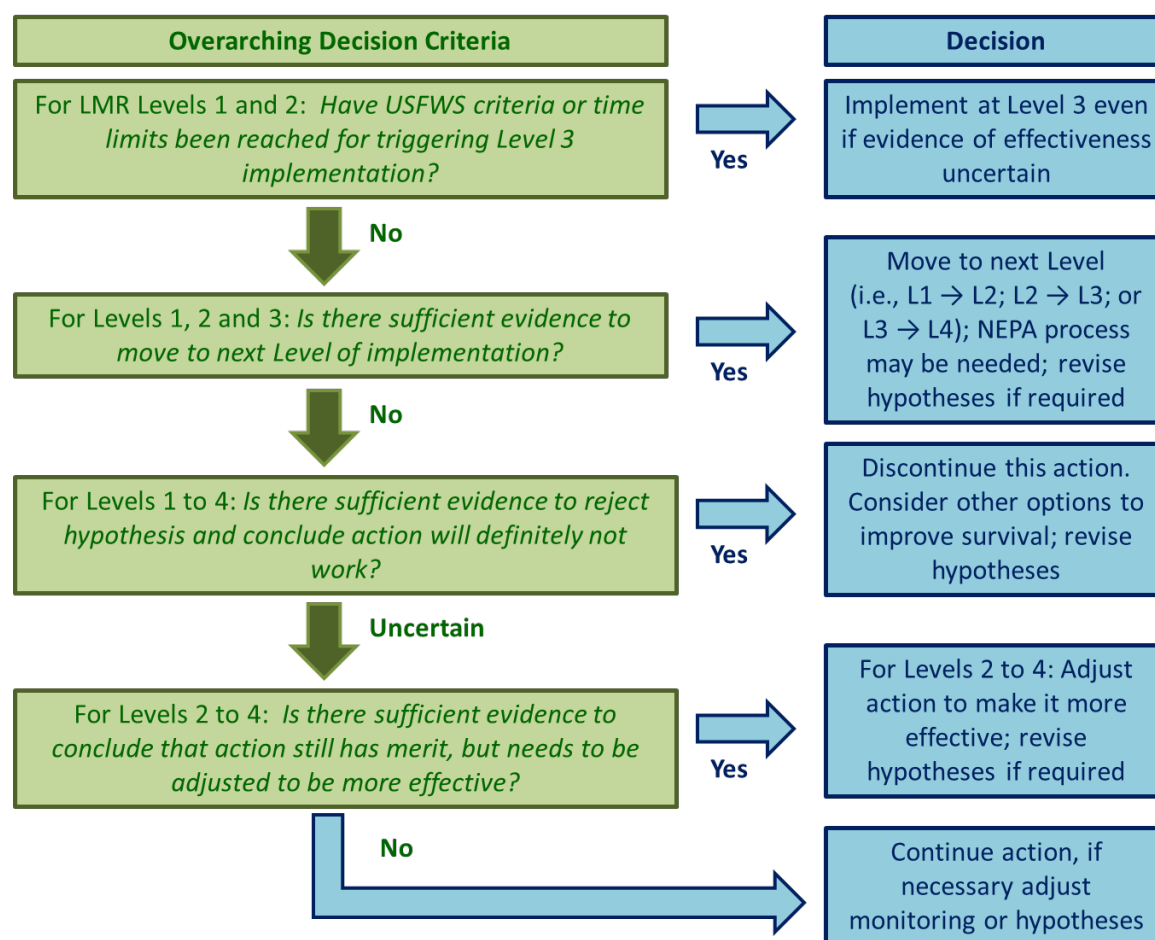


Figure 54 Overview of the decision criteria for various decisions in the Pallid sturgeon framework. The top green box refers to the decision criteria in Table 41 and Table 42. The remaining green boxes refer to the evidence and decision criteria in Appendix C, Table 43, Table 44 and Table 68. The blue box second from the bottom ("Discontinue this action, consider other options to improve survival") is illustrated by the decision trees in Figure 51 and Figure 52.

4.2.1.3 Level 3 Actions, Targets and Decision Criteria:

Requirements for Level 3 were developed collaboratively by the USACE and USFWS and reflect both best available science and policy considerations. Implementation of management actions at Level 3 for any limiting factor would commence at the earlier of two triggers (to allow quick response to information): 1) within two years of affirmative results from Level 1 and/or 2 studies indicating an action is needed for a limiting factor (see decision criteria in section 4.2.4 and Appendix C), or 2) the established time limits in Table 42 have been reached, and the results of studies/tests at Levels 1 and 2 of the associated hypotheses still remain equivocal.

There is a tradeoff between taking action and decreasing uncertainty. To help find an appropriate balance, USFWS and USACE (2015) defined a series of five questions as a proposed checklist to guide decisions to advance to implementation at Level 3 for any of the hypotheses identified by the EA (Table 41). Work at Level 1 will help to answer questions 1, 2, 3 and 5. The decision criteria described in Appendix C (and summarized in Table 43 and Table 44 for components prioritized for the first five years post-ROD) will help in deciding whether or not to move hypotheses from Level 1 to Level 2. Level 2 in-river tests of actions will be particularly helpful for providing empirical evidence to address question 4; strong experimental designs will be required to provide compelling evidence. If all five questions can be answered “Yes”, advancement to Level 3 implementation would be triggered. If an affirmative answer to four of the five questions exists and either question 1 or question 2 is equivocal, implementation of Level 3 management actions would be triggered within two years (unless the hypothesis is rejected in that timeframe). It may be possible to answer question 2 (e.g., the amount of spawning, feeding or rearing habitat required for age-0 fish) without knowing which of these factors are most limiting recruitment to age-1. In this chapter we provide a more detailed hierarchy of questions to evaluate the effectiveness of Level 2 and Level 3 actions, which are summarized in sections 4.5 (Evaluate) and 4.6 (Decide).

Table 41. Supplemental lines of evidence strategy for triggering Level 3 implementation. See above text.

Question		Y	U	N
1	Is this factor limiting pallid sturgeon reproductive and/or recruitment success?			
2	Are pallid sturgeon needs sufficiently understood with respect to this limiting factor?			
3	Do one or more management action(s) exist that could, in theory, address these needs?			
4	Has it been demonstrated that at least one kind of management action has a sufficient probability of satisfying the biological need?			
5	Have other biological, legal, and socioeconomic considerations been sufficiently addressed to determine whether or how to implement management actions to Level 3?			
Criteria for Level 3 implementation				
1 - A "Yes" to all five questions triggers Level 3 implementation				
2 - A "Yes" to four of five, with an "Uncertain" for either #1 or #2 triggers a two-year clock to either reject the hypothesis or implement at Level 3				

The USFWS and USACE (2015) defined time limits for implementation of Level 3 actions and their scope, expressed as targets (Table 42). These time limits are intended as a determination to proceed if the evidence for or against particular actions remains equivocal (i.e., a decision could be made to either abandon or proceed with actions at Level 3 prior to these time limits). The targets for IRCs were subsequently revised by the USFWS (2016). The time limits were set by the USFWS based on a recognition of the

tradeoff between two objectives: 1) learning what actions are likely to be effective (which requires more time for Level 1 work); and 2) the need to take actions to benefit the species even if uncertainty remains about the effectiveness of such actions. As knowledge is gained from Level 1, 2 and 3 actions, the timeframe for implementation may be adjusted, targets may be changed, management actions may be refined, and hypotheses may be dismissed. The “rules” by which these decisions will be made are outlined in the decision criteria for the respective management hypotheses, subject to the overarching governance and decision process laid out in Chapter 2 of this AM Plan.

Table 42. Summary of time limits for implementation and scope of actions.

Action Category	Time Limit	Minimum Scope	Maximum Scope
Population augmentation (Level 3)	Immediate	Current stocking rate as directed by USFWS Range-wide Stocking and Augmentation Plan	Variable over time as directed by USFWS Range-wide Stocking and Augmentation Plan
IRC habitat development (Levels 2 to 4)	Stage 1: study phase (years 1-3 post-ROD)	Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr of suitable habitat, using staircase design ¹ . Assess potential for refurbishing existing SWH sites as IRCs	
	Stage 2 – continue study phase (years 4-6 post-ROD)	Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr ¹ of suitable habitat. Refurbish SWH sites in addition to study sites (rate TBD).	
	Stage 3 - Level 3 implementation (years 7-10 post-ROD)	Continue assessing IRC sites and refurbishing new SWH sites, adding at least 66,000 ac-d/yr ¹ of suitable habitat. Determine required rate of Level 3 implementation based on stages 1 and 2.	
	Stage 4 – Level 4 implementation	Remove IRC habitat limitations to pallid sturgeon survival by implementation at Level 4.	
Spawning habitat ² (Level 2)	2 years	1 spawning site	See decision tree in Figure 54
Spawning cue flows at Gavins Point Dam (Level 2) ³	9 years	Requirement for spawning cue flows (and appropriate scope) depends on the outcome of Level 1 monitoring and modeling studies during years 1-9. ³	

Notes to Table 42

1. Units of ac-dy/year are calculated based on how the flow regime and channel configuration result in cumulative days of availability of suitable habitat during the growing season. Progression through each stage of IRC habitat development is contingent on outcomes and hypothesis tests (USFWS 2016); efforts could be halted if evidence shows IRCs are not successful. Experimental design for IRC sites is described in section 4.2.6.2 and Appendix E. Refurbishment of SWH sites into IRCs is described in section 4.2.6.3.

2. Anticipated as a Level 2 pilot projects focused on developing and evaluating high-quality spawning habitat. Spawning habitat implementation will be guided by the decision tree in section 4.2.6.3. The evaluation of spawning areas will be based on comparing attraction, egg survival, and hatch to existing spawning areas (see section 4.2.6.2).

3. See evidentiary framework in section 4.2.6.4.1. Bird impacts and status, reservoir levels, and HC impacts will inform decisions regarding spawning cue flows below Gavins Point Dam in any particular year.

In 2018 the Corps will work with the Service and MRRIC to review previous information generated since the EA to formulate test flows from Ft Peck. The potential benefits and costs of flow actions at Ft Peck will be analyzed through a NEPA process beginning in 2019 if such analysis is warranted.

4.2.2 Tradeoffs between different learning strategies

As noted in the previous section, there is a tradeoff between taking action and decreasing uncertainty. Taking actions at Level 3 or 4 without strong evidence of their effectiveness may be costly, and may use resources which could have been better allocated. On the other hand, there are constraints on how much can be learned from retrospective studies of past data, analyses of the current system, laboratory experiments and mesocosm experiments. Delaying Level 3 or 4 actions that have potential benefits could delay the recovery of pallid sturgeon. The AM strategy needs to find the appropriate balance between three risks: 1) premature implementation of ineffective actions, which wastes resources; 2) excessive delay in implementing actions which would have helped the population; and 3) implementation of multiple concurrent actions without an ability to determine which actions are most effective, which makes future management adjustments more difficult.

The SAMP embodies a fast pace of learning, by implementing many nondependent Level 1 components concurrently or nearly concurrently rather than sequentially (as explained in Appendix C). Too many concurrent activities could however be overwhelming and inefficient. Therefore, the SAMP also prioritizes some components to be implemented during the first five years post-ROD, and defers others for consideration beyond this period (as explained in Appendix F). Concurrent implementation of multiple components will require a substantial investment in early and carefully planned research. Level 1 science components jointly provide complementary lines of evidence that cumulatively affect decisions to implement field experiments at Level 2.

4.2.3 Recommended learning strategy for AM Plan

In developing a learning strategy for the AMP, we have adopted the following principles:

- Wherever possible conduct L1 research concurrently to accelerate learning, consistent with the criteria for prioritization described in Appendix F.
- Combine all lines of evidence from L1 research to determine level of support for and form of design of L2 experimental management actions.
- Use L2 actions to test action effectiveness and to develop experimental designs that would be applicable at both L2 and L3;

- For L3 actions already underway (e.g., propagation) use L1 and L2 actions to confirm that these actions are working as intended, to better understand cause and effect, and to determine if L3 actions need to be adjusted.
- In evaluating L2 actions and associated hypotheses, seek to maximize spatial and temporal contrasts within the constraints of both feasibility and authorized purposes, so as to develop the clearest possible inferences from L2 actions.
- Design L1 and L2 research to efficiently transition to Level 3 based on learning, rather than exceeding time limits.
- Ensure that Level 2 experiments do not risk negative effects on either pallid sturgeon or human considerations.

4.2.4 Overview of Level 1 and 2 Components and Decision Criteria

Table 4 and Table 5 list the 12 big questions and 21 associated hypotheses for pallid sturgeon. For each big question, science components have been developed for Level 1 and Level 2 (see definitions in Table 39). Appendix C of this document provides a detailed explanation of each study component, while this section provides a tabular overview of those activities prioritized for the first five years after the ROD (see Appendix F for further details on the prioritization criteria that were used). Study components are classified as:

- **Engineering/technology:** studies needed to a) develop technology to measure pallid sturgeon responses to a management action (for example, new telemetry technology, new population modeling approaches) or b) develop engineering approaches to achieving the management action (for example, engineering designs capable of increasing interception of drifting free embryos).
- **Biological screening:** studies to screen a management hypothesis and better determine the magnitude of potential benefit of a management action. For example, biological screening could describe a study to determine whether growth or survival of age-0 pallid sturgeon is food limited. If so, studies would proceed to quantify functional relations between the management action and the population response; if not, the management hypothesis might be placed in reserve until the biological relevance was established.
- **Level of biological effect:** studies to quantify the functional relationship between levels of management action and biological response, for example, to determine how much survival increases for an increment of increased food-producing habitat. The functional relations that come from understanding levels of biological effect are critical to modeling and projecting the effects of management actions on the species.

In addition, biological-screening and biological-effect studies are classified by approach. Because the sturgeon life cycle is complex and critical parts of it involve very small fish

in a fast, deep and turbid river, improvements in scientific understanding likely requires a combination of approaches. Approaches range from laboratory studies, which provide highly controlled, but unrealistic conditions, to field-gradient studies, which typically lack experimental controls and replication, but take place under realistic conditions.

- **Laboratory experiment** – controlled experiment at laboratory scale, typically involving randomization and replication for statistical rigor. Includes experiments to determine fundamental biological rates – for example, embryo development rate as a function of temperature – and behavioral experiments like drift studies in flumes.
- **Mesocosm experiment** – experiments outside of the strict controls of laboratories, but at less than field scale. Examples include experiments in controlled stream or pond environments. These conditions are incrementally closer to field conditions compared to laboratory experiments, but lack the full dynamism of the field example and typically involve somewhat less statistical rigor and precision of measurements compared to laboratory experiments.
- **Field-gradient experiment** - using existing gradients of hydrologic, geomorphic, and biotic conditions to identify and/or quantify biological effects. These experiments often substitute space for time, or for treatment level. They take advantage of existing conditions and offer to provide results under realistic conditions, but often lack replication and statistical rigor. Gradient studies require care to reduce or eliminate interacting variates.
- **Monitoring/assessment** – as used in this document, monitoring/assessment denotes data collection of physical and/or biological data, but not necessarily in a hypothesis-testing or adaptive-management framework (field experiments – next category – include hypothesis-driven monitoring/assessment in an AM framework). Monitoring often provides critical contextual or covariate information, for example water quality or discharge, or population indices or metrics. Monitoring also provides critical data to parameterize, test and validate the collaborative population model.
- **Modeling** – numerical experiments with computational models to test sensitivity of habitats or population dynamics to changing parameter values and to explore system dynamics. An example is using a well-calibrated population model to test population responses to variable stocking levels.
- **Field experiment** – manipulative field experiment to quantify responses to management actions and to test hypotheses. Examples would be pulsed-flow experiments to elucidate effects of spawning cues, or controlled experiments on varied channel reconfigurations to document effects on foraging habitat availability. Although these are planned experiments, they fit the definition of “quasi-experiment” because they typically lack randomization, replication, and/or independence of treatments.

Appendix C provides a detailed description of all Level 1 and 2 science components, as well as the decision criteria for evaluating their outcomes. Table 43 and Table 44 (for the Upper Missouri and Lower Missouri, respectively) provide a summary of the Level 1 and 2 components that are prioritized for the first five years after the ROD, based on the preferred alternative in the MRRP-EIS, and the prioritization process described in Appendix F. These tables summarize the metrics to be obtained by the work within each component, the criteria to be applied in decisions regarding progress to the subsequent component or level of investigation, and the degree of confidence in these decisions given the metrics to be provided by each component and the complexity of the component study. These tables are based on current understanding of research needs, and will need to be periodically revised, including after the ROD.

The following two sections (4.2.5 and 4.2.6) describe some of the details of those Level 2 and Level 3 actions which are either currently being implemented (e.g., propagation), or have been proposed for implementation in the near to medium term through policy determinations (e.g., spawning habitat, interception and rearing habitat, spawning cue flows).

Table 43. Overview of highest priority Level 1 and 2 science components for the Upper Missouri, anticipated to be completed within the first five years of the Record of Decision (ROD) (subject to budget and resource constraints). Appendix C contains a complete list of all Level 1 and 2 components, and Appendix F describes the prioritization process. Components listed in Appendix C but not in this table could be implemented beyond the 5-year, post-ROD period. Metrics and decision criteria with associated degrees of certainty for the working management hypotheses are summarized from Appendix C. Categories for Degree of Certainty: 1 = Definitive, 2 = Statistically rigorous, 3 = Indicative but not authoritative, 4 = Expert judgment of multiple lines of evidence required. BQ = Big Question, L = Level, C = Component (e.g., BQ1/L1/C2 is Big Question 1, Level 1, Component 2). Hypotheses under BQ6 are examples subject to change according to Recovery Team discussions and the Range-Wide Stocking and Augmentation Plan. Hypotheses are from Table 1 in Jacobson et al. 2016a.

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty *	Concurrent / Dependent Components
Big Question 1 – Spawning Cues: Can spring pulsed flows from Fort Peck synchronize reproductive fish, increase chances of reproduction and recruitment?				
Associated Hypotheses: H2. Attractant flow releases at Fort Peck will result in increased reproductive success through increased aggregation and spawning success of adults.				
BQ1/L1/C1-- Design study: complementary passive telemetry network	Detectability of telemetry tags by network receivers, variation of tag detectability with discharge-related characteristics, tag cost, tag reliability.	IF fish movements past strategic locations are successfully detected, THEN deploy a larger network of telemetry receivers to help evaluate sturgeon response to flow.	1	C1-C2 all concurrent. Also with design of lower basin telemetry network (Table 39 - BQ1/L1/C1)
BQ1/L1/C2 – Field study: opportunistic tracking of reproductive behaviors	Degree of association of reproductive behaviors and successful spawning with monitored hydrologic characteristics.	IF there are moderate to strong associations between hydrologic characteristics and reproductive behavior, THEN this provides stronger evidence for L2 studies. However, IF successful reproductive behavior is observed in the absence of the hypothesized hydrologic characteristics AND is sufficient to have a population-level effect THEN this provides evidence against hypothesis H2.	4	C1-C2 concurrent
BQ1/L1/C3 – Mesocosm experiments to better understand fish responses to flow	Degree of association of reproductive behaviors with manipulated hydrologic characteristics.	IF observed responses to flow are within the envelope of feasible flow releases from Fort Peck, this increases the potential for a Level 2 flow experiment.	2	Builds on observations from C2

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty *	Concurrent / Dependent Components
BQ1/L2/C4 – Analyses to assess potential fish and HC responses to Level 2 flow manipulations at Fort Peck.	Predicted movement, reproductive behaviors, spawning success and recruitment to age-1 in response to Fort Peck flows. Predicted impacts on human considerations.	IF Fort Peck flows are likely to have biological benefits without causing unacceptable impacts to human considerations, THEN proceed to BQ/L2/C5.	4	Builds on observations from C2 and C3
BQ1/L2/C5 – Level 2 experimental flow release from Fort Peck	Observed movement, reproductive behaviors, spawning success, and recruitment to age-1, as well as observed effects on human considerations.	IF results support the hypothesis that Fort Peck flows increase reproduction and recruitment to age-1, THEN move to L3 implementation.	4	Builds on C3 and C4
Big Question 2 – Food and Forage: Can naturalization of the flow regime from Fort Peck contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?				
Associated Hypotheses: H1. Naturalized flow releases at Fort Peck will result in increased productivity through increased hydrologic connections with low-lying land and flood plains in the spring, and decreased velocities and bioenergetic demands on exogenously feeding larvae and juveniles during low flows in summer and fall.				
No science components prioritized for first five years after ROD for BQ2 and H1. Postpone work on BQ2 until work on BQ5 is completed.				
Big Question 3 – Temperature Control: Can water-temperature manipulations at Fort Peck contribute significantly to increased chance of reproduction and recruitment?				
Associated Hypotheses: H4. Warmer flow releases at Fort Peck Dam will increase system productivity and food resource availability, thereby increasing growth and condition of exogenously feeding larvae and juveniles. H5. Warmer flow releases from Fort Peck Dam will increase growth rates, shorten drift distance, and decrease mortality by decreasing free embryos transported into headwaters of Lake Sakakawea.				
During first five years after ROD, focus on science components within BQ3 that are supportive of investigations under BQ5.				
BQ3/L1/C2b - lethality of Lake Sakakawea to age-0	2b – Spatial and temporal extent and variability of conditions lethal to benthic larval fish in Lake Sakakawea.	IF results indicate that Lake Sakakawea is not limiting, THEN this provides more support for Level 2 experiments.	3	C2b, C3b and C4b all concurrent
BQ3/L1/C3b – Field studies: validating advection / dispersion model	3b – Spatial and temporal distributions of larvae and surrogate flow tracers to determine larval retention.	IF results indicate that free embryos can be retained in the Fort Peck segment THEN this provides more support for Level 2 experiments.	3	C2b, C3b and C4b all concurrent

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty *	Concurrent / Dependent Components
BQ3/L1/C4b – Mesocosm studies: developing quantitative temperature-recruitment relationships	4b – Temperature-dependence of pallid sturgeon developmental rates.	IF data on developmental rates and other evidence indicates that drift/dispersal is not limiting, THEN this provides more support for Level 2 experiments.	4	C2b, C3b and C4b all concurrent
Big Question 4 – Sediment Augmentation: Can sediment bypass at Fort Peck contribute significantly to increased chance of reproduction and recruitment?				
Associated Hypotheses: H6. Installing sediment bypass at Fort Peck will increase and naturalize turbidity levels, resulting in decreased predation on embryos, free embryos, and exogenously feeding larvae.				
No science components prioritized for first five years after ROD for BQ4 and H6. Postpone work on BQ4 until work on BQ5 is completed.				
Big Question 5 – Drift Dynamics: Can combinations of flow manipulation from Fort Peck, drawdown of Lake Sakakawea, and fish passage at Intake Dam on the Yellowstone River increase probability of successful dispersal of free embryos and retention of exogenously feeding larvae?				
Associated Hypotheses: H3. Reduction of mainstem Missouri flows from Fort Peck Dam during free-embryo dispersal will decrease mainstem velocities and drift distance, thereby decreasing mortality by decreasing numbers of free embryos transported into headwaters of Lake Sakakawea. H7. Fish passage at Intake Diversion Dam on the Yellowstone River will allow access to additional functional spawning sites, increasing spawning success and effective drift distance, and decreasing downstream mortality of free embryos and exogenously feeding larvae. H10. Drawdown of Lake Sakakawea will increase effective drift distance, decreasing downstream mortality of free embryos and exogenously feeding larvae.				
BQ5/L1/C1a,b – Modeling / engineering study: drift dynamics and effects of anoxia	1a – Integrated model linking hydrodynamics, water temperature increases, developmental rates, and population dynamics. 1b – Spatial/temporal variation of anoxia in Lake Sakakawea. <u>Overall</u> : length of free-flowing river under drawdown and flow scenarios; frequency of occurrence	Complete C2 regardless of C1 outcomes. IF model results show that biologically significant movement of the anoxic zone is substantial across management scenarios, THEN this provides more support for L2 drawdown management actions.	1	C1, C2, C3 and C4 completed concurrently
BQ5/L1/C2a,b - Screening: anoxia-dependent recruitment limitation	2a - Spatial / temporal extent and variability of anoxia in Lake Sakakawea. 2b – Spatial distributions of suitable spawning habitat upstream of Intake Dam.	IF results indicate that anoxic zones are patchy, dispersal into Lake Sakakawea is not necessarily fatal AND suitable spawning habitat exists to take advantage of greater passage, THEN this provides more support for L2	1	C1, C2, C3 and C4 completed concurrently

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty *	Concurrent / Dependent Components
		drawdown management actions, and potentially other actions.		
BQ5/L1/C3 – Field studies: validating temperature, drift, and recruitment relationships	Spatial and temporal distributions of larvae and surrogate flow tracers to determine larval retention.	IF drift experiments show that advection is significantly different than predicted in passive transport models, THEN this provides more support for L2 drawdown management actions.	2	C1, C2, C3 and C4 completed concurrently
BQ5/L1/C4 – Mesocosm experiments: Larval dispersal rates	Virtual velocity of free embryos as a function of time, temperature, and developmental stage in relation to channel complexity.	IF results provide robust relationships among abiotic variables, developmental stages, and dispersal rates AND results of C1-3 indicate anoxia is patchy and retardation mechanisms can be identified and quantified, THEN use this information to inform design of L2 studies.	4	C1, C2, C3 and C4 completed concurrently. All mesocosm studies designed concurrently.
Big Question 6 – Population Augmentation. Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?				
Associated Hypotheses: H8. Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles. H9. Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.				
BQ6/L1/C1 - Engineering studies: feasibility hatchery needs, facilities, operations	Costs and measures of likely survival for a range of propagation facility designs.	IF alternative designs are expected to produce population benefits at a reasonable cost, THEN this provides more support for L2 management experiments	4	C1-C3 done concurrently
BQ6/L1/C2 - Retrospective study: survival linked to hatchery operations	Number and survival probabilities for stocked pallid sturgeon by stocked size, hatchery of origin, location of release and health history.	IF results indicate that changes in propagation facility operations could increase survival, THEN this provides more support for L2 management experiments. IF results indicate that more fish releases are required to estimate survival probabilities, then review alternative designs for BQ6/L2/C4.	3	C1-C3 done concurrently
BQ6/L1/C3 - Simulation models: population	Probability of quasi-extinction, instantaneous growth rates, and sensitivity	IF results indicate that population dynamics are sensitive to changes in augmentation practices AND	4	C1-C3 done concurrently

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty *	Concurrent / Dependent Components
sensitivity to size, health, genetics	measures under various model scenarios.	the information provided by previous components shows the need for L2 studies THEN this provides more support for L2 management experiments		
BQ6/L2/C4 – Manipulative field experiments: varying size, location of stocking	Estimated number and survival probabilities for stocked pallid sturgeon by stocked size and age, hatchery of origin; fish condition; water year conditions, and release location.	IF results indicate that survival is sensitive to size or age at stocking, THEN proceed to L3 implementation.	4	Decision criteria met for all three BQ6/L1 studies

Table 44. Overview of highest priority Level 1 and 2 science components for the Lower Missouri, anticipated to be completed within the first five years of the Record of Decision (ROD) (subject to budget and resource constraints). Appendix C contains a complete list of all Level 1 and 2 components, and Appendix F describes the prioritization process. Components listed in Appendix C but not in this table could be implemented beyond the 5-year post-ROD period. Metrics, and decision criteria with associated degrees of certainty for the working management hypotheses are summarized from Appendix C. Categories for Degree of Certainty: 1 = Definitive, 2 = Statistically rigorous, 3 = Indicative but not authoritative, 4 = Expert judgement of multiple lines of evidence required, BQ = Big Question, L = Level, C = Component. (e.g., BQ1/L1/C2 is Big Question 1, Level 1, Component 2). Hypotheses under BQ6 are examples subject to change according to Recovery Team discussions and the Range-Wide Stocking and Augmentation Plan. Hypotheses are from Table 1 in Jacobson et al. 2016a.

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty*	Concurrent / Dependent Components
Big Question 1 – Spawning Cues: Can spring pulsed flows synchronize reproductive fish, increase chances of reproduction and recruitment?				
Associated Hypotheses: H11. Naturalization of the flow regime at Gavins Point Dam will improve flow cues in spring for aggregation and spawning of reproductive adults, increasing reproductive success.				
BQ1/L1/C1-Design study: complementary passive telemetry network and biological modeling of potential population benefits	1a) Detectability of telemetry tags by network receivers, variation of tag detectability with discharge-related characteristics, tag cost, tag reliability. 1b) Power analysis to determine how many tagged adults required to detect various differences in level of spawning. Development of population model to model potential population benefits of spring pulsed flows as a function of frequency of implementation. 1c) Modeling analysis to determine required level of spawning to support a sustainable population	IF fish movements past strategic locations are successfully detected, THEN deploy a larger network of telemetry receivers to help evaluate sturgeon response to flow.	1	BQ1/L1 – C1, C2 done concurrently
BQ1/L1/C2 – Field study: Opportunistic tracking of reproductive behaviors	Degree of association of reproductive behaviors and successful spawning with monitored hydrologic characteristics. See Appendix E4 for a description of effectiveness monitoring.	IF there are moderate to strong associations between hydrologic characteristics and reproductive behavior, THEN this provides stronger evidence for L2 studies. However, IF successful reproductive behavior is observed in the absence of the hypothesized hydrologic characteristics AND is	4	BQ1/L1 – C1, C2 done concurrently

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty*	Concurrent / Dependent Components
		sufficient to have a population-level effect THEN this provides strong evidence to reject the hypothesis H11.		
Big Question 2 – Temperature Control: Can water-temperature manipulations at Fort Randall and/or Gavins Point contribute significantly to increased chance of reproduction and recruitment?				
Associated Hypotheses: H15. Operation of a temperature management system at Fort Randall Dam and/or Gavins Point Dam will increase water temperature downstream of Gavins Point, providing improved spawning cues for reproductive adults.				
BQ2/L1/C1 – Modeling study: water temperature management options, Gavins Point and Fort Randall	Absolute water temperatures and changes relative to historical values downstream of Gavins Point Dam and Fort Randall across various temperature control implementations, cost effectiveness.	IF temperatures are significantly lower than historical values, THEN this provides more support for other L1 studies.	2	Prerequisite for other L1 studies
Big Question 3 – Food and Forage: Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?				
Associated Hypotheses: H12. Naturalization of the flow regime at Gavins Point Dam will improve connectivity with channel-margin habitats and low-lying flood plain lands, increase primary and secondary production, and increase growth, condition, and survival of exogenously feeding larvae and juveniles. H13. Naturalization of the flow regime at Gavins Point Dam will decrease velocities and bioenergetic demands, resulting in increased growth, condition, and survival for exogenously feeding larvae and juveniles. H17. Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles. H18. Re-engineering of channel morphology will increase channel complexity and minimize bioenergetic requirements for resting and foraging of exogenously feeding larvae and juveniles.				
BQ3/L1/C1 - Screening: limitations of food or forage habitats	Indicators of starvation or impending death of age-0 sturgeon based on stomach contents (empty/full) or physiological indicators (lipid content).	IF results indicate bioenergetic constraints, THEN this provides more support for L2 experiments.	3	BQ3/L1 -C1, C2, and C3 done concurrently
BQ3/L1/C2 – Engineering study: Technology development for IRC sampling, modeling, measurement	Density, transport, and flux of food items (chironomid larvae) and estimates of age-0 survival rates in prospective IRCs obtained through measurement and modeling.	IF results demonstrate a spatial relationship between food and forage habitats AND food flux is a significant factor in growth and survival within and among IRCs, THEN this provides more support for L2 experiments.	2	BQ3/L1 -C1, C2, and C3 done concurrently

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty*	Concurrent / Dependent Components
BQ3/L1/C3 - Field studies: food and forage habitat gradients	Depths, velocities, substrate, and spatial complexity of habitat, as well as whether habitats are occupied by food items (chironimids) and foragers (age-0 sturgeon).	IF results demonstrate a systematic spatial relationship between habitat characteristics and selection by food sources and age-0 fish, this provides more support for L2 experiments.	3	BQ3/L1 -C1, C2, and C3 done concurrently
BQ3/L1/C4 - Mesocosm studies: quantitative habitat-survival relations	Depths, velocities, substrate, and spatial complexity of habitat, as well as relative growth rates and survival as a function of habitat characteristics.	IF results demonstrate a systematic relationship between habitat characteristics and growth/survival, THEN this provides more support for L2 experiments.	1	Complete this component unless BQ3/L1/C2 provides alternative methods of estimating survival in the field
BQ3/L2/C5 - Design studies: effect of channel reconfigurations on IRCs	Relative performance of designs, measured as areas of functional habitat, using linked hydraulic and biological models.	IF demonstrated ability to increase habitat components benefiting growth and survival without unacceptable risks to other authorized purposes, THEN proceed to C6 field experimentation.	4	Develop concurrently with BQ3/L1 studies
BQ3/L2/C6 - Manipulative field experiments: effect of channel reconfigurations on IRCs	Area of food-producing habitat, area of foraging habitat, catch per unit effort of age-0 sturgeon, stomach contents, and lipid content. See Appendix E1 and E2 for a description of effectiveness monitoring.	IF results support the hypothesis that channel reconfigurations can provide increased functional habitats, THEN move to L3 implementation.	4	Described in section 4.2.6.3
Big Question 4 – Drift Dynamics: Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to decreased direct mortality and increased interception of free embryos into supporting habitats?				
Associated Hypotheses: H14. Alteration of the flow regime at Gavins Point Dam can be optimized to decrease main stem velocities, decrease effective drift distance, and minimize mortality of free embryos. H19. Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.				
BQ4/L1/C1 - Technology development: surrogate particles, particle tracking applied to IRCs	Recovery rate of marked particles in tracer studies and strength of model predictions for particle fate (combination of 1D and 2D models).	IF methods can provide strong inference on transport pathways, THEN this provides more support for L2 experiments.	1	C1-C6 done concurrently with L1 IRC studies under BQ3

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty*	Concurrent / Dependent Components
BQ4/L1/C2 – Field studies: Resilience, stamina in turbulent flows	Survival of free embryos related to measures of fluid stress, including turbulent intensity and shear.	IF survival is sensitive to range of river velocities, turbulence, or shear during dispersal, THEN this provides more support for L2 experiments.	3	C1-C6 done concurrently with L1 IRC studies under BQ3
BQ4/L1/C3 - Field studies: free embryo exit paths	Proportion of surrogate particles (real or computational) that exit the thalweg and are retained in IRCs under various channel geometries.	IF advection of surrogate or digital particles varies substantially with discharge or channel configuration, THEN this provides more support for L2 experiments.	4	C1-C6 done concurrently with L1 IRC studies under BQ3
BQ4/L1/C4 – Field studies: age-0 survival and complexity across flow gradients	Catch per unit effort of free embryos and measures of channel complexity relevant to interception hydraulics.	IF there are moderate to strong associations between advection metrics and channel configuration options, THEN this provides more support for L2 experiments.	4	C1-C6 done concurrently with L1 IRC studies under BQ3
BQ4/L1/C5 – Field studies: Free embryo transport to Mississippi River	Estimated number and survival of age-0 to juveniles hatched in the Missouri that reach the Mississippi River, relative to the number and survival of those that remain in the Missouri River.	IF the population of Missouri free embryos recruiting in the Mississippi River is NOT high enough to sustain the Missouri population, THEN increase effort to intercept free embryos in the Missouri River.	3	C1-C6 done concurrently with L1 IRC studies under BQ3; C5 dependent upon feasibility assessment
BQ4/L1/C6 – Modeling studies and field experiments: embryo dispersal tracking	Distributions of free embryos or other tracers, over time and space, as the constituents disperse downstream over a range of opportunistic flows.	IF field tracking data validate the outputs of drift models over a range of opportunistic flows, THEN proceed to proceed with L2 field experiments.	4	C1-C6 done concurrently with L1 IRC studies under BQ3
BQ4/L2/C7 - Engineering study: designs for interception experiments	Range of engineering designs that meet practical hydraulic needs and contribute to interception of drifting free embryos, and their cost.	IF designs provide evidence that IRCs contribute to growth and survival of age-0 pallid sturgeon, without unacceptable risk to other authorized purposes, THEN proceed to C8 manipulative field experiments.	4	Follows BQ4/L1 work

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty*	Concurrent / Dependent Components
Big Question 5: Spawning Habitat. Can channel reconfiguration and spawning substrate construction increase probability of survival of eggs through fertilization, incubation, and hatch?				
Associated Hypotheses: H16. Re-engineering of channel morphology in selected reaches will create optimal spawning conditions -- substrate, hydraulics, and geometry -- to increase probability of successful spawning, fertilization, embryo incubation, and free-embryo retention.				
BQ5/L1/C1 –Field study: functional spawning habitat, Yellowstone River	River depth, velocity, substrate, and habitat stability of documented spawning habitat, and reproductive responses of adults and embryos.	IF there is sustained moderate to strong spawning habitat selection that contrasts strongly with Lower Missouri River results, AND the results agree with spawning habitats quantified for other sturgeon species, THEN this provides more support for spawning habitat designs that mimic Yellowstone spawning.	3	C1-C3 concurrent
BQ5/L1/C2 – Retrospective study: habitat condition gradients LMOR	River depth, velocity, substrate, habitat stability of documented spawning habitat, and reproductive responses of adults and embryos.	IF there is sustained moderate to strong spawning habitat selection that contrasts strongly with Yellowstone River results, THEN this provides more support for spawning habitat designs that mimic Lower Missouri spawning.	3	C1-C3 concurrent
BQ5/L1/C3 - Mesocosm studies: spawn conditions, behaviors	Hatch rate as a function of different combinations of depth, velocity, substrate, and hydraulic variables, with water quality and fish behaviors as covariates.	IF results provide quantitative criteria for abiotic (and biotic) variables influencing spawning behavior from aggregation of adults to hatch of embryos, THEN proceed to L2 field experiments.	3	C1-C3 concurrent C3 concurrent w other mesocosm studies
BQ5/L2/C4 - Engineering studies: sustainable design	Design performances, measured as ability to create the hydraulic and substrate conditions developed in components 1-3. Evaluate appropriate segments for spawning habitat using combined advection dispersion and population model	IF designs are judged capable of achieving functional spawning habitat while minimizing adverse effects to other authorized purposes, THEN proceed to C5 manipulative field experiments.	1	Build on learning from L1 C1-C3 studies
BQ5/L2/C5 - Manipulative field experiments: spawning habitat	Use of spawning sites compared to other areas; Hatch rate, as determined by catch per unit effort of free embryos or alternative techniques. See Appendix	IF created spawning patches are functioning as intended to improve spawning success, THEN proceed to L3 implementation	4	Build on learning from L1 C1-C4 studies

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty*	Concurrent / Dependent Components
	E3 for a description of effectiveness monitoring.			
Big Question 6: Population Augmentation. Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?				
Associated Hypotheses: H20. Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles. H21. Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.				
BQ6/L1/C1 – Engineering studies: feasibility hatchery needs, facilities, operations	Costs and measures of likely survival for a range of propagation facility designs.	IF designs are expected to produce population benefits at a reasonable cost, THEN this provides stronger support for L2 studies	4	C1-C3 done concurrently
BQ6/L1/C2 - Retrospective study: survival linked to hatchery operations	Number and survival rates for stocked pallid sturgeon by stocked size, hatchery of origin, and health history.	IF results indicate that changes in propagation facility operations could increase survival, THEN this provides stronger support for L2 studies	3	C1-C3 done concurrently
BQ6/L1/C3 – Modeling study: population sensitivity to size, health, genetics	Probability of quasi extinction, instantaneous growth rates, and sensitivity measures under various model scenarios.	IF results indicate that population dynamics are sensitive to changes in augmentation practices AND the information provided by previous components are not sufficient to make specific implementation decisions, THEN this provides stronger support for L2 studies	4	C1-C3 done concurrently
BQ6/L2/C4 - Field study: testing key hypotheses in revised Range-wide Stocking and Augmentation Plan	TBD based on revised Range-wide Stocking and Augmentation Plan	TBD based on revised Range-wide Stocking and Augmentation Plan	4	Build on results from L1 studies
Big Question 7 - Fish Condition: Are there combinations of management actions (flow alteration, channel re-configuration, population augmentation, water quality management, or management of other fish species) which could improve the condition of pallid sturgeon within key segments of the Lower Missouri River, resulting in population stability or growth?				
Associated Hypotheses: HFC1. 2011 flood altered fish habitats and populations. HFC2. Intraspecific competition among pallid sturgeon resulting from overstocking and high survival of hatchery-origin fish puts populations closer to carrying capacity. HFC3. Interspecific competition from shovelnose sturgeon and Asian carp has reduced prey available for pallid sturgeon. HFC4. Lack of fish prey				

Question, Level and Study Components	Key Metrics	Simplified IF - THEN Decision Criteria	Degree of Certainty*	Concurrent / Dependent Components
<p>HFC5. Diminished fish health, related to hatchery practices.</p> <p>HFC6. Diminished fish health, related to contaminant exposure.</p> <p>HFC7. Long-term channel adjustments to the dams and the Bank Stabilization and Navigation Project have reduced favorable habitats for pallid sturgeon or their prey.</p> <p>HFC8. Observed variations in condition are the normal range of variability and declines reflect a return to normality</p> <p>HFC9. Senescence. Some of the large, low-condition fish in the Lower Missouri River may be older, wild-origin fish reaching the end of their lifespan.</p> <p>Priority research activities are still to be determined for BQ7. Candidate research activities are described in Randall et al. (2017) and summarized in Appendix D of the 2017 AM Report (MRRP Science and Adaptive Management Technical Team, 2018).</p>				

4.2.5 Details on Level 2 and Level 3 Actions for Upper Missouri River

This section provides more details on each of the Level 2 and Level 3 actions included in the MRRMP-EIS, describing the scope of the action, as well as the associated hypotheses, objectives, metrics, monitoring designs, decision criteria, and contingent actions (if the outcomes are different from those anticipated). The EA recognizes the impacts of fragmentation in the Upper Missouri River imposed by dams which pose barriers to upstream migration of adults and of limited drift/dispersal distances of embryos. As well, recent analyses of anoxic conditions in Fort Peck Lake have been used to argue that such conditions in Lake Sakakawea would also be lethal to drifting free embryos, thereby potentially limiting natural recruitment. Currently, the wild pallid sturgeon population in the Upper River is dominated by old-age individuals.

Upper River Big Questions relate to management actions that are hypothesized to increase natural recruitment (see Table 40 and Table 43). The Level 2 and Level 3 actions described here are based on the scientific considerations and policy determinations that have been made to focus implementation on actions that are either proposed (fish passage at Intake Diversion Dam; flows at Fort Peck) or are currently being implemented (stocking and population augmentation). A detailed summary of all Level 1 and 2 actions is contained in Appendix C. It is possible that over time, other potential actions may move from L1 feasibility analyses to L2 or L3 implementation (Figure 54).

4.2.5.1 Stocking and Population Augmentation

4.2.5.1.1 Action Description

Since the 1990s, population augmentation (stocking) of pallid sturgeon has occurred at a level intended to have a measurable effect on the population. Population augmentation

has been designed to ensure genetic diversity using local and wild broodstock collection (Pallid Sturgeon Recovery Team 2008). Hatcheries have stocked 245,249 fish of varying sizes and ages in the Upper River from 1998 to 2016 (Rotella 2017). This number excludes releases of approximately 1.3 million additional larval fish as part of drift experiments. In the Lower River (and Middle Mississippi river), more than 175,000 pallid sturgeon have been stocked since 1992 (T.W. Huenemann, unpub. data as cited in Steffensen et al. 2017). Year to year variation in releases of yearling equivalents has been relatively high with ongoing challenges in meeting propagation targets in one of the management areas of the Lower Missouri River, mainly due to a lack of availability of genetically strong adult pallid sturgeon. There has also been high year-to-year variation in the locations of stocking across the Missouri River.

While population augmentation is necessary for recovery of the pallid sturgeon, by itself it is not sufficient as the ESA requires a self-sustaining population. As noted in Section 4.1.1, recruitment to the populations in the Upper and Lower Missouri River is sustained through population augmentation. Due to past augmentation practices and the anticipated continued reliance on hatchery progeny for population support, there are concerns that the carrying capacity of habitats in the Upper River may have been exceeded and genetic diversity may be adversely affected (Heist et al. 2013). In the Lower Missouri River, recent findings on deteriorating fish condition indicate that fish condition of adult Pallid Sturgeon has been declining, starting in 2013 with increasing declines in 2014 and 2015 (Steffensen and Mestl 2016; Randall et al 2016), as summarized in section 4.1.2.4. A variety of hypotheses have been proposed to explain this pattern, which include a recognition of possible limits on the carrying capacity for pallid sturgeon and intraspecific competition. If evidence supports these hypotheses, there are potential implications for the number of fish that should be stocked.

Given these emerging issues, the systematic and rigorous evaluation of propagation strategies is crucial. A Pallid Sturgeon Range-wide Stocking and Augmentation Plan is currently under development for release in 2018 by the US Fish and Wildlife Service. This Plan will document the purpose, goals, targets, rationale and effectiveness monitoring for all activities related to pallid sturgeon stocking and augmentation. The stocking and augmentation plan is part of a canon of documents that comprise the USFWS Pallid Sturgeon Conservation Propagation and Stocking Program. Program documents also include monitoring protocols, genetics management plans, hatchery propagation protocols, and handling protocols, which may also influence MRRP-related propagation and augmentation actions.

This AM Plan defers the majority of decision making around augmentation actions to the US Fish and Wildlife Service, and by extension to those entities that advise the

Service through established roles and responsibilities, including the Upper River and Middle Basin Working Groups, Pallid Sturgeon Recovery Team, and State hatcheries. For instance, while the authority and responsibility for hatchery management lie with the USFWS for those facilities operated by the USFWS, other entities, such as Montana Fish Wildlife and Parks, are responsible for their hatchery operations. The USFWS has the responsibility for oversight of all pallid sturgeon propagation efforts, including providing direction on rearing and stocking strategies, genetics, stocking targets, etc. Much of the existing information collected in the Missouri and Yellowstone rivers has been due in part to collaborative efforts among agencies.

4.2.5.1.2 *Objectives and Expected Benefits*

While population augmentation is *necessary* for recovery of the pallid sturgeon, it is not *sufficient* because the ESA requires a self-sustaining population. The forthcoming Basin-wide Stocking and Augmentation Plan is expected to clarify the specific objectives around population augmentation, though in general it is expected to have an emphasis on improving the quality of fish, as opposed to increasing the number of fish being stocked.

In the pallid sturgeon framework developed for the Lower Missouri River, the USFWS and USACE (2015) proposed stocking levels sufficient to maintain 5,000 adult pallid sturgeon per management unit, but noted that this target was subject to adjustment based upon the forthcoming revised Rangewide Stocking and Augmentation Plan. . Long-term objectives are to reduce and eventually eliminate the need for supplemental stocking by demonstrated wild recruitment at a level sufficient to meet the fundamental objectives and associated sub-objectives of species recovery (see Section 4.1.1). However, augmentation objectives for each management unit may be adjusted over time by the USFWS in response to increased knowledge about carrying capacity, effective population size, and other factors.

4.2.5.1.3 *Hypotheses*

The following management hypotheses from the EA are relevant to stocking and population augmentation in the Upper (and Lower) Missouri River, and are presented as examples that could be addressed with MRRP collaboration if supported by the USFWS:

- H8. Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.

- H9. Stocking with appropriate parentage will increase genetic diversity and health of the population (as opposed to individuals) resulting in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.

Additional hypotheses may emerge from the forthcoming Range-wide Stocking and Augmentation Plan that relate to the emerging issues and hypotheses around the influence of augmentation actions on population health and fitness in the Upper (and Lower) Missouri River.

4.2.5.1.4 Metrics

Monitoring metrics will be informed by the forthcoming Range-wide Stocking and Augmentation Plan. It is expected, however, that relevant metrics may include hatchery of origin, number, size, timing, stocking location (or River Mile), site and parental cross, water conditions (e.g., water temperature, velocity, discharge, turbidity, substrate), and various metrics related to genetics (to be determined). Upon recapture, key metrics may include habitat/location of sample (or River Mile), sampling method and intensity, number collected, size and age, hatchery of origin, measures of fitness including population genetics, incidence of disease, fish condition (length/weight), and water year conditions (to help explain survival probabilities). These data can be used to generate key metrics for analyses, such as proportion of recaptures from different release groups, catch efficiency, and ultimately survival probabilities between early years of life. Simulations of the benefits of augmentation actions can also be determined by using field-estimated survival rates in the collaborative population model (e.g., probability of quasi extinction, instantaneous growth rates, and sensitivity analyses under various scenarios and parameterizations of the collaborative model, including alternative hypotheses and functional relationships).

4.2.5.1.5 *Monitoring Design*

The monitoring design around stocking and population augmentation actions will depend upon the testable hypotheses that emerge from the Range-wide Stocking and Augmentation Plan. Important factors that need to be controlled or accounted for include genetic diversity, hatchery of origin, number and size of releases, disease (e.g., ranavirus, iridovirus, fin curl, *Polypodium hydriforme*), and water conditions across years.

4.2.5.1.6 *Decision Criteria*

In general, decision criteria are important for guiding the MRRP and related agencies when evaluating monitoring results and other information to develop recommendations

for making adjustments to population augmentation actions. When the Range-wide Stocking and Augmentation Plan or other guidance from the Pallid Sturgeon Conservation Propagation and Stocking Program becomes available, it will be helpful to develop clear decision criteria and triggers to support implementation of actions in their early stages. There are three broad situations around which triggers would be beneficial.

Triggers for adjusting augmentation practices to optimize fitness or genetic diversity: Criteria and triggers could be used to help assess hatchery and augmentation practices and their impact on fish health (e.g., fitness and genetic diversity).

Triggers for moving to higher implementation level: In the absence of the Range-wide Stocking and Augmentation Plan or other input from the Pallid Sturgeon Conservation Propagation and Stocking Program. The transition from Level 3 to Level 4 augmentation actions is unclear; although implementation of some action is expected to continue until supplemental stocking and population augmentation is no longer required. Criteria and triggers could help managers to decide when it's appropriate to scale stocking up or down.

Trigger for abandoning population augmentation actions: Population augmentation may be halted when population monitoring demonstrates that a self-sustaining population in excess of 5,000 adult fish exists in each management unit, when the threat of extirpation is less than 5 percent in 50 years, or as based on new criteria introduced through the Range-wide Stocking and Augmentation Plan. Criteria could include considerations, such as genetics, fish community health (carrying capacity), habitat availability and hybridization. Triggers could then be evaluated within the pallid sturgeon population model framework, with recognition of the carrying capacity of different sections of the river, for instance.

4.2.5.2 Fish Passage Improvements at Intake Diversion Dam on Yellowstone River

4.2.5.2.1 Action Description

The Bureau of Reclamation (Reclamation or USBR) operates Intake Diversion Dam (Intake) on the Yellowstone River 70 miles (112 km) upstream of the confluence with the Missouri River. The USACE is a joint lead agency for improvements to Intake per the 2003 Amended Biological Opinion (USFWS 2003).. Section 3109 of the 2007 Water Resources Development Act (WRDA) authorizes the USACE to assist Reclamation with funding from the Missouri River Recovery and Mitigation Program for the design and construction of Reclamation's Lower Yellowstone Project at Intake, Montana. As such, the USACE is working with Reclamation and others to ensure that modifications are effective and that the population response of pallid sturgeon is well documented. In its

Conservation Recommendations, the 2018 Biological Opinion (USFWS 2018, pg. 126) recommends that federal agencies continue to pursue completion of fish passage at Intake Dam on the Yellowstone River as authorized by WRDA in 2007.

In 2016, Reclamation released the final EIS and a Record of Decision, which summarize the environmental, social, and economic impacts of a preferred fish passage option at Intake and alternatives to it (USBR and USACE 2016). The preferred alternative (and management action discussed here) is to implement a bypass channel to support passage of adults, juveniles, and free embryos. Other alternatives that were considered in the EIS include existing channel modifications, dam removal, as well as no action. The Intake EIS (USBR and USACE 2016) is a separate document from the EIS being prepared for the Missouri River Recovery Program.

Construction of the bypass channel at Intake, however, has been the subject of litigation which has created uncertainty about the status and timing of implementation.

4.2.5.2.2 *Objectives and Expected Benefits*

The ultimate objective of this action is to support progress towards MRRP goals and objectives for pallid sturgeon (see Section 4.1.1), as well as recovery goals described in USFWS (2014), which include “*Increas[ing] pallid sturgeon recruitment to age-1.*” In the Upper Missouri River, drift distance is hypothesized as one of the limiting factors that constrains free embryo development and natural recruitment because Lake Sakakawea sediments and the sediment water interface are anoxic and likely unsuitable for free embryos and exogenously feeding larvae. These issues are summarized in Big Question 5: *Can combinations of flow manipulation from Fort Peck, drawdown of Lake Sakakawea, and fish passage at Intake Dam on the Yellowstone River increase probability of successful dispersal of free embryos and retention of exogenously feeding larvae?* Construction of the bypass channel is expected to improve adult migration past the weir at Intake Diversion Dam, enable upstream migration of spawners, and support access to potential spawning locations that will increase drift distance for free embryos so they can successfully develop into larvae prior to reaching the headwaters of Lake Sakakawea.

Given a limited set of Level 3 actions in the Upper Missouri River at this time, information about fish passage improvements at Intake will be important for informing decisions around implementation and effectiveness of management actions in other parts of the basin (e.g., flow, temperature, or sediment manipulations at Fort Peck, drawdown of Lake Sakakawea), as well as the design and construction of spawning habitat projects in the Lower Missouri River (see Section 4.2.6.4).

4.2.5.2.3 Hypotheses

Implementation of fish passage improvements at Intake Diversion Dam are framed around Big Question 5 and the associated management hypothesis identified in the Effects Analysis (see Table 43 and Jacobson et al. 2016c):

- H7. Fish passage at Intake Diversion Dam on the Yellowstone River will allow access to additional functional spawning sites, increasing spawning success and effective drift distance, and decreasing downstream mortality of free embryos and exogenously-feeding larvae.

This management hypothesis is broad and there is a need to tailor implementation and monitoring in a way that more specifically evaluates the effectiveness of passage improvements at different life stages and locations within the upper river. Greater specificity will allow scientists to better diagnose mortality bottlenecks in the life cycle. Effectiveness monitoring is designed to provide answers to more specific focal questions, intended to guide decision makers towards actions that provide the most benefit to the species.

Table 45 summarizes the focal questions being used to guide effectiveness monitoring, which are further parsed into testable hypotheses to ensure monitoring activities will collect the appropriate data and perform the required data analyses. Testable hypotheses are stated as alternative hypotheses that represent the preferred outcomes. Q1 and Q5 are specific to evaluating the passage alternative at Intake Diversion Dam, while Q2, Q3, and Q4 can be addressed in the absence of a passage alternative (if translocation or migration occurs through the natural side channel) or if a different passage alternative were to be implemented. Q2, Q3, Q4 and the related monitoring activities are also intended to be consistent with the monitoring design in the Lower Missouri River (see Sections 4.2.6.4 and 4.2.6.5), since there are similar questions and protocols for collecting data.

Table 45. Summary of focal questions and testable hypotheses for evaluating effectiveness of passage improvements at Intake Diversion Dam.

Focal Questions	Testable Hypotheses
Q1: Do adult and juvenile pallid sturgeon successfully move upstream / downstream past Intake Diversion Dam and through the bypass channel?	H1: Physical performance of bypass channel at Intake Diversion Dam is compliant with physical success criteria
	H2: Biological performance of bypass channel at Intake Diversion Dam is compliant with biological success criteria
Q2: Does the location of spawning provide sufficient drift distance to allow the development of drifting free embryos into exogenously feeding larvae?	H3: Spawning event occurs at a location that provides sufficient drift distance to support development and survival of free embryos into exogenously feeding larvae

Q3: Does successful spawning (aggregation-fertilization) occur?	H4: Spawners aggregate in sufficient numbers to initiate spawning
	H5: Spawning event leads to the successful release of fertilized eggs
Q4: Does successful reproduction (incubation-viable embryos) occur?	H6: Viable embryos are detected immediately downstream of a known spawning event at identified spawning patches
Q5: Do free embryos and larvae successfully move downstream past Intake Diversion Dam and through the bypass channel?	H7: Hatchery releases of free embryos / larvae are detected alive downstream of Intake Diversion Dam
	H8: Apparent mortality of hatchery released free embryos and/or larvae drifting over the weir and through the bypass channel is the same or lower than natural apparent mortality of hatchery released free embryos and/or larvae in the Yellowstone River
	H9: Wild produced age-0 and juvenile pallid sturgeon are detected in the Yellowstone, Missouri Rivers, or flowing reaches of Lake Sakakawea
	H10: Wild produced age-0 and juvenile pallid sturgeon detected in Yellowstone or upper Missouri Rivers originate from spawners known to migrate upstream past Intake Diversion Dam

4.2.5.2.4 Metrics

The monitoring activities associated with fish passage improvements at Intake require collecting a mix of physical and biological metrics to evaluate the above hypotheses. Appendix E5 provides more detail around the metrics and design of these monitoring activities. In general, effectiveness monitoring would include the following activities:¹

Physical monitoring

- **M2: Fixed in-river monitoring** to characterize discharge, stage, turbidity, and temperature conditions (where available) across segments and reaches across the study area.
- **M3: Detailed mapping of spawning habitats** using a hydroacoustic boat equipped with high-resolution multi-beam and single beam bathymetry systems, as well as an acoustic Doppler Current Profiler to develop detailed maps of hydraulic and bed conditions of identified locations after spawning has occurred.
- **M4: Acoustic Doppler Current Profiler at Intake** to analyze depths and velocities across bypass channel, deployed by boat or line across the channel.

Biological monitoring: Early life stages

¹ Note the numbering of monitoring activities is intended to be consistent with the numbering of similar activities associated with other management actions (e.g., as described for spawning habitat (Section 4.2.6.4) and spawning-cue pulses (section 4.2.6.5)).

- M5: Free embryo sampling (and genetic analysis) using rectangular plankton nets deployed by boat to collect free embryos at various locations across the upper river, and then use these samples to perform genetic analysis and identify parental origin.
- M6: Age-0 sampling (and genetic analysis) using benthic beam or otter trawling methods to collect age-0 fish.

Biological monitoring: Adult movement

- M7: Tagging (and genetic analysis) of reproductive and non-reproductive adults by deploying drifted trammel nets to catch, tag (with radio and/or acoustic tags), and collect baseline biological information. A telemetry design study is currently underway which will specify tagging technology and other design considerations. It will also be necessary to consider broodstock needs of the propagation program at the time of capture.
- M8: Passive telemetry network as represented by automated and fixed telemetry logging stations to document location, movement, and potential spawning of tagged individuals across segments and reaches across the study area.
- M9: Manual tracking of tagged adults by boat (or aerial flights if more appropriate) to provide a finer scale resolution of information on the location and movement of tagged individuals at the reach, bend, and macro-habitat scale (equipped with radio and/or acoustic receivers). This activity would also be linked to other data collection activities (M10 and M11).

Biological monitoring: Adult spawning

- M10: Detailed monitoring of spawners at a spawning site using 2D / 3D telemetry arrays and a boat with DIDSON acoustic imagery to precisely document fish location and behavior at a spawning site at the time of suspected spawning.
- M11: Adult recapture and reproductive assessment using drifted trammel nets to catch tagged adults after spawning has occurred and confirm spawning outcome (using surgical evaluation, endoscopy, weight, ultrasound, and/or blood samples).

Research experiment

- R1: Experimental release of hatchery-origin free embryos / larvae to assess the effect of Intake Diversion Dam (bypass channel, concrete weir, and rock field) on the

downstream movement of early life stages using hatchery raised embryos from a mix of wild and captive broodstock. This activity would also be accompanied by a basic characterization of physical habitat conditions and biological sampling of free embryos / larvae (M5).

Table 46 lists the monitoring activities, existing field protocols and related studies that are available to guide these activities, as well as the key metrics that would be generated to inform data analyses. This table also includes one targeted research activity to hasten learning about the impacts of Intake on survival of free embryos (R1). Linkages among monitoring activities and focal questions / hypotheses are also shown since an individual activity can inform more than one question / hypothesis and can involve collecting several types of data.

4.2.5.2.5 Monitoring Design

Table 47 summarizes the spatial, temporal, and sampling effort considerations for the twelve proposed monitoring activities described above. Most activities represent observational studies as opposed to manipulated experiments; an exception is the release of hatchery origin free embryos / larvae at Intake Diversion Dam which represents a targeted research study. The broad spatial boundaries for this monitoring design focus on the Yellowstone River and its related tributaries from the confluence with the Missouri River upstream to Cartersville Diversion Dam, which includes some sampling in the upper Missouri River near the confluence with the Yellowstone River. Monitoring is expected to occur for at least 8 years after construction of the bypass channel (as specified in USBR 2016), though is also expected to depend on the response of spawners to passage improvements and broader recovery of pallid sturgeon.

Table 46. Summary of monitoring activities, supporting field protocols, studies, and metrics as aligned with focal questions and testable hypotheses.

[illegible]

Monitoring Activity	Field Protocols / Related Studies	Performance Metrics	Q1		Q2	Q3		Q4	Q5			
			H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
Biological monitoring: Adult movement												
M7: Tagging (and genetic analysis) of reproductive and non-reproductive adults	<ul style="list-style-type: none">See Appendix DUSFWS 2012USBR 2016Welker and Drobish 2017USBR 2017	<ul style="list-style-type: none">Fish IDFish condition (length, weight, Kn, health metrics)SexReproductive stage		X	X	X						X
M8: Passive telemetry network	<ul style="list-style-type: none">USGS telemetry study (in prep.)USBR 2016USBR 2017	<ul style="list-style-type: none">Fish IDRiver mile locationMovement of tagged adults passing points along telemetry network		X	X	X						
M9: Manual tracking of tagged adults	<ul style="list-style-type: none">DeLonay et al. 2016b (Appendices 1 and 4)USBR 2017	<ul style="list-style-type: none">Fish IDlocation, movementAggregation and spawning behavior			X	X	X					
Biological monitoring: Adult spawning												
M10: Detailed monitoring of spawners at a spawning site	<ul style="list-style-type: none">DeLonay et al. 2016b (Appendix 3)USBR 2017Elliott and Jacobson (written communication)	<ul style="list-style-type: none">Fish ID2D / 3D locationMovement, aggregation and spawning behaviorSubstrate conditions			X	X	X					
M11: Adult recapture and reproductive assessment	<ul style="list-style-type: none">See Appendix DUSFWS 2012DeLonay et al. 2016b (Appendices 1 and 4)Welker and Drobish 2017	<ul style="list-style-type: none">Fish IDSpawning outcome					X					
Research experiment												
R1: Experimental release of hatchery-origin free embryos / larvae	<ul style="list-style-type: none">USFWS hatchery rearing protocolsUSGS drift study (in prep)Braaten et al. 2016Marotz and Lorang 2017	<ul style="list-style-type: none">Number of free embryos / larvaePhysical habitat characteristics (see above)							X	X		

Table 47. Proposed monitoring activities and related sampling design considerations.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
Physical monitoring			
M2: Fixed in-river monitoring	<p>Locations of in-river monitoring are pre-determined by locations of USGS gaging stations, which includes six locations in Yellowstone basin:</p> <ul style="list-style-type: none"> • USGS 06295000 Yellowstone R, Forsyth, MT • USGS 06309000 Yellowstone R, Miles City, MT • USGS 06327500 Yellowstone R, Glendive, MT • USGS 06329500 Yellowstone R near Sidney, MT • USGS 06329610 Yellowstone River No. 2 NR, Cartwright, ND • USGS 06326500 Powder River near Locate, MT <p>Other stations are operated in the upper Missouri and Milk Rivers if the design is expanded and needs to include these areas.</p>	Stations are operated continuously over the entire year at a fine scale temporal resolution (e.g., 15 minute intervals).	<p>Locations have been predetermined by the USGS Water Watch program. Available data for Montana are provided here: https://waterdata.usgs.gov/mt/nwis/rt</p>
M3: Detailed mapping of spawning habitats	Locations of high resolution mapping will occur at all identified spawning sites upstream of Intake Diversion Dam (using passive and manual telemetry systems). The spatial resolution of multibeam bathymetry and ADCP data collection are specified in Appendix 3 of DeLonay et al. (2016b).	One-time high resolution mapping would occur after spawning has been documented, at time when discharge is within 10% of when spawning occurred. This timing is expected to be from June to September.	Sampling design guided by the translocation plan for Intake Diversion Dam (USBR 2017) and previous spawning habitat studies (DeLonay et al. 2016b, App 3). Locations of mapping will depend on spawning sites, which are unknown at this time. Timing of effort is based on previous studies in the upper and lower Missouri Rivers.
M4: Acoustic Doppler Current Profiler (ADCP) at Intake	<p>Sampling is proposed at five cross sections:</p> <ul style="list-style-type: none"> • Downstream entrance to channel • 1,000, 5,000, and 10,000 feet up from downstream entrance or representative cross-sections • Upstream outlet to the river 	Deployed over a five month period reflecting three different flow conditions: Spring moderate (Apr-May), high runoff (Jun-Jul), and low flow (Aug). Sampling frequency undefined.	Sampling design guided by USBR 2016.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
Biological monitoring: Early life stages			
<p>M5: Free embryo sampling (and genetic analysis)</p>	<p>Free embryo sampling would occur for two reasons: (1) to confirm the emergence of free embryos after a spawning location / event has been confirmed, and (2) to assess the effect of the structures at Intake Diversion Dam.</p> <p>Sampling that coincides with spawning would occur immediately downstream of an all identified spawning locations upstream of Intake Diversion Dam (i.e., less than 1 mile downstream).</p> <p>Sampling would also occur to coincide and support experimental release locations of free embryos in the vicinity of Intake Diversion Dam (see Figure 56).</p>	<p>The timing of sampling would occur days after a spawning location / event has been confirmed. Egg incubation and hatching is expected to take between 4 and 5.5 days (101 hours at 22 °C, 131 hours at 18 °C, see DeLonay et al. 2016b). Since there are uncertainties in confirming the precise timing of a spawning event and in the time it takes for eggs to hatch and free embryos to emerge, a wide sampling window should be used (e.g., sampling from 3 to 7 days after spawning event). The general timing of this activity is expected to be between June and September.</p>	<p>Sampling design guided by previous spawning studies (DeLonay et al. 2016b, App 1), past drift studies and tests of alternative sampling methods (Braaten et al. 2010), the final EIS and translocation plan for Intake Diversion Dam (USBR 2016; 2017), as well as the standard operating procedures for fish sampling and data collection (Welker and Drobish 2017). The locations and timing of sampling to confirm successful reproduction will depend on identified spawning sites and confirmed spawning events.</p> <p>This activity does not include the sampling effort currently being proposed for Intake Diversion Dam at the headworks gates in the main canal, as well as at locations upstream and downstream of weir (USBR 2016).</p>

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
<p>M6: Age-0 sampling (and genetic analysis)</p>	<p>Sampling locations of age-0 pallid sturgeon have yet to be informed by the PSPAP sampling design (Appendix D). Previous studies suggest that sampling should occur at three locations:</p> <ul style="list-style-type: none"> • In the Missouri River above the confluence with the Yellowstone River • In the Missouri River below the confluence with the Yellowstone River • In the lower reach of Yellowstone River upstream of the confluence with the Missouri River. <p>Consistent with Appendix E1. The sample frame should be constrained to those habitats where past studies have shown the bulk of age-0 captures:</p> <p><u>Macro Habitats</u>: constrained to Island Side Bars (ISB) and Channel Crossover (CHXO)</p> <p><u>Meso Habitats</u>: constrained to Channel Borders (CHNB), Island Tips (ITIP), and bars.</p> <p><u>Micro Habitats</u>: constrained to L-dikes, wing dikes, rootless dikes, and channel sand bars.</p> <p>Sites should be selected randomly from this sample frame within a bend or reach consistent with the PSPAP design. The number of replicate bends and trawls per bend have yet to be determined.</p>	<p>Timing of sampling age-0 pallid sturgeon has yet to be informed by the PSPAP sampling design (Appendix D). Based on previous studies, age-0 sampling is expected to occur every week from mid-July to mid-September.</p>	<p>As noted, the sampling design for age-0 individuals is expected to be informed by the sampling design for PSPAP (Appendix D) as well as the standard operating procedures for fish sampling and data collection (Welker and Drobish 2017). The location and timing of proposed sampling provided here is based on previous studies and expectations around where and when age-0 individuals will most likely be encountered.</p>

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
Biological monitoring: Adult movement			
<p>M7: Tagging (and genetic analysis) of reproductive and non-reproductive adults</p>	<p>Capture location for tagging adults has yet to be determined and will be informed by an Upper River telemetry design study. Anticipate capture in vicinity of Intake Diversion Dam to ensure that motivated adults migrating upstream are tagged. Although a different location would be required, the catch zone described in the Intake translocation plan extends 1.3 miles upstream of the existing natural high flow side channel to ensure that truly motivated adults are translocated.</p>	<p>Timing for tagging of adults has yet to be determined and will be informed by an Upper River telemetry design study. It is expected that tagging would occur during the pre-spawn migration period and timing around which adults are most likely to arrive at Intake Diversion Dam, from late April to June.</p>	<p>Number of tagged adults has yet to be determined; informed by Upper River telemetry design study. Currently, radio tags have been implanted on 70 wild adults and 130+ hatchery-raised juveniles. Power analysis may be necessary to determine optimal number of tags, however biological success criteria for adult passage at Intake (USBR 2016) suggest at least 20 motivated adults need to be tagged to evaluate success at 5% level of precision. This number of tagged adults may be a challenge since only 12-16% of Upper River population migrates to the dam (Pat Braaten, U.S.Geological Survey, pers. Comm). Sampling informed by translocation plan for Intake (USBR 2017).</p>

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
<p>M8: Passive telemetry network</p>	<p>The passive telemetry network would include logging stations to discern movement across segments and reaches in three focal areas: Yellowstone River, upper Missouri River, and around Intake Diversion Dam. Eight locations are proposed to track movement around Intake Diversion Dam (USBR 2016):</p> <ul style="list-style-type: none"> • One mile D/S of Intake • D/S entrance to bypass channel • Two locations within bypass channel • U/S outlet to bypass channel • One mile U/S of Intake • D/S entrance to existing side channel • Old headworks structure <p>The following locations are also proposed around Intake to provide redundancy and early indications of movement:</p> <ul style="list-style-type: none"> • Two stations, 3-5 miles downstream from Intake to provide more lead time to mobilize and track a fish approaching Intake. One station on each side of the river to ensure complete coverage. • One additional station near the old headworks structure (one on each side of the river) to provide redundancy in detecting passage upstream of Intake <p>Stations in Yellowstone and upper Missouri Rivers would leverage current and discontinued locations since there are constraints on placement and a need to ensuring appropriate spacing (10 locations in the Yellowstone basin, 8 locations on the upper Missouri / Milk Rivers, see Figure 55). Additional stations should be located at the mouth of the Powder River and at 20 mile increments (up to 100 miles) to clarify the upstream extent of spawning.</p>	<p>The most critical passive logging stations would be operated year round where site-specific conditions allow; all sites should be active from April through October. Data should be retrieved two times per month outside of the migration and spawning period. Data should be downloaded more frequently (at least twice weekly) during the migration and spawning period (April-July) to guide manual tracking of adults during the spawning period, though daily data downloads would be preferable where remote communication is feasible.</p>	<p>Sampling design guided by the final EIS and translocation plan for Intake Diversion Dam (USBR 2016; 2017), previous telemetry studies (DeLonay et al. 2016b, App 1, 2 & 4), and a forthcoming telemetry design study from USGS. Responsibilities for oversight / maintenance of logging stations are expected to include a mix of agencies (e.g., USGS, Montana Fish, Wildlife and Parks, Reclamation, and the Corps).</p>

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
M9: Manual tracking of tagged adults	Locations of manual tracking would be informed by real-time data gathered from the passive telemetry network (M8) with a focus on understanding finer-scale location and movement of tagged adults identified as being in a reproductive condition. The purpose of manual tracking would be to identify all locations of suspected spawning upstream of Intake Diversion Dam. The Powder River was a recently documented area of interest for tagged and translocated adults in 2017.	Manual tracking by boat would occur from April to October. During pre- and post-spawn periods, tagged individuals would be located daily (if not hourly), so as to discern migration progress/impediments when the fish approach Intake. Individuals in reproductive condition would be tracked more frequently along their migration routes to spawning (from daily to hourly to constantly).	Sampling design guided by the translocation plan for Intake Diversion Dam (USBR 2017), previous telemetry studies (DeLonay et al. 2016b, App 1, 2 & 4), and a forthcoming telemetry design study from USGS. Locations of manual tracking will depend on the suspected spawning sites, which are unknown at this time. Timing of effort is based on previous telemetry studies in the upper and lower Missouri Rivers.
Biological monitoring: Adult spawning			
M10: Detailed monitoring of spawners at a spawning site	Detailed monitoring of spawners will occur at all identified spawning sites upstream of Intake Diversion Dam (using passive and manual telemetry systems).	Detailed monitoring of spawners would occur when there is evidence of spawning through other activities. This timing is expected to be from June to September.	Sampling design guided by the translocation plan for Intake Diversion Dam (USBR 2017) and previous spawning habitat studies (DeLonay et al. 2016b, App 3). Locations of monitoring will depend on spawning sites, which are unknown at this time. Timing of effort is based on previous studies in the upper and lower Missouri Rivers.
M11: Adult recapture and reproductive assessment	Locations of adult recapture and reproductive assessment will occur at all identified spawning sites upstream of Intake Diversion Dam (using passive and manual telemetry systems).	Adult recapture and reproductive assessment would occur when there is evidence through other monitoring activities that spawning may have occurred. This evidence can include changes in the pattern of movement and holding of tagged individuals, observations of aggregations of males, and/or spawning behaviors noted through DIDSON acoustic imagery. Recapture might occur on multiple occasions if an individual is known to be in reproductive condition and a reproductive assessment has not been able to confirm spawning. The timing of this activity is expected to be between June and September.	Sampling design guided by the translocation plan for Intake Diversion Dam (USBR 2017) and previous spawning studies (DeLonay et al. 2016b, App 4). Locations and timing of recapture will depend on identified spawning sites and observed behavior of adults.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
Research experiment			
R1: Experimental release of hatchery-origin free embryos / larvae	<p>Experimental release and related sampling of free embryos would occur at the following locations in the vicinity of Intake Diversion Dam. These locations are illustrated in Figure 56.</p> <ul style="list-style-type: none"> • (A) Immediately upstream of the concrete weir on the Yellowstone River (A1) with sampling immediately downstream (A2). • (B) Upstream inlet to the bypass channel (B1) with sampling at the downstream outlet to the channel (B2). • (C) On the Yellowstone River, upstream of all structures (C1), with sampling a short distance (~100m) immediately downstream of the point of release (C2). <p>Releases and related sampling for (A) and (B) would be used to determine combined mortality effects from the gear plus weir and gear plus bypass channel, respectively. Release (C) would be used to estimate gear mortality only since the release and sampling happens quickly with no structures in the way, so any mortality that is observed can be assumed to result from the sampling gear.</p>	<p>The exact dates for implementation of a one-time free embryo release experiment cannot be known until spawning chronologies for females and hatch dates are determined, though it can generally be expected to occur in June (as per Braaten et al. 2016).</p> <p>Given the short travel distances involved, the timing of biological sampling would occur simultaneously with release. The duration of sampling at each location could persist through an extended period of zero catch following the peak and descending limb of the catch curve to ensure that the tail of the drifting population of embryos has been characterized.</p> <p>The individual releases would need to occur at independent points in time to ensure that the free embryos from one release experiment are not captured during sampling for another release experiment (i.e., spread over 2 or more days depending on the number of replicate releases). Alternatively, independence could be maintained if embryos could be distinguished into distinct batches with genetics or other markings / dyes.</p>	<p>Release and sampling locations in Figure 56 are approximated based on important locations for disentangling gear effect and site effect on mortality of free embryos. Hatchery rearing, experimental releases, and sampling considerations are based on previous experiments conducted elsewhere in the Upper River (Braaten et al. 2016). The potential effect of the headworks structure on embryo mortality is not included in this experimental design, but would ideally be conducted at the same time.</p> <p>Additional consideration needs to be given to (1) the number of embryos in each batch of releases, and (2) the number of batches of releases. These considerations are important to ensure that the variation in mortality effect is sufficiently characterized. The initial design suggests that the number of embryo releases needs to be large enough to allow for at least 30 individuals to be captured and that a minimum of two batches of embryo releases needs to occur.</p>

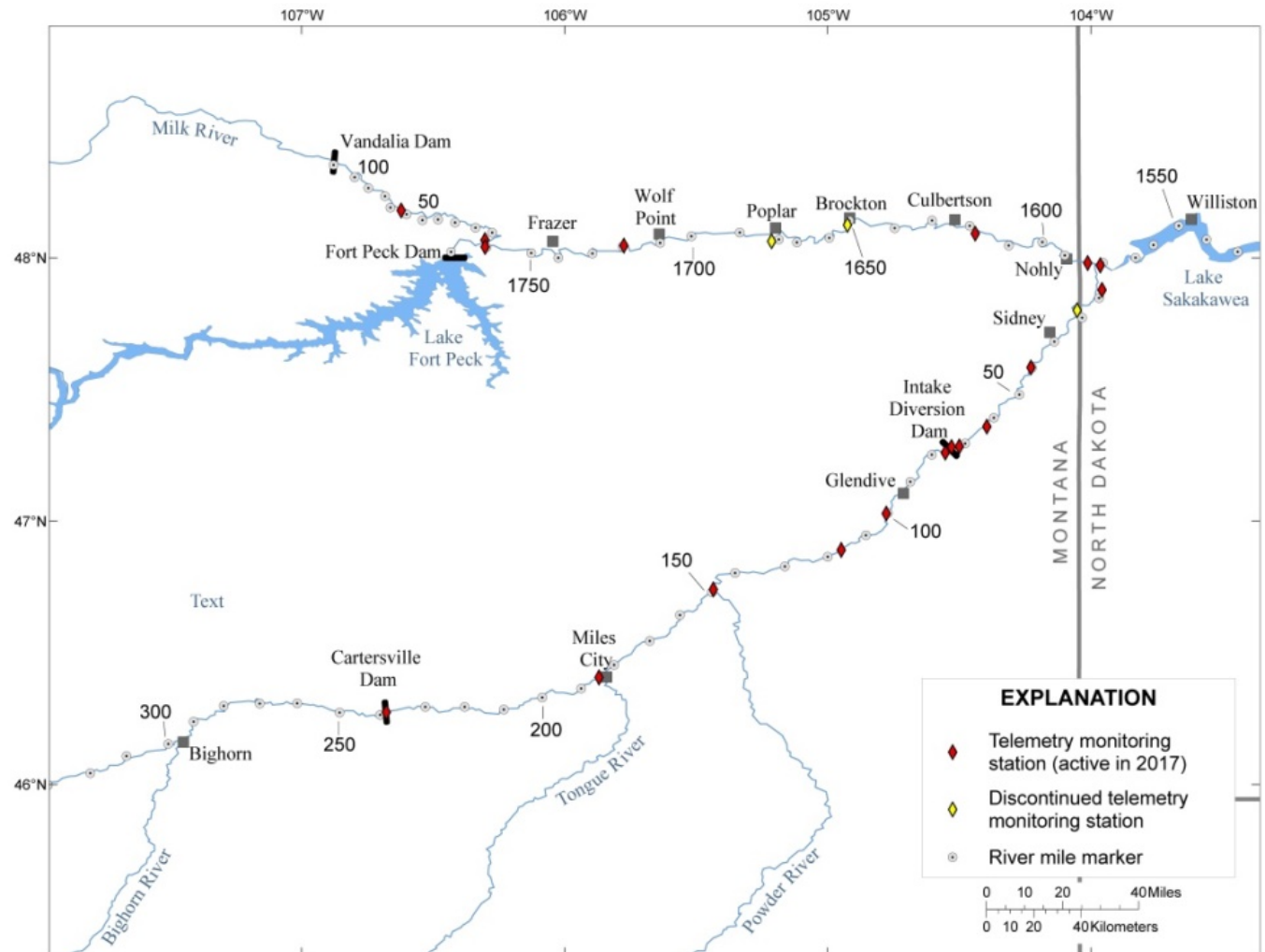
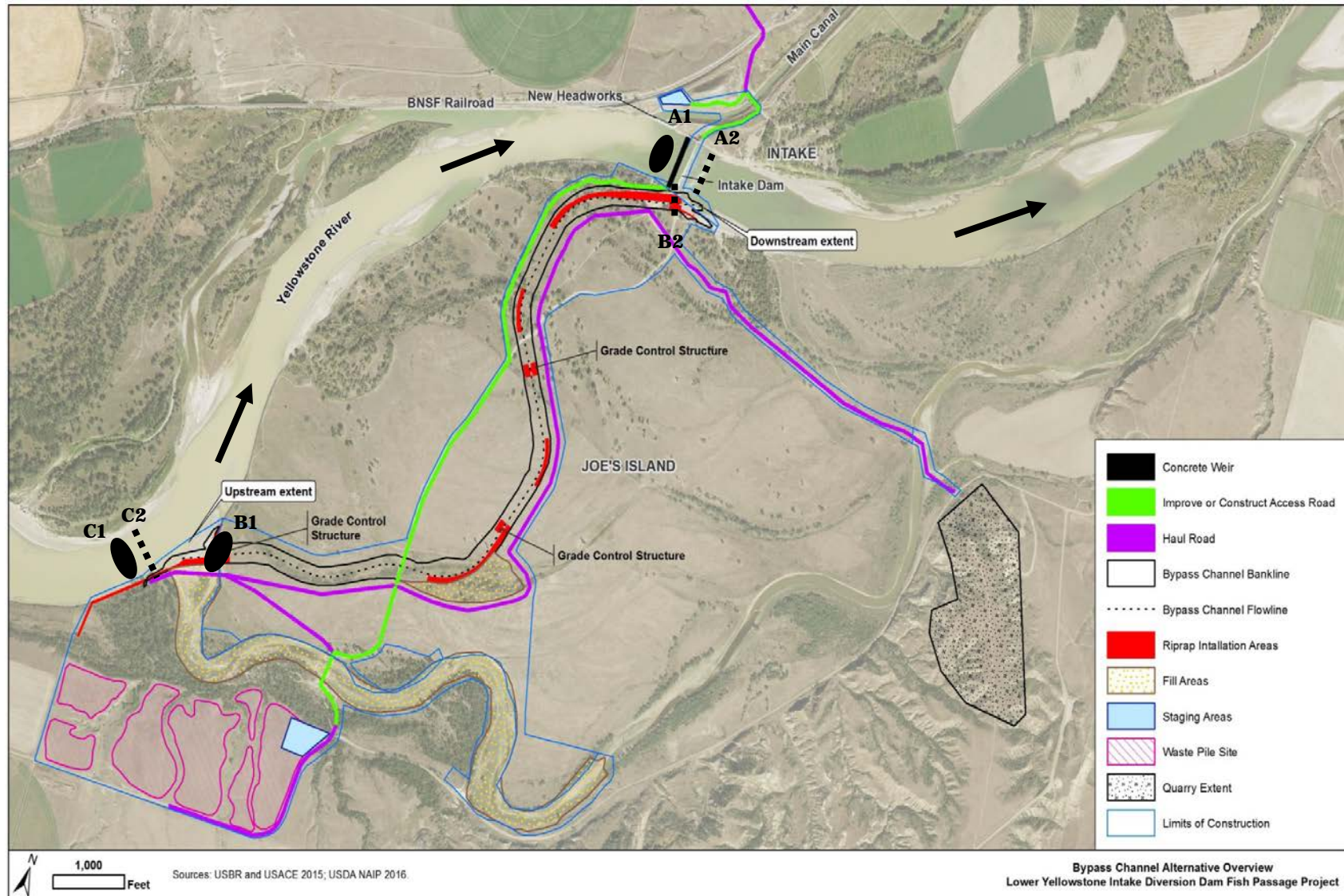


Figure 55. Map of the active and discontinued fixed telemetry logging stations (Source USGS).



4.2.5.2.6 *Decision Criteria*

Decision criteria would guide the MRRP when evaluating monitoring results and developing recommendations for consideration by the agencies. The focal questions and testable hypotheses presented earlier provide guidance on how to evaluate this information. There is an intentional sequence in answering these focal questions to best understand at which stages in the life cycle there may problems with passage improvements, and whether additional actions may be required to support natural recruitment of juvenile pallid sturgeon and ultimate progress towards the program's recovery goals.

Table 48 presents the sequence of focal questions and testable hypotheses alongside the decision relevance of different monitoring results (i.e., yes, inconclusive, or no). In many cases, success is defined as a binary determination of a whether a target or set of conditions was achieved. In a few cases, a simple statistical test may be used to assess whether the estimated mean (or average) of a parameter, with a quantifiable variance, is different than a target value. In most cases, success criteria or biologically significant effect sizes have not been defined at this time. Defining more specific success criteria is expected to involve additional engagement and ongoing review and evaluation of field results over time. Where available, success criteria for these testable hypotheses are provided in Appendix E.

Ultimately, successful natural recruitment would occur if monitoring results reveal that: spawners were able to migrate successfully past Intake and sufficiently far upstream; successful aggregations and spawning occurred; Intake provided for safe downstream passage of embryos; and age-0 pallid sturgeon were detected in the lower Yellowstone River and/or Upper Missouri River that could be genetically linked to the spawners passing Intake. To understand whether natural recruitment is sufficient to support population recovery, more robust population monitoring would be required to better quantify the benefits of passage improvements and inform parameter estimates in the collaborative population model (see Appendix D). Ambiguity in the results would be expected if answers to the above questions were equivocal (e.g., a limited amount of successful spawning is documented or natural recruitment can only be documented in 1 of 5 years). Additional monitoring would likely be required if results were equivocal, since the data could not be used to defensibly provide answers to these questions. There should also be cautions around the potential for Type II errors when interpreting data (i.e., failing to detect an effect when one actually occurred). Natural variability in environmental conditions is high and detectability of wild fish is low. Therefore, a lack of an observed effect should not be interpreted as no effect.

1 Table 48. Summary of the monitoring questions for Intake and the decision relevance of different answers to these questions.

Focal questions	Testable hypotheses	Decision relevance of answers to questions		
		No / reject hypothesis [👎 or 👎]	Inconclusive [🤔]	Yes / do not reject hypothesis [👍 or 👍]
Q1: Do adult and juvenile pallid sturgeon successfully move upstream / downstream past Intake Diversion Dam and through the bypass channel?	H1: Physical performance of bypass channel at Intake Diversion Dam is compliant with physical success criteria H2: Biological performance of bypass channel at Intake Diversion Dam is compliant with biological success criteria	If physical success criteria are being met, but not biological success criteria, re-assess physical success criteria. If physical and biological success criteria are not being met, investigate potential deficiencies in passage (attraction and passage efficiency).	Collect more data and/or revise monitoring design. (e.g., location, frequency, and/or timing of sampling).	If biological and physical success criteria are being met, investigate distance of upstream movement (Q2). If biological success criteria are being met, but not physical success criteria, re-assess physical success criteria.
Q2: Does the location of spawning provide sufficient drift distance to allow the development of drifting free embryos into exogenously feeding larvae?	H3: Spawning event occurs at a location that provides sufficient drift distance to support development and survival of free embryos into exogenously feeding larvae	If the location of spawning is consistently insufficient, other Level 3 actions in the Upper River may be necessary.	Collect more data and/or revise monitoring design(e.g., location, frequency, and/or timing of sampling).	If the location of spawning is consistently sufficient, investigate success of spawning (Q3). Consider other actions if necessary (i.e., passage at Cartersville).
Q3: Does successful spawning (aggregation-fertilization) occur?	H4: Spawners aggregate in sufficient numbers to initiate spawning H5: Spawning event leads to the successful release of fertilized eggs	If aggregations and/or fertilization are unsuccessful, consider ways to increase success (e.g., increase number as hatchery primed spawners). Other Level 3 actions in the Upper River may be necessary.	Collect more data and/or revise monitoring design (e.g., location, frequency, and/or timing of sampling).	If spawning (aggregation and fertilization) is successful, investigate whether reproduction is successful (Q4).
Q4: Does successful reproduction (incubation-viable embryos) occur?	H6: Viable embryos are detected immediately downstream of a known spawning event at identified spawning patches	If reproduction (incubation-viable embryos) is unsuccessful, consider ways to increase success (e.g., increase number as hatchery primed spawners). Other Level 3 actions in the Upper River may be necessary.	Collect more data and/or revise monitoring design (e.g., sampling methods, sampling effort).	If reproduction (incubation-viable embryos) is successful, investigate downstream movement past Intake (Q5).

Focal question	Testable hypotheses	Decision relevance of answers to questions		
		No / reject hypothesis [👎 or 👎]	Inconclusive [🤔]	Yes / do not reject hypothesis [👍 or 👍]
Q5: Do free embryos and larvae successfully move downstream past Intake Diversion Dam and through the bypass channel?	H7: Hatchery releases of free embryos / larvae are detected alive downstream of Intake Diversion Dam	If the weir and bypass channel have an impacts on survival of free embryos, investigate source of mortality and ways to mitigate them.	Collect more data and/or revise monitoring design (e.g., location, frequency, and/or timing of sampling, sampling effort, gear type).	If free embryo survival is unaffected by downstream passage, investigate whether age-0 individuals are caught downstream (see below).
	H8: Apparent mortality of hatchery released free embryos and/or larvae drifting over the weir and through the bypass channel is the same or lower than natural apparent mortality of hatchery released free embryos and/or larvae in the Yellowstone River			
	H9: Wild produced age-0 and juvenile pallid sturgeon are detected in the Yellowstone, Missouri Rivers, or flowing reaches of Lake Sakakawea H10: Wild produced age-0 and juvenile pallid sturgeon detected in Yellowstone or upper Missouri Rivers originate from spawners known to migrate upstream past Intake Diversion Dam	If age-0 individuals are not caught downstream of Intake, investigate other sources of mortality downstream of Intake.	Collect more data and/or revise monitoring design (e.g., location, frequency, and/or timing of sampling, sampling effort, gear type).	If age-0 individuals are caught downstream of Intake, investigate whether natural recruitment will have a population level effect (see Appendix D, PSPAP).

Intentionally Left Blank

4.2.5.2.7 *Contingent Actions and Supporting Studies*

A variety of other Level 1 research studies and monitoring are ongoing or planned which will support monitoring around effectiveness of fish passage improvements at Intake Diversion Dam. These other programs and studies include (described in more detail in Appendices C and D):

- **Adult tagging and telemetry**

- BQ1/L1/C1 – Design study: complementary passive telemetry network: This component involves a study to design, optimize, and implement a passive, fixed-station telemetry receiver network to complement intensive, boat-based tracking throughout the Upper Missouri and Yellowstone Rivers.
- BQ1/L1/C2 – Field study: opportunistic tracking of reproductive behaviors: This component involves opportunistic monitoring of water discharge and pallid sturgeon location / movement. Flows will be measured continuously at multiple locations downriver from Fort Peck Dam and on the lower Yellowstone River. Pallid sturgeon in reproductive condition will be tracked via telemetry methods to determine movement patterns. Telemetry will include documenting reproductive behavior (aggregation, spawning) and spawning success. Statistical relationships of flow-regime components (e.g., mean discharge, change in discharge) and covariates (e.g., turbidity and temperature) to pallid sturgeon behavior will be evaluated.
- Translocation of Pallid Sturgeon above Intake Diversion Dam: In 2016, the U.S. Fish and Wildlife Service also established a Reasonable and Prudent Measure to “relocate motivated adult and juvenile pallid sturgeon above the current weir” as an interim measure until the construction of the bypass channel is complete (USFW 2016). In 2017, motivated and currently tagged adults were translocated upstream of Intake Diversion Dam and this measure is expected to continue until a passage alternative is implemented at Intake (USBR 2017). This activity has the potential to inform the hypotheses described in this monitoring design and facilitate learning about the suitability of habitats upstream of Intake even in the absence of fish passage improvements. In addition, there continues to be monitoring of movement of fish in the existing side channel, which has seen passage in 2014, 2015, and 2017.

- **Advection/dispersion modelling**

- BQ3/L1/C3b – Field studies: validating advection / dispersion model: This component involves a field experiment which tracked dispersal of free embryos and surrogate tracers, combined with robust characterization of flow fields and dispersion coefficients, to test/validate/refine the advection/dispersion model

(release completed in 2016 with ongoing monitoring / catch of survivors). Based on results of the 2016 experiment, another drift experiment(s) should be considered.

- BQ3/L1/C4b – Mesocosm studies: developing quantitative temperature-recruitment relationships: This component involves a laboratory study that will document developmental rates of embryos, free embryos, and exogenously feeding larvae as a function of water temperature. Some of these relations already exist, but they need to be confirmed and expanded to a wider temperature range to apply to Yellowstone River temperatures.
- BQ5/L1/C4 – Mesocosm experiments: Larval dispersal rates: This component is a mesocosm study designed to quantify how and why free-embryo velocities depart from passive transport assumptions. The study will take place in racetrack flume mesocosms, or similar facility, to quantify the factors that may operate to alter transport conditions from purely passive assumptions.

- **Pallid Sturgeon Population Assessment Program v 2.0**

- This program is being designed to provide population-level information for decision makers about status and trends about pallid sturgeon, serve as a validation of predictions from the Collaborative Population Model, and enhance understanding of linkages between actions and population response.

As noted in Table 43, fish passage improvements at Intake are linked to other management actions in the Upper Missouri River since pallid sturgeon use habitats in both rivers (e.g., spawning cue flow releases from Fort Peck, drawdown of Lake Sakakawea, drift distance and mortality of free embryos and exogenously feeding larvae). The effectiveness of linked hypotheses / actions would be explored through the Level 1 and Level 2 actions summarized in Table 43 and Appendix C. There are also expected to be linkages to the forthcoming Range-Wide Stocking and Augmentation Plan which may have an effect on the genetic diversity, carrying capacity, and survival of hatchery releases in the Yellowstone and Upper Missouri Rivers.

4.2.6 Details on Level 2 and Level 3 Actions for Lower Missouri River

Figure 52 (in section 4.1) presented a decision tree for possible actions to ensure survival and recovery of pallid sturgeon in the Lower Missouri River. A more detailed decision tree for the Lower Missouri is found in Appendix F. The following potential Level 2 and Level 3 actions emerge from these decision trees: population augmentation, creation of interception and rearing complexes (IRCs), construction of spawning habitat projects, and manipulation of spawning cue pulses and/or temperatures. The remainder of section 4.2.6 discusses each of these actions (with the exception of manipulation of

temperatures, which is not yet a candidate Level 3 action, and is discussed for Levels 1 and 2 in Section 4.2.4 and Appendix C).

4.2.6.1 Stocking and Population Augmentation

Future actions around stocking and population augmentation in the Lower Missouri River will be guided by the Pallid Sturgeon Range-wide Stocking and Augmentation Plan, currently under development for release in 2018 by the US Fish and Wildlife Service. This Plan will document the purpose, goals, targets, rationale and effectiveness monitoring for all activities related to pallid sturgeon stocking and augmentation. The stocking and augmentation plan is part of a canon of documents that comprise the USFWS Pallid Sturgeon Conservation Propagation and Stocking Program. Program documents also include monitoring protocols, genetics management plans, hatchery propagation protocols, and handling protocols, which may also influence MRRP-related propagation and augmentation actions. See Section 4.2.5.1 for preliminary considerations around stocking and population augmentation actions from the perspective of this AM Plan.

4.2.6.2 Interception and Rearing Complexes (IRCs)

4.2.6.2.1 Action Description

USACE will build Interception and rearing complexes (IRCs) to promote the interception of free-drifting embryos and age-0 larvae. Interception and Rearing Complexes (IRCs) are defined as habitat where interception occurs within the geographic proximity of food producing and foraging habitats to benefit age-0 pallid sturgeon. The physical components of these habitat types are defined as follows: (1) food-producing habitat occurs where velocity is less than 0.08 m/s, (2) foraging habitat are areas with 0.5 – 0.7 m/s velocity and 1-3 m depth, and (3) interception habitat is qualitatively described as zones of the river where hydraulic conditions allow free embryos to exit the channel thalweg (Figure 57). IRC restoration habitat construction will occur at the bend level.

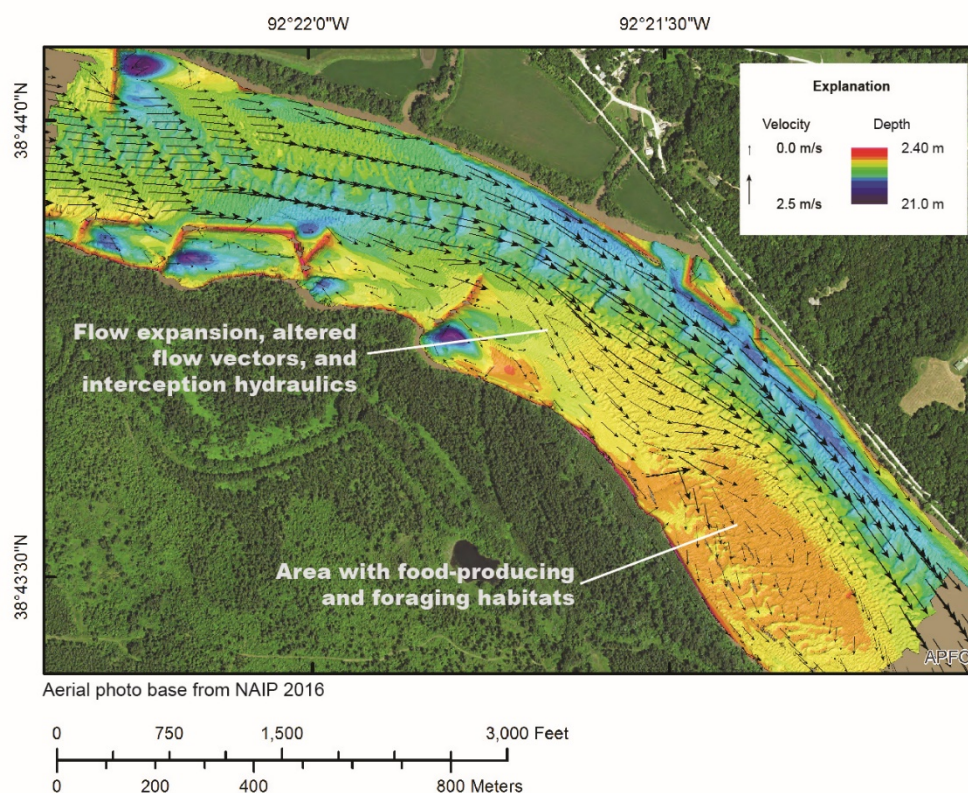


Figure 57. Concept of an interception-rearing complex near river mile 162. Flow expansion and interception are shown by modeled current velocity and direction (arrows) angled away from the channel and towards the right descending bank. Background multibeam bathymetric data from USGS, July 24, 2011, 216,000 cfs. Modeled velocities are from Jacobson, Lindner, and Bitner (2015).

4.2.6.2.2 Objectives and Expected Benefits

The primary objective of IRC restoration habitat construction is to maximize interception and biological performance, rather than to maximize the amount of suitable habitat, as discussed in section 3.3.2.2.1 of the AM report for 2017 (MRRP Science and Adaptive Management Technical Team 2018). A secondary objective of IRC construction is to increase the percentage of acre-days of foraging and food-producing habitat within the IRC habitat. Ultimately, the expected benefit of IRC construction is to improve survival of age-0 pallid sturgeon to age-1, leading to a higher probability of recovery in the Lower Missouri River.

4.2.6.2.3 Hypotheses

Management hypotheses were developed based on the hypotheses from the EA and the AM Plan. Hypotheses 17 to 19 of the EA are relevant to this monitoring plan (Jacobson et al. 2016c).

- H17. Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density abundance (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.
- H18. Re-engineering of channel morphology will increase channel complexity and minimize bioenergetic requirements for resting and foraging of exogenously feeding larvae and juveniles.
- H19. Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.

This plan describes how to monitor the effects of IRC restoration sites on recruitment of age-0 pallid sturgeon. The monitoring plan addresses two focal questions, and supporting testable hypotheses:

Q1: Within river bends that include IRC sites, do catches (CPUE) of age-0 sturgeon increase relative to control sites and pre-construction conditions?

To address focal question 1, this study will test the following hypothesis for the biological response of sturgeon to IRC restoration sites measured by catch per unit effort (CPUE) of age-0 sturgeon:

H_{A,1}: Catches of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.

Tests of secondary hypotheses will provide some secondary measures of the outcomes of IRC habitat construction.

H_{A,2}: The stomach content of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.

H_{A,3}: The percent lipid of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.

H_{A,4}: The length distribution of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.

Q2: Do the hydrodynamics of river bends that include IRC sites increase (a) the proportion of free embryos that exit the channel thalweg after IRC construction, (b) the area of foraging habitat, and (c) the area of food-producing habitat, relative to pre-construction conditions?

To address focal question 2, physical response monitoring will characterize the hydrodynamics of interception habitat at treatment and control bends.

H_{A,5}: The hydrodynamics of the river bends that include IRC sites increase the percent change in interception relative to control sites after IRC construction.

IRC restoration habitat construction will also change the percentage of acre-days of foraging and food-producing habitat. In some IRC habitat designs, increases are expected. The following secondary hypotheses are subordinate to the primary hypothesis test of changes in interception rates (i.e., H_{0,5} and H_{A,5}) –

H_{A,6}: The hydrodynamics of the river bends that include IRC sites provide an increase in the percentage of acre-days of foraging habitat, defined as areas with 0.5 – 0.7 m/s velocity and 1-3 m depth, relative to control sites after IRC construction.

H_{A,7}: The hydrodynamics of the river bends that include IRC sites provide an increase in the percentage of acre-days of food-producing habitat, defined as areas where velocity is less than 0.08 m/s, relative to control sites after IRC construction.

Finally, the biological and physical data will contribute to support the development of resource selection models, but this will not be the only source of this information used to develop these models. This can be expressed as a hypothesis:

H_{A,8}: There is a relationship between age-0 CPUE (and other biological metrics) and physical habitat measures of interception rate, the area of food producing habitat, and the area of foraging habitat.

4.2.6.2.4 *Metrics*

The biological response to IRC construction is measured primarily by catch per unit effort (CPUE) of age-0 *Scaphirhynchus sp.* sturgeon (i.e., both pallid and shovelnose sturgeon). Using CPUE as the primary biological response variable combines the interception and retention components of age-0 sturgeon biology within a site. Secondary metrics to measure the biological response include stomach content, lipid/protein content, and length-at-date of captured pallid sturgeon. The 2018 Biological Opinion (USFWS 2018, page 31) notes that “there should be careful consideration when using the shovelnose sturgeon as a surrogate for the pallid sturgeon in scientific studies of natural history and physiology”.

The physical response to IRC construction is measured primarily by the percent interception of age-0 sturgeon. Secondary measures of physical response to IRC construction are the number of acre-days of foraging habitat and food-producing habitat. Appendix E1 provides more detail around the metrics and design of monitoring activities.

4.2.6.2.5 *Monitoring Design*

For the biological response, a hierarchical staircase study design will be used to implement and monitor the response of age-0 sturgeon catch to IRC habitat restoration activities. A staircase design is a series of staggered before-after-control-impact (BACI) designs (Walters et al. 1988), and therefore requires control and treatment bends for the duration of the study. Each IRC and control site should be sampled annually and at least one year prior to initiation of construction. The decision to use this design was based on both logistical constraints, and statistical considerations. Logistical constraints included the speed at which IRC habitat restoration sites could be constructed. It was estimated that up to two sites could be constructed per year. Statistical considerations consisted of power analyses conducted on several candidate configurations to determine a sampling design that would have the most power to detect a significant difference when such a difference exists.

The sampling design will involve the construction of 12 IRC treatment and 12 control sites implemented over 7 years (i.e., baseline monitoring for the first IRC-control site pair, followed by six years of building and monitoring 2 IRC-control site pairs per year; Table 49). This sampling led to approximately 80% power to detect an 80% increase in CPUE within approximately 7 years, at an $\alpha=0.05$ and $\beta=0.2$ at the river bend scale based on estimates of variance. An 80% increase in CPUE was selected as the effect size because, based on the power analyses, it was a detectable effect within the first half of the 15-year time frame of the MRRP (Figure 58).

Table 49. Biological data collections at IRC and control bends. 'X' represents site-years where monitoring occurs. Shaded boxes indicate the year in which construction will be initiated; CT refers to the control site.

Site/Year	1	2	3	4	5	6	7	8
01	X	X	X	X	X	X	X	X
01 CT	X	X	X	X	X	X	X	X
02	X	X	X	X	X	X	X	X
02 CT	X	X	X	X	X	X	X	X
03		X	X	X	X	X	X	X
03 CT		X	X	X	X	X	X	X
04		X	X	X	X	X	X	X
04 CT		X	X	X	X	X	X	X
05			X	X	X	X	X	X
05 CT			X	X	X	X	X	X
06			X	X	X	X	X	X
06 CT			X	X	X	X	X	X
07				X	X	X	X	X
07 CT				X	X	X	X	X
08				X	X	X	X	X
08 CT				X	X	X	X	X
09					X	X	X	X
09 CT					X	X	X	X
10					X	X	X	X
10 CT					X	X	X	X
11						X	X	X
11 CT						X	X	X
12						X	X	X
12 CT						X	X	X

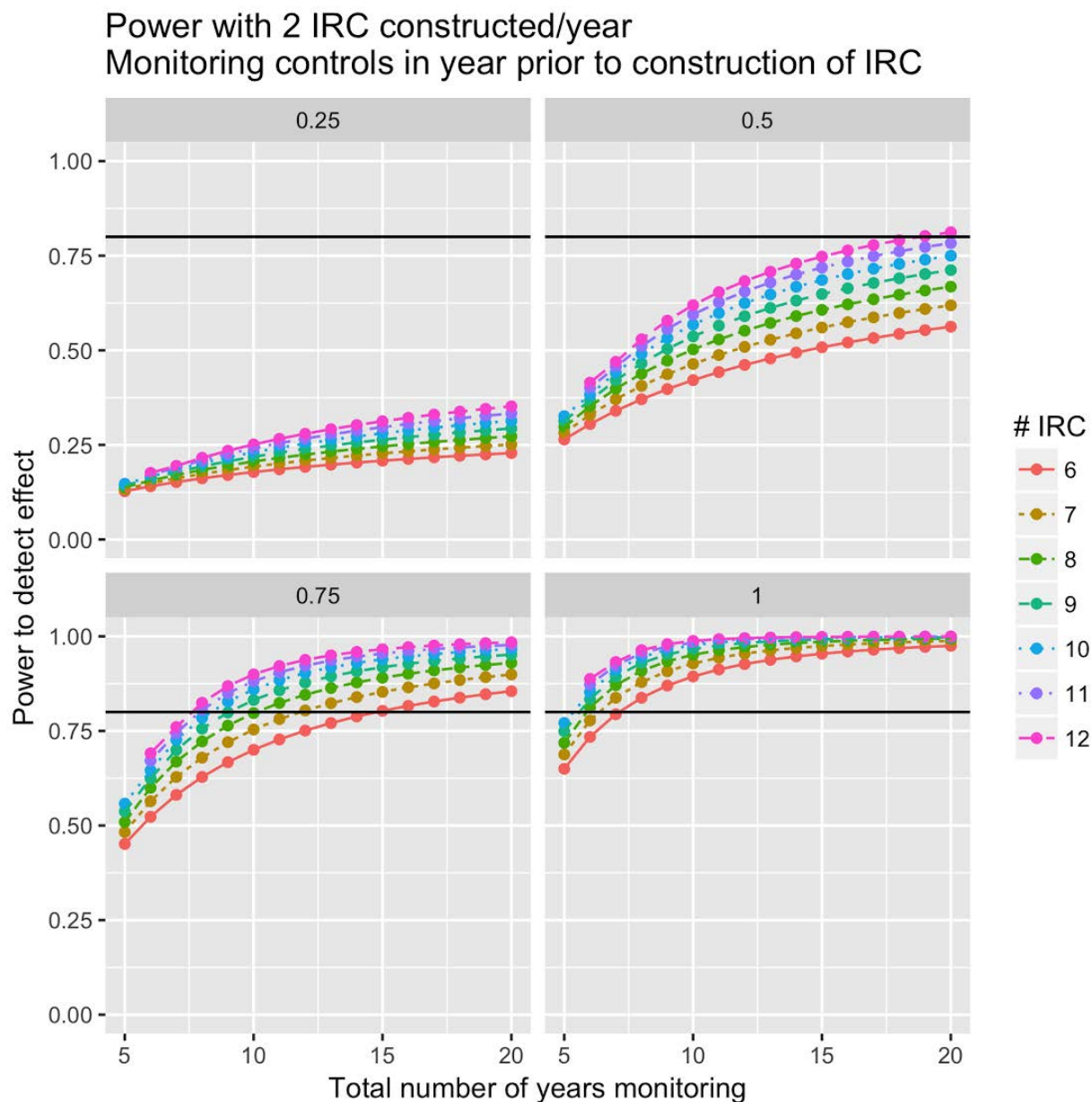


Figure 58. Comparisons of power for different sampling designs. The four graphs show statistical power when the number of IRC sites is varied from 6 to 12 with 5 to 20 years of monitoring and two IRCs added per year. The panels correspond to a 25%, 50%, 75%, or 100% increase in mean CPUE in the IRC sites.

For the physical response, physical monitoring and physical modeling will be used to assess the effects of IRC construction on interception, and the acre-days of food-producing and foraging habitat. The proposed physical monitoring and modeling activities, and their timing, is shown in Table 50.

Table 50. Types of surveys and analyses proposed for physical habitat in Interception-Rearing Complexes.

Type of survey	Frequency	Spatial Resolution	Timing	Analysis	Notes
Full modeling	Pre-construction, year after construction, and 2-4 year intervals after, depending on documented geomorphic change	125' spacing (based on subdivisions of standard 250' transects) with 62.5' spacing as needed in areas of high variability; supplement with Lidar and/or ground surveys of banks and structures. To cover full IRC bend and sufficient up- and downstream distance for model stability.	High flows, sufficient to survey bank to bank	Habitat availability and habitat assessment through 2D hydrodynamics models, particle tracking, spatial analysis.	For both geomorphic change assessment and modeling of interception and habitat availability. May be complemented with breaklines on banks and structures, longitudinal surveys along banks, as needed for computational mesh. Transect density will be optimized based on model analysis needs (USACE, 2013; Legleiter et al., 2011; Glenn et al., 2016; Jacobson et al., 2009; Erwin et al., 2017).
Full geomorphic	Annual post construction	Standard 250' transects, supplemented as needed to optimize change detection. To cover full IRC bend and sufficient upstream and downstream distance to evaluate associated geomorphic changes.	High flows, sufficient to survey bank to bank	Geomorphic change analysis through change detection on continuous-surface elevation models, transect by transect change, relative to detectability limits.	For geomorphic change assessment not needed in full modeling years. Detectability limits will be evaluated according to repeatability of surveys and analysis of gridding methods (USACE, 2013; Wheaton et al., 2010; Elliott et al., 2009).
Velocity	Annual pre- and post-construction	Selected transects within IRC bend to evaluate velocity fields and habitat availability	Target median May-July discharge (interception season).	Mapped mean velocity vectors in vicinity of altered structures, interception zone.	Collection and analysis methods are provided by Mueller et al. (2013), Parsons et al. (2013).
Calibration	Three-four times per year as needed to maintain calibration and validation.	Selected transects within IRC bend for velocity and longitudinal surveys for water-surface elevations.	As needed over range of flows, 75-25% exceedance (May – October, rearing season).	Calibration of hydrodynamic models by optimization of roughness values to match to water-surface elevations. Validation of modeled velocities relative to measured.	Includes longitudinal water-surface profiles for model calibration and velocity transects for model validation. May include data collected for velocity surveys.

Currently proposed locations of IRCs (and control sites) are shown on the map in Figure 59. These locations are tentative and subject to change through on-going study. The site selection strategy is discussed in greater detail in Appendix E1. Projects with potential to quickly reduce uncertainties will be emphasized to the extent practicable. New IRC habitat resulting from both Level 2 and Level 3 actions that meets the IRC criteria will be counted as contributing to the targets for Level 3, as described in section 4.2.6.2.2 Metrics and section 4.2.6.2.6 Decision Criteria . Level 3 actions and outcomes are focused on helping to understand and describe future Level 4 actions and targets.

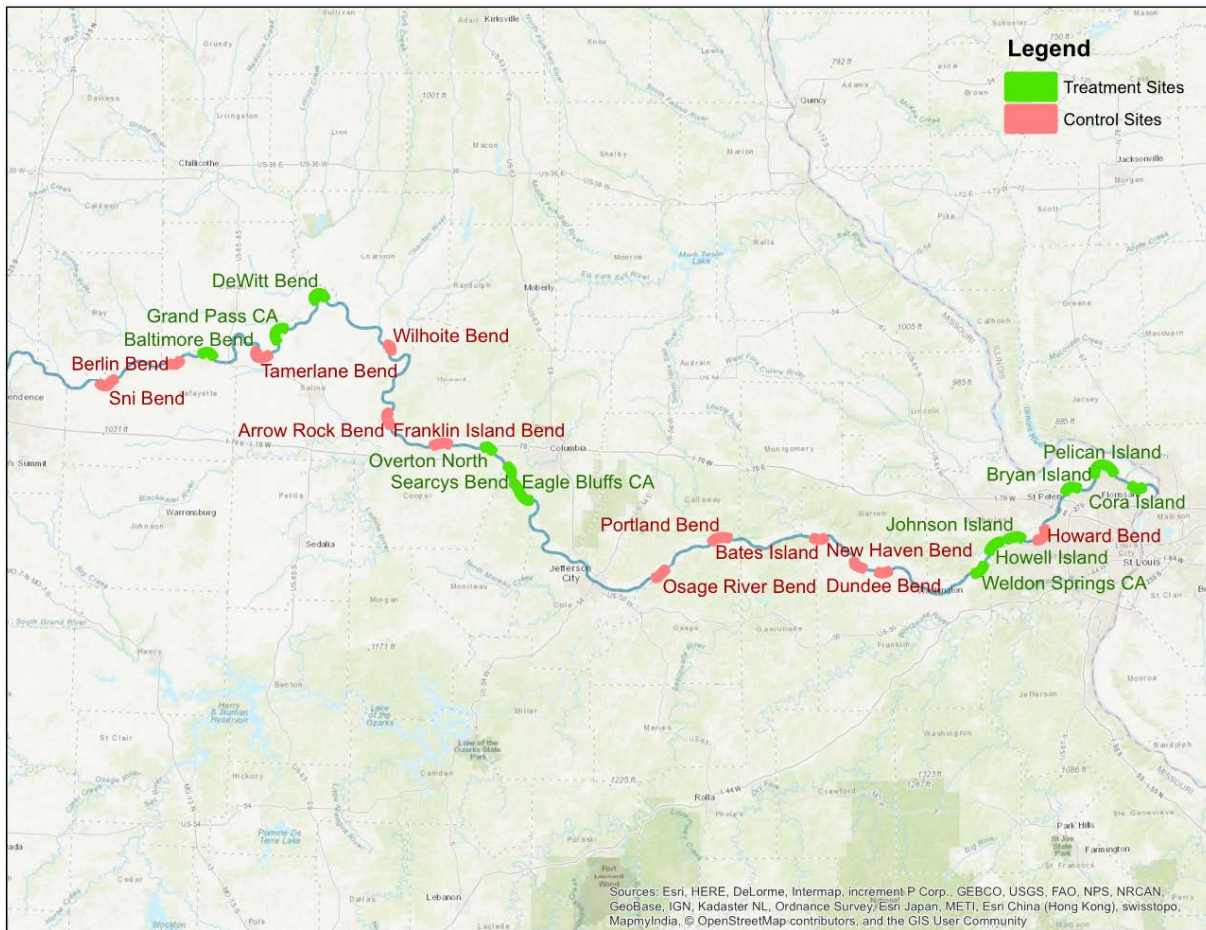


Figure 59. Proposed locations of Interception and Rearing Complexes (IRCs; green symbols and text), and control bends (red symbols and text), as of February 2018. Source: Dane Morris, USACE

4.2.6.2.6 Decision Criteria

Evaluations of action effectiveness will be dictated by biological and physical metrics specific to IRC construction. Effective implementation of IRCs would result in a mean increase in CPUE of age-0 sturgeon of 80% or more, as determined through analysis of data from the 12 treatment-control pairs over a 7-year period. Further, the USFWS and USACE (2015) defined time limits for implementation of Level 3 actions and their scope, expressed as targets (Table 42). Decision criteria guide the Technical and Implementation Teams when evaluating monitoring and other information and in developing recommendations for consideration by the agencies. The targets for implementation (Table 42) afford a straight-forward measure of compliance with the means objectives for IRCs at Level 3. Net increases in habitat will be computed on an annual basis. The intention is to permit flexibility to address needs while promoting learning through Level 2 actions and to address programmatic requirements related to

pallid sturgeon. Performance relative to targets will be assessed using a running average of annual lift in effective acre-days of IRC habitat (described above in section 4.2.6.2.2). Acceptable performance is meeting or exceeding the targets in Table 42 based on a three-year running average for at least 4 of every 5 years (80% success rate). Level 3 / Stage 3 targets could be revised based on the outcome of actions at Level 2 / Stage 2. Of note is how IRC designs have primarily focused on the percent change in estimated interception with secondary consideration given to the acre-days of food-producing and foraging habitat created.

Additional decision criteria for prioritized Level 1 and Level 2 studies are listed above in Table 44 (with all L1 and L2 studies listed in Appendix C), and below in Table 68 for Level 2/3 studies. If experimental results in Level 2 studies fail to demonstrate an increase in key metrics relative to control areas and pre-treatment conditions, there are several potential responses depending on syntheses of all lines of evidence: IRC designs may need to be adjusted to be more effective; the hypothesis may need to be refined; the hypothesis should be moved into set of the reserve hypotheses; or the hypothesis should be abandoned. If the experimental results support the hypothesis that channel reconfigurations can provide increased food-producing and foraging functional habitats, and increase pallid sturgeon condition, then the decision would be to move toward Level 3 implementation. The four stages of development of IRCs proposed by the USFWS are described in USFWS (2016) and summarized in Table 42.

Triggers for Moving to Higher Implementation Level: The decision to move from Level 3 to full implementation at Level 4 will be based on a systematic relationship between IRCs and increases in growth and survival of age-0 sturgeon that permits modeling of the needed scope of IRC implementation to meet the fundamental objectives. This judgment should be based on the strength and replicability of functional relationships between abiotic habitat variables describing food and forage habitats, and growth and survival of age-0 sturgeon. In addition, the need for supplemental flow management at Level 3 or 4 would be based on the availability of sound functional relationships between flow conditions, IRC habitat, and growth and survival of age-0 sturgeon.

Timeframes: The timeframes for implementation of IRC habitat work are described in USFWS (2016) and summarized in Table 42.

4.2.6.2.7 *Contingent Actions and Supporting Studies*

The primary focus of IRC construction is on interception, with secondary analyses for other biological measures. The primary biological response used in this study is age-0 CPUE of sturgeon, which is considered a process-level response.

The physical responses for IRC construction (i.e., the acre-days of food-producing and foraging habitat that are produced) are contingent on the hypothesized velocity and depth criteria as outlined in the Effects Analysis (Jacobson et al. 2016c). Food-producing habitat definition is based on habitat conditions (fine sediments in low velocity) favorable for the 6 chronomid taxa that make up 74% of age-0 sturgeon diets (estimated at 0.08 m/s). Foraging habitat is defined by hydraulic conditions conducive to foraging for food items, which has been linked to a velocity range of 0.5 – 0.7 m/s and a depth range of 1 – 3 m where age-0 sturgeon are found (Ridenour et al. 2010). A Level 1 study could be considered to further evaluate the definitions for food-producing and foraging habitats that might include the quantification of benthic invertebrate biomass within the depth and velocity criteria and the velocities and depths where age-0 sturgeon are captured. In developing a Level 1 study to address these uncertainties, water quality could also be measured. However, this Level 1 study should be considered separately from the effectiveness monitoring proposed in Appendix E.1 because the uncertainties are not limited to IRC restoration habitats.

The population-level implications of changes in age-0 CPUE of sturgeon and the other secondary biological responses are supported by several population-level monitoring and modeling efforts, which are described in Appendix D. The studies outlined in Appendix D adopt an integrative approach to exploring the implications of how IRC restoration habitat construction might lead to a population-level response. There are several other past, on-going, or planned studies that support the monitoring efforts of Appendix E.1, many of which are outlined in the Appendix D. The relevance of these past, on-going, and planned studies to the current monitoring program is outlined below:

- **Habitat Assessment and Monitoring (HAMP) Project (2004-2009, 2014-2015)**: This project developed the basis for the monitoring protocol used in Appendix E.1. Furthermore, the power analyses in Appendix E.1 were based on data collected from this study.
- **Pallid Sturgeon Population Assessment Program (PSPAP)**: This program monitors population status of sturgeon throughout the Missouri River system. Furthermore, information is collected on survival, growth, and habitat use of wild and stocked pallid sturgeon. This program will inform the secondary hypotheses $H_{A,2}$, $H_{A,3}$, and $H_{A,4}$. The process and outcomes of redesigning the PSPAP are described in Appendix D (to be revised).
- **HAMP diet and condition study (2014-2018)**: This study examines the % empty stomachs and condition of captured sturgeon. Importantly, the area where this study is conducted overlaps but is not limited to the planned IRC restoration habitats, as limitations in food-producing and foraging habitat may not be

limited to only IRC sites. This program will inform the secondary hypotheses $H_{A,2}$, $H_{A,3}$, and $H_{A,4}$.

- **Flume Studies (planned)**: These studies will help differentiate differences in drifting behavior between pallid and shovelnose sturgeons and better understand the mechanisms that promote transfer of drifting free embryos to channel margin habitats. These studies are expected to help us understand both the biological and physical responses to the construction of IRC restoration habitat (i.e., $H_{A,1}$ to $H_{A,7}$ will be supported). Further details are provided in Appendix C of the draft SAMP.
- **Genetic studies (on-going)**: This information is collected as part of other, on-going monitoring and research efforts. These studies help differentiate between pallid and shovelnose sturgeons but may also provide insight into the origin of some pallid sturgeon progeny. These studies may also provide critical information regarding the use of shovelnose sturgeon as surrogates for specific life history traits of pallid sturgeon. Genetic identification will be a critical aspect of any future larval stocking studies to aid in identification of stocked pallid sturgeon. This information will inform hypothesis $H_{A,1}$.
- **Microchemistry studies (on-going)**: These studies help determine the environmental life history of pallid sturgeon including the use of the Mississippi River and other tributaries. Additional information regarding the river of origin for naturally reproduced pallid sturgeon may also be learned.
- **Dye and days-post-hatch larvae releases and hydraulic studies (planned)**: These planned studies will test the ability of constructed IRC restoration habitat to intercept free-drifting larvae in the field. Releases of 10-14 days post-hatch larvae are still being considered but are dependent on the availability of larvae from hatcheries. These studies will provide direct tests of achieved interception rates following the construction of IRC habitats. This would help understand the *retention* component to the biological response measured by CPUE (hypothesis $H_{A,1}$). Dye releases would help understand interception, thereby informing hypothesis $H_{A,5}$, and will provide a means of testing the predictions of Particle Tracking Models.

4.2.6.3 Interception and Rearing Complexes (SWH-IRCs) via Modification of Existing Shallow Water Habitat (SWH) Projects

4.2.6.3.1 Action Description

USACE will modify existing chute-based shallow water habitat (SWH) to become Interception and rearing complexes (IRCs) to promote the interception of free-drifting embryos and age-0 larvae. Shallow Water Habitat (SWH) is defined as water in with a depth <1.5 m and velocity <0.61 m/s, and includes side channels, backwaters,

depositional sandbars detached from the bank, and low-lying depositional areas adjacent to shorelines. SWH restoration projects were focused on the creation of chutes, notches, chevrons, backwaters, and top width river widening. These projects were a part of the Corps efforts to support recovery but have not achieved the desired outcome of increased age-0 sturgeon. Recently the scientific understanding of age-0 pallid sturgeon habitat has changed to include interception as a key component of habitat design. This development has led to the development of Interception and Rearing Complexes (IRCs) (Section 4.2.6.2) and the associated monitoring plan (provided in Appendix E.1).

This section describes how to monitor the effects of modifications to SWH on the recruitment of age-0 pallid sturgeon. Among the different microhabitats that the SWH projects focused on, chutes are thought to be the best suited for modifications to become IRC habitats. It is therefore expected that most (but not all) of the SWH modification projects will be chute-based. This plan will focus only on the chute-based SWH modifications.

IRC habitat created from modifying SWH will be referred to as SWH-IRCs. It is important to distinguish SWH-IRC from IRC habitat discussed in 4.2.6.2 because they are different in several ways. SWH-IRCs are at the chute-level (off-channel) while IRCs are at the bend-level (main channel), and the management actions or treatments for SWH-IRCs and main-channel IRCs are different. Therefore, data from SWH-IRCs and main channel IRCs can only be combined to evaluate the response of the fish community to changes in the depth and velocity criteria; they cannot be combined to evaluate the effectiveness of IRCs on biological and physical responses.

The 2003 BiOp presents a reasonable and prudent alternative (RPA) that contains requirements for the restoration of SWH in the channelized portion of the Missouri River. According to the 2003 BiOp, SWH may be restored through flow management, increasing the top width of the channel (top-width widening), restoring chutes and side channels, manipulation of summer flows, or combinations thereof (USFWS 2000; 2003). Modification of in-channel structures, top-width widening, and creation of chutes and backwaters are SWH restoration measures that have been implemented (USACE 2014).

4.2.6.3.2 *Objectives and Expected Benefits*

The primary objective of this action is to create well-functioning SWH-IRC habitats by modifying existing chute-based SWH. Secondary objectives are to contribute to the IRC targets and to ensure that impacts to HCs are minimized.

The proposed benefit of this plan is the same as that described for IRC restoration habitat (see Section 4.2.6.2) – to enhance interception of age-0 sturgeon as they transition from the drift stage to benthic feeding and provide increased amounts of foraging and food producing habitats. An additional potential benefit is that modification of existing SWH projects may be more cost-effective and rapid than building new IRCs, thereby permitting earlier assessments of the project performance and corresponding biological and physical responses.

4.2.6.3.3 *Hypotheses*

Management hypotheses were developed based on the hypotheses from the EA and the AM Plan. Hypotheses 17 to 19 of the EA are relevant to this monitoring plan (Jacobson et al. 2016c).

- H17. Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density abundance (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.
- H18. Re-engineering of channel morphology will increase channel complexity and minimize bioenergetic requirements for resting and foraging of exogenously feeding larvae and juveniles.
- H19. Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.

The following hypothesis captures the intent of this proposed action:

- $H_{SWH \rightarrow IRC}$: A subset of Shallow Water Habitat projects can be successfully converted into effective IRC habitats, providing suitable interception, food production and foraging habitats for exogenously feeding larvae and juveniles, which result in higher abundances, stronger growth and better survival of age-0 pallid sturgeon and shovelnose sturgeon.

This plan describes how to monitor the effects of the modifications of SWH into SWH-IRC sites on increasing the recruitment of age-0 pallid sturgeon. The monitoring plan addresses two focal questions, and supporting testable hypotheses:

Q1: Within SWH-IRC, do catches (CPUE) of age-0 sturgeon increase relative to pre- modification conditions?

To address this focal question, this study will test the following hypothesis for the biological response of sturgeon to SWH-IRC restoration sites measured by catch per unit effort (CPUE) of age-0 sturgeon:

H_{A,1}: Catches of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.

Tests of secondary hypotheses will provide some secondary measures of the outcomes of SWH-IRC habitat construction.

H_{A,2}: The stomach contents of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.

H_{A,3}: The percent lipid of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.

H_{A,4}: The length distribution of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.

Q2: Do the hydrodynamics of SWH-IRC sites increase (a) the proportion of free embryos that exit the channel thalweg, (b) the area of foraging habitat, and (c) the area of food-producing habitat, relative to pre-modification conditions?

To measure the effect of SWH-IRC restoration activities, physical characteristics will be integrated into physical models to estimate the percent change in interception, and the amount of food-producing and foraging habitat. Specifically, this study will test the following hypothesis on the physical response to the SWH-IRC sites:

H_{A,5}: The hydrodynamics within SWH-IRC sites increase the proportion of free embryos that exit the channel thalweg relative to pre-modification conditions.

SWH-IRC restoration habitat construction will also change the percentage of acre-days of foraging and food-producing habitat. In some SWH-IRC habitat designs, increases are expected. The following secondary hypotheses are subordinate to the primary hypothesis test of changes in interception rates (i.e., H_{A,5}):

H_{A,6}: The hydrodynamics within SWH-IRC sites provide an increase in the percentage of acre-days of foraging habitat, defined as areas with 0.5 – 0.7 m/s velocity and 1-3 m depth, relative to pre-modification conditions.

H_{A,7}: The hydrodynamics within SWH-IRC sites provide an increase in the percentage of acre-days of food-producing habitat, defined as areas where velocity is less than 0.08 m/s, relative to pre-modification conditions.

Finally, the biological and physical data will contribute to support the development of resource selection models, but this will not be the only source of this information used to develop these models. This can be expressed as a hypothesis:

H_{A,8}: There is a relationship between age-0 CPUE (and other biological metrics) and physical habitat measures of interception rate, the area of food producing habitat, and the area of foraging habitat.

4.2.6.3.4 *Metrics*

The biological response to SWH-IRC restoration is measured primarily by catch per unit effort (CPUE) of age-0 *Scaphirhynchus* sp. sturgeon (i.e., both pallid and shovelnose sturgeon). Using CPUE as the primary biological response variable combines the interception and retention components of age-0 sturgeon biology within a site. Secondary metrics to measure the biological response include stomach content, lipid/protein content, and length-at-date of captured pallid sturgeon.

The physical response to SWH-IRC construction is measured primarily by the percent interception of age-0 sturgeon. Secondary measures of the physical response are the number of acre-days of foraging habitat and food-producing habitat. Appendix E.2 provides more detail around the metrics and design of monitoring activities.

4.2.6.3.5 *Monitoring Design*

For the biological response, the effect of modifications of SWH-IRC on age-0 CPUE will be compared using a staircase Before-After (BA) comparison, analyzed using a paired t-test. As for the IRC construction discussed in section 4.2.6.2, the decision to use a staircase design for SWH-IRC restoration was based on both logistical constraints, and statistical considerations. Logistical constraints included the speed at which SWH could be modified – it was estimated that two to three sites could be modified per year. The rationale for using a Before-After comparison instead of a BACI (Before-After-Control-Impact) design is that: (1) it is difficult to designate Treatment and Control groups for SWH-IRC because each SWH and its modification will be unique; and (2) some chutes

will not be available for a variety of reasons, reducing the number of samples to fewer than 29. For example, some recently worked chutes are still being evaluated, some sites have silted in and are not good candidates, and within the candidate sites, there are at least three categories of chutes, each differing in the expected treatments: (a) increase interception, (b) improve depth and velocity, or (c) both.

A power analysis will be used to determine whether a Before-After design is better than a BACI design. In other words, is there more power to detect an increase in CPUE of 80% with a B-A design compared to a BACI design, given the limited sample size? For example, a B-A design with $n=6$ for each treatment type compared to a BACI design with 3 controls and 3 treatments?

For the physical response, physical monitoring and physical modeling will be used to assess the effects of SWH-IRC construction on interception, and the acre-days of food-producing and foraging habitat. The physical monitoring and modeling, along with the schedule will be similar to Table 50, but with methods adapted to survey chute-based habitat.

The selection of chute-based SWH to modify to SWH-IRCs will be based on a site selection process discussed in Appendix E.2. The chutes that are being considered are shown in Figure 60.



Figure 60. Map of the 29 chute-based Shallow Water Habitats (SWHs) on the lower Missouri River.

4.2.6.3.6 *Decision Criteria*

As for the IRC decision criteria discussed in section 4.2.6.2.6, the evaluations of effectiveness for SWH-IRC actions will be dictated by specific biological and physical metrics. The targets for implementation (Table 42) afford a straight-forward measure of compliance with the means objectives for IRCs at Level 3, computed on an annual basis using 2D hydrodynamic models. Net increases in habitat will be computed on an annual basis. The intention is to permit flexibility to address needs while promoting learning through Level 2 actions and to address programmatic requirements related to pallid sturgeon. Performance relative to targets will be assessed using a running average of annual lift in effective acreage of IRC habitat (described above in section 4.2.6.2.2). Acceptable performance is meeting or exceeding the targets in Table 42 based on a three-year running average for at least 4 of every 5 years (80% success rate). SWH-IRC designs will primarily focused on the percent change in estimated interception with secondary consideration given to the acre-days of food-producing and foraging habitat created.

Additional decision criteria for Level 1 and Level 2 studies are listed above in Table 44, and below in Table 68 for Level 2/3 studies. If experimental results in Level 2 studies fail to demonstrate an increase in key metrics relative to control areas and pre-treatment conditions, there are several potential responses depending on syntheses of all lines of evidence: IRC designs and locations may need to be adjusted to be more effective; the hypothesis may need to be refined; the hypothesis should be moved into set of the reserve hypotheses; or the hypothesis should be abandoned. If the experimental results support the hypothesis that channel reconfigurations can provide increased food-producing and foraging functional habitats, and increase pallid sturgeon condition, then the decision would be to move toward Level 3 implementation.

Triggers for Moving to Higher Implementation Level: The decision to move from Level 3 to full implementation at Level 4 will be based on a validation of a systematic relation between SWH-IRCs and increases in growth and survival of age-0 sturgeon that permits modeling of the needed scope and distribution of SWH-IRC implementation to meet the fundamental objectives. This judgment should be based on the strength and replicability of relations between abiotic habitat variables describing food and forage habitats, and growth and survival of age-0 sturgeon. In addition, the need for supplemental flow management at Level 3 or 4 would be based on the availability of sound relationships between flow conditions, SWH-IRC habitat, and growth and survival of age-0 sturgeon.

Timeframes: The design of SWH-IRC habitat at Level 3 will begin in FY21, and construction will follow in FY22. The specific implementation of SWH-IRC construction

(i.e., how many SWH-IRC constructed per year) will be contingent on the outcome of the Site Selection process, power analysis, and an evaluation of logistical constraints.

4.2.6.3.7 Contingent Actions and Supporting Studies

Contingency plans for modifying existing SWH projects into IRCs are mainly associated with the secondary objectives (e.g., structure manipulations will not adversely affect navigation); however, adjustments to the targets, habitat criteria, methods, etc. might be required if performance fails to meet expectations. Analyses of performance across multiple water years may reveal flow management strategies that enhance the performance of modified SWH projects.

The primary focus of the monitoring plan outlined in Appendix E.2 is on interception, with secondary analyses for other biological measures. The primary biological response used in this study is age-0 CPUE of sturgeon, which is considered a process-level response. The population-level implications of changes in age-0 CPUE of sturgeon and the other secondary biological responses are supported by several population-level monitoring and modeling efforts, which are described in Appendix D. The studies outlined in Appendix D adopt an integrative approach to exploring the cumulative effects of multiple actions on population-level responses. There are several other past, on-going, or planned studies that support the monitoring efforts of Appendix E.2, some of which are outlined in the Appendix D.

As previously discussed in section 4.2.6.2.7, the physical responses for IRC construction (i.e., the acre-days of food-producing and foraging habitat that are produced) are contingent on the hypothesized velocity and depth criteria as outlined in the Effects Analysis (Jacobson et al. 2016c). These criteria may be re-evaluated with further Level 1 studies. The relevance of past, on-going, and planned studies to the current monitoring plan is outlined in Appendix E.1, Section E.1.2.

4.2.6.4 Spawning Habitat Projects

4.2.6.4.1 Action Description

The Effects Analysis (EA) found that there was theoretical support for improving spawning habitat, based on evidence from other sturgeon species and hydrodynamic models, but that data were equivocal as to whether spawning habitat was a limiting factor. There are two competing theories regarding spawning habitat: first is that additional high-quality spawning habitat is needed, while the other is that too much poor-quality (i.e. “confusion”) spawning habitat exists on the river, dispersing pallid sturgeon among multiple spawning sites. Actions could include construction or

enhancement of spawning habitat or the potentially costly removal of low-quality habitat. The proposed approach is to start by building and evaluating a single high-quality spawning habitat. An ideal outcome would be that the development of high-quality spawning habitat will attract fish away from low-quality confusion habitat, and that gradual degradation of confusion habitat will increase the relative attractiveness of high-quality spawning habitat. If fish are not attracted to the created spawning habitat, this could mean that either spawning habitat is not limiting, or that the design needs to be adjusted.

The action of creating spawning habitat relates to Big Question 5: *Can channel reconfiguration and spawning substrate construction increase the probability of survival through fertilization, incubation, and hatch?*

There is insufficient understanding to characterize the necessary actions at Level 3 or determine quantifiable targets for spawning habitat at this time. Hence, the focus of the Level 1 and Level 2 studies (Figure 61) will be to reduce the uncertainty regarding spawning habitat characteristics and needs for successful recruitment.

Level 1:

There are three Level 1 spawning habitat studies identified for the Lower Missouri River. These studies use a combination of historical and current data from the Lower Missouri and the Yellowstone River as well as controlled mesocosm studies to improve the understanding of spawning habitat needs. Specifically, the studies propose to:

- Determine the characteristics of ideal spawning habitat for pallid sturgeon, based on observations of successful spawning sites on the Yellowstone River (BQ5/L1/C1 in Table 44);
- Assess the habitat characteristics of historical spawning sites on the Lower Missouri River (BQ5/L1/C2 in Table 44); and
- Use mesocosms to experimentally determine how spawning varies with depth, velocity, substrate, hydraulic variables and water quality (BQ5/L1/C3 in Table 44).

Level 2:

There are two Level 2 spawning habitat studies identified for the Lower Missouri River. Both studies involve field testing of spawning habitat construction, including:

- *An engineering feasibility study in the Middle Decatur Bend.* This Level 2 study was initiated in 2016 to evaluate the practical implementation and physical response of

several spawning patch construction alternatives. Preliminary results are discussed in Appendix E.3 (BQ5/L1/C4 in Table 44).

- *Creating a single high quality spawning habitat site.* This Level 2 action (specified in Table 42) will be monitored in terms of the *relative use* of this site compared to control areas, and the *relative spawning and reproductive success*, as determined by aggregations, spawning events, catch per unit effort of free embryos and other indicators (BQ5/L1/C5 in Table 44). This study is discussed in more detail in Appendix E.3.

Big Question 5: Spawning Habitat	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Level 1																	
C1 Study of functional spawning habitat, Yellowstone River																	
C2 Field gradient study, habitat conditions LMOR																	
C3 Mesocosm studies on spawn conditions, behaviors																	
Level 2																	
C4 Engineering studies for sustainable design																	
C5 Manipulative field experiment for spawning habitat																	
Level 3																	
If successful and appropriate, expand spawning habitat																	

Figure 61. Proposed sequencing of actions and studies for spawning habitat, revised from USFWS and USACOE (2015) to reflect current USFWS priorities and timelines.

4.2.6.4.2 Objectives and Expected Benefits

The primary objective of the Level 1 studies is to describe the characteristics of suitable spawning habitat for pallid sturgeon in the Lower Missouri River. This information is critical to guide the potentially expensive implementation of Level 2 and Level 3 in-river construction activities. The objectives of the Level 2 studies are to: (1) determine how to create the desired physical characteristics within the geomorphic and logistical constraints; (2) verify that the constructed habitat is used preferentially; and (3) improve spawning and reproductive success over control areas (i.e., what is currently available).

If Level 1 and Level 2 studies fulfill their objectives, and Level 2 pilot / proof-of-concept projects show improved spawning success over control areas, it will allow the development of Level 3 designs for spawning habitat. If the proof-of-concept shows benefits at a site scale, then scaling up should increase spawning and reproductive success and therefore the abundance of pallid sturgeon in the Lower Missouri River.

4.2.6.4.3 Hypotheses

The following broad management hypothesis, identified in the Effects Analysis (EA), is relevant to evaluating the effectiveness of constructed spawning habitat projects:

- H16. Re-engineering of channel morphology in selected reaches will create optimal spawning conditions -- substrate, hydraulics, and geometry -- to increase probability of successful reproduction, including stages from aggregation, fertilization, embryo incubation, hatch and recruitment to drift.

4.2.6.4.4 Metrics

Many of the metrics associated with spawning habitat creation are similar to those for Spawning-cue pulse releases (see Section 4.2.6.5.4) and fish passage improvements at Intake Diversion Dam (see Section 4.2.5.2). Metrics for spawning habitat creation can be organized around a series of questions and testable hypotheses (Table 51):

Table 51. Summary of focal questions and associated testable hypotheses, stated as alternative hypotheses that represent the preferred outcome.

Focal Questions	Testable Hypotheses
Q1: Can suitable spawning habitat be constructed and maintained without further intervention?	H1: Optimal spawning conditions, according to best available knowledge (substrate, hydraulics, and geometry), are constructed.
	H2: Constructed spawning habitat (substrate, hydraulics, and geometry) are maintained under prevailing hydrologic and hydraulic conditions.
Q2: Are created spawning habitats selected over other areas?	H3: The relative density of reproductive fish (pallid sturgeon or surrogate species) at the constructed site is greater than at control sites.
	H4: The proportion of tagged reproductive pallid sturgeon adults that select the constructed site over the control sites is greater, when corrected for the relative availability of each.
Q3: Does successful spawning (aggregation-fertilization) occur in the created spawning habitats?	H5: Aggregations of reproductive adults occur at the constructed spawning habitat.
	H6: Spawning events are observed at the constructed spawning habitat.
Q4: Does successful reproduction (incubation-viable free embryos) occur in the created spawning habitats?	H7: Viable embryos are found at or immediately downstream of the constructed spawning habitat.
	H8: Viable offspring age-0 or older can be linked to spawning events at the constructed habitat.

4.2.6.4.5 Monitoring Design

The monitoring design for the Level 2 spawning habitat action describes the implementation design, the response design (what and how to sample), sampling design (where and when to sample), and the data analysis required to answer the focal questions and evaluate the testable hypotheses described above to evaluate the effectiveness of the Level 2 constructed spawning habitat. A brief summary is provided here, with the full monitoring design described in Appendix E.3.

The implementation design process involves a team of designers working collaboratively to draft solutions. The design team should consist of biologists, hydrologists, and engineers and will use a formalized, systematic and collaborative approach to evaluate tradeoffs in site selection and site-design.

There are several considerations for deciding where to build. The site should be located in a segment: where spawning has been observed previously (Figure 62); with suitable physical characteristics (e.g., sufficient turbidity and naturalized flows), and where data from other studies (e.g., IRC and Spawning Flows) may be leveraged. Bend scale and within bend scale selection should consider where spawning has occurred historically but will also be influenced by engineering feasibility and human considerations. Control sites will be defined as all available spawning habitat within \pm one bend surrounding the constructed habitat. Controls should be in close proximity to the constructed site to ensure that reproductive status isn't confounding the results.

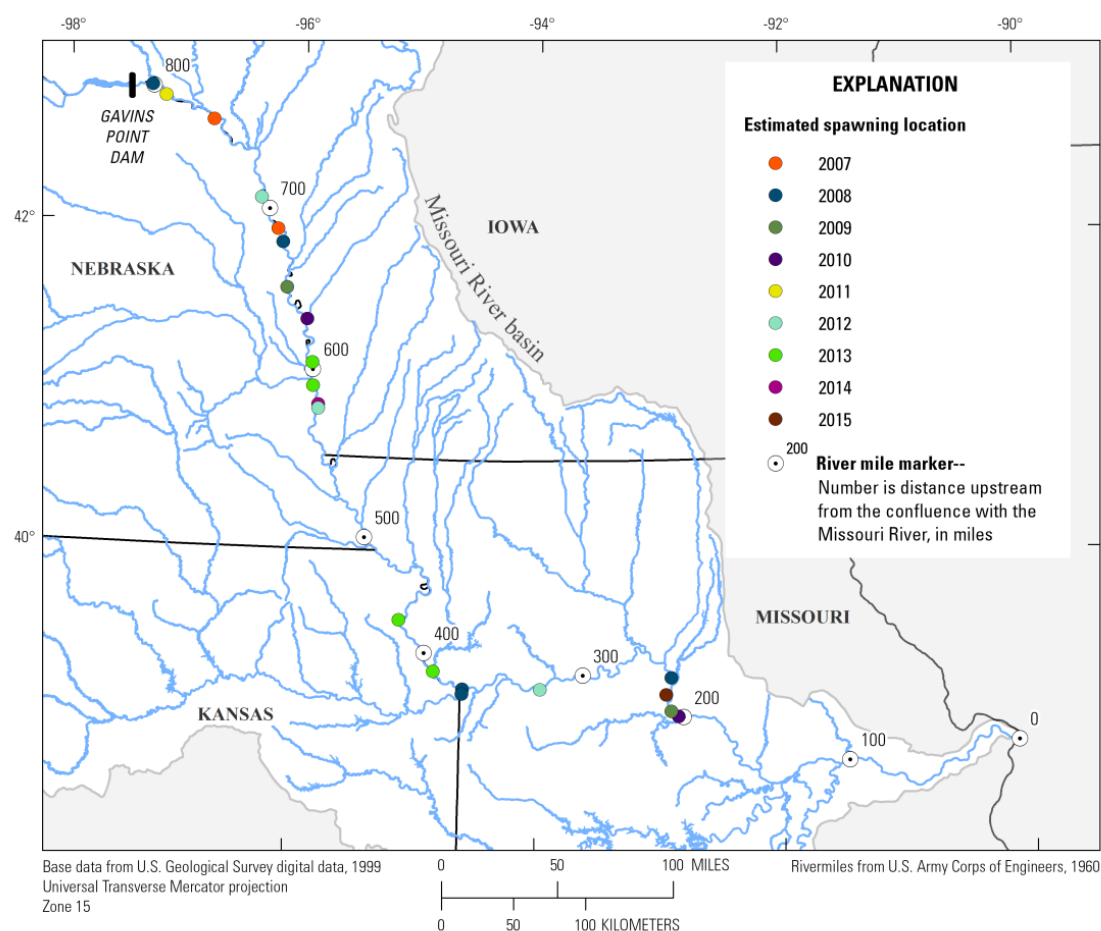


Figure 62. Spawning locations of pallid sturgeon in the Lower Missouri River, 2007-2015 (Kim Chojnacki, USGS, pers. comm.).

The Level 1 studies will inform the design of the constructed habitat by providing guidance on the preferred physical characteristics of spawning habitat (e.g., depth, velocity, and substrate). In addition the site design will consider how to maximize encounter probability, the engineering feasibility, and human considerations such as maintaining the navigation channel. A range of options will be considered, varying in their orientation in the river, the degree of engineering involved, and cost.

There is substantial overlap in monitoring activities among different Level 2 management actions (e.g., IRCs, spawning habitat, spawning-cue pulse releases, and passage at Intake). An individual activity can inform more than one action, focal question, and testable hypothesis. Table 52 summarizes the proposed monitoring activities, existing field protocols, and the key metrics to evaluate the effectiveness of the constructed spawning habitat. The primary limitation of the spawning habitat study will be achieving sufficient numbers of tagged reproductive pallid sturgeon that encounter the constructed site. To address this limitation, an experimental release of hatchery primed spawners is proposed to increase the number of reproductive adults which encounter the constructed habitat and therefore improve the ability to evaluate the effectiveness of the constructed spawning habitat. Details of this proposed experiment are discussed further in Sub-Attachment E.3A. Table 53 summarizes the sampling design considerations (i.e., spatial, temporal, and sampling effort) for the nine proposed monitoring activities described below. The overall spatial extent of this monitoring design includes the full extent of the constructed site as well as all control sites.

Detecting spawning locations will help to ensure that maintenance of revetment and other structures does not occur at spawning locations during the May 1 to June 15 spawning period. As noted in the 2018 BiOp on the MRRP (FWS 2018, pg. 30):

“USACE will use the results of ongoing monitoring of pallid sturgeon spawning behavior on the lower Missouri River to evaluate if seasonal restrictions on maintenance activities are warranted. USACE will implement seasonal restrictions on maintenance activities if monitoring identifies important spawning site(s) based on evidence of spawning site fidelity linked with successful spawning.”

1

Monitoring Activity	Field Protocols / Related Studies	Performance Metrics	Q1		Q2		Q3		Q4	
			H1	H2	H3	H4	H5	H6	H7	H8
Physical monitoring										
M3: Detailed mapping of spawning habitats	<ul style="list-style-type: none"> DeLonay et al. 2016b (Appendix 3) Elliott and Jacobson (written communication) 	<ul style="list-style-type: none"> High resolution maps of spawning locations (hydraulic and bed conditions) 	X	X						
Biological monitoring: Early life stages										
M5: Free embryo / larval sampling (genetic analysis)	<ul style="list-style-type: none"> Schrey and Heist 2007 Braaten et al. 2010 Eichelberger et al. 2014 DeLonay et al. 2016b (Appendices 1 and 4) Welker and Drobish 2017 	<ul style="list-style-type: none"> Number of free embryos / larvae Genetic ID 							X	
M6: Age-0 sampling (genetic analysis)	<ul style="list-style-type: none"> Braaten and Fuller 2007 Welker and Drobish 2017 	<ul style="list-style-type: none"> Number of age-0 individuals Genetic ID 								X
Biological monitoring: Adult movement										
M7: Tagging (and genetic analysis) of reproductive and non-reproductive adults	<ul style="list-style-type: none"> USFWS 2012 Fischenich et al. 2016 (Appendix D) Welker and Drobish 2017 	<ul style="list-style-type: none"> Fish ID Fish condition (length, weight, Kn, health metrics) Sex Reproductive stage 				X	X	X		
M8: Passive telemetry network	<ul style="list-style-type: none"> USGS telemetry study 	<ul style="list-style-type: none"> Fish ID River mile location Movement of tagged adults passing points along telemetry network 				X	X	X		
M9: Manual tracking of tagged adults	<ul style="list-style-type: none"> DeLonay et al. 2016b (Appendices 1 and 4) 	<ul style="list-style-type: none"> Fish ID 3D location, movement Aggregation and spawning behavior 				X	X	X		
Biological monitoring: Adult spawning										

Monitoring Activity	Field Protocols / Related Studies	Performance Metrics	Q1		Q2		Q3		Q4	
			H1	H2	H3	H4	H5	H6	H7	H8
M10: Detailed monitoring of spawners at a spawning site	<ul style="list-style-type: none"> DeLonay et al. 2016b (Appendix 3) Elliott and Jacobson (written communication) 	<ul style="list-style-type: none"> Fish ID 3D location Movement, aggregation and spawning behavior Substrate conditions 				X	X	X		
M11: Adult recapture and reproductive assessment	<ul style="list-style-type: none"> Fischenich et al. 2016 (Appendix D) USFWS 2012 DeLonay et al. 2016b (Appendices 1 and 4) Welker and Drobish 2017 	<ul style="list-style-type: none"> Fish ID Spawning outcome Presence or CPUE of untagged fish 			X	X	X	X		
Research experiment										
R2: Experimental release of hatchery primed spawners	<ul style="list-style-type: none"> Refer to Sub-Attachment E3.A 	N/A this experiment is intended to increase the sample size of reproductive fish which encounter the constructed habitat.				X	X	X		

1 Table 53. Proposed monitoring activities and related sampling design considerations.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
Physical monitoring			
M3: Detailed mapping of spawning habitats	<p>Constructed habitat:</p> <ul style="list-style-type: none"> Measure depth, velocity, and substrate along transects (10m spacing) throughout the constructed habitat For a subset of the treatment site, resurvey 2-4 hours later to enable assessment of substrate stability and dune movement Collect a minimum of 12 verification sediment samples to confirm the substrate mapping from imagery. <p>Entire study area¹:</p> <ul style="list-style-type: none"> Measure depth, velocity, and substrate along transects (15-20m spacing) throughout the study area (e.g. +/- 1 bend). This information will be used to define the boundaries of the control areas as well as provide context for bend level patterns in flow and sediment. 	<p>Constructed habitat:</p> <ul style="list-style-type: none"> Complete a detailed as built survey, immediately after construction. Complete detailed mapping bi-weekly during spawning season (March-June), plus after large flow pulses. Surveys would be repeated for each year of the study. <p>Entire study area:</p> <ul style="list-style-type: none"> Complete mapping once per year at typical spawning discharge. 	The recommended spatial and temporal intensity of surveys was informed by Elliot & Jacobson (written communication). A detailed as-built survey is recommended to improve the ability to evaluate the physical characteristics of the constructed site over time (USACE Draft 2018).
Biological monitoring: Early life stages			
M5: Free embryo sampling (and genetic analysis)	<p>Free embryo sampling would occur to confirm the emergence of free embryos after a spawning location / event has been confirmed.</p> <p>Sampling would occur immediately downstream of all identified spawning locations within the study area (i.e., control & treatment sites).</p>	The timing of sampling would occur days after a spawning location / event has been confirmed. Egg incubation and hatching is expected to take between 4 and 5.5 days (101 hours at 22 °C, 131 hours at 18 °C, see DeLonay et al. 2016b). Since there are uncertainties in confirming the precise timing of a spawning event and in the time it takes for eggs to hatch and free embryos to emerge, a wide sampling window should be used (e.g., sampling from 3 to 7 days after spawning event). The general timing of sampling of free embryos is expected to be between March and late June.	Sampling design guided by previous spawning studies (DeLonay et al. 2016b, App 1), past drift studies and tests of alternative sampling methods (Braaten et al. 2010), as well as the standard operating procedures for fish sampling and data collection (Welker and Drobish 2017). The sampling effort will depend on the number of confirmed spawning events.

2

¹ Study area: the constructed site plus all control areas as defined in the Implementation Design Section E.3.3.1.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
<p>M6: Age-0 sampling (and genetic analysis)</p>	<p><u>System wide:</u> Sampling locations of age-0 pallid sturgeon have yet to be informed by the PSPAP sampling design (Appendix D). Previous studies suggest that sampling should occur throughout the Lower Missouri River (e.g., between Sioux City and St. Louis).</p> <p>Consistent with Appendix E.1. The sample frame should be constrained to those habitats where past studies have shown the bulk of age-0 captures:</p> <p><u>Macro Habitats:</u> constrained to Island Side Bars (ISB) and Channel Crossover (CHXO) <u>Meso Habitats:</u> constrained to Channel Borders (CHNB), Island Tips (ITIP), and bars. <u>Micro Habitats:</u> constrained to L-dikes, wing dikes, rootless dikes, and channel sand bars.</p> <p>Sites should be selected randomly from this sample frame within a bend or reach consistent with the PSPAP design.</p>	<p>Timing of sampling age-0 pallid sturgeon has yet to be informed by the PSPAP sampling design (Appendix D) and possibly the IRC sampling design (Appendix E.1). Based on previous studies, age-0 sampling is expected to occur every week from mid-July to mid-September.</p>	<p>As noted, the sampling design for age-0 individuals is expected to be informed by the sampling design for PSPAP (Appendix D) as well as the standard operating procedures for fish sampling and data collection (Welker and Drobish 2017). The location and timing of proposed sampling provided here is based on previous studies and expectations around where and when age-0 individuals will most likely be encountered. No additional age-0 sampling is proposed as part of this Appendix, but rather this Appendix will leverage data collected via other efforts (i.e., PSPAP and possibly IRC).</p>
Biological monitoring: Adult movement			
<p>M7: Tagging (and genetic analysis) of reproductive and non-reproductive adults</p>	<p>Capture location for tagging adults has yet to be determined but should try to be more representative than past efforts which may have been biased to particular reaches and possibly sub-populations (DeLonay et al. 2016b).</p>	<p>Timing for tagging of adults has yet to be determined and will be informed by the forthcoming telemetry design study from USGS.</p>	<p>This Appendix will opportunistically utilize information from reproductive adults tagged as part of the spawning cue flows study (Appendix E4). Additionally, an experimental release of hatchery primed fish is proposed, refer to R2 below.</p>

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
<p>M8: Passive telemetry network</p>	<p>The passive telemetry network would include logging stations to discern movement across segments throughout the Lower Missouri River. At a minimum, receivers should be placed at segment boundaries and major tributary mouths. Ideally a minimum spacing of 25 miles between receivers as most spawning movements are greater than 25 miles (Aaron DeLonay, pers. comm.).</p> <p>Several additional receivers are proposed at the location of the constructed spawning habitat. In particular 3 active sentinel receivers should be placed in close proximity to the constructed habitat. This will alert researchers if a tagged fish is approaching the study area and will provide directional information. In addition, receiver efficiency should be evaluated using QA/QC tags.</p>	<p>Passive logging stations would be operated year round where possible based upon site-specific conditions. Data should be downloaded two times per month outside of the migration and spawning periods. Data should be downloaded more often during the peak migration and spawning period (April-June) to guide manual tracking of adults during the spawning and post-spawn recovery period.</p> <p>Ideally, active sentinel receivers operate continuously from March through July and possess remote communication capabilities to alert investigators when a fish approaches. If resources are adequate, some or all of the receivers may be upgraded to provide real-time data delivery through cell phone or satellite communications.</p>	<p>Sampling design guided by previous telemetry studies (DeLonay et al. 2016b, App 1, 2 & 4), and a forthcoming telemetry design study from USGS.</p>

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
M9: Manual tracking of tagged adults	Locations of manual tracking would be informed by real-time data gathered from the passive telemetry network (M8) with a focus on understanding finer-scale location and movement of tagged adults identified as being in a reproductive condition. The purpose of manual tracking would be to identify all locations of suspected spawning within the study area.	<p>Manual tracking by boat would occur from March through November. During pre- and post-spawn periods (February-March and July-August), tagged individuals would be located 1-3 times per month, while individuals in reproductive condition would be tracked more frequently along their migration routes to spawning (between weekly and hourly intervals, April-June). During the fall (September-October) tracking efforts would again intensify to recapture adults to replace transmitters and assess reproductive condition for the following spring.</p> <p>Water temperature would be monitored to determine when to increase intensity of sampling, as temperature (or cumulative thermal units) is typically a threshold for reproductive activities. Very few sturgeon spawn below 16 °C. Setting a temperature trigger around 10-12 °C should enable observers to track more of the migration as well as spawning. Typically, pallid sturgeon spawning occurs over a relatively short time period (e.g., 2-3 weeks) in a given segment, so this will make it logistically challenging to complete all of the proposed monitoring activities.</p>	Sampling design would be guided by previous telemetry studies (DeLonay et al. 2016b, App 1, 2 & 4), and a forthcoming telemetry design study from USGS.
Biological monitoring: Adult spawning			
M10: Detailed monitoring of spawners at a spawning site	Detailed monitoring of spawners would occur wherever an aggregation or spawning event is suspected within the study area. With sufficient lead time, a network of acoustics receivers would be deployed in spawning reaches to provide high-resolution spatial and temporal data during aggregation and spawning.	Detailed monitoring of spawners would occur when there is evidence of spawning through other activities. This timing is expected to be from June to September. If high-resolution receivers can be deployed they would provide resolution on positions of as little as one location per second.	All suspected aggregations or spawning events would be evaluated if possible. Feasibility (i.e., the ability to get to a suspected site in the right time period to observe spawning behavior) rather than cost would likely be the limiting factor in the short term.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
<p>M11: Adult recapture and reproductive assessment</p>	<p>Adult recapture and reproductive assessment would occur for three reasons: 1) to estimate relative density of other species or untagged sturgeon; 2) to observe aggregations, and 3) to confirm spawning.</p> <p>Adult recapture and reproductive assessment would occur wherever an aggregation or spawning event is suspected within the study area, but also at random locations within the control areas and constructed site to evaluate relative density of untagged reproductive fish.</p>	<p>Adult recapture would occur when there is evidence through other monitoring activities that spawning may have occurred. This evidence can include changes in the pattern of movement and holding of tagged individuals, observations of aggregations of males, and/or spawning behaviors noted through DIDSON acoustic imagery. Recapture might occur on multiple occasions if an individual is known to be in reproductive condition and a reproductive assessment has not been able to confirm spawning. The timing of this activity is expected to be between June and September.</p> <p>Randomized CPUE samples (using drifted trammel nets and PSPAP sampling protocols) should be collected weekly-monthly through the spawning period at both the constructed site and control sites.</p>	<p>All suspected aggregations or spawning events will be evaluated if possible. Feasibility (i.e., the ability to get to a suspected site in the right time period to net and recapture possible spawners) rather than cost will likely be the limiting factor in the short term.</p> <p>Frequency of CPUE estimates depends on available budget and success of the experimental release (R2), if lots of tagged sturgeon encounter the constructed habitat H3 will be less important.</p>
Research experiment			
<p>R2: Experimental release of hatchery primed spawners</p>	<p>The details of this experiment are discussed in Sub-Attachment E3A. In general, the tagged fish would be released downstream of the constructed habitat so that they would be likely to encounter the habitat on their upstream migration.</p>	<p>The details of this experiment are discussed in Sub-Attachment E3A. In general, the tagged fish would be released when they are approaching reproductive readiness to maximize the number of reproductive sturgeon that encounter the constructed habitat when they are 'ready' to spawn.</p>	<p>The details of this experiment are discussed in Sub-Attachment E.3A. In general, the goal is to tag more males than females as they are believed to arrive at spawning sites first (Pat Braaten, pers. comm.). The sample size will probably be limited by feasibility.</p>

4.2.6.4.6 Decision Criteria

Decision criteria guide the MRRP when evaluating monitoring and other information and in developing recommendations for consideration by the agencies. The relevant decision for the Level 2 studies associated with hypothesis H16 would be whether to move forward into full Level 3 implementation, change the experimental patch design, or abandon the spawning habitat quality hypothesis and pursue the confusion habitat hypothesis. Robust statistical results cannot be expected for the preferred metric (hatch rate) because of the difficulties in enumerating this under field conditions. However, the results of other metrics described above should contribute to a lines-of-evidence decision of whether the spawning patches are functioning as intended.

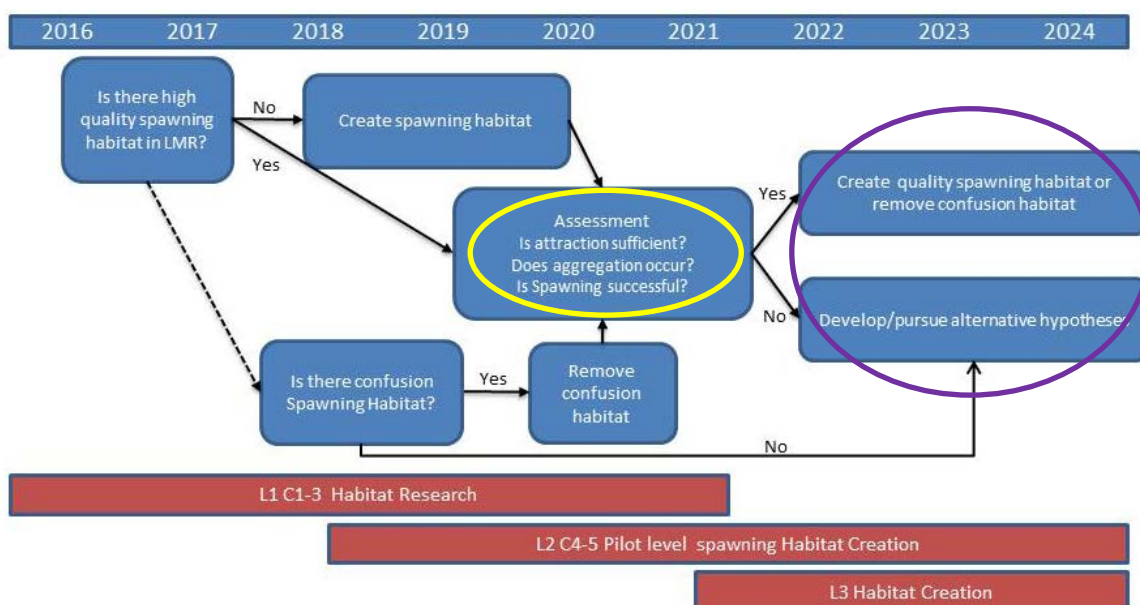





Figure 63. Decision tree for spawning habitat. Source: USFWS and USACOE (2015)

Figure 63 illustrates the broader decision context including Level 1, Level 2, and Level 3 actions. Table 54 provides guidance on interpreting the results of the Level 2 spawning habitat construction (within the yellow ellipse of Figure 63). Table 55 provides guidance on how to proceed depending on the outcome of the initial Level 2 study (within the purple ellipse of Figure 63). Specific performance measures and definitions of success for each focal question are provided in Appendix E.3.

Table 54. Decision criteria to guide the interpretation of results from Level 2 spawning habitat construction.

Focal question	Decision Criteria
Q1: Can suitable spawning habitat be constructed and maintained without further intervention?	The key limitation for this question is the uncertainty around the definition of suitable spawning habitat, which is informed by ongoing Level 1 studies. The physical aspects of this question should be relatively straight forward to interpret assuming the proposed assessments occur.
Q2: Are created spawning habitats selected over other areas?	<p>Do reproductive adults encounter the constructed habitat?</p> <ul style="list-style-type: none"> • No <ul style="list-style-type: none"> ➢ Impossible to evaluate the effectiveness of the habitat. Attempt to increase encounter rate by releasing more reproductive adults or consider changing the location or timing of releases. • Yes <ul style="list-style-type: none"> ➢ Proceed with effectiveness evaluation. <p>Do reproductive adults or other species show interest in the constructed habitat?</p> <ul style="list-style-type: none"> • No, but there is also no evidence of spawning behavior nearby (within one bend) of the habitat. <ul style="list-style-type: none"> ➢ Individuals may not be ready to spawn or may have preference for another location on the river. Try tagging more individuals known to spawn in that segment or consider changing the location or timing of releases. • No, and spawning behavior is documented nearby (within one bend) of the habitat. <ul style="list-style-type: none"> ➢ Constructed habitat as designed is not suitable. • Yes, other species show interest in the constructed habitat. <ul style="list-style-type: none"> ➢ Early indicator of success. • Yes, adults show interest in the constructed habitat. <ul style="list-style-type: none"> ➢ Early indicator of success.
Q3: Does successful spawning (aggregation-fertilization) occur in the created spawning habitats?	<p>Given that constructed habitats are selected, does spawning occur at the constructed habitat?</p> <ul style="list-style-type: none"> • No, spawning is not observed. <ul style="list-style-type: none"> ➢ Uncertain conclusion, continue monitoring and try tagging more reproductive adults. ➢ Constructed habitat may not provide suitable conditions for spawning. Consider redesigning the constructed habitat. • Yes, spawning is observed. <ul style="list-style-type: none"> ➢ Strong signal of success. • Yes, spawning occurs at greater rate than control sites. <ul style="list-style-type: none"> ➢ Very strong signal of success (unlikely to be able to assess this given the limited number of tagged fish and difficulty in observing spawning).
Q4: Does successful reproduction (incubation-viable free embryos) occur in the created spawning habitats?	<p>Given that spawning occurs at the constructed habitat, does reproduction occur?</p> <ul style="list-style-type: none"> • No, reproduction is not documented (i.e., no viable embryos are detected). <ul style="list-style-type: none"> ➢ Uncertain conclusion, continue monitoring. ➢ Constructed habitat may not provide suitable conditions for incubation-hatch. Consider redesigning the constructed habitat. • Yes, reproduction occurs (i.e., viable embryos are observed). <ul style="list-style-type: none"> ➢ Strong signal of success. • Yes, reproduction occurs at greater rate than control sites. <ul style="list-style-type: none"> ➢ Very strong signal of success (unlikely to be able to assess this given that the data will likely be a simple Y/N at each site).

Table 55. A summary of guidance for decision-making based on results of Level 2 spawning habitat construction.

Is the Level 2 constructed spawning habitat effective?	Proposed next steps depending on Level 2 findings
<p>No</p> 	<p>Re-evaluate the implied hypothesis that existing spawning habitat on the Lower Missouri River is inadequate, either in terms of quantity or quality.</p> <p>If yes (spawning habitat is inadequate),</p> <ul style="list-style-type: none"> • Re-evaluate the physical design of the constructed habitat. • Re-evaluate the location of the constructed habitat. • Consider removing confusion habitat. <p>If no (spawning habitat is adequate),</p> <ul style="list-style-type: none"> • Re-allocate efforts into other SAMP actions.
<p>Inconclusive</p> 	<p>Inconclusive evidence will most likely result from the case where spawning is suspected but reproduction isn't confirmed. Given the logistical difficulties of confirming spawning and more so reproduction, it is possible that reproduction occurs without being detected. If the results of the Level 2 constructed habitat study are inconclusive, the MRRP has several options:</p> <ul style="list-style-type: none"> • Continue / improve monitoring until the findings are conclusive. • Re-evaluate the physical design of the constructed habitat. • Re-evaluate the location of the constructed habitat. • Remove confusion habitat.
<p>Yes</p> 	<p>There are a number of different management options if the constructed habitat is successful:</p> <ul style="list-style-type: none"> • Make the existing site bigger to enable additional spawning and to concentrate more reproductive males and females at one location. • Construct a second (or more) spawning habitat targeting a different part of the river and possibly a different sub-population of sturgeon (e.g., downstream of Kansas City). • Consider removing confusion habitat to increase the number of spawners that utilize the constructed habitat.

Timelines: A timeline for these hypotheses has not been established, though the timelines in Figure 63 provide a sense of the expected outlay of effort and the sequencing/dependencies of certain activities.

4.2.6.4.7 Contingent Actions and Supporting Studies

Level 3 studies to scale up the implementation at a level that is expected to have biological benefit have not yet been described. Information provided through field experimentation will indicate whether channel geometries and/or substrate should be altered to improve performance of spawning patches, and whether additional locations would contribute to spawning success and population growth. Rejection of the “quality habitat” hypothesis would result in pursuit of the alternative “confusion habitat”

hypothesis, though the daunting nature of that undertaking has prevented an outlay of the necessary actions to date.

A variety of other Level 1 or Level 2 research studies and monitoring are ongoing or planned which will support effectiveness monitoring in the lower river. These other programs and studies include (described in more detail in Appendices C, D, and E):

- **Adult tagging and telemetry**

- BQ1/L1/C1: This component involves a study to design, optimize, and implement a passive, fixed-station telemetry receiver network to complement intensive, boat-based tracking throughout the upper Missouri and Yellowstone Rivers. This work is being pursued through the USGS Comprehensive Sturgeon Research Project, which is carrying out a formal review of technological, communication, and data collection solutions to inform management decisions on the upper and lower rivers.

- **Pallid Sturgeon Population Assessment Program v 2.0**

- This program is being designed to provide population-level information for decision makers about status and trends about pallid sturgeon, serve as a validation of predictions from the Collaborative Population Model, and enhance understanding of linkages between actions and population response. It is also evaluating alternative system-wide sampling strategies which will inform the sampling strategies in this appendix.

- **Range-wide Stocking and Augmentation Plan**

- USFWS is responsible for determining the appropriate hatchery management plan for stocking and augmenting the pallid sturgeon populations. Reproductive fish tagged for the purpose of this study would not be available to the stocking program.

- **Related Appendices**

- Appendix E.4 relates to Big Question 1. While the management action is different (construction of spawning habitat vs. spawning cue flows) many of the monitoring activities and performance metrics overlap.
- Appendix E.5 relates to Big Questions 1-6 as applicable to the Upper Missouri and Yellowstone Rivers. There are numerous overlaps with Appendix E.3, particularly with respect to Big Question 5. The monitoring activities described in this appendix are generally similar, although the data analysis and spatial and temporal considerations differ.

4.2.6.5 Spawning-Cue Pulses

4.2.6.5.1 Action Description

The action of creating spawning-cue pulse releases relates to Big Question 1 for the Lower Missouri River: Can spring pulsed flows synchronize reproductive fish, and increase chances of reproduction and recruitment? Level 1, 2, and 3 studies have been proposed to address this question in the Lower Missouri River.

The Level 1 study involves an opportunistic evaluation of pallid sturgeon responses to naturally occurring spawning-cue pulses. The Level 2 and Level 3 studies involve intentional spawning-cue pulse releases. A Level 2 release would be used to create more contrast if the prevailing conditions in the Level 1 observational study were insufficient to test the Effects Analysis (EA) hypothesis H11 (listed below). If required, Level 3 spawning-cue pulse releases would be implemented periodically to generate biological benefits.

The MRRMP-EIS assumes that the Level 1 observational study would occur after a Record of Decision (ROD) for up to 9 years. At the end of this 9-year period, the MRRP would apply the decision criteria and evidentiary framework shown in Table 60 to determine if it is appropriate to implement spawning-cue pulse releases at either Level 2 or Level 3. The exact nature of Level 3 intentional spawning-cue pulses are not yet defined but are currently conceived as bi-modal pulse releases from Gavins Point Dam (Table 56) and would be implemented at a maximum frequency of 1 in 3 years.

4.2.6.5.2 Objectives and Expected Benefits

Spawning-cue pulse releases are intended to elicit a movement response in reproductive pallid sturgeon that results in an aggregation of reproductively ready pallid sturgeon, improving spawning and reproductive success and therefore recruitment to the population.

If the evidentiary framework in Table 60 leads to the conclusion that Level 2 spawning-cue pulse releases are warranted, the expected benefits will be a more definitive test of the effectiveness of this action. If the Level 2 experiment in turn shows biological benefits (i.e., movement, aggregation and successful spawning), then Level 3 flows are likely to increase spawning and reproductive success, increasing the probability of survival and recovery. Implementation of such flows would need to minimize impacts on both birds and human considerations.

Table 56. Proposed characteristics of Level 3 spawning cue pulses.

The first pulse from Gavins Point would conform to the following guidelines:

- Rise begins on first day after flow to target navigation flows are achieved.
- Peak release from Gavins Point is equal to double the flow to target level release the first day of navigation flow to target levels are achieved from Gavins Point
- Increase to peak by 2,200 cfs per day
- Maintain peak for 2 days
- Reduce pulse by 1,700 cfs/day until releases are back to base flow to target levels

The second pulse is cued by water temperature (**16-18 degrees**) at Sioux City Iowa as follows.

- Checks to implement release increases
 - > 40.0 MAF in System Storage on March 15 storage check
 - Steady release has been set and implemented for 3 days
- Releases from Gavins Point
 - Rise begins on May 18 or later based upon water temperature and implementation of steady release for at least 3 days
 - Increase to peak by 2,200 cfs per day
 - Peak release from Gavins Point is equal to twice the steady release from Gavins Point
 - Maintain peak for 2 days
 - Reduce pulse by 1,900 cfs per day until the steady release flows are reached
- Flood targets will be the full service flood targets increased by the steady release level
 - If the steady release is 31 kcfs and the full service flood targets are 41 kcfs, 47 kcfs, and 71 kcfs at Omaha, Nebraska City, and Kansas City, respectively, the new flood targets will be 72 kcfs at Omaha (31 + 41), 78 kcfs at Nebraska City (31 + 47), and 102 kcfs at Kansas City (31 + 71).

4.2.6.5.3 Hypotheses

The following broad management hypothesis identified in the Effects Analysis (EA) is relevant to evaluating the behavioral response of pallid sturgeon to spawning-cue pulses:

- H11. Naturalization of the flow regime at Gavins Point Dam will improve flow cues in spring for aggregation and spawning of reproductive adults, increasing reproductive success.

The 2018 Biological Opinion (USFWS 2018, pages 57-60) provides an overview of the effects of altered flow regimes in the Missouri River on habitat availability, food availability and spawning.

4.2.6.5.4 Metrics

Many of the metrics associated with spawning-cue pulse releases are identical to those for the creation of spawning habitat (described in Section 4.2.6.4) and for fish passage improvements at Intake Diversion Dam (described in Section 4.2.5.2). Metrics for evaluating spawning-cue pulse releases can be organized around a series of questions and testable hypotheses (see Table 57 and Table 58). The focal questions and testable hypotheses are the same for both the Level 1 observational study and the contingent Level 2 experimental spawning-cue pulse release.

Table 57: Summary of focal questions and associated testable hypotheses, stated as alternative hypotheses that represent the preferred outcome.

Focal Questions	Testable Hypotheses
Q1: Are there attributes of river flow that are strongly correlated with upstream movement of reproductive male and female pallid sturgeon?	H1: There is a significant correlation between directional movements of reproductive males and females and attributes of river flows.
Q2: Are there attributes of river flow that are strongly correlated with successful spawning (aggregation-fertilization)?	H2: There is a significant correlation between aggregations of reproductive males and females and attributes of river flows. H3: There is a significant correlation between the number of successful spawning events and attributes of river flows.
Q3: Are there attributes of river flow that are strongly correlated with synchronous behavior of reproductive male and female pallid sturgeon?	H4: There is a significant correlation between the spatial distribution of spawning and attributes of river flows. H5: There is a significant correlation between the temporal distribution of spawning and attributes of river flows.
Q4: Are there attributes of river flow that are strongly correlated with successful reproduction (incubation, hatch, viable embryos)?	H6: There is a significant correlation between the presence of viable embryos found at or immediately downstream of confirmed spawning locations and attributes of river flows. H7: There is a significant correlation between the number of age-0 pallid sturgeon and attributes of river flows.

4.2.6.5.5 Monitoring Design

The monitoring design for the Level 1 observational study and Level 2 or 3 spawning-cue pulse release actions includes the implementation design, the response design (what and how to sample), sampling design (where and when to sample), and the data analysis required to answer the focal questions and evaluate the testable hypotheses described above. A brief summary is provided here, with the full monitoring design described in Appendix E.4.

There are three key decisions to make regarding the implementation of the management action: (1) Should the MRRP implement a Level 2 test spawning-cue pulse release? (2) When (what year) should the MRRP implement a spawning-cue pulse release? and (3) What should the spawning-cue pulse release look like? The evidentiary framework,

(Table 60) provides the weight of evidence approach to determining whether or not a Level 2 or Level 3 spawning-cue pulse release should be considered. The other two decisions depend on the outcome of the Level 1 study, feasibility, impacts to birds, and human considerations.

As described in section 4.2.6.4, there is substantial overlap in monitoring activities among different Level 2 management actions (e.g., IRCs, spawning habitat, spawning-cue pulse releases, and passage at intake). An individual activity can inform more than one action, focal question, and testable hypothesis.

Table 58 summarizes the proposed monitoring activities using terminology consistent with other studies in the SAMP. Table 58 also summarizes existing field protocols, and the key metrics to evaluate the effectiveness of the constructed spawning habitat. This study will build on past efforts by the Comprehensive Sturgeon Research Program (CSRP) with several notable additions:

- More tagged fish selected from more reaches and more years of data;
- A supplemental Passive Receiver Network to improve tracking of tagged fish;
- Monitoring of age-0 fish at observed spawning sites as well as across the study area more broadly; and
- New genetic techniques which enable the ability to identify parents and to quickly distinguish pallid sturgeon from shovelnose sturgeon.

Table 59 summarizes the sampling design considerations for the eight proposed monitoring activities in the response design. The spatial boundaries of the study include the entire Lower Missouri River (e.g., from Gavins Point Dam to the confluence with the Mississippi).

Table 58. Summary of monitoring activities, supporting field protocols / related studies, and metrics as aligned with the testable hypotheses.

Monitoring Activity	Field Protocols / Related Studies	Performance Metrics	Q1	Q2			Q3		Q4	
			H1	H2	H3	H4	H5	H6	H7	
Physical monitoring										
M2: Fixed in-river monitoring	<ul style="list-style-type: none">Turnipseed and Sauer 2010; and other USGS protocols.	<ul style="list-style-type: none">Water temperatureDischargeTurbidity or conductivity	X	X	X	X	X	X	X	
Biological monitoring: Early life stages										
M5: Free embryo sampling (genetic analysis)	<ul style="list-style-type: none">Schrey and Heist 2007Braaten et al. 2010Eichelberger et al. 2014DeLonay et al. 2016b (Appendices 1 and 4)Welker and Drobish 2017	<ul style="list-style-type: none">Number of free embryosGenetic ID						X		
M6: Age-0 sampling (genetic analysis)	<ul style="list-style-type: none">Braaten and Fuller 2007Welker and Drobish 2017	<ul style="list-style-type: none">Number of age-0 individualsGenetic ID							X	
Biological monitoring: Adult movement										
M7: Tagging (and genetic analysis) of reproductive and non-reproductive adults	<ul style="list-style-type: none">USFWS 2012Fischenich et al. 2016 (Appendix D)Welker and Drobish 2017	<ul style="list-style-type: none">Fish IDFish condition (length, weight, Kn, health metrics)SexReproductive stage	X	X	X	X	X			
M8: Passive telemetry network	<ul style="list-style-type: none">USGS telemetry study	<ul style="list-style-type: none">Fish IDRiver mile locationMovement of tagged adults passing points along telemetry network	X	X	X	X	X			
M9: Manual tracking of tagged adults	<ul style="list-style-type: none">DeLonay et al. 2016b (Appendices 1 and 4)	<ul style="list-style-type: none">Fish IDlocation, movementAggregation and spawning behavior		X	X	X	X			
Biological monitoring: Adult spawning										

Monitoring Activity	Field Protocols / Related Studies	Performance Metrics	Q1	Q2		Q3		Q4	
			H1	H2	H3	H4	H5	H6	H7
M10: Detailed monitoring of spawners at a spawning site	<ul style="list-style-type: none"> DeLonay et al. 2016b (Appendix 3) Elliott and Jacobson (written communication) 	<ul style="list-style-type: none"> Fish ID 2D / 3D location Movement, aggregation and spawning behavior Substrate conditions 		X	X				
M11: Adult recapture and reproductive assessment	<ul style="list-style-type: none"> Fischenich et al. 2016 (Appendix D) USFWS 2012 DeLonay et al. 2016b (Appendices 1 and 4) Welker and Drobish 2017 	<ul style="list-style-type: none"> Fish ID Spawning outcome 		X	X				

Table 59. Proposed monitoring activities and related sampling design considerations.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
Physical monitoring			
M2: Fixed in-river monitoring	<p>Locations of in-river monitoring are pre-determined by locations of USGS gaging stations, which includes 22 locations in the Lower Missouri mainstem between Sioux City, IA and St. Charles, MO. They vary in terms of which parameters they measure:</p> <ul style="list-style-type: none"> • Stage (19 gages) • Discharge (11 gages) • Temperature (14 gages) • Turbidity (6 gages) 	Stations are operated continuously over the entire year at a fine scale temporal resolution (e.g., 15 minute intervals). They vary in terms of the time period they have been in operation and which parameters were measured over which time periods.	Locations to date have been predetermined by USGS. Available data for the Lower Missouri River are provided here: https://ne.water.usgs.gov/missouri/riverwq/sitelist.html
Biological monitoring: Early life stages			
M5: Free embryo sampling (and genetic analysis)	<p>Free embryo sampling would occur to confirm the emergence of free embryos after a spawning location / event has been confirmed.</p> <p>Sampling would occur immediately downstream of all identified spawning locations in the LMOR. If too many spawning events are observed (i.e., costs are too high), a random sample of sites may be selected.</p>	The timing of sampling would occur days after a spawning location / event has been confirmed. Egg incubation and hatching is expected to take between 4 and 5.5 days (101 hours at 22 °C, 131 hours at 18 °C, see DeLonay et al. 2016b). Since there are uncertainties in confirming the precise timing of a spawning event and in the time it takes for eggs to hatch and free embryos to emerge, a wide sampling window should be used (e.g., sampling from 3 to 7 days after spawning event). The general timing of this activity is expected to be between March and late June.	Sampling design guided by previous spawning studies (DeLonay et al. 2016b, App 1), past drift studies and tests of alternative sampling methods (Braaten et al. 2010), as well as the standard operating procedures for fish sampling and data collection (Welker and Drobish 2017). The sampling effort will depend on the number of confirmed spawning events.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
<p>M6: Age-0 sampling (and genetic analysis)</p>	<p>Sampling locations of age-0 pallid sturgeon have yet to be informed by the PSPAP sampling design (Appendix D). Previous studies suggest that sampling should occur throughout the LMOR (e.g., between Sioux City and St. Louis). However, logistical constraints on the field protocols may emerge farther downstream as discharge increases.</p> <p>Consistent with Appendix E1. The sample frame should be constrained to those habitats where past studies have shown the bulk of age-0 captures:</p> <p><u>Macro Habitats:</u> constrained to Island Side Bars (ISB) and Channel Crossover (CHXO)</p> <p><u>Meso Habitats:</u> constrained to Channel Borders (CHNB), Island Tips (ITIP), and bars.</p> <p><u>Micro Habitats:</u> constrained to L-dikes, wing dikes, rootless dikes, and channel sand bars.</p> <p>Sites should be selected randomly from this sample frame within a bend or reach consistent with the PSPAP (Appendix D) and IRC (Appendix E.1) designs.</p>	<p>Timing of sampling age-0 pallid sturgeon has yet to be informed by the PSPAP sampling design (Appendix D) and possibly the IRC sampling design (Appendix E.1). Based on previous studies, age-0 sampling is expected to occur every week from mid-July to mid-September.</p>	<p>As noted, the sampling design for age-0 individuals is expected to be informed by the PSPAP (Appendix D) and IRC (Appendix E.1) as well as the standard operating procedures for fish sampling and data collection (Welker and Drobish 2017).</p> <p>The location and timing of proposed sampling provided here is based on previous studies and expectations around where and when age-0 individuals will most likely be encountered.</p> <p>While data from other monitoring efforts (E.g., PSPAP or IRC) may be utilized opportunistically they should be supplemented to ensure sufficient data to inform the focal questions associated with spawning-cue pulses.</p>

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
Biological monitoring: Adult movement			
M7: Tagging (and genetic analysis) of reproductive and non-reproductive adults	Capture location for tagging adults has yet to be determined but should try to be more representative than past efforts which may have been biased to particular reaches and possibly sub-populations (DeLonay et al. 2016b).	Timing for tagging of adults has yet to be determined and will be informed by the forthcoming telemetry design study from USGS.	Number of tagged adults has yet to be determined. Power analysis may be necessary to determine the optimal number of tags however preliminary targets have been suggested of 20 females and 40 males per segment. This number of tagged adults may not be attainable in the short term. Numbers of tagged individuals are based on expectations of female and male recrudescence (numbers in reproductive condition in any given year). Past CSRP studies have attempted to maintain a portfolio of 80 tagged individuals in the core study areas with active tags across years. Maintaining adults with known reproductive histories is preferable to tagging larger numbers of new fish.
M8: Passive telemetry network	<p>The passive telemetry network would include logging stations to discern movement across segments throughout the Lower Missouri River. At a minimum, receivers should be placed at segment boundaries and major tributary mouths. Ideally a minimum spacing of 25 miles between receivers as most spawning movements are greater than 25 miles (Aaron DeLonay, pers. comm.).</p> <p>Several additional receivers are proposed at the location of the constructed spawning habitat (see Appendix E3). If feasible, it would also be useful to increase the spatial resolution near known spawning sites as they are identified.</p>	Passive logging stations would be operated year round where possible based upon site-specific conditions. Data should be downloaded two times per month outside of the migration and spawning periods. Data should be downloaded more often during the peak migration and spawning period (April-June) to guide manual tracking of adults during the spawning and recovery period.	Sampling design guided by previous telemetry studies (DeLonay et al. 2016b, App 1, 2 & 4), and a forthcoming telemetry design study from USGS.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
M9: Manual tracking of tagged adults	Locations of manual tracking would be informed by near real-time data gathered from the passive telemetry network (M8) with a focus on understanding finer-scale location and movement of tagged adults identified as being in a reproductive condition. The purpose of manual tracking would be to identify all locations of suspected spawning. This is a substantial challenge that may be difficult to and expensive to meet completely with acoustic technology on the LMOR, whereas it is expected to be more feasible on the UMOR.	<p>Manual tracking by boat would occur from March through November. During pre- and post-spawn periods (February-March and July-August), tagged individuals would be located 1-3 times per month, while individuals in reproductive condition would be tracked more frequently along their migration routes to spawning (between weekly and hourly intervals, April-June). During the fall (September-October) tracking efforts would again intensify to recapture adults to replace transmitters and assess reproductive condition for the following spring.</p> <p>Water temperature will be monitored to determine when to increase intensity of sampling, as temperature (or cumulative thermal units) is typically a threshold for reproductive activities. Very few sturgeon spawn below 16 °C. Setting a temperature trigger around 10-12 °C should enable observers to track more of the migration as well as spawning. Typically pallid sturgeon spawning occurs over a relatively short time period (e.g., 2-3 weeks) in a given segment, this will make it logistically challenging to complete all of the proposed monitoring activities.</p>	Sampling design guided by previous telemetry studies (DeLonay et al. 2016b, App 1, 2 & 4), and a forthcoming telemetry design study from USGS.
Biological monitoring: Adult spawning			
M10: Detailed monitoring of spawners at a spawning site	Detailed monitoring of spawners would occur wherever an aggregation or spawning event is suspected.	Detailed monitoring of spawners would occur when there is evidence of spawning through other activities. This timing is expected to be from June to September. Spawning often occurs during the night in the LMR which adds additional logistical constraints (Aaron Delonay, pers.comm.).	All suspected aggregations or spawning events will be evaluated if possible. Feasibility (i.e., the ability to get to a suspected site in the right time period to observe spawning behavior) rather than cost will likely be the limiting factor in the short term.

Monitoring Activity	Spatial Considerations	Temporal Considerations	Method for Determining Sampling Effort
M11: Adult recapture and reproductive assessment	Adult recapture and reproductive assessment would occur for two reasons: 1) to observe aggregations, and 2) to confirm spawning. Adult recapture and reproductive assessment would occur wherever an aggregation or spawning event is suspected.	Adult recapture would occur when there is evidence through other monitoring activities that spawning may have occurred. This evidence can include changes in the pattern of movement and holding of tagged individuals, observations of aggregations of males, and/or spawning behaviors noted through DIDSON acoustic imagery. Recapture might occur on multiple occasions if an individual is known to be in reproductive condition and a reproductive assessment has not been able to confirm spawning. The timing of this activity is expected to be between June and September.	All suspected aggregations or spawning events will be evaluated if possible. Feasibility (i.e., the ability to get to a suspected site in the right time period to net and recapture possible spawners) rather than cost will likely be the limiting factor in the short term.

4.2.6.5.6 *Decision Criteria*

Decision criteria guide the MRRP when evaluating monitoring and other information and in developing recommendations for consideration by the agencies. Decision criteria for implementing a spawning-cue pulse release after the first 9 years post-ROD are described in the evidentiary framework (Table 60). If a spawning-cue pulse release were implemented after year 9, the significant experimental control that could be exerted over this action (above the confluence of the Platte and Missouri Rivers) will enhance the ability to detect and quantify reproductive behavioral changes related to spawning-cue pulses. However, the releases will still take place within a system where many sources of variability are not controlled, such as weather systems that can abruptly change water temperature or discharge in the mainstem or tributaries. As discussed in Appendix E.4, there are several confounding factors which will make it challenging to separate the spawning-cue pulse signal from other noise in the system created by spatial and temporal variability in flows. It is therefore unlikely that these experiments will result in a statistically rigorous result. Instead, a decision to accept the value of manipulated flow pulses in increasing pallid sturgeon reproductive success, or to reject it, will probably be based on judgement of multiple lines of evidence.

Timelines: The time to implementation at Level 3 and sequencing of this action should be considered in light of other actions. For example, before managers run a spawning-cue pulse release, they should be assured that functional spawning habitat is available, and that a sufficient number of tagged fish in reproductive condition are present in the river to assess aggregation and spawning. A nine-year time limit for implementation at Level 2 was agreed upon by the USFWS and the USACE to allow for habitat and propagation efforts to enhance the potential success of spawning-cue pulse releases (see Section 4.2.1.3). Information derived from passive monitoring of prevailing spawning-cue pulse events could yield a number of different outcomes relative to EA hypothesis H11 (for instance, see Table 60), and lead to the conclusion that a spawning-cue pulse release would not be required. The degree of natural variability in flows over the first nine years will be a primary determinant of the ability to test EA hypothesis H11.

Table 60. Evidentiary Framework for flow observations. This decision aid is intended to determine if sufficient spawning-cue pulse events occur during the first nine years of implementation post ROD, and if an explicitly managed spawning-cue pulse release should be implemented after the ninth year to test flow hypotheses.

Question	Potential Metrics and Lines of Evidence Based on Observations over 9 years		
	No [👎👎👎 or 👎👎]	Inconclusive [🤔]	Yes [👍👍👍 or 👍👍]
Q1. Are there attributes of river flow that are strongly correlated with upstream movement of reproductive male and female pallid sturgeon?	Sufficient contrast of flows has occurred over first 9 years to answer this question, and movements of pallid sturgeon have been well monitored, but no significant correlations are apparent between flow and movement. Flows aren't associated with movement.	Insufficient contrast of flows has occurred over first 9 years to be able to rigorously answer this question. Effects of flows unclear.	Sufficient contrast of flows has occurred over first 9 years to answer this question, movements of pallid sturgeon have been well monitored, and significant correlations are apparent between flow and movement, at flow magnitudes that could be released by managers. Flows are associated with movement.
Q2. Are there attributes of river flow that are strongly correlated with successful spawning (aggregation-fertilization)?	Wide contrast of flows has occurred over first 9 years (below and above potential spawning flows) and telemetered pallid sturgeon movements have been monitored, but no significant correlations between flow and spawning success apparent. Flows aren't associated with successful spawning.	Insufficient contrast of flows has occurred over first 9 years to be able to rigorously answer this question. Effects of flows unclear.	Wide contrast of flows has occurred over first 9 years (below and above potential spawning flows). Aggregations and spawning events observed (gravid females released eggs in the presence of males), following flow-associated upstream movement. Flows are associated with successful spawning.
Q3. Are there attributes of river flow that are strongly correlated with synchronous behavior of reproductive male and female pallid sturgeon?	Sufficient contrast of flows has occurred over first 9 years, and movements and spawning of pallid sturgeon have been well monitored, but no evidence of correlation between synchronous behavior (temporal or spatial) and flows. Flows aren't associated with synchronous behavior.	Insufficient contrast of flows has occurred over first 9 years to be able to rigorously answer this question. Effects of flows unclear.	Sufficient contrast of flows has occurred over first 9 years to answer this question, movements of pallid sturgeon have been well monitored, and significant correlations are apparent between flow and synchronous behavior (temporal or spatial distribution of spawners). Flows are associated with synchronous behavior.
Q4. Are there attributes of river flow that are strongly correlated with successful reproduction (incubation-viable embryos)?	n.a. [Answers to Q1 and Q2 was "No", so Q4 does not apply. If successful reproduction did occur, it was not due to flow-associated movement and spawning]	Insufficient contrast of flows has occurred over first 9 years to be able to rigorously answer this question. Effects of flows unclear.	Viable embryos found downstream of successful spawning events that are genetically related to the males and females observed to be spawning. Flows are associated with successful reproduction, which provides additional evidence that flows are associated with spawning.
Conclusions regarding need for Level 2 spawning flows after Year 9	Despite sufficient contrast in flows to test hypotheses, flows aren't associated with movement, successful spawning or synchronous behaviour. Do not implement Level 2 flows.	Implement spawning flows on a trial basis (Level 2) to get enough contrast and answer Q1-Q4.	Yes to Q1-Q4: No need for Level 2 spawning flows. Rely on existing flows. Yes to Q1-Q2 but No to Q3 or Q4: Research what's limiting synchronous behaviour or reproduction. Possible Level 2 spawning flow test if evidence supports it.

Triggers for Moving to Levels 3 or 4: The trigger for moving to Level 3 implementation would be convincing evidence of upstream movement, increased synchronization, and successful spawning and reproduction in response to one or more instances of Level 2 spawning-cue pulse releases, without unacceptable impacts on birds or human considerations. If repeated implementation at Level 3 were to generate a reliable functional relationship between spawning-cue pulse releases and the probability of successful spawning and reproduction, then together with population modeling and survival estimates for other life history stages, it should be possible to estimate the required scale and frequency of this action at Level 4.

4.2.6.5.7 *Contingent Actions and Supporting Studies*

Contingent actions will need to take into account all of the lines of evidence for different factors that may affect pallid sturgeon recruitment, as summarized in Section 4.2.1.3.

A variety of other Level 1 research studies and monitoring are ongoing or planned which will support effectiveness monitoring in the lower river. These other programs and studies include (described in more detail in Appendices C, D, and E):

- **Adult tagging and telemetry**
 - BQ1/L1/C1 - This component involves a study to design, optimize, and implement a passive, fixed-station telemetry receiver network to complement intensive, boat-based tracking throughout the upper Missouri and Yellowstone Rivers. This work is being pursued through the USGS Comprehensive Sturgeon Research Project, which is carrying out a formal review of technological, communication, and data collection solutions to inform management decisions on the upper and lower rivers.
- **Pallid Sturgeon Population Assessment Program v 2.0**
 - This program is being designed to provide population-level information for decision makers about status and trends about pallid sturgeon, serve as a validation of predictions from the Collaborative Population Model, and enhance understanding of linkages between actions and population response. It is also evaluating alternative system-wide sampling strategies which will inform the sampling strategies in this appendix. The PSPAP v. 2.0 is described in Appendix D.

4.2.7 **Potential Effects of bird actions on pallid sturgeon**

A management action for any one objective along the Missouri River has the potential to affect other objectives, especially if an action involves changes to reservoir operations.

USGS has completed a preliminary evaluation of pallid sturgeon sensitivity to potential bird-management actions by looking at how ESH flow pulses would affect pallid sturgeon food-producing and foraging habitats (using the IRC habitat criteria defined in section 4.2.6.2.1; Robert Jacobson, U.S. Geological Survey, pers. comm.). These habitats are key components of IRCs and are thought to be critical to growth and survival of age-0 pallid sturgeon. Fall and spring ESH pulse flows (without low summer flow components) resulted in a modest gain (about 10%) in only food-producing habitats and only in a restored upstream reach where the flow regime is strongly linked to releases from Gavins Point Dam. Food-producing habitats were insensitive to ESH flows in downstream reaches where flows are not strongly regulated by releases from Gavins Point Dam and foraging habitats were insensitive to ESH flow releases in all cases. Food-producing habitats were also insensitive to ESH flow pulses in channelized (non-restored) reaches, upstream and downstream. Spring ESH pulses resulted in about a 10% increase in qualifying pallid sturgeon spawning cues (that is, doubled flows above navigation support in May). Though this comparison was limited to just a few sites, it provides a preliminary assessment which suggests that effects of ESH flows on pallid sturgeon habitats could be quite minor. Table 61 provides a qualitative assessment of other actions.

Table 61. Preliminary and qualitative assessment of the effects of bird actions on pallid sturgeon habitats and populations.

Action	Geographic overlap with action area for fish*	Direct effect on fish habitat	Direct effect on fish reproduction or survival	Effects on ability to implement fish management actions (other than budget)
Fall and spring ESH flow pulses	Overlap with potential spawning areas downstream of Gavins Point Dam; far upstream of most IRCs (Figure 22)	Spring pulses could possibly assist pallid sturgeon in upstream movement and aggregation for spawning. (10% increase in qualifying spawning cue pulses) Analysis of 2 sites shows neutral or positive effects on IRCs (see text)	Spring pulses likely to be either neutral or positive effect on spawning success and survival of age-0 fish; Fall pulses unlikely to influence reproduction	Unlikely. Spring ESH flows have somewhat different attributes from the ideal spawning cue flow; the latter would only occur at least 9 years post-ROD; may not be implementable in the same year; an ESH spring pulse might use stored water then unavailable for spawning cue.

Action	Geographic overlap with action area for fish*	Direct effect on fish habitat	Direct effect on fish reproduction or survival	Effects on ability to implement fish management actions (other than budget)
Habitat conditioning flows	Overlap with potential spawning areas downstream of Gavins Point Dam; far upstream of most IRCs (Figure 22)	Unlikely, as these flows are lower magnitude than fall and spring ESH flow pulses, which showed neutral or positive effects.	Unlikely given that magnitude is lower than fall and spring ESH pulses, which showed neutral or positive effects.	Unlikely given that magnitude is lower than fall and spring ESH pulses.
Vegetation removal	No.	No.	No.	No.
Low flow management and lowered flows to reduce take	Overlap with potential spawning areas downstream of Gavins Point Dam; far upstream of most IRCs (Figure 22)	Low flow management would occur after pallid sturgeon spawning, and is unlikely to affect spawning habitat. Effects on IRCs are variable and include increases in foraging habitats in channelized reaches, increases in food-producing habitat in upstream reconfigured reaches, and decreases in food-producing habitats in both upstream and downstream reaches.	No effects on spawning due to differences in timing. May increase age-0 survival through increases in foraging habitat and food-producing habitat. First assess potential for effects on IRC habitat (if nil, then don't need to evaluate effects on survival).	Not in the year of implementation. Storing or releasing water from reservoirs might affect operational flexibility for spawning cue flows in subsequent year.
Mechanical ESH creation and augmentation of sandbars	Limited overlap possible from Gavins Point Dam to Ponca, NE. ESH located in areas of low river energy, whereas spawning habitats would be in areas of high river energy. ESH construction is hundreds of miles upstream of IRCs	Unlikely due to low spatial overlap. Also, addition of sand for ESH replaces natural supply.	Very unlikely.	No.
Reservoir habitat creation	No overlap.	No – pallid sturgeon do not use reservoirs	No.	No.

Action	Geographic overlap with action area for fish*	Direct effect on fish habitat	Direct effect on fish reproduction or survival	Effects on ability to implement fish management actions (other than budget)
Reservoir level management	No direct spatial overlap with range of pallid sturgeon.	Unlikely. Possible, through low summer flow effects on IRCs described above. Should be evaluated further to assess how reservoir level management may affect flows in IRCs.	Possible. First assess effect on habitat.	Reservoir level management could affect storage available for spawning cue flow actions and flows in IRCs, especially low summer flows.
Population protection measures	No.	No.	No.	No.
Off-channel habitat creation	No overlap, as spawning habitat is in channel, and IRCs are much further downstream	No.	No.	No.

If low summer flows are added to consideration, the potential interactions between bird and fish actions increase. Low summer flows as modeled to decrease take of bird nests increased availability of foraging habitat in the upper channelized reaches by as much as 30% and the lower channelized reaches by 10%; IRC-qualifying habitats in reconfigured reaches were not sensitive to low summer flows. Low summer flows increased food-producing habitat by 20% in the upstream reconfigured reaches but the food-producing habitats in the downstream reaches were insensitive. Channelized reaches, both upstream and downstream, showed a 10% decrease in food-producing habitats with low summer flows.

4.3 Implement

4.3.1 Implementation Plan

Figure 64 and Figure 65 summarize the current implementation schedules for the actions described above in sections 4.2.5 and 4.2.6, and the associated components at Levels 1, 2 and 3 (in the order of presentation of each of these actions). These schedules build on the plans presented by the USFWS and USACE (2015), and have been updated to reflect both the preferred alternative and current USFWS priorities and timelines, as well as joint USFWS and USACOE work on prioritization of Level 1 and Level 2 activities, described in Appendix F.

The longer term schedule for Level 1 and Level 2 activities is presented in Appendix F. The schedule will require a well-funded and focused surge in research activity conducted by multiple research teams that work in close coordination (see Appendix F).

As noted in section 4.2.1 summarizing the Lower Missouri River Pallid Sturgeon Framework (USFWS and USACE 2015), the timeframe for implementation may be adjusted as knowledge is gained from Level 1, 2 and 3 actions, hypotheses are tested, and the likelihood of biological benefits is better understood. Budget allocations may also affect the timing of particular activities. The rationale for any adjustments in schedule should be well documented.

Task Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Big Question 1: Spawning Cues																	
Level 1																	
C1 Design complementary passive/active telemetry network																	
C2 Opportunistic tracking of reproductive behaviors																	
C3 Mesocosm studies: quantitative habitat – survival relations																	
C4 Assess potential fish and HC responses to Level 2 flow expt. at Fort Peck																	
Level 2																	
C5 Fort Peck Flow expt. to stimulate spawning, reproduction, recruitment																	
Big Question 2: Flow Naturalization and Productivity																	
Level 1																	
C1 Engineering models, interactions with authorized purposes																	
C2 Screening: limitations of food or forage habitats																	
C3 Field studies along gradients, food and forage habitats																	
C4 Mesocosm studies: quantitative habitat – survival relations																	
Big Question 3: Temperature manipulations at Fort Peck																	
Level 1																	
C1 Screening: Feasibility, modeling of effects																	
C2a Screening: is food limiting to age-0 survival?																	
C2b Are Lake Sakakawea conditions limiting to age-0 survival?																	
C3a Field gradient, temperature and food production																	
C3b Field experiment drift/dispersal advection/dispersion validation																	
C4a Mesocosm studies: temperature, food, survival relations																	
C4b Development rates of embryos, free embryos, larvae																	
Big Question 4: Sediment bypass																	
Level 1																	
C2 Mesocosm study of turbidity-limited survival																	
C3 Mesocosm study of turbidity-limited survival rates																	
Big Question 5: Passage, drift, and recruitment																	
Level 1																	
C1a Model integration, drift and development																	
C1b Modeling location and rate of change of headwaters																	
C2a Patchiness of anoxic zone																	
C2b Spawning habitat distribution on the Yellowstone River																	
C3 Field experiment drift/dispersal, modeling of advection/dispersion validation																	
C4 Mesocosm studies to quantify transport																	
Level 2																	
C5 Engineering studies for effects of low flows																	
C6a Drift experiments, Fort Peck flows and drawdowns																	
C6b Adult translocation experiment, Yellowstone																	
Big Question 6: Population Augmentation																	
Level 1																	
C1 Engineering feasibility hatchery needs, facilities, operations																	
C2 Retrospective study survival linked to hatchery operations																	
C3 Simulation models, population sensitivity to size, health, genetics																	
Level 2																	
C4 Field experiments (TBD from Basin-Wide Stocking & Augmentation Plan)																	
Level 3																	
Stocking																	

Figure 64. Current schedule for implementation of actions in the Upper Missouri River, revised from USFWS and USACE (2015) to reflect the preferred alternative and current USFWS priorities and timelines, and described in sections 4.2.5 of this report. Arrows represent flexibility in the timing of implementation. This figure is an illustration of the intended implementation schedule. There may be further adjustments in the schedule. In-river actions at Level 2 and Level 3 are shown in bolded blue text. Changes since AMP V6 are shown in light blue.

Task Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Big Question 1: Spawning Cues																	
Level 1																	
C1 Design complementary passive telemetry network																	
C2 Opportunistic tracking of reproductive behaviors																	
C3 Mesocosm experiments, reproductive behaviors																	
Level 2																	
C5 Experimental flow releases, Gavins Point										if req'd							
Big Question 2: Temperature Control																	
Level 1																	
C1 Model water temperature management options, Ft. Randall																	
C2 Field studies temperature and reproductive behaviors, surrogates																	
C3 Mesocosm studies temperature and reproductive behaviors																	
Big Question 3: Food and Forage																	
Level 1																	
C1 Screening: limitations of food or forage habitats																	
C2 Technology development for IRC sampling, modeling, measurement																	
C3 Field studies along gradients, food and forage habitats																	
C4 Mesocosm studies: quantitative habitat – survival relations																	
Level 2																	
C5 Design studies for IRC experiments																	
C6 Build IRCs in staircase design & refurbish SWHS																	
Level 3																	
Implement more IRCs if found to be successful																	
Big Question 4: Drift Dynamics																	
Level 1																	
C1 Technology development surrogate particles, particle tracking																	
C2 Resilience, stamina in turbulent flows (lab or mesocosm study)																	
C3 Field studies on free embryo exit paths																	
C4 Field gradient study, age-0 survival and complexity																	
C5 Free embryo transport to Mississippi River																	
C6 Field experiments with particle tracking, embryos, models																	
Big Question 5: Spawning Habitat																	
Level 1																	
C1 Study of functional spawning habitat, Yellowstone River																	
C2 Field gradient study, habitat conditions LMOR																	
C3 Mesocosm studies on spawn conditions, behaviors																	
Level 2																	
C4 Engineering studies for sustainable design																	
C5 Manipulative field experiment for spawning habitat																	
Level 3																	
If successful and appropriate, expand spawning habitat																	
Big Question 6: Population Augmentation																	
Level 1																	
C1 Engineering feasibility hatchery needs, facilities, operations																	
C2 Retrospective study survival linked to hatchery operations																	
C3 Simulation models, population sensitivity to size, health, genetics																	
Level 2																	
C4 Field experiments (TBD from Basin-Wide Stocking & Augmentation Plan)																	
Level 3																	
Stocking																	
Big question 7: Fish Condition																	
Level 1																	
Specific activities TBD																	
Technical Development: Modeling and Monitoring Needs																	
Adaptive design and optimization of population monitoring																	
Continued integration and refinement of population model																	
Research: contingency, outreach, reporting																	
Research contingency for basic science, surprises																	
Reporting and outreach																	

Figure 65. Current schedule for implementation of actions in the Lower Missouri River, revised from USFWS and USACE (2015) to reflect the preferred alternative and current USFWS priorities and timelines, and described in section 4.2.6 of this report. Arrows represent flexibility in the timing of implementation. This figure is an illustration of the intended implementation schedule. There may be further adjustments in the schedule. In-river actions at Level 2 and Level 3 are shown in bolded blue text. Changes since AMP V6 are shown in light blue.

4.4 Monitor

There are 3 types of monitoring that need to be conducted as the AM Plan proceeds:

- Implementation Monitoring – did the action get successfully completed as intended?
- Action Effectiveness Monitoring – is there a biological and/or habitat response that has the potential to increase survival or appropriately inform the next Level of implementation towards achieving increased survival?
- Population Monitoring – is age-1 recruitment occurring, the population growing, and attaining the right size?

Foundational research is required at Level 1 to support all three forms of monitoring, including the design of new protocols, the establishment of monitoring hardware such as stationary telemetry networks, and the development of models and power analyses to test out monitoring protocols and experimental designs.

Implementation monitoring is essential to determine if intended actions did in fact occur. This is important to document compliance and essential for cause-effect evaluations of action effectiveness. Scientists need to know where and when a given type of action was present in order to assess whether pallid sturgeon might have been exposed to the effects of that action.

Appendix D describes the proposed revisions to current protocols for population monitoring, replacing a catch per unit effort approach with a mark-recapture approach. Population monitoring is a complex issue which will need further review. As explained in Appendix D (section B.1.3), and to be further tested by Level 1 research, there are three broad reasons for improving the current methods of population monitoring:

5. Current methods of population monitoring rely on catch per unit effort (CPUE), which is confounded by by factors that affect catchability, like changes in flow, does not provide accurate data for model calibration, and in the Lower Missouri River is poorly correlated with trends in stocking of hatchery fish;
6. Mark-recapture estimates of various life history stages will provide much better estimates of survival rates and abundance for use in the collaborative population model, which will be used to assess the potential population-scale benefits of Level 2 and Level 3 actions. The model will also be used in the revised design of the population monitoring protocol, so that the monitoring protocol and model structure will be well integrated.
7. Accurate estimates of population size will be an important input to decisions on stocking (which need to account for density dependence, and use population

abundance as an integrative measure of the effectiveness of stocking), and ultimately on recovery (which requires an estimate of the population size, not just its trend).

Appendix E contains references to the current design for monitoring the effectiveness of actions. Table **62** summarizes the effectiveness monitoring activities that relate to the actions described in sections 4.2.5 and 4.2.6.

4.5 Evaluate

4.5.1 Evaluation Methods

Table 63 through Table 67 summarizes the proposed methods to evaluate the effectiveness of various actions using the more specific and testable hypotheses summarized in Appendix E.

1
2[illegible]

Table 63. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of interception and rearing complexes.

H#	Testable hypotheses	Data analysis	Performance metrics
H1	Catches of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.	Staircase-design Before-After-Control-Impact (BACI) analysis	<ul style="list-style-type: none"> Mean CPUE of age-0 sturgeon per site
H2	The stomach content of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.	Staircase-design Before-After-Control-Impact (BACI) analysis	<ul style="list-style-type: none"> Mean % empty stomachs per site
H3	The percent lipid of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.	Staircase-design Before-After-Control-Impact (BACI) analysis	<ul style="list-style-type: none"> Mean % lipid of captured age-0 sturgeon per site
H4	The length distribution of age-0 sturgeon within river bends that include IRC habitat restoration sites increase relative to control sites after habitat restoration actions.	Staircase-design Before-After-Control-Impact (BACI) analysis	<ul style="list-style-type: none"> Length-at-date distribution of age-0 sturgeon per site
H5	The hydrodynamics of the river bends that include IRC sites increase the percent change in interception relative to control sites after IRC construction.	Comparison of particle tracking model before and after IRC construction	<ul style="list-style-type: none"> Mean CPUE of age-0 sturgeon per site Modelled results for interception from the Particle Tracking Model
H6	The hydrodynamics of the river bends that include IRC sites provide an increase in the percentage of acre-days of foraging habitat, defined as areas with 0.5 – 0.7 m/s velocity and 1-3 m depth, relative to control sites after IRC construction.	Comparison of 2-D model before and after IRC construction, and compared to control	<ul style="list-style-type: none"> Modelled results for 2D hydrodynamic models based on surveys of geomorphology, depths, and velocities
H7	The hydrodynamics of the river bends that include IRC sites provide an increase in the percentage of acre-days of food-producing habitat, defined as areas where velocity is less than 0.08 m/s, relative to control sites after IRC construction.	Comparison of 2-D model before and after IRC construction, and compared to control	<ul style="list-style-type: none"> Modelled results for 2D hydrodynamic models based on surveys of geomorphology, depths, and velocities
H8	There is a relationship between age-0 CPUE (and other biological metrics) and physical habitat measures of interception rate, the area of food producing habitat, and the area of foraging habitat.	Regression model relating biological response variables to physical response variables	<ul style="list-style-type: none"> Mean CPUE of age-0 sturgeon per site Mean % empty stomachs per site Mean % lipid of captured age-0 sturgeon / site Length-at-date distribution of age-0 sturgeon per site Modelled results for 2D hydrodynamic models based on surveys of geomorphology, depths, and velocities

Table 64. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of modifications to shallow water habitats.

H#	Testable hypotheses	Data analysis	Performance metrics
H1	Catches of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.	Staircase-design Before-After analysis	<ul style="list-style-type: none"> Mean CPUE of age-0 sturgeon per site
H2	The stomach contents of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.	Staircase-design Before-After analysis	<ul style="list-style-type: none"> Mean % empty stomachs per site
H3	The percent lipid of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.	Staircase-design Before-After analysis	<ul style="list-style-type: none"> Mean % lipid of captured age-0 sturgeon per site
H4	The length distribution of age-0 sturgeon within SWH-IRC sites increase relative to pre-modification conditions.	Staircase-design Before-After analysis	<ul style="list-style-type: none"> Length-at-date distribution of age-0 sturgeon per site
H5	The hydrodynamics within SWH-IRC sites increase the proportion of free embryos that exit the channel thalweg relative to pre-modification conditions.	Comparison of particle tracking model before and after SWH modification	<ul style="list-style-type: none"> Mean CPUE of age-0 sturgeon per site Modelled results for interception from the Particle Tracking Model
H6	The hydrodynamics within SWH-IRC sites provide an increase in the number of acre-days of foraging habitat, defined as areas with 0.5 – 0.7 m/s velocity and 1-3 m depth, relative to pre-modification conditions.	Comparison of 2-D model before and after SWH modification	<ul style="list-style-type: none"> Modelled results for 2D hydrodynamic models based on surveys of geomorphology, depths, and velocities
H7	The hydrodynamics within SWH-IRC sites provide an increase in the number of acre-days of food-producing habitat, defined as areas where velocity is less than 0.08 m/s, relative to pre-modification conditions.	Comparison of 2-D model before and after SWH modification	<ul style="list-style-type: none"> Modelled results for 2D hydrodynamic models based on surveys of geomorphology, depths, and velocities
H8	There is a relationship between age-0 CPUE (and other biological metrics) and physical habitat measures of interception rate, the area of food producing habitat, and the area of foraging habitat.	Regression model relating biological response variables to physical response variables	<ul style="list-style-type: none"> Mean CPUE of age-0 sturgeon per site Mean % empty stomachs per site Mean % lipid of captured age-0 sturgeon / site Length-at-date distribution of age-0 sturgeon per site Modelled results for 2D hydrodynamic models based on surveys of geomorphology, depths, and velocities

1 Table 65. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of spawning habitat projects.

H#	Hypothesis	Data analysis	Response metrics
H1	Optimal spawning conditions, according to best available knowledge (substrate, hydraulics, and geometry), are created.	Transect data on depth, velocity, and substrate will be used to generate a detailed Digital Elevation Map, a gridded map of depth averaged velocity, and a substrate patch map for constructed habitat. These data will be used to evaluate habitat creation metrics.	<ul style="list-style-type: none"> Success in achieving design purpose
		Each constructed feature will then be assessed in terms of whether it achieves its intended designed purpose. This could be documented as a simple Y/N or rated on a scale (e.g., 1-5). This is intended to evaluate effectiveness of particular features of the constructed site at a scale smaller than the site (e.g., a particular section of revetment).	
H2	Created spawning habitat (substrate, hydraulics, and geometry) are maintained under prevailing conditions.	Suitable habitat defined in terms of depth, velocity, and substrate for the entire site at index flows to allow comparisons over time.	<ul style="list-style-type: none"> Area of suitable habitat
		Substrate type would be categorized into 8 broad groups and then mapped throughout the constructed site, first using imagery techniques and then validated through sediment samples. Resurveys of topography and substrate would indicate stability at the site and potential for egg disturbance or burial. Analysis would involve evaluating changes in maps of substrate conditions over time.	<ul style="list-style-type: none"> Substrate condition
H3	The relative density of reproductive fish (pallid sturgeon or other species) at the constructed site is greater than at control sites	Comparison of the relative density (or presence / absence) of spawning by other species at constructed site compared to control sites.	<ul style="list-style-type: none"> Number of reproductive fish from other species (presence/absence; count; CPUE)
		Comparison of the relative density (or presence / absence) of pallid sturgeon spawning at constructed site compared to control sites.	<ul style="list-style-type: none"> Number of reproductive pallid sturgeon (presence/absence; count; CPUE)

H#	Hypothesis	Data analysis	Response metrics
H4	The proportion of tagged reproductive pallid sturgeon adults that select the constructed site over the control sites is greater, when corrected for the relative availability of each.	Total number of times a spawner encounters the constructed site.	• Encounter frequency
		Total length of time a spawner spends in the vicinity of the constructed site.	• Residence time
		The proportion of tagged spawners that aggregate at the constructed vs. control sites.	• Aggregation rate
		The proportion of tagged spawners that aggregate at the constructed compared to control sites.	• Spawning rate
H5	Aggregations of reproductive adults occur at the constructed spawning habitat.	Count of the number of fish in close proximity to the constructed habitat. Aggregation defined as observations of 3 or more fish.	• Presence of aggregation
		Number of distinct aggregations that form through the season in close proximity to the constructed habitat.	• Number of aggregations
		Tally of the maximum number of reproductive pallid sturgeon observed in any given aggregation.	• Size of aggregation
H6	Spawning events are observed at the constructed spawning habitat.	Any evidence of a spawning event within the constructed site.	• Presence of spawning
		The number of females observed to have spawned at the constructed site.	• Number of spawning events
H7	Viable free embryos are found at or immediately downstream of the constructed spawning habitat.	The presence of at least one viable embryo of known parentage (known male only, known female only, or both known) immediately downstream of a documented spawning event at the constructed site.	• Presence of viable embryos
		Presence of at least one viable embryo of hybrid parentage immediately downstream of a spawning event at the constructed site.	• Presence of viable hybrid embryos
H8	Viable offspring age-0 or older can be linked to spawning events at the constructed habitat.	Confirmation of any offspring that can be genetically linked to a documented spawning event at the constructed site.	• Presence of offspring
		The number of viable pallid sturgeon / shovelnose sturgeon hybrid embryos detected in the Lower Missouri River. This number should be corrected for effort if effort is not standardized across years.	• Presence of hybrid embryos

1 Table 66. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of spawning cue pulses.

H#	Testable Hypothesis	Data analysis	Explanatory metrics	Response metrics
H1	There is a significant correlation between directional movements of reproductive males and females and attributes of river flows.	<p>The general structure of the analysis is similar across focal questions and testable hypotheses. In each case a hypothesis will be tested using multiple regression analysis. Response metric(s) differ for each hypothesis but the explanatory metrics are consistent across hypotheses. Candidate explanatory metrics and candidate response metrics are proposed to the right. Several analytical tools are available for the analysis which include the following:</p> <ul style="list-style-type: none"> • Generic regression analysis • Principle Components Analysis • Kolmogorov-Smirnov Goodness of Fit 	<p><u>Physical characteristics</u></p> <ul style="list-style-type: none"> • Total flow • Substantive spring pulse • Spring pulse - rate of change • Spring pulse – peak flow • Spring pulse - water source • Temperature disruption • Temperature threshold • Conductivity or turbidity <p><u>Biological characteristics</u></p> <ul style="list-style-type: none"> • Reproductive status • Migrant type • Reproductive experience • Sex • Density <p><u>Random effects</u></p> <ul style="list-style-type: none"> • Year • Individual differences between fish 	<ul style="list-style-type: none"> • Migration type • Migration initiation • Total distance • Total time • Maximum upstream position
H2	There is a significant correlation between aggregations of reproductive males and females and attributes of river flows.			<ul style="list-style-type: none"> • Number of aggregations • Aggregation participation • Size of aggregations
H3	There is a significant correlation between the number of successful spawning events and attributes of river flows			<ul style="list-style-type: none"> • Successful spawning • Number spawned
H4	There is a significant correlation between the spatial distribution of spawning and attributes of river flows. ¹			<ul style="list-style-type: none"> • Distance between aggregations • Distance between spawning events
H5	There is a significant correlation between the temporal distribution of spawning and attributes of river flows. ¹			<ul style="list-style-type: none"> • Timing of migration • Timing of aggregations • Persistence of aggregations
H6	Viable embryos are found at or immediately downstream of confirmed spawning locations.			<ul style="list-style-type: none"> • Presence of viable embryos • Presence of hybrid embryos
H7	There is a significant correlation between the number of age-0 pallid sturgeon and attributes of river flows.			<ul style="list-style-type: none"> • Number of viable embryos • Number of hybrid embryos

¹ Kolmogorov Smirnov Goodness of Fit tests may be useful to compare spatial and temporal distributions as an alternative approach to evaluating H4 and H5.

1 Table 67. Summary of testable hypotheses, analytical approaches, and performance metrics for evaluating effectiveness of passage at Intake Diversion
2 Dam.

H#	Testable Hypotheses	Data Analysis	Performance metrics
H1	Physical performance of bypass channel at Intake Diversion Dam is compliant with physical success criteria	Analysis of variance (ANOVA) comparing the mean of observed depth and velocity conditions to the success criteria. Across season also calculate percentage of time and locations successfully meeting criteria.	<ul style="list-style-type: none"> • Depth • Velocity • Flow • Cross-section profile
H2	Biological performance of bypass channel at Intake Diversion Dam is compliant with biological success criteria	<p><u>Attraction and passage:</u> Calculate passage efficiency (with estimated variance) based on attraction efficiency and passage success. Compare passage to success criterion.</p> <p><u>Adult movement:</u> Calculate velocity for each tagged adult through bypass channel. Compare to success criterion. Across season calculate percentage of adults meeting success criterion.</p> <p><u>Adult / juvenile mortality:</u> Compare mortality (with estimated variance) to success criteria for bypass and weir.</p>	<ul style="list-style-type: none"> • Fish ID • Fish condition • Sex • Reproductive stage • Movement of tagged adults passing points along telemetry network
H3	Spawning event occurs at a location that provides sufficient drift distance to support development and survival of free embryos into exogenously feeding larvae	Generate a cumulative distribution function (CDF) using the advection / dispersion and development rate / drift distance models to representing likelihood of successful free embryo drift and development at different river mile locations. Plot river miles of observed / identified spawning against CDF to determine likelihood of successful drift and development.	<ul style="list-style-type: none"> • Fish ID • Fish condition • Sex • Reproductive stage • River mile location • Movement of tagged adults passing points along telemetry network • Aggregation and spawning behavior • Water temperature • Discharge • Turbidity • High resolution maps of spawning locations (hydraulic and bed conditions)
H4	Spawners aggregate in sufficient numbers to initiate spawning	Sum of the number and sex of tagged individuals at each spawning location.	<ul style="list-style-type: none"> • Fish ID • Fish condition • Sex • Reproductive stage • River mile location • Movement of tagged adults passing points along telemetry network • Aggregation and spawning behavior

H#	Testable Hypotheses	Data Analysis	Performance metrics
H5	Spawning event leads to the successful release of fertilized eggs	Qualitative interpretation of DIDSON acoustic imagery of individuals at a spawning site, with results from ultrasound of female spawners, and comparison of pre- and post-spawning weight.	<ul style="list-style-type: none"> Fish ID 2D / 3D location Movement, aggregation and spawning behavior Spawning outcome
H6	Viable embryos are detected immediately downstream of a known spawning event at identified spawning patches	Sum of total and surviving number of free embryos captured downstream of a spawning location and genetic analysis of these free embryos for species identification.	<ul style="list-style-type: none"> Number of free embryos Genetic ID Basic physical habitat / site characteristics
H7	Hatchery releases of free embryos and/or larvae are detected alive downstream of Intake Diversion Dam	Sum of total and surviving number of free embryos captured downstream of bypass channel and concrete weir at Intake Diversion Dam with genetic analysis to confirm species and hatchery origin.	<ul style="list-style-type: none"> Number of free embryos Genetic ID Basic physical habitat / site characteristics
H8	Apparent mortality of hatchery released free embryos and/or larvae drifting over the weir and through the bypass channel is the same or lower than natural apparent mortality of hatchery released free embryos and/or larvae in the Yellowstone River	Estimate mortality effect based on proportion of dead vs. total number of free embryos captured downstream of release locations, after adjusting for the effect of gear mortality.	<ul style="list-style-type: none"> Number of free embryos Genetic ID Basic physical habitat / site characteristics
H9	Wild produced age-0 and juvenile pallid sturgeon are detected in the Yellowstone, Missouri Rivers, or flowing reaches of Lake Sakakawea	Sum of the total and surviving number of wild age-0 pallid sturgeon captured downstream of Intake Diversion Dam in the Yellowstone or upper Missouri Rivers and genetic analysis to confirm species and parentage.	<ul style="list-style-type: none"> Location and number of age-0 individuals Genetic ID Basic physical habitat / site characteristics
H10	Wild produced age-0 and juvenile pallid sturgeon detected in Yellowstone or upper Missouri Rivers originate from spawners known to migrate upstream past Intake Diversion Dam	Sum of the total and surviving number of wild age-0 pallid sturgeon captured downstream of Intake Diversion Dam in the Yellowstone or upper Missouri Rivers and genetic analysis to confirm species and parentage.	<ul style="list-style-type: none"> Location and number of age-0 individuals Genetic ID Basic physical habitat / site characteristics

4.6 Decide

Table 41 (from USFWS and USACE 2015) outlined a series of 5 questions relevant to decisions regarding each of the factors reviewed in the EA, and whether actions associated with this factor should be implemented at Level 3:

- Is this factor limiting pallid sturgeon reproductive and/or recruitment success?
- Are pallid sturgeon needs sufficiently understood with respect to this limiting factor?
- Do one or more management action(s) exist that could, in theory, address these needs?
- Has it been demonstrated that at least one kind of management action has a sufficient probability of satisfying the biological need?
- Have other biological, legal, and socioeconomic considerations been sufficiently addressed to determine whether or how to implement management actions to Level 3?

At a somewhat broader level, there are three major categories of decisions on pallid sturgeon (summarized in Figure 54):

- A. Is there enough evidence at Level 1 to proceed with an action at Level 2?
- B. Is there enough evidence at Level 1 and Level 2 to proceed with an action at Level 3?
- C. Have time limits been reached for implementation of Level 3 actions?
- D. Is there enough evidence at Level 3 to proceed with an action at Level 4?






The evidence that is used for these decisions includes metrics and decision criteria specific to a single action as well as the accumulating evidence of the relative amount of support for multiple actions. An overview of decision criteria is provided in Figure 54. Metrics and decision criteria pertaining to single actions can be found in Appendix C, as well as in Table 43 and Table 44 for decisions in categories A and B. Decisions related to single actions for categories B and C are discussed in the sub-sections on Metrics and Decision Criteria in Sections 4.2.5 and 4.2.6. For evidence on the relative amount of support for multiple actions, this chapter also includes decision trees for recruitment in the Upper Missouri River (Figure 51), recruitment in the Lower Missouri River (Figure 52), and spawning habitat (Figure 63). The collaborative population model (described in Appendix D) will be used to integrate information from Level 1 through 3 studies to provide rank order estimates of the relative benefits of different actions in helping with the recovery of pallid sturgeon.






Evidence is largely about understanding cause and effect. That is, does the cause of implementing an action (or multiple actions) to improve reproduction, growth or survival of pallid sturgeon have a measurable and desired effect on one or more life

history stages? How strong is the overall weight of evidence from multiple sources? Previous studies that have retrospectively assessed multiple lines of evidence for potential causes of changes in biota (Forbes and Callow 2002; Burkhardt-Holm and Scheurer 2007, Diefenderfer et al. 2011, Marmorek et al. 2011) have generally looked at four different factors: (1) a *plausible mechanism* by which the cause could create a biological effect (which makes sense scientifically); (2) the biota are *exposed* to the causative factor (i.e., the cause overlaps the distribution of the species in space and time) ; (3) changes in biota are *correlated in space and time* with the causative factor; and (4) there is *experimental evidence* that the causative factor can create the hypothesized effect (e.g., from laboratory, mesocosm or field experiments, or natural events that are opportunistic experiments). Diefenderfer et al. 2016 provide a more comprehensive conceptual framework for evaluating the evidence for cumulative effects in areas subjected to ecosystem restoration actions.

Table 68 more specifically summarizes the focal questions for deciding whether to move from a Level 2 action to a Level 3 action, and whether to move from Level 3 to Level 4 (i.e., decision categories B and C). These focal questions are presented in the ‘Decision Criteria’ parts of sections 4.2.5 and 4.2.6, and would be informed by the more specific and testable hypotheses that will be evaluated for each action (described in more detail in Appendix E). The colored columns to the right of Table 68 show five possible answers to each question, drawn from the approach used in the Platte River Recovery Implementation Program (PPRIP 2014), and similar to other approaches used for weight of evidence syntheses (e.g., Peterman et al. 2010, Marmorek et al. 2011). Details on decision criteria are provided in the sections listed in the first column of Table 68. Chapter 2 of this AMP describes the governance process for the Missouri River Management Plan and how the emerging evidence will specifically be considered by different entities.

Table 68. Summary of focal questions to be applied to the currently proposed set of actions in Section 4.2.5 and 4.2.6. Hypotheses listed in first column are those most relevant to the action, as discussed in section 4.2. The sections listed in the first column provide more details on the decision criteria for each action.

Level 2 / 3 Action [Hypothesis]	Focal Questions	Answers				
		Clearly NO. 	Likely NO. 	Incon- clusive 	Likely YES. 	Clearly YES. 
Fish Passage Improvement at Intake Diversion Dam [H7] Decision criteria: section 0	Q1: Do adult and juvenile pallid sturgeon successfully move upstream / downstream past Intake Diversion Dam and through the bypass channel?					
	Q2: Does the location of spawning provide sufficient drift distance to allow the development of drifting free embryos into exogenously feeding larvae?					
	Q3: Does successful spawning (aggregation-fertilization) occur?					
	Q4: Does successful reproduction (incubation-viable embryos) occur?					
	Q5: Do free embryos, larvae, and young-of-year successfully move downstream past Intake Diversion Dam and through the bypass channel?					
Interception and Rearing Complexes (IRCs) [H17, H18, H19] Decision criteria: section 4.2.6.2.6	Q1: Within river bends that include IRC habitat restoration sites, does catch per unit effort (CPUE) and growth of age-0 sturgeon increase relative to control sites, and pre-construction conditions?					
	Q2: Do the hydrodynamics of river bends that include IRC sites increase: (a) the proportion of free embryos that exit the channel thalweg after IRC construction, (b) the area of foraging habitat, and (c) the area of food-producing habitat, relative to pre-construction conditions?					
Modifications to existing SWH projects [H17, H18, H19] Decision criteria: section 4.2.6.3.6	Q1: Within modified SWH sites, do catches (CPUE) of age-0 sturgeon increase relative to pre-modification conditions?					
	Q2: Do the hydrodynamics of modified SWH sites increase: (a) the proportion of free embryos that exit the channel thalweg, (b) the area of foraging habitat, and (c) the area of food-producing habitat, relative to pre-modification conditions?					

Level 2 / 3 Action [Hypothesis]	Focal Questions	Answers				
		Clearly NO. 	Likely NO. 	Incon- clusive 	Likely YES. 	Clearly YES. 
Spawning habitat projects [H16] Decision criteria: section 4.2.6.4.6	Q1: Can suitable spawning habitat be created and maintained without further intervention?					
	Q2: Are created spawning habitats selected over other areas?					
	Q3: Does successful spawning (aggregation-fertilization) occur in the created spawning habitats?					
	Q4: Does successful reproduction (incubation-viable embryos) occur in the created spawning habitats?					
Spawning cue pulses [H11] Decision criteria: section 4.2.6.5.6	Q1: Are there attributes of river flow that are strongly correlated with upstream movement of reproductive male and female pallid sturgeon?					
	Q2: Are there attributes of river flow that are strongly correlated with successful spawning (aggregation-fertilization)?					
	Q3: Are there attributes of river flow that are strongly correlated with synchronous behavior of reproductive male and female pallid sturgeon?					
	Q4: Are there attributes of river flow that are strongly correlated with successful reproduction (incubation, hatch, viable embryos)?					

5 Human Considerations

The purpose of the Missouri River Recovery Program (MRRP) is to fulfill the requirements of the Endangered Species Act (ESA) while minimizing the impacts to Human Considerations (HCs). The Science and Adaptive Management Plan (SAMP) is designed to guide the MRRP implementation process and help achieve the MRRP's purpose.

This chapter discusses how HCs were programmatically addressed during the MRRMP-EIS and how they will be considered and adaptively managed during implementation of the MRRMP.

Section 1 presents a brief **introduction to HCs in Missouri River basin**. It summarizes the range of HCs that may be directly affected by the MRRMP and outlines how HCs were evaluated during the development of the MRRMP-EIS.

Section 2 presents **planning context** related to the Corps' Missouri River responsibilities and authorities. In practice, steps taken to minimize impacts to HCs occur at varying levels of planning, design, construction and maintenance. The degree to which the USACE can minimize impacts to HCs is informed by the basis for and limits of these responsibilities and authorities.

Section 3 discusses how the **specific actions in the preferred alternative could potentially affect HCs**, and how USACE plans to avoid or minimize adverse impacts to the HCs, while fulfilling the requirements of the ESA. Because all impacts may not be avoidable, and more than one HC has the potential to be impacted, there may be tradeoffs to be considered.

Section 4 discusses issues concerning **HCs**, such as:

- SAMP governance and HCs
- Responding to new situations or concerns that arise while implementing the preferred alternative.
- Screening and prioritizing HC monitoring.
- Tradeoffs involving HCs.

5.1 Introduction to HCs related to the MRRP

5.1.1 Brief introduction to HCs in the MR

The Missouri River mainstem flows for over 2,000 miles before merging with the Mississippi River at St Louis. Over this vast length, a wide and diverse range of interests are potentially affected by actions the USACE might consider for the listed species. These interests are discussed in detail in the MRRMP-EIS, and they include:

- A multitude of aquatic and terrestrial habitat types that sustain rich assemblages of fish and wildlife species;
- Although modified, the Missouri River provides a steady flow of ecosystem benefits that sustain life and bestow values for humans;
- USACE has a federal compliance and stewardship responsibility to ensure the preservation and protection of cultural resource sites located on federal lands and for historic properties that may be affected by USACE undertakings;
- Various land uses are present within the Missouri River floodplain, including developed lands, agricultural lands, open water, and other types of use;
- Commercial sand and gravel dredging occurs in the Lower River;
- A main objective of Mainstem Reservoir System is to regulate the reservoirs to reduce the risk of Missouri River flows from contributing to flood damage in the reaches downstream from dams;
- The Missouri River hydropower system contains six USACE facilities with a combined nameplate capacity of 2,500 megawatts (MW);
- Irrigators in 42 counties in Montana, North Dakota, South Dakota, and Nebraska hold permits to use water from the Missouri River for the purpose of agriculture production;
- The navigation channel in the mainstem of the Missouri River stretches 735 miles, from Sioux City, Iowa to St. Louis, Missouri;
- The Missouri River corridor between Fort Peck Lake and St. Louis, Missouri, supports a wide range of water, land, and wildlife-related recreational activities

and is a popular destination for outdoor enthusiasts, attracting millions of visitors each year;

- There are 21 thermal power plants (2 nuclear and 19 coal-fired power plants) located along the mainstem of the Missouri River or its reservoirs;
- Water is withdrawn from the Missouri River and its mainstem reservoirs for multiple purposes including municipal, industrial, and commercial water supply as well as domestic and public uses;
- Several facilities discharge treated wastewater to the Missouri River and its reservoirs;
- The Tribes of the Missouri River basin are diverse in their histories and their perspectives regarding the Missouri River.

5.1.2 The role of HCs during the Management Plan development

Chapters 3 and 4 include summaries of the processes through which proposed actions to be considered for implementation on behalf of the listed species were identified. As discussed in the MRRMP-EIS, various alternative combinations of these actions were iteratively evaluated to explore the balance of benefits to the listed species versus the expected impacts on HCs. The lead agencies employed a modified version of a structured decision-making process called ProACT to assist with the planning and coordination of this MRRMP-EIS. ProACT (an acronym derived from the steps followed in the decision-making process) provides a systematic approach for making decisions. The process as implemented for this MRRMP-EIS involved six steps (Figure 66Figure 52).

First, a **Problem Definition** was identified. The definition used for the MRRMP-EIS was to: “Develop a management plan that includes a suite of actions that removes or precludes jeopardy status for the piping plover, interior least tern, and pallid sturgeon, and that:

- Complies with the authorization requirements from Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007.
- Continues to serve the Missouri River authorized purposes and accounts for human considerations; and

- Includes an EIS and establishes an AM process for implementing the preferred alternative.”

Next, **Objectives** were defined for the ESA species and for HCs. In the PrOACT use of the word, ‘objectives’ refer to statements of the things that matter to people (e.g. ‘minimize impacts to recreation’, ‘minimize impacts to irrigation’ etc) and that should be considered as part of the technical analysis of alternatives.

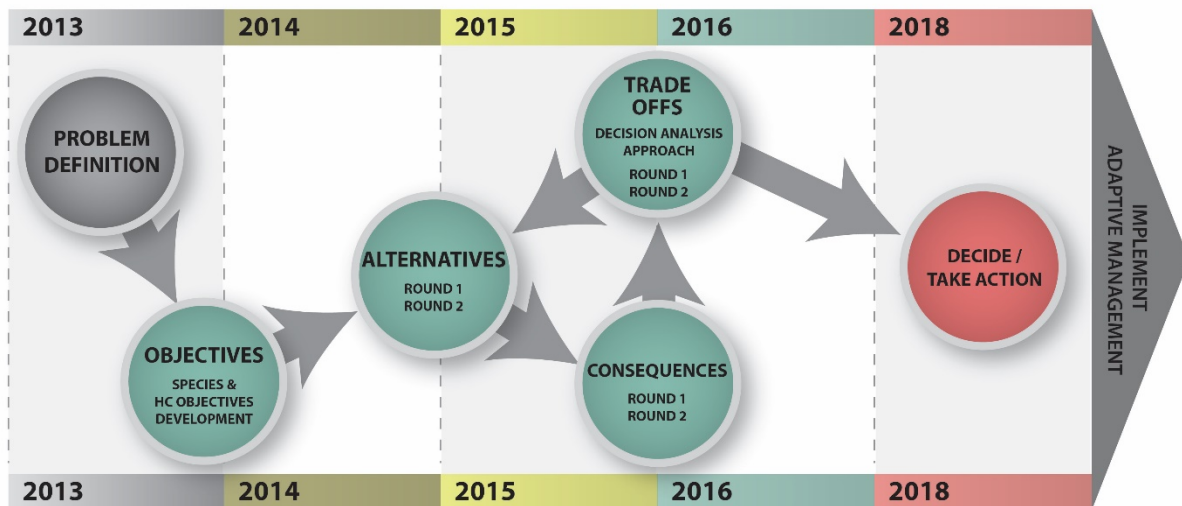


Figure 66. PrOACT process used to identify, evaluate and iterate through alternative suites of actions to identify a preferred alternative

In August 2014, MRRIC reached final consensus on “Human Considerations (HC) Objectives and Performance Metrics” (MRRIC 2014) a 90-page report that detailed how MRRIC would prefer to see potential impacts from alternatives on human considerations expressed. To ensure consistency across other USACE projects, HCs were broadly organized into the four primary accounts of Environmental Quality (EQ), National Economic Development (NED), Regional Economic Development (RED) and Other Social Effects (OSE). Within each account, performance measures for various HCs were outlined, along with flow charts that illustrated how changes in physical components of the system could lead to ultimate outcomes of concern expressed in performance measures.

The Effects Analysis identified and screened a range of management actions, including new operations that might be undertaken to avoid jeopardizing the three federally-protected species. A subset of these actions was incorporated into numerous iterations of **Alternatives** evaluated in the MRRMP-EIS.

The actions considered during this process are discussed in Chapter 2 of the EIS.

The anticipated **Consequences** of each of the alternatives on the objectives were estimated in various ways. In the preliminary stages of alternative formulation, various tools were used to help communicate how alternatives might affect HC interests, including:

Hydrology and Hydraulics Visualization - (H&H) modeling by the USACE resulted in daily stage and flow predictions for several thousand cross sections of the Missouri River mainstem for each alternative. Data were made available to stakeholders for a subset of locations through an interactive spreadsheet tool, HydroViz. With this tool and knowledge of critical flow and stage levels for any given HC, a qualitative comparative assessment of impacts on HCs could be made.

Proxy measures - During all but the final round of alternative development, proxy measures were used to help compare the relative impacts of alternatives. Proxy measures were selected in collaboration with MRRIC (see EIS Chapter 2 and Appendix A: Human Considerations Proxies and Round 1 and 2 Bird Alternative Proxy 2 Results for further discussion of this process). Because most proxies were readily derived from H&H modeling, they could be calculated and summarized within 2-3 weeks of the completion of H&H model runs. In this way, numerous iterations of alternatives could be examined. An important limitation of proxies, however, is that while they are helpful for comparing relative performance across alternatives, they may not provide information on the significance of impacts (e.g. how important is a 14-day reduction in number of days of summer boat ramp access?). Proxy measures were also left unweighted in terms of relative importance across locations, though supplementary information (e.g. number of boat ramps per area) was provided where possible to help inform this consideration.

A summary of the proxies used in the development and screening of initial alternatives is shown in Table 69.

Table 69: Summary of proxies used during the development of the MRRMP-EIS

Resource Area	Proxies considered
Commercial Sand and Gravel	Average annual change in sediment accumulation rate at St. Joseph, Kansas City, and Hermann
Cultural Resources	Days and site-days of greater-than-normal erosion and/or exposure risk in reservoir and river reaches.
Fish and Wildlife	Change in Aquatic/Floodplain Habitat Classes along the mainstem Acres of wetland habitat classes along the mainstem Number of occurrences of flows below 9,000 cfs (thought to be associated with dewatering) in the Ft Randall to Lewis and Clark Lake reach
Flood Risk and Interior Drainage	Days of flood stage exceedance Days of flood stage +5' exceedance Interior drainage flapgate elevation exceedance
Hydropower	Annual seasonal generation (MWh) Seasonal generational value (\$) Seasonal maximum capacity (MW)
Irrigation	Number of days outside normal operating conditions during the irrigation season by county
Property Tax Base	Number of acres that would be acquired by the Federal Government, as an indicator of lost local tax revenue
Navigation	Number of days at or above full service Number of days above at least minimum service Season Length Service level at Sioux City, Omaha, Nebraska City and Kansas City
Recreation	Number of days of boat ramp operability by season Number of days that upper three reservoirs are at conservation pool, mid-elevation or minimum drought elevation (indicators of conservation and fisheries health) Number of years of "good" fishing success
Thermal Power	Number of days that water intakes are inoperable Number of days that river temperatures exceed thresholds considered to be problematic
Wastewater	Number of days below low flow criteria
Water supply	Number of days outside normal and shutdown operating elevations for numerous municipal, commercial and industrial facilities

Detailed socioeconomic analysis - Finally, six MRRMP-EIS alternatives were evaluated using the detailed analyses described in Chapter 3 of the EIS and accompanying Human Considerations technical reports. Where applicable, the methods used to calculate National Economic Development (NED), Regional Economic Development (RED),

Environmental Quality (EQ) and Other Social Effects (OSE) measures followed USACE guidance (Planning Guidance Notebook ER 1105-2-100).

These model results provided the best available estimates of how management actions might affect HCs for *long term planning purposes*, and were vital in aiding conversations about alternatives during the MRRMP-EIS review process. Detail on how HCs were considered during the development of the preferred alternative can be found in the MRRMP-EIS, along with documentation of the analysis of the predicted impacts of each alternative on the objectives.

At the conclusion of each iteration, the USACE considered the **Trade-offs** associated with each of the alternatives on the objectives, and used the insights gained to redefine the next iteration of alternative definitions. Throughout, the USACE sought and received input from MRRIC.

A draft EIS was issued in December 2016 and public and agency feedback on the methodologies used to evaluate the impacts of alternatives on HCs were received. In many cases, updates were made to the methods and the documentation to address public comments.

5.1.3 Actions for species that could affect HCs

As a result of this process, a preferred alternative was identified for the MRRMP-EIS. A proposed action was described in a Biological Assessment for ESA Section 7 consultation with the USFWS. Following the consultation and receipt of a new Biological Opinion, the EIS was finalized and a Record of Decision (ROD) determined which set of actions may be implemented in the AM program. (This process is described in the MRRMP-EIS). During implementation of the MRRMP, new information acquired about action effectiveness, population dynamics, and system performance may lead to a determination that the actions in the ROD are insufficient and that other actions should be evaluated for future implementation.

This SAMP accompanies the EIS and reflects the preferred alternative, but retains the broader set of management actions and associated decision criteria developed as part of the EIS/SAMP process. There are three categories of actions:

- 1) actions that have been evaluated in the EIS and identified as part of the Preferred Alternative;
- 2) actions evaluated in the EIS but not identified as part of the Preferred Alternative;
- 3) actions not evaluated in the EIS.

Actions in the first category can be implemented at a programmatic level when needed (though see Section 5.2 for further discussion on tiered NEPA authorization). Actions for birds that were evaluated in the EIS and identified as part of the preferred alternative for birds include (see Section 3.2.4):

- In-channel habitat construction
- Flow management to avoid take
- Sandbar augmentation and modification
- Vegetation management
- Predation management
- Human restrictions measures

Actions for pallid sturgeon evaluated in the EIS and identified as part of the preferred alternative include (see Sections 4.2.5):

- Population augmentation
- Mechanical construction of IRC habitat
- Mechanical construction of spawning habitat
- A possible, single test spring pulse flow aimed at learning about the potential of an operation to synchronize pallid sturgeon spawning

Actions in the second category may be implemented but may require supplemental environmental review or compliance depending upon the circumstances. Some of the flow actions in the second and third categories *may* require operations that could be outside the boundaries set by the Master Manual. If so, the Master Manual would need to be adjusted prior to implementation, which could require a public process similar to that followed for the MRRMP-EIS. Guidance on the steps necessary for this to occur is provided in Attachment 9 of Appendix A and is discussed in several sections in Chapter 2.

Some of the actions that are not in the preferred alternative include, for birds (see Section 3.2.4.2):

- Habitat-forming flow releases (Spring and Fall)
- Lowered nesting season flows

Beyond the potential test flow noted above, changes in flow regime for pallid sturgeon recruitment were evaluated in the EIS but are not included in the preferred alternative.

Under the preferred alternative, considerable scientific research efforts are focused on reducing critical uncertainties around the birds and pallid sturgeon, as described in Section 3.1.2 and Section 4.1.2 and detailed in Appendix C and Appendix G.

In response to USFWS feedback on the Biological Assessment, in December 2017 the USACE issued an Amendment that included two additional categories of proposed actions for fish (one concerning investigations potentially leading to the provision of foraging habitat in the lower river, the other concerning investigations potentially leading to actions for fish in the reach downstream of Fort Peck given uncertainty surrounding the Intake Dam fish passage construction). The specifics of these actions and their AM implementation are unknown at the time of writing, and additional NEPA authorizations may be sought as required at a future date.

Section 3 discusses how HCs will be addressed in the implementation of actions in the preferred alternative. However, before detailing these, Section 2 provides some planning context that may help some readers understand some of the implementation issues that may arise from an HC perspective.

5.2 Planning context

- *“Interception rearing complexes for pallid sturgeon could affect dredging potential; is this an issue for this SAMP or is it a Section 404 permitting issue to be determined by Regulatory?”*
- *“I’m concerned about navigational safety issues associated with a particular IRC – where do we talk about this?”*
- *“Tribes have a right to be consulted under Section 106”*
- *“USACE’s activities could affect my issue – therefore I think they should monitor it”*
- *“Bird predator management actions are subject to tiered NEPA”*

Discussions around the AM implementation of the management plan involve an array of technical and planning terms that can create a barrier to engagement. Many of these terms relate to federally-listed species, and these are described in the previous two chapters of this SAMP. However, there are numerous other terms and concepts that relate to the AM implementation and their HC implications that also need to be

understood. A full description of these is outside of the scope of this document, but to partially address this need, this section is provided as a short primer on some of the key operational, planning, and regulatory considerations that guide how the USACE undertakes and discusses its activities in the Missouri River.

Attachment 6.1 of Appendix A contains a short overview of the internal organization of the USACE insofar as this is relevant to understanding roles and areas of responsibility in the Missouri River basin. Since different groups deal with different issues, sometimes with different mandates and methods, it can help to know how, in this sense, the USACE ‘works’.

This appendix also contains a brief summary of how the USACE operates the Missouri River System, highlighting the role of the Master Manual in creating an operational decision-space within which discretion can be used to meet species objectives whilst ensuring that human considerations are generally provided for and negative effects are minimized.

The MRRP is primarily designed to meet the requirements of the Endangered Species Act. However, USACE must also comply with a range of other laws, and in so doing, participate in various processes that have their own requirements for engagement with HC issues. Action implementation issues will often refer to these processes and therefore they represent important planning context with which to be familiar.

5.2.1 National Environmental Policy Act (NEPA)

The USACE must comply with NEPA when planning and implementing actions for listed species. NEPA requires federal agencies to consider the effects of a proposed action on the human environment, including potential impacts on social, cultural, economic and natural resources. The results of the NEPA impacts assessment are considered during agency decision-making.

Figure 67 shows a generalized process for determining the appropriate level of NEPA review that should be undertaken for any proposed action. In complying with NEPA, USACE follows the Council on Environmental Quality (CEQ) regulations for implementing the procedural provisions of NEPA (40 CFR Parts 1500-1508) and USACE Engineer Regulation (ER) 200-2-2, Procedures for Implementing NEPA.

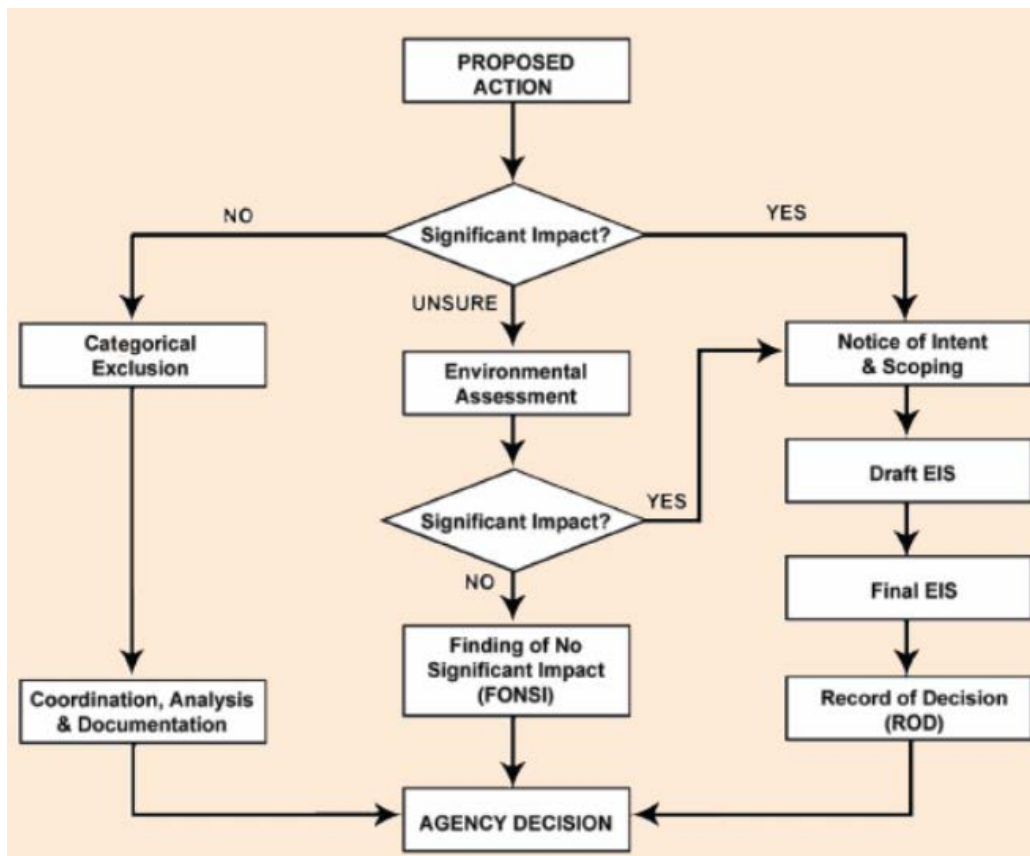


Figure 67: NEPA process flowchart

Categorical Exclusions

A first question in the NEPA process concerns whether a 'significant' impact may be associated with the action. A "Categorical Exclusion" refers to actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. Categorical Exclusions applicable to USACE activities are specified in ER 200-2-2.

Environmental Assessments

If it is unclear as to whether a significant impact might occur, an Environmental Assessment is undertaken. This is sometimes abbreviated to EA, though in our context care must be taken to avoid confusion with the Effects Analysis process followed for the birds and fish, also abbreviated as EA.

EAs have expectations for public involvement based on the magnitude of the proposed action, extent of anticipated public interest, the urgency of the proposal etc. Best practices for conducting EAs include opportunities for robust Tribal and public participation.

If, as an outcome of the EA, the agency determines that the action will not have significant environmental impacts, the agency will issue a Finding of No Significant Impact (FONSI). A FONSI is a document that presents the reasons why the agency has concluded that there are no significant environmental impacts projected to occur upon implementation of the action.

Environmental Impact Statements

If the EA determines that the environmental impacts of a proposed Federal action will be significant, an Environmental Impact Statement is prepared. If a Federal agency knows the proposed action is likely to have significant impacts, it can initiate the EIS process without having first prepared an EA. The regulatory requirements for an EIS are more detailed and rigorous than the requirements for an EA. The components of an EIS are described here:

<https://www.epa.gov/nepa/national-environmental-policy-act-review-process>

If an agency makes substantial changes to the proposed action that are relevant to its environmental concerns, or if there are significant new circumstances or information relevant to the environmental effects that have bearing on the proposed action or its impacts, the agency may issue a supplement to the EIS.

5.2.1.1 NEPA Tiering

A “programmatic” EIS is a strategic approach to meeting an agency’s NEPA responsibilities in a cost effective, streamlined manner. Due to the nature of the interrelated federal actions on the Missouri River, a programmatic EIS enables USACE to ‘tier’ future project proposals from the overarching programmatic EIS analysis, helping to streamline environmental reviews in the future. Tiering, as defined by the CEQ regulations, is covering “general matters” in policy or program EISs with subsequent tiered or narrower environmental analyses, while referencing the general discussion and focusing on the project-specific impacts important to the decision maker.

The MRRMP-EIS is a programmatic approach to NEPA. A programmatic EIS allows managers to make decisions more rapidly to change federal actions when monitoring indicates that objectives are not being met, thus strengthening the implementation of an

AM plan. Implementation of specific plans or management actions may require subsequent analysis that can be tiered from this EIS. Additional NEPA analysis would likely be required if the AM process identifies a need for an action that was not included within the range of impacts and alternatives considered in this EIS or new and significant information affecting the decision and relevant to environmental concerns.

For some actions, no further NEPA assessment would be necessary (e.g. human restriction measures, PSPAP, monitoring). For other actions, a tiered or separate NEPA review may be completed prior to implementation, which would examine individual projects or actions in greater detail and at a site-specific scale.

The consideration of HCs as part of planning and implementing fish and bird management actions thus spans multiple spatial and temporal scales:

- At the broadest scale, potential HC impacts are described in the MRRMP-EIS. Combined impacts of the various management actions are analyzed across a broad geographic area using metrics and methodologies appropriate to this scale.
- At the project-level, the potential relevant HC impacts of a proposed management action are explored as part of a site-specific NEPA evaluation. Detailed modelling may be undertaken if necessary to understanding site-specific HC impacts.

In the preferred alternative, most of the actions undertaken for birds and fish are covered by EAs that are tiered to pre-existing programmatic NEPA documents. Future ESH construction activities will be tiered from the MRRMP-EIS. An example of a tiered site-specific EA is the Searcy Bend Environmental Assessment, which will be discussed further in Section 3.

5.2.2 Other Important Laws and Regulations

Although arguably the most relevant for the present discussion, NEPA is only one of many environmental laws that determine the practices and processes through which effects of actions taken for the species are considered in terms of their HC effects.

Implementation of management actions for the ESA-listed species must comply with a range of other laws of relevance to HCs, some of which have their own processes that, whilst for good reasons separate, nevertheless serve complicate efforts to centralize and co-ordinate efforts to adaptively manage for human considerations. The box below (abridged from a fuller discussion in the MRRMP-EIS) summarizes some of the key environmental laws that the USACE must comply with when implementing actions for the listed species; most of these involve their own established interactions between the

USACE, Tribes, other agencies and stakeholders. This may give rise to questions as to whether potential interactions between an action and HCs are suitable for discussion by the HC Work Group or are more appropriately addressed as part of another regulatory process or forum. This is discussed further in Section 5.4.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) (16 USC 661 et seq.) requires federal agencies to coordinate with USFWS or the National Marine Fisheries Service and appropriate state wildlife agencies to avoid or minimize adverse impacts of federal actions that propose to modify any stream or water body. Modification of a stream or water body includes impoundment, diversion, and deepening of channels. USACE has coordinated with USFWS and various state wildlife agencies throughout the development of the draft MRRMP-EIS and has received and incorporated planning aid letters (Appendix B) into the development of this draft MRRMP-EIS.

Clean Water Act

The objective of the Clean Water Act (CWA) (33 USC 1251 et seq.), as amended, is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. USACE regulates discharges of dredge or fill material into waters of the United States pursuant to Section 404 of the CWA. This permitting authority applies to all waters of the United States including water deemed jurisdictional by virtue of possession of a significant nexus with traditionally navigable waters. The selection of disposal sites for dredged or fill material is done in accordance with the Section 404(b)(1) guidelines, which were developed by the U.S. Environmental Protection Agency (USEPA) (40 CFR Part 230). Section 401 of the CWA allows states to grant or deny water quality certification for any activity that results in a discharge into waters of the United States and requires a federal permit or license.

Executive Order 11988 Flood Plain Management

This order requires federal agencies to evaluate the potential effects of their actions on floodplains and to consider alternatives to avoid or minimize impacts. This requirement applies to the following actions: (1) acquiring, managing, and disposing of federal lands and facilities; (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (16 USC 470) requires federal agencies to evaluate the effects of federal undertakings on historical, archeological, and cultural resources. To do this, USACE must identify any district, site, building, structure, or object that is located in or near the project area, and is included in or eligible for inclusion in the National Register of Historic Places. In addition to ongoing coordination, the USACE Omaha District has developed a programmatic agreement in consultation with Tribes, THPOs, SHPOs, agencies, and interested parties to address problems associated with cultural and historic resource impacts involved with the ongoing operation and maintenance of the Missouri River System. Additionally, all construction management actions implemented under the management plan will be coordinated with the appropriate THPO and/or SHPO and will be constructed on lands owned in fee title by the federal government, therefore, all federal cultural and historical protection laws will apply to construction projects. Any future actions will be undertaken with the processes outlined and identified in the programmatic agreement (PA) and in compliance with Section 106 of the NHPA. The Kansas City District is planning to consult on the development of a PA in the lower basin of the Missouri River from Rulo to the Mouth.

Other relevant Cultural Resources and Heritage laws include

- Archaeological Resources Protection Act
- Native American Graves Protection and Repatriation Act
- American Indian Religious Freedom Act
- Executive Order 13007 Indian Sacred Sites

Farmland Protection Policy Act

The Farmland Protection Policy Act (7 USC 4201, et seq.) requires federal agencies to coordinate with the USDA to develop criteria for identifying the effects of federal programs on the conversion of farmland to non-agricultural uses.

Rivers and Harbors Act

The Rivers and Harbors Appropriation Act of 1899 (33 USC 1344) prohibits obstruction or alteration of any navigable water of the United States. The purpose of the act was to preserve the public right of navigation and prevent interference with interstate and foreign commerce unless authorized by Congress and approved by the Chief of Engineers and Secretary of the Army. The Missouri River is designated a navigable water under the Rivers and Harbor Act.

Actions implemented as part of the Management Plan are not likely to impact navigation because each project will be designed to avoid impacts to the authorized purposes including navigation. Prior to any site-specific construction project, a NEPA analysis will be completed and monitoring will be conducted to detect any issues such as shoaling in the navigation channel. If issues are detected then adjustments will be made to restore the authorized 9-foot- deep by 300-foot-wide navigation channel.

Wild and Scenic Rivers Act

The Missouri River National Recreational River (MNRR) 59-mile and 39-mile reaches were designated in 1978 and 1991 under the Wild and Scenic Rivers Act. The 39-mile segment extends from Fort Randall Dam to Running Water, South Dakota, along with the lowest 20 miles of the Niobrara River and ten miles of Verdigre Creek. The 59-mile segment of the MNRR starts at Gavins Point Dam and ends near Ponca State Park, Nebraska. The Wild and Scenic Rivers Act (16 USC 1278 et seq.) states that certain rivers of the nation, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. Under the Wild and Scenic Rivers Act, a federal agency may not carry out actions that would have a direct and adverse effect on the free-flowing, scenic, and natural values of a federally designated wild or scenic river. If the action would affect the free flowing characteristics of a designated river or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the area, such activities should be undertaken in a manner that would minimize adverse impacts and should be developed in consultation with the National Park Service (NPS). Currently USACE is undergoing Wild and Scenic Rivers Act consultation with NPS as part of the development and preparation of the Management Plan.

Federal Water Project Recreation Act

The Federal Water Project Recreation Act (16 USC 4612 et seq.) requires federal agencies to give full consideration to outdoor recreation and fish and wildlife enhancement in the investigating and planning of any federal navigation, flood control, reclamation, hydroelectric, or multipurpose water resource project, whenever any such project can reasonably serve either or both purposes consistently. Projects must be constructed, maintained, and operated to provide recreational opportunities, consistent with the purposes of the project.

5.3 Actions that have been evaluated in the EIS and identified as part of the Preferred Alternative and their potential impacts on HCs

Actions that will be undertaken as part of the preferred alternative and that have the potential to affect HCs include sandbar construction for birds, flow management to reduce inundation of bird nests and chicks, sandbar augmentation and modification for birds, vegetation management for birds, predation management for birds, human restriction measures to prevent damage to bird nests, pallid sturgeon stocking, channel reconfigurations for Interception Rearing Complexes, spawning habitat construction, and, potentially, a pallid sturgeon spawning test flow.

As Section 5.2 laid out, the impacts of these actions on HCs are evaluated and addressed through different regulatory processes. The potential impacts to HCs of these actions at this programmatic level are comprehensively described in the MRRMP-EIS. Many of these actions in the MRRMP-EIS will additionally receive more specific analysis (typically EA processes) at the site-specific level (e.g. sandbar and IRC habitat sites).

5.3.1 HC Monitoring of actions in the preferred alternative

Most of the detailed discussions about HC concerns at specific sites will occur during site-specific NEPA analysis.

Stakeholders have expressed concerns that ESH and IRC habitat projects could have negative consequences for human considerations, including socio-economic benefits and cultural resources. Most of these concerns are related to perceptions that habitat projects may negatively affect flood stages, groundwater levels, ice jams, or channel conditions (erosion or deposition) and would subsequently impact interests (e.g. navigation or water intakes). At the same time, it is possible that ESH and IRC projects could have positive socio-economic benefits, by increasing the capacity of the channel to convey floodwater and by providing recreational benefits, for example.

Assessment of potential effects of ESH and IRC construction on HCs generally requires data collection sufficient to clarify cause and effect; e.g. is flooding or bank erosion or shoaling the result of the project or the result of background variation of the river? This question can be challenging to answer in a highly dynamic river system. There are three potential approaches to establishing an assessment of cause and effect; these will generally be used, as required, during site-specific EA processes.

- **Before/after monitoring.** Before/after monitoring seeks to establish processes and rates at a site before and after manipulation, so the amount of change can be associated with the manipulation. The before/after approach is frequently limited by the ability to monitor the before condition sufficiently to establish baseline conditions. In a river system characterized by high inter-annual to inter-decadal variability establishment of sufficient baseline conditions may require many years of monitoring. Pre-existing data may be useful in some cases, but data that were not collected specifically for the monitoring question at hand are frequently poorly focused.
- **Control/impact monitoring.** In control/impact monitoring a manipulated site is matched to a non-manipulated (control site) and differential change is taken as the result of the manipulation. The challenge in control/impact designs is establishing that sites are sufficiently comparable.

Before/after and control/impact designs are frequently combined in so-called BACI designs. The “staircase” design for IRCs (chapter 4) is a type of BACI design that accounts for the time-varying construction of IRC sites. The ability of a BACI or staircase design to capture changes in a way that can be used to infer cause and effect is also dependent on the length of baseline (before) monitoring and comparability of control and impact sites.

- **Computational modeling.** The third general approach is to use computational modeling of sites, with and without manipulation, to assess sensitivity of HCs to the ESH or IRC project.

Variations or combinations of these three general approaches will likely be necessary to provide useful assessments within budget and time constraints.

5.3.2 Additional routine monitoring of value to understanding impacts of operations on HCs

The USACE Master Manual Chapter V describes the various data collection and communication networks used to monitor the system, and much of this information is of value to passively monitoring impacts on some aspects of some HCs. Other information is available from other sources. Examples include:

- A wide range of data are collected on existing and anticipated hydrologic and meteorological conditions (e.g. snowpack depths, evaporation rates, temperatures etc), including real time automated reporting of hydrological and reservoir flow and stage elevation data. This information is not only crucial for

operating the system, but is also helpful in understanding impacts on HCs, since most HC impacts are directly correlated to river and reservoir flow and stage/elevation readings (over various timescales).

- Much of this information is available to the public in real time today by the USACE and USGS. For example, Hourly Data Collection Platform (DCP) data are available online at: <http://www.nwd-mr.usace.army.mil/rcc/current.html>, while maps, graphs, and tables describing real-time, recent, and past streamflow conditions for USGS gages are available at: <http://waterwatch.usgs.gov/>
- The National Weather Service (NWS) also provides real-time and forecast data for various points on the river. In this case, information is also provided on observed historical flooding impacts associated with various stage levels (e.g. <http://water.weather.gov/ahps2/hydrograph.php?wfo=fsd&gage=grws2>)
- Stage-discharge trends and rating curves at various locations throughout the system are periodically updated by the USACE based on information from the USGS, as are the hydrologic and hydraulic models that are calibrated with this information. These tools and data can be used with stage-damage functions to estimate the effects of flows on certain HCs.
- Other HC impacts are periodically examined and reported upon in various Technical Reports issued by the USACE. For example, the flow requirements to meet navigation targets were studied in 2000 (USACE 2000a).
- Major events, such as floods, are occasionally the subject of post-event investigations that result in updated information on the effects of flows on HCs. For example, a Post 2011 Flood Event Analysis of Missouri River Mainstem Flood Control Storage (USACE 2012) examined how additional flood control storage could reduce flood risk in the future and the impacts such a change might have on navigation, water supply, hydropower, recreation, etc.
- USACE personnel make numerous reconnaissance trips to portions of the Missouri River that are affected by project releases and of the reservoirs to obtain information pertinent to System regulation. Effects of unusual release rates or reservoir levels are also documented by field observations.
- Stakeholder concerns regarding HC impacts are gathered during the AOP stakeholder review process.
- MRBWM routinely receive feedback (usually via phone calls) from the public on various issues when flows or elevations reach levels of concern.



Figure 68. Example of online observed, real time and forecast flow and stage information,

Monitoring is also undertaken to assess the effects of projects implemented as part of the ongoing maintenance of the BSNP, related mitigation actions, projects undertaken as part of the MRRP, and other flood risk management, navigation, and ecosystem restoration initiatives. Although some of the specific monitoring requirements vary depending on the project objectives, authority, and other factors, there are regular monitoring efforts conducted in the lower Missouri River to track levee safety, and responses in channel sedimentation and stability. These monitoring efforts are conducted or overseen by the H&H Engineering staff from the Districts, and are used to update models and assess effects to authorized purposes.

5.3.3 Scheduling of action implementation

Under the MRRMP, the USACE will be implementing actions outlined in the ROD as prescribed by the requirements set forth in the BiOp and the SAMP. They will operate from a five-year Strategic Plan, wherein activities in the current FY are generally in implementation, and have already undergone significant programmatic and site-specific planning and design. Management actions planned for the following year (FY+1) would

have undergone similar evaluation and have been budgeted by the USACE. Subject to appropriations and some modification due to changed site conditions, these projects are generally “shovel ready”. Note that significant new findings, decision criteria in the SAMP, or system conditions that prevent construction could, in addition to appropriations, affect the implementation of those projects.

Generally speaking, the projects identified in out years (FY+ 3 and FY+4) will have been identified in general scope, but will not have undergone significant site-specific planning and design. Within the current year, the planning and design for specific projects is usually focused on those slated for implementation in FY+2. Those projects will be the focus of the Strategic Plan development process and, consequently, to planning and analysis similar to the process used to evaluate alternatives under the MRRMP-EIS. Alternative sites will be considered relative to Program objectives, targets, constraints (budget, etc.) and impacts (including beneficial and adverse impacts to HCs). These will be evaluated using the same tools and procedures employed for the MRRMP-EIS, except that the tools may have been updated or otherwise improved through implementation, monitoring, assessment and validation.

The essential components of these efforts are, for each project (or set of projects if so treated), a discussion of the proposed action, its environmental impacts (including impacts to HCs), reasonable alternatives to the proposed action and their consequences, mitigation of adverse impacts and any irreversible commitments of resources. Once the alternative combinations of projects (specific management actions at specific sites) have been evaluated in the planning process and a tentatively selected plan identified, each specific project is subject to the traditional USACE Preconstruction Engineering and Design process. Cost estimates will be prepared, along with construction specifications, operation and maintenance (O&M) requirements, AM standards and criteria, and monitoring plans, as warranted.

As projects are contemplated in out-years (FY+4 and FY+3), then considered in more detail at the FY+2 stage (including site-specific analyses) as part of the Strategic Plan development and budgeting process, and finally revised and refined (as needed) in FY+1, there are ample opportunities for evaluation, re-evaluation and engagement around possible HC effects. Additionally, monitoring and assessment of implemented projects and validation of the models and tools used to support HC analyses provide added opportunity to revisit plans based on new understanding of impacts (adverse and beneficial) of categories of management action on HCs.

For the most part these HC issues will be most appropriately addressed through site-specific EAs or with Tribes via NHPA Section 106 discussions. However, there may be

situations where specific issues are elevated to consideration by the HC Work Group because of wider implications to the program, as discussed in Section 5.4.4.

Proposed implementation schedules for pallid sturgeon actions are outlined in Section 4.3.1. No comparable schedule exists for the bird actions; implementation needs will be driven by the current population status and the current and projected availability of ESH, which will change with system storage and releases. Budget availability, new information and other factors add uncertainty to the implementation plans and schedules for management actions, and the Strategic Plan will require annual updates.

The Strategic Plan is a rolling, five-year projection of the most current implementation plans and schedules. The Strategic Plan for the current year is typically implemented as planned, but may deviate from the Strategic Plan developed during the prior year's planning effort as a consequence of changed field conditions or budget, or on the basis of new information. Such changes would require approval at the appropriate level and include the necessary collaboration/coordination as outlined in Chapter 2. Plans for the following year are treated similarly, as the budget is generally set (subject to appropriations), but has added flexibility over the current year's plans. Out-year plans are mostly for strategic planning and budgeting purposes, but also provide stakeholders an early indication of potential action implementation, and therefore provides a signal to begin discussion of relevant issues of interest among the HC Work Group and others.

5.3.4 Sandbar construction for birds

5.3.4.1 Programmatic site selection

As discussed in Chapter 3 of this SAMP, ESH construction will be undertaken periodically to address predicted shortfalls between expected habitat availability and requirements to meet targets. Because of the dynamic nature of sandbars, site identification more than a few years in advance of planned construction is of limited value and would need to be repeated to assure site changes have not occurred.

ESH site selection decisions are supported by the use of a spatial decision support tool known as the Emergent Sandbar Habitat Evaluation and Ranking (ESHER) tool. This tool is used as needed to score and rank potential ESH restoration sites based on various indicators, including implementation costs, sandbar sustainability, nesting and habitat suitability. Many of the indicators relate to the distance between the site and known HC locations such as boat ramps, water intakes, power stations and cultural resources. Sites that are located further away from HCs receive a higher score, because they are deemed more suitable for birds due to reduced potential for disturbance. A corollary is that this avoidance may also be to the benefit of minimizing impacts of site construction on HCs.

An outline of the ESHER tool is included in the Programmatic EIS and Appendix G6 of the SAMP.

Initial applications of the ESHER criteria to the Garrison reach have shown that only 3.8 miles of river are both technically suitable and may have a relatively low potential for HC conflicts, enough for 5-8 additional sites. In the future, therefore, it is likely that ESH site selection discussions will need to include co-ordination between bird scientists, Tribes and stakeholders, a role that may be suitable for the HC WG.

5.3.4.2 *Site-specific Environmental Assessment and construction*

As part of site-specific review processes, the USACE engages with relevant agencies, Tribes and the broader public. During public scoping meetings, the USACE shares an initial list of potential construction sites and/or site-specific designs and stakeholder feedback is invited. This feedback informs the scope and depth of issues to be addressed during the site evaluation and planning process. Engagement with Tribes and the State Historic Preservation Office is initiated where appropriate in accordance with NHPA Section 106.

For each identified potential site, the USACE undertakes a detailed evaluation of potential issues regarding HC impacts, land use, site access and regulatory requirements, and creates localized alternative options. The potential HC impacts and costs associated with each site, and associated mitigative actions (if necessary), are explored. A comparison of the potential impacts from different localized alternatives is undertaken as required.

Once potential sites have been selected for ESH construction, site-specific Draft Environmental Assessments are prepared. One past example is the Draft Project Implementation Report (PIR) and EA for ESH construction and maintenance in Nebraska and South Dakota (USACE 2010). Construction projects are designed to avoid impacts to authorized purposes of the Missouri River, such as flood control and navigation.

5.3.4.3 *Monitoring*

HC monitoring of ESH sites may be undertaken to address concerns identified by the agencies or raised by Tribes and/or stakeholders during the NEPA process and NHPA Section 106 discussions. For example, due to concerns regarding the 2010 Gavins Point Reach project, pre- and post-construction monitoring was undertaken to study potential changes in erosion patterns.

To address water quality concerns during vegetation management of ESH sites in North Dakota, USACE collects samples to assess possible water quality impacts from the application of herbicides used to restore ESH sites. Water quality samples are collected before, during, and after vegetation spraying. Results from the sampling are reported annually to the Tribes in a Water Quality Sampling Report. Water quality monitoring will continue in association with the vegetation management action.

Hydrologic metrics are also monitored daily by USACE Water Management. Additional monitoring of habitat metrics may be undertaken upon identification of a critical need, subject to availability of resources. This habitat monitoring will provide insights that will be useful for inferring potential impacts on HCs.

Sandbars have been identified as a possible contributor to ice jamming on some rivers, resulting in localized and reach-wise increases in stage and flooding. Ice-jam floods are common on the upper Missouri River, and the potential for localized flooding downstream of Garrison Dam is of particular concern. Predicting the effects of ESH construction on flooding potential, if any, requires a site- or reach-specific evaluation that considers the causes and effects of ice jams in the reach. Ice jams can cause considerable channel scouring, avulsion, remove vegetation in the riparian zone, and affect the morphology of sandbars upstream from the jam, within the jam, and downstream from the jam when it breaks up and releases a pulse of water (Ettema and Daly, 2004).

This topic has received comparatively little study, and separating the effects of ESH construction from other geomorphological processes in the reach may be a challenge. For these reasons, two technical studies have been proposed to address these concerns. The first study involves mining of historic ice formation records and associated ESH conditions to try and obtain a useful relationship. The second study involves real-time monitoring of ice conditions and water surface elevations in reaches with and without ESH over time so as to obtain data useful for simulating ice jamming and flooding in the reach.

Additionally, a geomorphic investigation of the reach with a focus on ESH was initiated in 2018 that, while focused on updating the ESH models, will also provide important information to support the ice jam concerns. Detail for the proposed studies will be developed by the Technical Team and will be coordinated with the HC Team.

5.3.5 Flow management to reduce inundation of bird nests and chicks

MRBWM holds weekly calls with USFWS during bird nesting season to discuss water releases from Missouri River dams and potential effects on nesting plovers and terns. In

general, releases from Gavins Point are adjusted as needed to meet target flow levels on the lower Missouri River, taking advantage of downstream tributary runoff. However, during the nesting season of the least tern and the piping plover, care must be taken to avoid impacts to nesting areas. Several scenarios have been used in past years to regulate the System during the nesting season, and these are described in the Biological Assessment (USACE 2017). Flow management activities undertaken to retain sandbar habitat and reduce nest inundation are implemented in accordance with the Master Manual. The Master Manual provides sufficient operational flexibility for the implementation of flow management activities for the plover and tern within constraints designed to prevent or minimize adverse impacts to the authorized purposes.

5.3.6 Sandbar augmentation and modification for birds

In general, for this action the USACE follows similar site-specific NEPA and NHPA Section 106 processes to that employed for ESH construction projects. Potential HC impacts from sandbar augmentation are typically of a similar nature to those associated with constructing new ESH, but of a lesser magnitude because sandbar modification activities are limited to areas where ESH already exists.

5.3.7 Vegetation management for bird habitat

The area of suitable habitat available to the listed birds can be increased through vegetation management actions. The primary and preferred method of vegetation control and removal is application of pre- and/or post-emergent herbicides to selected sandbars. Herbicides may be applied by spraying from all-terrain vehicles or by hand in smaller, less vegetated areas. Herbicides are sprayed by air in large, densely vegetated areas. Additional vegetation control and removal methods include cutting, mulching, disking, mowing, raking, burning, and removing vegetation from sandbars. Post-treatment removal using these additional methods may be necessary depending on the height and density of the vegetation on the selected sandbar. Vegetation that is woody with large stems may need post treatment breakdown and removal.

The process of selecting sites for vegetation management draws on the criteria and tools applied as part of the sandbar construction program. Sandbar habitat is essentially excluded from the vegetation management program where impacts to HCs would be expected. Sandbars are generally selected for vegetation control and removal on the basis of historical use as nesting habitat by least terns or piping plovers.

At the time of writing (April 2018), the USACE has prepared two vegetation management EAs, one for North Dakota (USACE 2013a) and one for Nebraska and South Dakota (USACE 2013b). The EAs include an outline of sites that are included in

the vegetation management and list several reasons for which certain types of sites were excluded, such as being within proximity to a dam, landowner issues and recreation use.

Potential HC concerns associated with these activities, and analyzed in recent site-specific EAs, include aesthetics, water quality, air quality, noise, socioeconomics / environmental justice, recreation, cultural resources and non-listed species fish and wildlife. To address water quality concerns, USACE collects samples analyzing for the typical herbicides used for controlling vegetation on sandbars. Water quality samples are collected before, during, and after vegetation spraying.

5.3.8 Bird predation management

Predator management is an ongoing activity aimed at increasing the productivity of least terns and piping plovers by reducing the loss of eggs and chicks to predation and reducing the number of adults that are predated or driven away from nesting areas due to disturbance by predator species. Direct management actions include the lethal or non-lethal removal of predators such as raccoons, coyotes, mink, and great horned owls. Indirect management actions may include caging, fencing, or hazing. Plover nests are primarily protected by placing enclosure cages around them.

Sandbars are surveyed for cultural resources prior to the placement of any traps. Beyond these, no other HCs have to-date required explicit consideration as part of program implementation. Predator management is conducted in accordance with the relevant Federal and State laws, including the attainment of relevant permits.

5.3.9 Human restriction measures to prevent damage to bird nests

Throughout the least tern and piping plover breeding season there is the possibility of interaction between birds and people, whether inadvertent or deliberate. Measures that can be taken to restrict disturbance to the birds include posting signs that restrict access to breeding areas, placing barricades to exclude human access, and outreach efforts. Experience from recent years question the relative ineffectiveness of these measures. The federally-listed birds nest on sandbars and are often destroyed by recreational use of ATVs. The lead agencies will continue to implement access restrictions under the MRRMP-EIS.

5.3.10 Stocking pallid sturgeon

USACE assists the USFWS in pallid sturgeon propagation and augmentation efforts as guided by the Propagation Plan (USFWS 2008). USACE provides funding sufficient to facilitate achievement of the “average annual shortfall” as initially described in the 2003 Amended BiOp for those areas downstream of Fort Peck Dam. The Pallid Sturgeon Conservation Augmentation Program (PSCAP) uses stocking to supplement year class

structure due to the lack of natural recruitment in the Missouri River. The PSCAP also preserves the remaining population genetics and structure. Surplus individuals are also used for scientific studies to reduce uncertainties in both the upper and lower Missouri River.

The PSCAP has not revealed any impacts of stocking and associated activities on HCs in the Missouri River. No angling of sturgeon is allowed. Therefore, HCs are not considered as part of propagation and stocking activities.

5.3.11 Channel reconfigurations for Interception Rearing Complexes

Section 4.2.6.3 discusses actions undertaken towards the reconfiguration of the channel to increase interception of drifting free embryos and to provide supportive habitats for their growth and survival. As of early 2018 (and therefore before the ROD for the MRRMP-EIS), EAs had been performed on two IRC sites¹.

An overview of the site selection process for IRC construction projects is outlined in Appendix E. In 2017, a detailed program-level process for identifying potential IRC construction sites was drafted and presented to MRRIC for comment. The USACE implemented several of the site-selection steps, and in 2018 shared a preliminary draft schedule for the design and construction of twelve future IRC projects (including the preliminary identification of IRC and control site locations).

5.3.11.1 Programmatic Site-selection

In the process outlined in Appendix E, steps one through three saw sites being screened on geophysical and biological criteria. During step four, a subset of HCs that have potential sensitivity to IRC construction were analyzed. The location of potential IRC construction sites was cross-referenced with potentially affected resources. Examples include wetlands, river infrastructure (levees, bank stabilization structures), cultural and Tribal resources, sand and gravel mining sites, and water supply intakes. The USACE also investigated land ownership and uses, such as recreation, agriculture, interior drainage, conservation and navigation. Sites were provisionally removed from further consideration where a substantial conflict with a known HC concern or current land use would potentially arise.

The preliminary list of candidate sites and control sites was a first attempt to find locations that meet the species needs whilst minimizing HC impacts. As site-specific factors are examined as the program unfolds, it may be necessary to reject some of the initially-identified candidate sites and to find new options, or reexamine previously

¹ Both occurred in 2016 under tiered coverage of the Final Supplemental EIS for the Missouri River Fish and Wildlife Mitigation Project (USACE 2003).

rejected sites. As with the issue of ESH site availability in the Garrison reach discussed above, there is a shortage of available sites for IRCs that meet functional criteria whilst eliminating the potential for HC conflicts. The USACE will therefore engage with Tribes and stakeholders in ongoing discussions on this issue, and moving forward the HC Work Group will play an important role in coordinating and communicating these discussions to a broader range of interests.

The USACE continues its ongoing efforts to incorporate a rigorous National Historic Preservation Act Section 106 consultation with the Tribes to ensure their views are integrated into its IRC site-selection process. Omaha District coordinates Section 106 compliance through a Programmatic Agreement (2005) with Tribes and states with historical ties to their area of operation. During 2017, Kansas City District initiated a Programmatic Agreement for Tribes and states with historical ties to their area of operation, with an anticipated completion date of August 2018.

5.3.11.2 *Site-specific Environmental Assessment and Construction*

For each proposed IRC construction project, a site-specific Environmental Assessment will be prepared as required. The Searcy's Bend Interception-rearing-complex Habitat Project Environmental Assessment (USACE 2016c) is an example. The Environmental Assessment references the programmatic site-selection and engagement process outlined above and details how it was applied to the specific site.

For each proposed IRC construction site, potential impacts are analyzed in detail for relevant HCs. Potential impacts are considered throughout the entire riverine area where HCs could be affected by the IRC project, referred to as the Area of Potential Effect. IRCs are designed to avoid impacts to HCs such as navigation and flood control. It is USACE standard practice to make the Draft Environmental Assessment available for public comment. The USACE also engages potentially affected Tribes via Section 106 at the site level.

In the Searcy Bend EA example, numerous alternative configurations for the site were examined in considerable detail for a broad array of issues including safety, environmental performance, cost, water quality, wetland resources, terrestrial resources, fish and wildlife, threatened and endangered species, invasive species, cultural resources, local socioeconomics, recreation, navigation, flood risk management, air quality, and climate change.

All IRC construction projects are compliant with the National Historic Preservation Act, Section 404 of the Clean Water Act, the ESA and other relevant laws, regulations and trust responsibilities.

5.3.11.3 *Monitoring*

IRC sites are extensively monitored, primarily for the determination of efficacy of physical performance and for potential species response. Much of this monitoring is therefore aimed at observing physical changes to the channel from IRC construction, and so will be of value in understanding any potential for impacts to HCs. For example, at the Searcy Bend IRC, physical monitoring consists of performing hydro-acoustic depth and velocity surveys of the site at least twice per year to monitor changes to the bed and variations in velocity from preconstruction conditions. Bathymetric surveys with single-beam sonar and velocity measurements are conducted with an acoustic Doppler current profiler. Conditions will be monitored to ensure depths and velocities are progressing in the desired direction to promote interception and increase foraging habitat as well as ensure that conditions in the main channel remain favorable for commercial navigation. Sediment will also be monitored either by physical sampling or side-scan sonar to assess how the bed sediment at the site is affected by the changes in hydrodynamics.

Post-project monitoring at the Deer Island (Lower Little Sioux Bend) top-width widening project was conducted to ensure that changes in geomorphology were confined to the new habitat areas and not affecting the navigation channel. Monitoring results have been used to determine which rock structures needed to be modified to keep the navigation channel and habitat functional. Similarly, based on monitoring results, several chute entrances at existing Shallow Water Habitat sites have been modified to ensure the chutes were not capturing excessive amounts of flow from the main channel which could affect navigation and other interests.

5.3.12 Pallid sturgeon spawning habitat

The pallid sturgeon Effects Analysis hypothesized that insufficient spawning habitat (defined here as high quality, functioning spawning habitat, in contrast to outside, revetted bends) limits pallid sturgeon recruitment downstream of Gavins Point Dam. USACE proposes to construct up to three high-quality spawning habitat sites, and monitor effectiveness of this action in terms of sustainability, relative use of these sites compared to other control areas, and relative spawning success, as determined by hatch rate, catch per unit effort of free embryos, and other indicators. As spawning habitats are aquatically-based, their construction will have relatively limited implications for HCs but this activity would be subject to appropriate NEPA evaluation and NHPA Section 106 discussions.

5.3.13 Pallid sturgeon spawning test flows

Under circumstances described in Table 60, Section 4.2.6.5 of the SAMP (version 6), a requirement for spawning cue flows (and appropriate scope) may emerge from the

outcome of Level 1 and Level 2 monitoring and modeling studies following year 9 of plan implementation. Should a spawning cue flow be required after year nine, HC concerns will be addressed via appropriate NEPA mechanisms at that time, if necessary.

5.3.14 Intake passage / Fort Peck flows for pallid sturgeon

Impacts associated with the construction and operation of the Intake Diversion Dam Modification project are evaluated as part of the EIS the Bureau of Reclamation and USACE have jointly prepared for the Intake Diversion Dam Modification project. An Amendment to the USACE's Biological Assessment includes a proposal to develop an AM framework to utilize the reach of the Missouri River between Fort Peck and the Lake Sakakawea pool to address impacts from system operations on pallid sturgeon.

5.3.15 Foraging habitat for sturgeon

Also included in the Biological Assessment Amendment is a proposal to develop an AM framework to provide foraging habitat for juvenile pallid sturgeon in the lower River. This framework will similarly be developed separately from the MRRMP-EIS and will, if necessary, be the subject of a supplement to it in future years.

5.4 HCs and Adaptive Management

5.4.1 Role of the HC Work Group

Section 5.2.2 introduced some of the many laws and processes that govern how relevant activities are regulated. Since each potential HC impact has its own 'right place' in this complex regulatory context, this can lead to potential confusion over the appropriate forum to discuss HCs. A key question is, therefore, 'what roles should the HC Team / Work Group play that add sufficient value and do not confuse or overlap with existing regulatory and engagement processes'?

Answers to this question include:

5.4.1.1 Provide draft recommendations to MRRIC on mechanical habitat siting decisions

The preferred alternative includes prescriptions for bird and fish mechanical habitat construction. Where possible, the HC Work Group will be invited to consider and propose draft recommendations for MRRIC and the lead agencies regarding approaches used for future ESH and IRC site selection decisions. Siting decisions will continue to be strongly driven by species priorities, and authorities under which those actions occur remain unchanged. However, opportunities exist to explore with MRRIC the processes and criteria used to support siting decisions, with attendant potential for mutual learning and improved program performance.

5.4.1.2 Help to co-ordinate and track the flow of information about Missouri River HC issues as they arise

The lead agencies are involved in many activities in the Missouri River basin, and stakeholders on the river could be forgiven for misunderstanding or losing track of which specific issues are most appropriately discussed as part of this SAMP implementation. The HC Work Group could play a valuable role in helping the lead agencies provide a transparent and consistent approach to helping direct questions or queries regarding impacts to HCs to the appropriate place, and in helping to track, where worthwhile, the outcomes of these exchanges in order to learn for future requests.

To this end a draft flowchart, discussed in Section 5.4.4, could be further refined with input from the HC Work Group to help clarify which issues should be tackled in which forums. In concert with MRRIC-administered issue tracking tables, the flowchart could help MRRIC participants and the general public in developing a set of commonly asked questions and issues to reduce frustration and repeated work. The intent here would not be to provide a comprehensive issue tracking mechanism, which in this context would be infeasibly complex; rather, the Work Group could help route and track those issues of which it became aware, and to provide such information to MRRIC members and the public.

5.4.1.3 Make suggestions to MRRIC concerning any issues that have relevance for the program as a whole

Questions around the potential for actions to impact HCs will inevitably arise over time and may come from various sources. Some could be raised in the context of site-specific EAs and most of these may best be addressed as part of these processes. However, in some cases, issues that arise from any source could have wider implications for the program. This may be the case for IRC habitat sites, for which designs are new and implementation experience is limited. It could be, for example, that initial IRC designs result in unforeseen impacts on a particular HC that could affect future similar IRCs unless the design issue was elevated to a programmatic design examination. The HC Work Group could serve as a forum for coordinating the examination of such potential issues, and in working with the Fish Group (in this case) or other agency experts to bring the issue to the attention of MRRIC for discussion with the lead agencies.

5.4.1.4 Make recommendations for MRRIC to consider concerning new issues that emerge and that may require monitoring or actions

The dynamic and large-scale nature of the Missouri River ensures that new issues will arise over the coming years that have not been foreseen to date. Many of these issues

will relate to the listed species and the Bird and Fish Work Groups will help the lead agencies work through approaches to dealing with them. However, these responses may create new potential impacts to HCs that are important to address. It may also be that new issues emerge of relevance to HCs that have nothing to do with the species, such as significant changes in the socioeconomic context. In such cases, it may be that additional monitoring for HCs outside of the scope of site specific EAs is warranted. Section 5.4.7 discusses a proposed approach to dealing with new information.

5.4.1.5 Make recommendations for MRRIC to consider regarding HC adjustments to the Strategic Plan

At the time of the conclusion of the MRRMP-EIS process (April 2018), there are relatively few HC issues to consider in the Strategic Plan since habitat construction and other management actions are being initiated. However, in future years, this may not be the case, and it could be that HCs could be at the forefront of strategic decision making in certain years. The HC Work Group could play a key role in helping to ensure that MRRIC and decision makers are provided with suitable information concerning the potential HC trade-offs associated with alternative courses of action.

5.4.1.6 Help in the consideration of actions outside the MRRMP that may be required in future

The HC Work Group will be a valuable technical resource by making draft recommendations to the lead agencies for consensus determination by the full MRRIC as they prepare to address new issues that are not in the preferred alternative. Although these new issues might ultimately need supplementary NEPA processes, the HC Work Group could help work through some of the technical issues, options for characterizing impacts and trade-offs in order to inform MRRIC deliberations.

One example of this could be the actions that may be undertaken by the USACE as part of the Amended Biological Assessment. How, for example, could the HC impacts of flows from Fort Peck be characterized for decision makers?

5.4.1.7 Help MRRIC act as a trusted, engaged and informed advisory body that can knowledgeably comment on HC issues that arise

It takes a considerable investment of time and study to gain a working familiarity of the Missouri River System and its planning and regulatory context. The HC Work Group provides the agencies with continuity and consistency in communicating with MRRIC and with the public when issues arise over time. Without this group, the agencies would

need to bring relevant parties up to speed on myriad issues, and it is likely that much nuance and context would be lost.

5.4.2 HCs in the annual AM planning cycle

The annual cycle of decision making from perspective of HCs and HC Work Group members is as follows:

5.4.2.1 *October-November Fall Science Meeting and HCs*

As described in Section 2.4.3.2, the Fall Science meeting is an opportunity for researchers and scientists to exchange updates on technical developments that have occurred over the previous year. Much of the meeting concerns the interpretation of new bird and fish scientific developments, and it is important for HC Work Group members and others with interests in HCs to learn about these developments and to consider their potential implications.

In addition, there may also be updates to exchange on technical changes that directly concern HC issues:

There may be **updates to specific HC monitoring studies** initiated in previous years, for example. In some circumstances, it may be possible to compare the range of outcomes that were predicted from a particular management action with the monitored (i.e. measured) impact on a given HC from MRRP management actions (though in many cases it may be hard to identify what can be attributed to MRRP management actions from natural variability). Predictions are most readily made for proxy-style indicators of the type that predict the number of days above a threshold thought to be associated with an impact. The value of this sort of analysis would need to be weighed against its costs. A post-season review could investigate comparisons of the predicted versus observed proxy indicator levels and predicted versus observed harm (or benefit) observed on the ground. In some cases such evaluations might be straightforward, but in many situations more involved analysis will be required. Over time, calibration could occur between the predicted outcomes and measured ones; however, establishing the validity of a causal relationship between actions and measured response or impacts would be necessary before decisions based on the information could be used.

Also of interest could be information on any **significant changes in the HC context** that could have implications for decision-making. Examples might include planned construction of a major new marina, the decommissioning of a power plant, or a planned change in hydropower operations to accommodate a capacity upgrade. Items of

interest in this way could include anything with the potential to affect the execution or interpretation of experiments or actions for the species. Any significant new information may be subject to review via the new information protocol as discussed in Section 5.4.5 below.

The **current status of HC metrics/indicators** may also be of interest to decision makers (for example, it may be relevant to be aware if there has been several years of unusually dry or wet conditions that have given rise to particular problems and that could be exacerbated by decisions being made for the program.

Specific technical expertise may need to be brought into the group as required.

5.4.2.2 *February-March AM Workshop and HCs*

At these workshops and meetings, the findings of the previous months are processed for their implications for decision making in subsequent years. The HC Group could play an important role in coordinating with the Fish and Bird Work Groups to identify issues and discuss potential resolutions for the MRRIC and the lead agencies to discuss.

5.4.2.3 *March-June HCs and the Strategic Plan*

If there are actions in the Strategic Plan that have implications for HCs, the HC Work Group may help to ensure that other MRRIC members understand what these are and inform MRRIC members to empower them to express their views (e.g. in the form of a consensus recommendation from MRRIC) to decision makers when strategic planning decisions are made.

At this stage, a predictive assessment of the consequences of the one or more strategic plan alternatives may be made, if important trade-offs between bird, fish and/or HC interests are anticipated. Such situations may lend themselves to an abbreviated form of PrOACT analysis. The important point is to have a process that recognizes that any given alternative action carries with it a range of consequences that may need to be considered and weighed by decision makers.

5.4.3 **Clarifying the flow of information**

As with the bird and fish equivalents, the HC Work Group serves as a forum for sharing and discussing information throughout the annual AM planning cycle. Although also important for the Bird and Fish Work Groups, clarity around the flow of information and the nature of how the lead agencies receive recommendations is of particular importance in the HC context. Not all HC interests are represented on the HC Work

Group, nor could they be for logistical reasons; it is therefore imperative that particular HC viewpoints are not advanced and acted upon by the agencies directly via the HC Work Group without the filter of deliberation that MRRIC provides. In addition, not all HC interests are represented on MRRIC and additional expertise and / or points of view may need to be sought out (an example of this occurred in March 2009 when MRRIC hosted a panel discussion that included commercial fishermen to better understand the USFWS's proposed listing of the shovelnose sturgeon under the "similarity of appearance" provision of ESA).

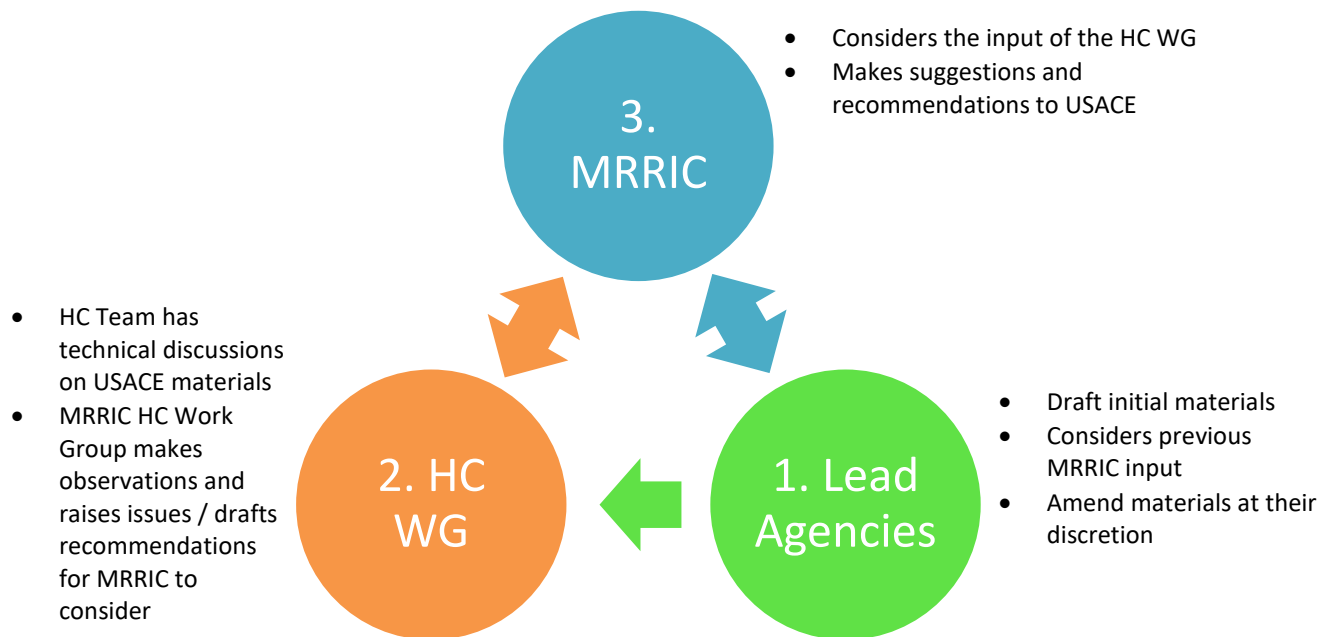


Figure 69: Flow of information and guidance between the Lead agencies, HC Work Group and MRRIC

To further clarify the intended functions of these groups from that stated previously in Chapter 2, Figure 69 shows the general flow of information between the lead agencies, the HC Work Group and MRRIC.

Initial materials intended for review by the HC Work Group are typically drafted by or on behalf of the lead agencies. These materials are shared with the HC Team during any of their several meeting points through the year. HC Work Group members discuss the materials with their agency counterparts during these Team meetings. Nothing but the most neutral and technical discussions should occur at these meetings; their purpose is primarily the one-way flow of information from the lead agencies to the HC Team to clarify facts and identify any issues that have implications for the other HC interests that are not at the HC Team table. HC Work Group members may then choose to raise any issues or recommendations to MRRIC for consideration. (In a parallel way, agency

members of the HC Team may wish to raise issues to their leadership via a Memorandum for Record). Issues raised may subsequently be raised and discussed at one of the several MRRIC plenary meetings that occur through the year. MRRIC may choose in turn to make a recommendation on the issue back to the lead agencies. At their discretion, the agencies may act on the recommendation, or otherwise take whatever course of action they deem appropriate as decision makers.

5.4.4 Scoping HC issues and new information

5.4.4.1 HC Issues Routing Flow Chart

Figure 70 is a draft flowchart that was developed to help route issues that arise to the most appropriate forum for their discussion. This Figure is in development and will benefit from further discussion with the HC Work Group (an initial review in February 2018 generated several points that require further dialogue). The chart is intended to act as a guide as to where and when a particular issue might most appropriately be discussed. While the questions in the flowchart are shown as mostly discrete and binary, most real situations are more nuanced; the flowchart helps merely to serve as a prop for such conversations. Choices about whether and when an issue should be discussed by the HC Work Group should ultimately lie with that Work Group and the agencies together.

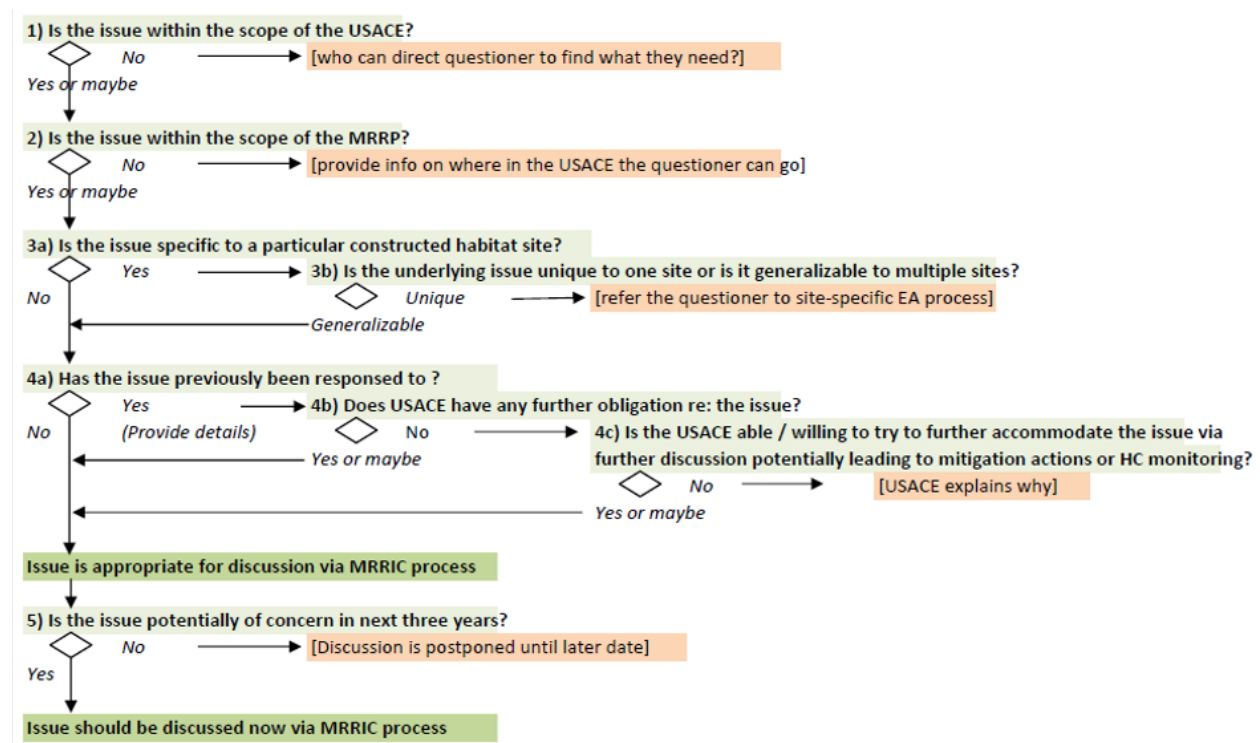


Figure 70: Draft HC concern routing flowchart

The draft flowchart poses a series of questions that first help to ensure that the HC Work Group is the best forum for a conversation. Question 1 enquires whether the issue pertains to the USACE sphere of influence, or does it relate to different agency? Question 2 asks whether the issue relates to the MRRP or another program within the USACE. Sometimes issues straddle more than one program, and so conversations may focus on which program or forum is best placed to tackle the concern at hand. Question 3 probes whether the issue is relating to an issue that is only of concern in a context of only local significance and might better be dealt with via an EA. Since MRRIC takes the perspective of the mainstem river as whole and meets only several times a year, it is not the appropriate forum for detailed comments on each ESH or IRC site, for example. However, as previously noted, sometimes issues raised at a particular site can have relevance for the program as a whole.

Question 4 examines if an issue has already been addressed by the USACE, and whether there is a need for further investigation. Where reasonable, the USACE may be willing to direct resources to further accommodate learning about HC impacts, but there are limits on its ability to do so that are based, among other things, on limits to its authority to direct public funds to issues other than species protection directly. This is discussed further in Section 5.4.7. Finally, question 5 reminds us that some discussions can be premature, and may more appropriately be deferred until it becomes clearer that it actually needs to occur.

To emphasize, the purpose of this figure is not to ‘rule out’ issues unduly; rather it is to help be clear about which issues should receive the HC Work Group’s attention so as to be clear about the purpose of the group.

5.4.5 Incorporation of new information

Research that is conducted over the course of the year is summarized in the annual AM Report. MRRP-funded research will typically be reported upon in the Fall Science Meeting and the Annual AM Workshop. Relevant non-MRRP research findings will also be discussed in the report when available, with consideration given to the level of QA/QC and peer-review or related evaluations such findings have undergone and to the design and strength of studies.

Occasionally, new or unexpected information might become available that has the potential to significantly alter some aspect of management under the MRRP and which is not captured in the annual AM science process. This may be a matter of timing (urgent findings which miss the AM reporting cycle) or because the information was not identified by the Technical or HC Teams. Such information would be vetted and addressed through the process described in Section 2.5.3. Important insights

emanating from the vetting process would be incorporated into the AM process in the same way as other monitoring and assessment results.

5.4.6 Ancillary information

The HC Work Group may play an informal role in collecting additional information that reflects learning or provides important insight into decision making but was not targeted through specific monitoring or studies. Examples of ancillary information include: observations about flood conditions on agricultural lands during a flow event; local changes in bed level that might reflect shoaling or scour; measurements of stage relative to water intakes over a low flow period; or patterns of erosion caused by flows within normal ranges. To the extent possible, such information should be quantified and reported along with monitoring data in annual reports. Other information sources can be included if appropriately vetted (see Chapter 6). Such information may be used to adapt localized management actions, help explain patterns in monitoring data (e.g. multiple local factors could result in unusually high or low stage in a reach), and identify questions and hypotheses for future research and analyses. The quality of ancillary information will vary and may be subject to bias due to how factors are observed and when they are noted and should be assessed when data is collected and/or compiled. Ancillary observations may indicate the need for more systematic monitoring of factors not previously monitored.

5.4.7 New monitoring requests

Section 5.3.2 describes the routine System monitoring that occurs and that could help inform learning about the impacts of actions on HCs in passive ways. SAMP Appendix D, Appendix E, and Appendix G describe monitoring protocols that are and/or will be undertaken to monitor the performance of the actions on fish and birds; much of this monitoring will be of geophysical changes that may be opportunistically be used to inform learning regarding potential HC concerns. While there are several sources of uncertainty in predicting impacts on HCs, not all uncertainties matter for the purposes of planning, and some are more significant than others for decision making.

Monitoring can be employed to help reduce uncertainties in a variety of contexts and can be valuable for:

- Confirming that planned activities are undertaken properly (compliance monitoring)
- Passively observing actual impacts on the ground to provide data against which to compare predictions or to watch out for possible unintended negative impacts
- As part of carefully crafted experiments to help test cause and effect hypotheses

Although some data can be obtained from third parties or with little or no incremental effort to the program, other possible studies, while providing valuable information, could compete for resources that might otherwise be used for other program priorities. It is essential to have a structured and disciplined approach to identifying monitoring proposals for HCs in this process.

The process of identifying and specifying monitoring needs for HCs, and the specific identified studies introduced here should not be considered definitive. Rather it should be seen as a starting point for discussions. The intent is for the HC Work Group to further consider the issues and provide recommendations (for MRRIC consensus) for monitoring and analysis needs under AM implementation of the MRRMP.

5.4.7.1 Identifying HC monitoring opportunities – implementation and compliance monitoring

In general, there is relatively little leeway for discretion in determining what could or should be studied in the context of implementation and compliance monitoring. Some compliance monitoring is legally required or prescribed by professional codes of practice, and typically involves common-sense and low-cost activities (e.g. good record keeping, noting the conditions under which an action is implemented). Moreover, much compliance monitoring is undertaken already by default (e.g. as-built surveys of structures or habitat projects, operational details such as river flow rates and reservoir storage levels are continuously monitored already).

5.4.7.2 Selecting what to monitor - effectiveness monitoring

Some effectiveness monitoring also has a low cost, and some is also automatically monitored (especially those with well-established hydrologic response curves, e.g. boat ramp availability). Even in such cases, data needs to be analyzed to extract meaning, and such data analysis requires resources.

However, effectiveness monitoring could easily consume large discretionary budgets unless careful consideration is applied to the selection of which outcomes are most valuable to monitor. Effectiveness monitoring provides useful background reference information, but it does not necessarily provide or link up with other useful diagnostic information that might ultimately be required to understand why the status and trend of a particular outcome might be changing. A key consideration, therefore, is to ensure that to the extent possible effectiveness monitoring is integrated with targeted studies (discussed below).

Some considerations for determining which areas to focus on for effectiveness monitoring may include:

Responsiveness to management actions. The MRRMP-EIS analysis indicated which aspects of HCs, in which locations and under which seasons are most likely to be affected by specific actions (e.g. spring or fall habitat creation releases). HC indicator selection should focus first on those areas predicted by the analysis to be differentially affected by actions.

Significance of potential impact being monitored. The MRRMP-EIS analysis also revealed the potential magnitude of HC impacts. All else equal, HC indicators should focus on high potential impact areas, should any exist.

Representativeness to underlying concern. When selecting indicators, consideration should be given to the relationship between the indicator and the underlying issue of interest; the closer this relationship, the better. Care needs to be taken to identify non-linear relationships between an indicator that can be measured and the underlying interest.

Credibility and verifiability. It is important that decision makers and stakeholders have access to accurate and credible information. Credibility may be imparted by various characteristics of a situation, but is enhanced when readings can be checked (e.g. through regular QC reviews) or are subject to spot auditing.

Cost effectiveness of collection / interpretation. All else being equal, the least cost way of obtaining required information should be sought.

Versatility. Where a single measurement could act as an effective indicator for a wide range of issues, it should be preferred.

Timeliness for intended purpose. Information is needed on different timescales. When HC indicators are selected, thought should be given to the practicality of whether information from each source could be made available in time for its intended use.

Ability to simplify. Because of the scale of the task at hand, it will be important to seek out indicators that can be scaled back or simplified over time once the indicators map to actual impacts.

Engagement and partnership. Information from various sources should be sought and welcomed; however, all information should be subject to the credibility and verifiability tests previously mentioned.

5.4.7.3 Selecting what to monitor - targeted studies

Targeted studies may be expected to require the most resources, but should also have the potential to deliver the greatest benefit to decision makers. Features of circumstances where targeted studies might be of highest value (and therefore have the highest priority) may include:

- Where the MRRMP-EIS HC analysis has identified a potentially high value impact associated with an action but where there is a large uncertainty as to the probability and/or consequences of the hypothesized impact;
- Where the influence of this uncertainty is significant to understanding the overall MRRMP-EIS HC analysis for a resource area;
- Where future management choices may be influenced by resolving or reducing the uncertainty;
- Where there is a realistic and practical way of reducing the uncertainty, in a way that could be expected to have sufficient statistical power or otherwise to provide compelling weight of evidence within a reasonable timeline;
- Where there is a high ratio of the value to managers of the information anticipated to be gained from the study relative to the cost (money, time etc) of acquiring the information.

5.4.7.4 Target study screening and prioritization questions

The above considerations can be used to help screen and prioritize candidate target HC studies during the adaptive implementation of the MRRMP. The questions below are drawn from those considerations and are provided as examples, cast in a relatively open-ended form. The HC Team should revise these as needed to guide screening and prioritization activities should they be required.

What is the key assumption / relationship / hypothesis needing analysis? Summarize the source of uncertainty in understanding or estimating the potential impacts of alternatives on a resource area.

How wrong or inaccurate could the base assumption be? There are often limits to how wrong an assumption could reasonably be. If being off by the maximum possible error is unlikely to influence a decision, then the issue may not require further investigation.

Being wrong or inaccurate is not necessarily important; sometimes even an order of magnitude of error in one assumption may not be of significance to an overall output.

How frequently is the issue relevant? The consequences of some uncertainties may be felt continuously or every season or year. Some events, such as major floods, occur rarely but may lead to significant impacts when they do occur. Other issues may require an unlikely combination of factors to align before the assumption becomes relevant. In cases where extremely large consequences could result, this may nevertheless be a valid reason to investigate further. However, all else equal, priority should be given to those issues that are likely to be relevant more often than not.

How readily could new information resolve the issue or reduce the uncertainty? Not all uncertainties can readily be resolved or reduced through desktop or field studies. A priority study would provide actionable information in a timely way.

How conclusive could this new information be expected to be? A major challenge on the Missouri River will be to provide information that can help distinguish the signal of an impact associated with a particular management action from the noise that results from the large range of natural variation on the river. Care must be taken to ensure that the information collected can ultimately be used to resolve the issue.

What resources would be required to acquire this new information? Outline the approach to address the uncertainty and estimate (at first to an order of magnitude), the cost of the investigation, including staff time and other resource requirements.

What is the return on investment? Aggregating the above, describe (or otherwise estimate) the relative value of the new information that the study could yield relative to the cost of acquiring it.

5.4.8 Actions outside the MRRMP-EIS and HCs

Chapter 2 of the MRRP-EIS describes the iterative process of how actions for federally-protected birds and fish were assembled into alternatives and assessed for both their efficacy in meeting their primary objectives with respect to these species, but also for their impacts on human considerations.

The process for implementing an action outside of the preferred alternative is discussed in SAMP Section 2.4.5. Any reconsideration of actions in the EIS but outside the preferred alternative may require supplemental NEPA review if there are significant new circumstances or significant new information relating to the proposed project or its

impacts. Additionally, measures not included in the EIS may be subject to additional NEPA review.

Before a decision could be made to implement a decision authorizing a flow release, the following issue of land inundation should be resolved:

The channel capacity of inter-reservoir reaches varies depending on the amount of aggradation or degradation that occurs during periods of low or high runoff, and, in some locations, downstream pool levels and tributary inflows. Consequently, high flow releases from reservoirs must be managed to minimize downstream impacts. The preferred alternative includes a provision for a Level 2 in-river spawning cue release test. Additionally, flow actions for the creation of ESH were investigated, but not included in the preferred alternative for the MRRMP-EIS.

The MRRMP-EIS analysis shows that the proposed flow for pallid sturgeon and the ESH creation flows, as currently defined, could potentially inundate private lands along the Missouri River, in the Ft. Randall and Garrison reaches, as well as downstream of Gavins Point due to coincident flows from tributary rivers. This impact is one the USACE has sought to minimize in its selection of its preferred alternative. USACE has sought to minimize this impact as much as possible in the very selection of this alternative. USACE will continue to effectively strategize how to minimize the impacts over the next 9 years should this test be required.

5.4.8.1 Monitoring of HC issues that need only be undertaken in the event of a flow modification

If flow releases were to be implemented, a program of field-based groundtruthing around sensitive assets may help reduce remaining uncertainties, though these would need to be carefully targeted to ensure that the value of information justified the expenditure. This suggests an exercise could be undertaken as part of the Plan involving the HC Work Group and USACE analysts to identify and prioritize specific groundtruthing activities to undertake during a specific planned flow event. The selection of activities would depend on the precise flow under evaluation. For example, different sites and features may be threatened under recruitment flows, vs ESH spring release flows versus ESH fall release flows etc. Even across the spring release alternatives 2, 4 and 6, the different nature and timing of the releases may imply different monitoring regimes for HCs.

Therefore, specific groundtruthing studies could be suggested by the HC Work Group and adopted by the USACE nearer the time of potential implementation.

5.4.8.2 *Monitoring considerations for potential future management actions*

As the MRRP-EIS Chapter 3 shows, the largest potential for negative impacts to human considerations come from the use of flow modifications. As discussed in Chapter 2, over time it could be discovered that the preferred alternative may not be sufficient to meet the objectives of the MRRP, and it might be necessary to consider other alternatives, including actions involving flow modifications. These may include those actions evaluated in the MRRMP-EIS or other, as yet undefined actions that would be dictated by the science and understanding developed through the AM Program.

Given this, it is prudent to consider the kinds of monitoring for human considerations that might be necessary in such a case. These could include:

1. Monitoring of HC issues that could be undertaken now in order to create better baseline data against which to understand the impact of potential future flow modifications,
2. Monitoring of HC issues that could be undertaken and completed before a flow modification action is taken, and
3. Monitoring of HC issues that could be only undertaken in the event of a flow modification.

In all cases, consideration should be given to the fact that channel changes are a consistent feature of the river and the relevance of monitoring results over time should be a factor considered in monitoring activity design and use.

6 Data Acquisition, Management, Reporting and Communications

6.1 Principles and practices underpinning monitoring and evaluation, data management, and effective communications

This Chapter outlines a set of principles for developing and implementing a monitoring and evaluation (M&E) strategy. Underpinning these principles is recognition that the activities in the AM Plan are intended to increase knowledge of how to best protect and recover listed species, while concurrently meeting authorized purposes and minimizing undesirable effects. Thus, M&E is a crucial post-implementation activity, and many of the activities are optimized for the twin objectives of learning and ecological effectiveness (within HC constraints). The objectives will shift over time and, as the underpinning science and species needs are better understood, actions will focus more strongly on ecological effectiveness, with learning as a secondary benefit.

The principles outlined in this Chapter are drawn from multiple sources designed to ensure the development and iterative evolution of an effective M&E strategy:

1. The Data Quality Objectives process (DQO; EPA 2006), developed by the U.S. EPA to guide development and evaluation of alternative M&E designs to make decisions, is a collection of qualitative and quantitative statements that help to clarify program objectives, define appropriate types of data to collect/analyze, and specify tolerable limits on potential decision errors. This provides a basis for establishing the quality and quantity of data needed to support decisions.
2. Applications of the DQO process and evolutionary development of M&E strategies in various ecosystem restoration, environmental monitoring and species recovery programs provided relevant examples. These include the U.S. EPA's Environmental Monitoring and Evaluation Project (Barber 1994), the Columbia Basin's Collaborative System-wide Monitoring and Evaluation Project (CSMEP 2007), other M&E strategies for the Columbia Basin (Hillman 2006), the Comprehensive Everglades Restoration Program (CERP) Monitoring and Assessment Plan (MAP; RECOVER 2009) and the associated Quality Assurance Systems Requirements (QASR; RECOVER 2004), the Integrated Assessment Program for the Trinity River Restoration Program (TRRP and ESSA 2009), and the Platte River Recovery Implementation Program (PRRIP 2014).
3. Expert advice from scientists familiar with the M&E challenges specific to the Missouri River and other large-scale ecosystems were instrumental.

Effective M&E requires attention to detail organized around each of the steps in the AM cycle (see Figure 5):

1. **Plan/Design:** Assess the problem, identify priority decisions, questions, hypotheses and indicators, and design the M&E strategy for each hypothesis and management decision (this strategy guides the remaining steps)
2. **Implement** management actions
3. **Monitor** the ecosystem, its species and selected metrics for human considerations, and collect appropriate data
4. **Evaluate** monitoring data and determine the implications of the data for priority decisions, hypotheses, and the original M&E strategy
5. **Decide** whether or not to adjust actions, hypotheses and/or the M&E strategy.

In addition to the principles summarized in this section, issues of scale are discussed and the term “actionable science” is defined and discussed in the context of the MRRP. The agencies are committed to a collaborative process for developing and implementing the MRRP, so an open data-management strategy, transparent decision-making, and good reporting and communications are central to success. Section 6.2 provides a summary of monitoring and data acquisition for the system and the listed species. Section 6.3 outlines the approach for addressing “new information”, Section 6.3 discusses the needed data management and communications, and quality assessment and quality assurance processes are discussed in Section 6.4.

6.1.1.1 *M&E Principles for the Plan/Design step of the AM Cycle*

The Plan/Design step (Step 1) for the MRRP AM Plan was addressed through the EA and the MRRMP. An M&E design describes the combination of logical, statistical, field/logistical and cost strategies to answering one or more management questions that feed into a management decision. Components of an M&E strategy can include (modified from Hillman 2004):

- a) a “statistical” design, which provides the logical structure for testing hypotheses, using spatial and temporal contrasts, and identifying the minimum requirements for implementation monitoring, process / effectiveness monitoring and population monitoring;
- b) a “sampling” design which describes the process for selecting sampling sites and sampling times;
- c) a “measurement” design outlining the specific performance measures and the protocols used to monitor them at the chosen sites and times; and
- d) a “response” design that explains how the monitoring data will be analyzed to make inferences in the AM Evaluate step.

The plan/design step is the most critical part of the AM cycle for development of M&E strategies, since it must anticipate all of the steps to follow. Many of the research activities described for pallid sturgeon under Level 1 will help with the design of M&E strategies. The following principles, drawn directly from the DQO process described in EPA (2006), set the foundation for effective M&E strategies in Step 1:

1. *State the problem* – define the problem based on a conceptual model, identify priority hypotheses and indicators related to management actions
2. *Identify the decision* – state the decision to be made, the actions to be undertaken, the key questions to be answered. Clarify the wording of those questions until they can be answered positively or negatively, specifying location, timing, target populations, relative comparisons and other attributes.
3. *Identify inputs to the decision* – decision criteria, key metrics. Metrics ideally should have: a high signal to noise ratio (not too variable in space or time), have direct relevance to decision criteria, have high cost effectiveness, be ecologically responsive (i.e., do not have a long lag in response to changing conditions), are unambiguously interpretable, have minimal environmental impact and have a clearly defined measurement protocol. Evaluating metrics against these and other criteria (see Table 5-1 in Barber 1994) will help to refine the list of key metrics.
4. *Define the study boundaries* – must be sufficiently large to encompass the distribution of management actions over space and time, and the potential impacts of those actions
5. *Develop a clear path from data to decisions* - Effective M&E strategies have a defensible reason for all information that will be collected, which either directly or indirectly have implications for management decisions.
6. *Develop “if-then” decision rules* – Define a statistical parameter of interest for each metric (e.g., median survival rate or abundance for species; flow, stage or reservoir level thresholds for impacts on HCs), and a set of positive or negative outcomes for each priority question, which can be melded into “if-then” decision rules with biologically or socioeconomically significant effect sizes. Such decision rules may involve multiple questions and metrics, as described for pallid sturgeon (see section 4.6).
7. *Specify limits on decision errors* – Define precision requirements for decisions and acceptable limits for decision errors (e.g. lower precision is required to determine whether pallid sturgeon spawning occurs in a given location than to determine the survival rate from eggs to age-1). False positives for species’ metrics (e.g., falsely concluding that an action was effective in helping listed species when in fact it wasn’t) could lead to implementation of ineffective actions

in place of effective actions, potentially resulting in negative economic and ecological impacts. False negatives (e.g., falsely concluding that an action had no effect on a population, when in fact it had a positive effect) could lead to negative ecological effects if effective actions are stopped. False positives for HC metrics (e.g., falsely concluding that a management action negatively affected HCs when in fact such impacts were unrelated to the action), might also lead to unnecessary reduction or cessation of an ecologically effective action. False negatives for HC metrics (e.g., concluding that an action had no effect on HCs when in fact it had a negative impact) could have undesirable social and economic effects.

8. *Optimize the M&E design for obtaining data* – Develop and evaluate different M&E designs, examining their ability to meet the required levels of precision at an acceptable cost. Optimization of the design may involve considerable work at Level 1 and Level 2, including various efforts to refine methods before finalizing the design, which leads to the following principles. Monitoring of HC metrics should follow a similar process.
 - a. Ensure that important time series are maintained if monitoring protocols are being improved.
 - b. Use past data and possibly intensive pilot sampling to gain insight into spatial and temporal variability of key metrics (e.g., relative abundance of age-0 pallid and shovelnose sturgeon within different habitat types), and how relative abundance varies over time and river conditions.
 - c. Perform statistical power analyses to determine how false positives and false negatives vary with sampling effort, number of treatment (management action) and reference sites, the staging of implementation of management actions, and the number of years of monitoring before and after the action is implemented (see Appendix E for an example of statistical power analyses applied to IRCs).
 - d. Allow for an adjustment period with new monitoring needs, and use pilot approaches to discover bugs and solve initial problems.
 - e. Complete laboratory and mesocosm work at Level 1 to define biological effect sizes of interest, clarify mechanisms of impact, assess measurement errors and refine monitoring protocols.
 - f. Complete modelling studies at Level 1 to simulate different M&E strategies.

6.1.1.2 M&E Principles for the Implement Stage of the AM Cycle

The implementation of experimental management actions at Level 2 provides an opportunity to both further species objectives and to refine M&E strategies:

1. Use L2 management experiments to benefit listed species and test M&E strategies, examining their ability to reliably evaluate the effectiveness of management actions, and their effects on selected HC metrics.
2. In designing L2 management experiments, seek to maximize spatial and temporal contrasts within the constraints of both feasibility and authorized purposes.
3. Ensure that L2 management experiments have a low risk of negative effects on listed species (e.g., use hatchery fish in a manner which does not affect stocking programs) and HCs (e.g., implement habitat restoration actions in locations and forms which maximize ecological effectiveness and minimize impacts on HCs).

6.1.1.3 M&E Principles for the Monitor step of the AM Cycle

Monitoring (Step 3) includes the following considerations for metrics and data collection:

1. Ensure adequate training of field crews on the sampling and measurement design (the why, in addition to the where, when, how and who).
2. Apply the sampling design and measurement design as laid out in the Design step, and document any deviations from that design.
3. Where there are insufficient field data to estimate measurement error, do replicate tests of monitoring (e.g., the same field crew sampling the same location on the same day; multiple crews sampling the same location on the same day)
4. Collect information on key covariates which might affect sampled values (e.g., turbidity, velocity, temperature) and be helpful in subsequent Evaluate step.
5. Ensure that the data are stored in a reliable data storage and management system, and promptly reviewed for data quality (section 6.4).
6. Apply good principles of data management (section 6.3.2.2).

6.1.1.4 M&E Principles for the Evaluate step of the AM Cycle

Evaluation of monitoring data (Step 4) includes determining the implications for priority decisions, hypotheses, and the original M&E strategy. Important principles include:

1. Apply the statistical and response designs laid out in the Design step of the AM cycle, and test out whether the key assumptions of the design have been fulfilled.
2. Synthesize multiple metrics and multiple lines of evidence in decision-focused assessments.
3. As problems are detected in analyzing the data, develop and evaluate possible revisions to the sampling and measurement designs.

6.1.1.5 M&E Principles for the Adjust Step of the AM Cycle

An important component of the Decide step (Step 5) of the AM cycle involves determination of whether or how to adjust actions or decision, with the following important guidelines:

1. Test pilot data evaluations (and the decision criteria developed in AM step 2) with managers to ensure that the M&E strategy is providing the appropriate inputs to decisions, in terms of form and content.
2. If changes to existing M&E protocols are considered, particularly those with implications for trend analyses, ensure that there is a sufficient period of overlap of the old and new methods to permit cross-comparisons.
3. Ensure that changes being considered to management actions are harmonized with the overall experimental designs and objectives for all system components.

6.1.2 Issues of scale

The effects from implementing the MRRP projects must be monitored at both system-wide and local scales. The ISP is responsible for the design and implementation of system-wide monitoring of birds and fish, and will work with the individual MRRP PDTs for design and implementation of monitoring to determine local effects and project performance. To guide implementation of the system-wide program, the AM Team is developing the MRRP Monitoring and Assessment Plan (MAP), an associated Quality Assurance Requirements (QAR), and a QA/QC document. Materials addressing monitoring and assessment that comprise the MAP are presently included in several chapters, appendices and attachments to the SAMP (see particularly chapters 3, 4 and 5; and appendices D, E, G, H and I). These materials and associated QAR will be integrated together into the complete MAP as part of the implementation of the AM Plan. The MAP and the individual project monitoring plans will be closely coordinated to ensure that measures and targets selected by the project teams are consistent with system-wide measures and that duplication of effort is effectively minimized.

Monitoring at the project scale should ensure appropriate temporal and spatial coverage of monitoring parameters, which may require filling gaps in the MAP monitoring effort or adding additional project-level parameters not included in the MAP, particularly for monitoring action effectiveness at local scales.

6.1.3 Actionable science

For the MRRP to meet its objectives and work effectively with its partners and stakeholders, it is important that decisions be based on the best available science (see Murphy and Weiland 2011, 2016 for a definition). The science is currently challenged by a number of underpinning uncertainties (see Jacobson et al. 2015, Buenau, et al. 2016, Fischenich et al. 2016; and see Sections 3.1.2.5 and 4.1.2.5), and the AMP includes a number of studies aimed at addressing these challenges. Meanwhile, implementation decisions are necessary in order to meet the requirements of the ESA and avoid jeopardizing the listed species.

The term “actionable science,” was coined by the Department of Interior’s Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS 2015) and it serves as a useful concept for guiding the information necessary to support MRRP decision-making while fulfilling the best-available science mandate. Actionable science provides data, analyses, projections, or tools that can support decisions regarding management of the risks and impacts of operations on the Missouri River. Ideally co-produced by scientists and decision makers, actionable science creates rigorous and accessible products to meet the needs of stakeholders.

The following principles, adapted from ACCCNRS 2015, are presented to guide efforts for producing actionable science and are entirely consistent with the principles for monitoring and evaluation described in section 6.1:

- Scientists, decision makers and stakeholders working in concert are more likely to arrive at actionable science than scientists acting alone.
- Start with a decision that needs to be made. Research needs are rarely precisely known (and seldom clearly specified) in advance, so must be identified collaboratively and iteratively.
- Give priority to processes and outcomes over products, and use the process to build connections across disciplines and organizations, and among scientists, decision makers, and stakeholders.
- Periodically evaluate the utility of products and processes, and the ability to take actions based on the science developed by the program. Use the lessons learned to adjust products and processes as needed, and to refine the definition of “actionable” based on evolving views of risk.

This approach recognizes that actionable science is not only actionable information, but also includes longer-term processes and relationship building to help ensure the appropriate use of that information. Time and resources will be required to develop and maintain interpersonal interactions among scientists, decision makers, stakeholders and other users of the scientific information. Deploying these services efficiently and effectively also requires building connections across disciplines, and among the organizations engaged in the effort. The budgets for the program and individual projects, project evaluations, and staff incentives and evaluations should reflect commitment to this need.

6.2 Monitoring and data acquisition

The MRRP Monitoring and Assessment Plan (MAP) is the primary guide for evaluating the performance of the MRRP. The MAP is an integrated system-wide monitoring and assessment plan that: (1) provides a framework that supports measurements of the responses of habitats, species and human considerations at both project and system-widescales, to determine how well MRRP is achieving its goals and objectives; (2) helps identify and prevent unintended adverse outcomes from management actions; and (3) supports and enables AM for updating and improving the Plan, as well as management actions, when needed. The scientific and technical information in the MAP is organized in such a way as to facilitate status and performance assessments and report these findings in annual system status reports.

The MAP is structured around the conceptual ecological models (CEMs), which are organized by species, but also provides a framework for system-wide monitoring and assessment for the MRRP.

Implementation of the MAP builds on trends relative to reference conditions and baselines established for the MRRP to detect change including unexpected responses of the ecosystem, and address not only “what” is happening (e.g., status and trends) but “why” it is occurring (e.g., stressors-response functions), which is essential for implementing AM. Monitoring designs and protocols to assess the effectiveness of specific management actions are tailored to those actions, as described in chapters 3, 4 and 5, as well as in Appendix E (for IRCs).

Note: Materials addressing monitoring and assessment are presently distributed among chapters 3, 4 and 5 and appendices D, E, G, H and I to the AM Plan. We refer to these collectively herein as the Monitoring and Assessment Plan (MAP). These materials, and associated Quality Assurance Requirements (QAR) will be integrated into the MAP as part of the implementation of the AM Plan.

Data acquisition practices for individual projects will follow the overall monitoring and evaluation strategy designed for the AM program. Methods of acquiring field data need to be fully integrated with the overall monitoring and evaluation strategy for each component of the AMP, to ensure that, to the extent budget and field conditions permit, necessary data are acquired, receive QA/QC reviews, and are entered into a secure data management system with all associated metadata, as described in section 6.3. The specific objectives and approaches associated with individual projects will likely necessitate

6.2.1 Pallid sturgeon monitoring data acquisition and analysis approach

Pallid sturgeon monitoring data have been collected by multiple teams from several state and federal agencies who have been involved with the MRRP since its inception. This approach has been used for both the Pallid Sturgeon Population Assessment Program and the Habitat Assessment and Monitoring Program. HAMP and PSPAP monitoring coordinators (USACE) manage contracts with partners, coordinate monitoring activities, work with monitoring teams to adjust monitoring efforts if needed, and assist with data analysis and reporting. See Appendix D for a review of current PSPAP guidance and a proposed substantial revision to the current protocols for population monitoring. Other data collection protocols specific to evaluating the effectiveness of Interception and Rearing Complexes are summarized in Appendix E.

This multi-team approach has several advantages. Long-term monitoring efforts benefit from a consistent approach and sustained expertise. Substantial pallid sturgeon expertise has been developed within these agencies and long-term involvement of these partners has resulted in needed consistency. Since the missions of these partner agencies overlap with the MRRP objectives, these partnerships help ensure that MRRP activities are closely coordinated with similar and potentially beneficial actions of partner agencies. Finally, inclusion of multiple partners in monitoring efforts helps offset the bias, perceived or real, within any one partner agency, including the USACE.

It is vitally important that fish monitoring crews understand the key hypotheses to be tested, the overall monitoring and evaluation strategy, and the reasons for the specific details incorporated into fish monitoring protocols. Understanding the ‘why’ of a monitoring and evaluation program will help to ensure that the ‘what’, ‘where’, ‘when’ and ‘how’ are correctly implemented. This deeper understanding by field crews will also catalyze communications between field crews and Technical Team members regarding field observations which may be particularly relevant to the existing set of big questions and hypotheses, as well as potentially suggesting other factors to be considered (e.g., potential predators or competitors to pallid sturgeon that frequently appear in the same places and times as various life stages of pallid sturgeon).

Historically, fish monitoring crews have had little involvement in subsequent data analyses. Some partners have the necessary expertise to assist in these analyses, however, and because analyses will be identified in advance through the AM Plan, some of these analyses (if appropriate to the expertise of contractors) can be included in monitoring contracts, framed around specific hypotheses and questions from the AM Plan. This will allow the MRRP to capitalize on the expertise of partners (i.e., providing key contributions to the Technical Team) while focusing their work in the non-sampling seasons on the most productive efforts. In the past, the limited off-season analyses which were conducted by individual partners have been uncoordinated and often not focused on the most important information needs of the MRRP. Involvement of monitoring crews in conducting pre-defined analyses will provide a cost-effective means to ensure timely data analysis. In addition, the PSPAP and HAMP coordinators' duties will be redirected to allow more focus on data analyses and reporting.

6.2.2 Bird monitoring data acquisition and analysis approach

Bird monitoring data are currently collected by USACE staff with a heavy reliance on part-time summer employees. This approach works well for the bird monitoring needs as it allows for a high level of staffing during the season (May-August) when the birds are on the Missouri River. This approach also offers potential to adjust staffing levels relatively quickly based on system conditions. For example, a high water year may significantly reduce the area to sample and temporary staffing levels can easily be adjusted. A disadvantage of this approach is the inexperience and annual turnover of many of the bird monitoring staff. This is a challenge that has been identified and is being addressed in order to ensure the needed consistency and quality of data collection. For example, additional oversight and field assistance by roaming veteran staff in 2015 has helped to increase consistency among crews. Recent reviews of the strengths and weaknesses of alternative methods for monitoring key bird metrics (Schwarz and Porter 2016) provide a basis for considering possible improvements to existing monitoring protocols. Staffing requirements will depend on what bird monitoring protocol is selected (see section 3.3 and Appendix G for a discussion of bird monitoring protocols).

Analyses of bird monitoring data are performed annually by the USACE bird monitoring coordinator including trend analyses and take reporting. Utilizing a full-time bird monitoring coordinator to lead these analyses ensures consistency, commitment, and the necessary close communication with USACE water management.

6.2.3 System status and HC data acquisition and analysis

System status refers to conditions of the reservoir system, riverine segments, and affected resources. Status measures include primary measures such as tributary

inflows, reservoir storage levels, outflows (discharges and stages), channel condition, sediment transport, and water quality parameters. Status measures can also be usefully extended to secondary measures of system resources, such as power production, habitat availability, water supply, navigation support, flooding and other HC metrics. The reasons for monitoring system status include:

1. Information is needed to guide operational decisions. For example, reservoir releases and downstream stages are needed to evaluate, manage and minimize downstream flooding, a key concern to stakeholders.
2. Information is needed to assess AM Plan components. For example, reservoir releases, stages, and discharges are needed to evaluate piping plover and pallid sturgeon habitat availability.
3. Information is needed to assess effects of AM Plan components on human considerations. For example, river stages, sediment transport and state of interior drainage are needed to evaluate effects of flow releases and other actions (e.g., habitat creation) on agricultural production.
4. Information is desired to understand unanticipated changes in the river and associated resources. For example, low reservoir releases, high air and water temperatures, and local thunderstorms may generate local inflows with high nutrient concentrations, resulting in low dissolved oxygen and fish kills. As discussed in Chapter 4, low oxygen concentrations in the bottom waters of Fort Peck Lake and Lake Sakakawea reservoirs cause mortality of pallid sturgeon embryos (Guy et al. 2015).

Investments in monitoring for these types of information will certainly vary by category. Category 1 is essential to Missouri River System operations and continued investment is highly justified. Categories 2 and 3 are additive to category 1, and are central to AM of the habitats and species; return on investment for monitoring this information is considered high but may be implemented variably depending on affected resources. Information relating reservoir releases, river stage, and water intake efficiencies, for example, may be prioritized for category 3. Which human-consideration metrics will be included in system status monitoring will be determined based on results of the impacts analysis being conducted for the EIS, the preferred alternative, and the range of factors discussed in Section 5.4.7. For years in which flow actions are not implemented (all years under alternative 3 in the EIS), a major focus of HC monitoring is likely to be in the immediate vicinity and downstream of projects to construct ESH, IRCs or spawning habitat. Monitoring priorities and strategies will be discussed and designed

collaboratively with stakeholders as part of the AM Plan development process, and periodically reviewed following the processes laid out in Chapter 2.

Category 4 relates in large part to water-quality data and return on investment to the MRRP is not as clear as the other categories, except in cases where they directly influence MRRP decisions (e.g., the extent of anoxic waters in the bottom waters of Lake Sakakawea has important implications for decisions on Upper Missouri pallid sturgeon actions, as discussed in the summary of the EA in section 4.1.2). Water-quality stressors result from combinations of USACE management actions and from widespread actions beyond USACE authority. Examples include point discharges from municipal and industrial water-treatment facilities and non-point discharges of nutrients, sediment, and bacteria from basin agricultural sources. Concerns about water quality are therefore shared among many agencies and authorities. Although it is reasonable to expect all riverine biota to be affected to some extent by water quality, specific water-quality stressors to piping plovers and pallid sturgeon did not emerge as dominant hypotheses from the EA, except for the issue discussed above for Lake Sakakawea oxygen concentrations. Therefore, no clear link between water quality and AM of the two species presently exists. Some level of foundational water quality monitoring may be justified to the MRRP to avoid risk and to prepare for unanticipated conditions, and the USACE plans to work with other Federal and State agencies and other stakeholders to seek a cost-effective, collaborative ambient water quality monitoring program to assess status and trends of parameters that may affect habitats and socio-economic values.

Analysis of the system status information will be performed annually by the Technical Team, and will include trends analyses and model validation results along with other data related to system status. This information will be presented at the AM Science and AM Workshop and included in the annual report.

6.2.4 Research data acquisition

Many research efforts will be relatively short term (i.e. 1 to 3 years). For most research, the MRRP Integrated Science Program will utilize a competitive proposal solicitation process open to government agencies, public sector contractors, and universities through an open Request for Proposals. Research projects will be selected on the basis of their support of MRRP AM needs, demonstrated capabilities of proposers, the value of information, and cost effectiveness. Selections will be made by the USACE but informed by proposal reviews from an independent panel. The selected researcher will then become the principal investigator for that particular research project. Solicitation of proposals should occur far enough in advance so that information on potential costs and timelines is available as budgets are being developed. The Integrated Science

Program is committed to the use of peer review and will refine peer review guidelines for reviewing research proposals, publications, and other products or deliverables.

If research or monitoring efforts have little staff turnover or outside influence, they can suffer from a narrow perspective and a tendency to not question the current paradigm while missing key lessons learned in other systems. These challenges can be overcome in the AMP with appropriate independent reviews, interdisciplinary feedback at annual AMP science meetings and workshops, a competitive research proposal process, and increased room for scientific influence from outside the basin (e.g., a defined role for Federal Recovery Teams).

Many Level 1 science components for pallid sturgeon will be implemented concurrently, subject to budget constraints, which will require an intensive effort to organize the science plan, coordinate multiple science components, and communicate interim findings to all parties.

6.2.5 New Information

New or newly introduced information related to the listed species life history, their habitats, or system response requires a consistent and rigorous review process.

Information derived as a product of the research and monitoring of the MRRP will be subjected to the review processes outlined throughout this AMP. Review is also needed for the occasional “new information” that originates outside the Program. That review process will help ensure that the MRRP is using the best available and verifiable science information in informing AM decisions. Under the current structure, this process will progress through the Technical Team and will end up as a topic of review by the ISAP, as described in detail in section 2.5.3. The new information process has been used in 2016 for the issue of fish condition, as described in section 4.1.2.4.

6.3 Data and Information Management

6.3.1 Overview

A critical component of AM is accurately transforming the best available science into actionable and accessible information, and communicating information in the right format and in a timely manner to support decisions regarding implementation of the program. To address this need the MRRP is developing a decision support system for the Program that will integrate a variety of data inputs generated by multiple sources, perform a variety of functions to transform that data into actionable and accessible information, and communicate that information in the right form and timeframe to meet the needs of different user groups (Figure 71).

A decision support system (DSS) is defined as a set of related computer programs/web based applications and the data required to assist with analysis and decision-making within an organization. An effective DSS provides for effective long-term maintenance of data, unbiased data analysis, and real time monitoring and rich reporting. A meticulously designed DSS makes use of analytical models, various statistical and spatial tools, and human intelligence and insights to support decision making.

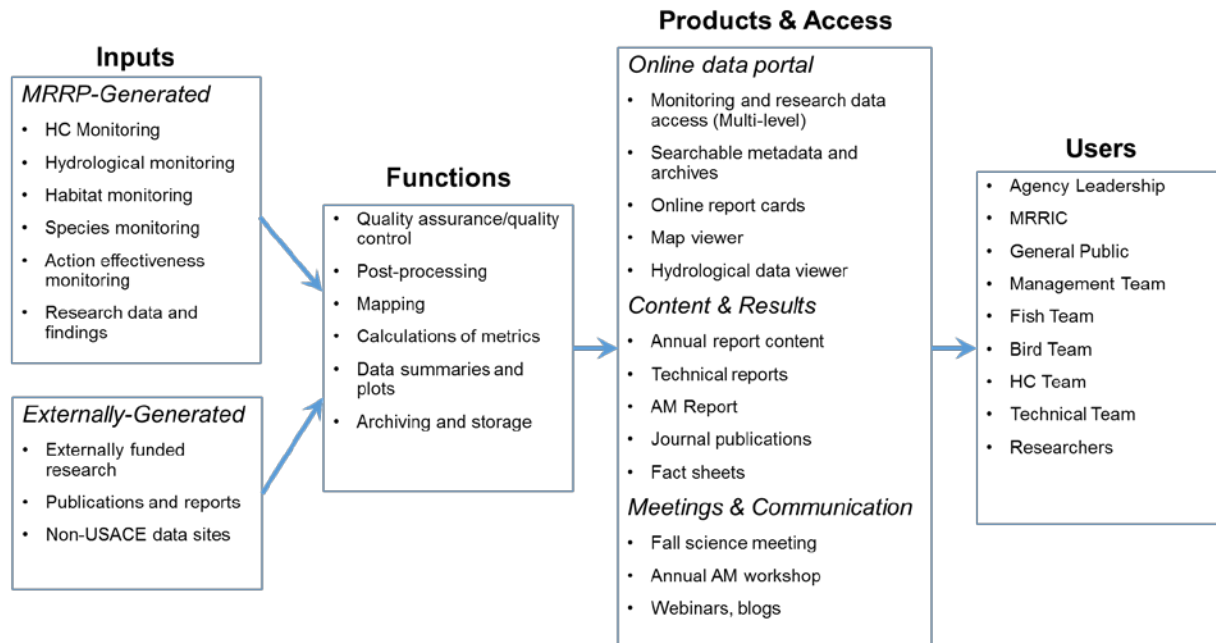


Figure 71. A conceptual model depicting the management of data to inform the MRRP.

6.3.2 Purpose and Objectives

6.3.2.1 Purpose and Objectives of the Data Management System (DMS)

The primary purpose of the MRRP DSS is to provide an intuitive web based system for accessing and analyzing all relevant data and information used for MRRP planning and decision making.

The overall objectives of the MRRP DSS are to:

- 1 Provide access to MRRP data and information specifically designed to meet the needs of researchers, planners, decision makers, stakeholders, and the general public;
- 2 Address the needs of a diverse group of data providers and consumers to facilitate efficient planning and execution of the MRRP;

- 3 Ensure data and information are available on a timely basis in appropriate formats meeting required quality standards.
- 4 Facilitate awareness amongst related programs in the Missouri River Basin including those not directly part of the MRRP which have overlapping interests and information needs.

6.3.2.2 *Principles and Guidelines*

The design and development of the DSS will be guided by the following principles:

- 1 There will be a commitment to a high level of transparency, recognizing that there may be certain data sets that have access controls associated with them through Federal or other policies.
- 2 The system will be designed to minimize the unnecessary duplication of data.
- 3 The system will leverage existing technologies and systems where possible and appropriate in order to avoid unnecessarily re-creating what has already been done well.
- 4 Identification and reduction of institutional and technological barriers will be a priority for system design and implementation.
- 5 Policies and procedures associated with the DSS will avoid being overly prescriptive about how scientists manage their data while recognizing the need for applying and managing appropriate data quality standards.
- 6 The DSS will promote the use of standards for data exchange and reporting. Data gathered using program funding will have requirements for data provision and reporting.

6.3.2.3 *High Level System Requirements*

It is critical to understand what requirements of the DSS are needed by whom, when, and how. While the detailed requirements have not been identified, some of the candidate high level requirements for the data management system have been identified and are summarized in the following sections.

6.3.2.3.1 *Information Stewardship*

- 1 Accommodate varied sources and types of information, including information generated external to the program.
- 2 Capture and maintain decision-relevant information including monitoring data, research data and findings, supporting information, scientific reports, project performance reports, summary status reports for systems/species, project

activity reports, analyses of results of activities, and key reports for decision makers.

- 3 Protect MRRP information assets at a level necessary to achieve the desired degree of ownership and user access control by honoring formal data use agreements, legal standards, publication rights, and user rights and responsibilities that are enacted by data owners or delegated custodians.
- 4 Capture and document the information used to make decisions.
- 5 Accommodate access to legacy systems to capitalize on existing MRRP investments when feasible.

6.3.2.3.2 *Access to Information*

- 6 Provide reliable and timely data access for technical teams and external researchers, facilitating communication of information.
- 7 Provide easily searchable meta-data.
- 8 Facilitate and enhance the communication of decision-relevant information through accessible and searchable online interfaces and data visualization tools that are customized to target user groups.
- 9 Clarify which data exist, how they have been analyzed and applied, and what further applications they have.
- 10 Provide access to near-real-time hydrological data and accompanying visualization tools to help understand the effects of reservoir management on habitat, species, and human considerations.

6.3.2.3.3 *Processing and Analysis*

- 11 Accelerate learning by processing information into formats that are appropriate for use by all user groups.
- 12 Provide fast, accurate processing of species and habitat information so that outcomes of the previous year's monitoring can be used in the upcoming AM evaluation and decision cycle.
- 13 Provide summaries for management, partners and the public.
- 14 Ensure tools are practical for use by data generators, saving time rather than creating additional workload.

6.3.2.3.4 *System Management and Quality Assurance*

- 15 Adjust to changes over time in data, software, and user needs.
- 16 Ensure a reasonable cost of development, use, and upkeep.

- 17 Establish governed QA/QC standards, tools and processes to ensure information is available and reported promptly.
- 18 Facilitate report creation that reduces or eliminates bottlenecks that delay the communication of information, and frees up staff time spent on conducting repetitive tasks.
- 19 Maximize accuracy in data acquisition, processing, and reporting by reducing data disparity and providing automated measures of quality.
- 20 Maintain data integrity and its measure of uncertainty.

6.3.2.4 User information needs

The DSS being developed for the MRRP will support varying data and information needs for multiple user groups within the program (right side of Figure 71). These data and information needs will vary at different stages of the AM cycle (as described in section 6.1), and at different times of the annual cycle (described in section 2.4.2). The following short sections provide an overview of the user groups shown in Figure 71 and their general information needs. User needs will be further defined as the framework and content management requirements for the DSS are scoped out.

Monitoring staff

Monitoring staff will input, QA, and access information generated from monitoring programs including data, metadata, and derived results from the data (e.g., population estimates of piping plovers derived from field survey data).

Researchers

Researchers will submit data and metadata, as well as research findings and publications. MRRP-funded researchers will have data ownership, intellectual property rights, and publication obligations specified in contracts and the DSS will be designed to accommodate individual project requirements. Researchers not funded by the MRRP may also submit data, but with different rights and obligations as defined by their sources. To the extent practicable, the DSS will facilitate data sharing allowing researchers to build connections across disciplines and support interpersonal interactions among scientists for collaborative data analysis resulting in efficient use of MRRP resources.

Technical Team

The Technical Team will have access to a wide variety of information to ensure the accuracy and completeness of information used in data synthesis and evaluation. Testing hypotheses requires integration of data from diverse sources, and evaluation of many different lines of evidence. Effectively meeting the needs of monitoring staff and researchers will partially fulfill the needs of the Technical Team, in addition to data organization and evaluation driven by the scientific and learning needs of the AM program. The Technical Team will also benefit from data-processing and reporting tools in the DSS that automate routine analyses and visualizations which will shift time away from repetitive tasks and facilitate prompt reporting.

Bird, Fish and HC Teams

Team staff are both generators and users of monitoring and research information at the implementation level. They require access to on-the-ground decision-relevant information including site-specific monitoring and research results and real-time status of hydrology, species, habitat, etc. They also require the ability to efficiently quantify and document actions implemented and their outcomes. The DSS will provide access to data summaries and post-QA/QC data to all members on the Bird, Fish and HC Teams that is not otherwise restricted from release by policy.

Management and Oversight

Decision makers at the management and oversight levels require ready access to succinct summary and status information, particularly as related to species' objectives and targets, implementation commitments and forthcoming decisions on program actions and expenditures. The DSS will provide access to information synthesized by the Technical, Bird, Fish and HC Teams. Managers and members of the oversight level will also have direct access to more detailed information as their needs are better identified and evolve over time.

MRRIC and public

Stakeholders, partner agencies, and members of the public have a broad range of information needs and interests ranging from real-time hydrological data to species status to research findings. The DSS will provide summaries and information in report-card format to meet the majority of information needs. Access to more detailed information for those who are interested may be made available after the need is thoroughly vetted and data sensitivities are accounted for. Needs, tools, and access requirements for these groups will be determined through demos and training.

6.3.3 DSS Structure and Functionality

The products needed to address MRRP needs will include websites, analytic software, dashboards, databases, catalogues, maps, and reports. All technology products share a need for some common functionality, such as a secure computing environment, information (metadata) about where the data came from, and its attributes (e.g., locations and times sampled, sampling design, monitoring protocols, methods of computing metrics, precision, accuracy). To make development effective and efficient, the same structure will be used for all common functionality when possible across all MRRP systems.

6.3.3.1 User Interface Components

The details of the decision support system design will be developed during the requirements analysis and design phases, however we can in general list functionality of the system we think we may need. Experience with other systems provides a basis for considering some of the different functionality needed including;

1. General Information and Communication
 - Calendars of events related to MRRP
 - News feeds/significant events related to project components, timelines, results etc.
2. Compiled and Summarized Information interfaces
 - Dashboards showing the system status (projects, habitat, species' abundance, flows, reservoir levels, river stage)
 - Report cards focused on key issues (e.g., state of current understanding with respect to key hypotheses)
3. Data access
 - Tabular/text based interfaces for finding and viewing information using searchable metadata
 - GIS/Mapping interfaces for finding and viewing information
4. Analytical tools
 - Automated report generation and/or query engine to produce charts and tabular results tables, for example for hydrological data
 - Access to analytical software operating on raw data such as demographic models for birds and fish, habitat models, floodplain models.

6.3.3.2 Conceptual Architecture

Based on the principles, guidelines, and high level objectives described in the previous sections we can describe a conceptual architecture for the DSS as shown in Figure 72.

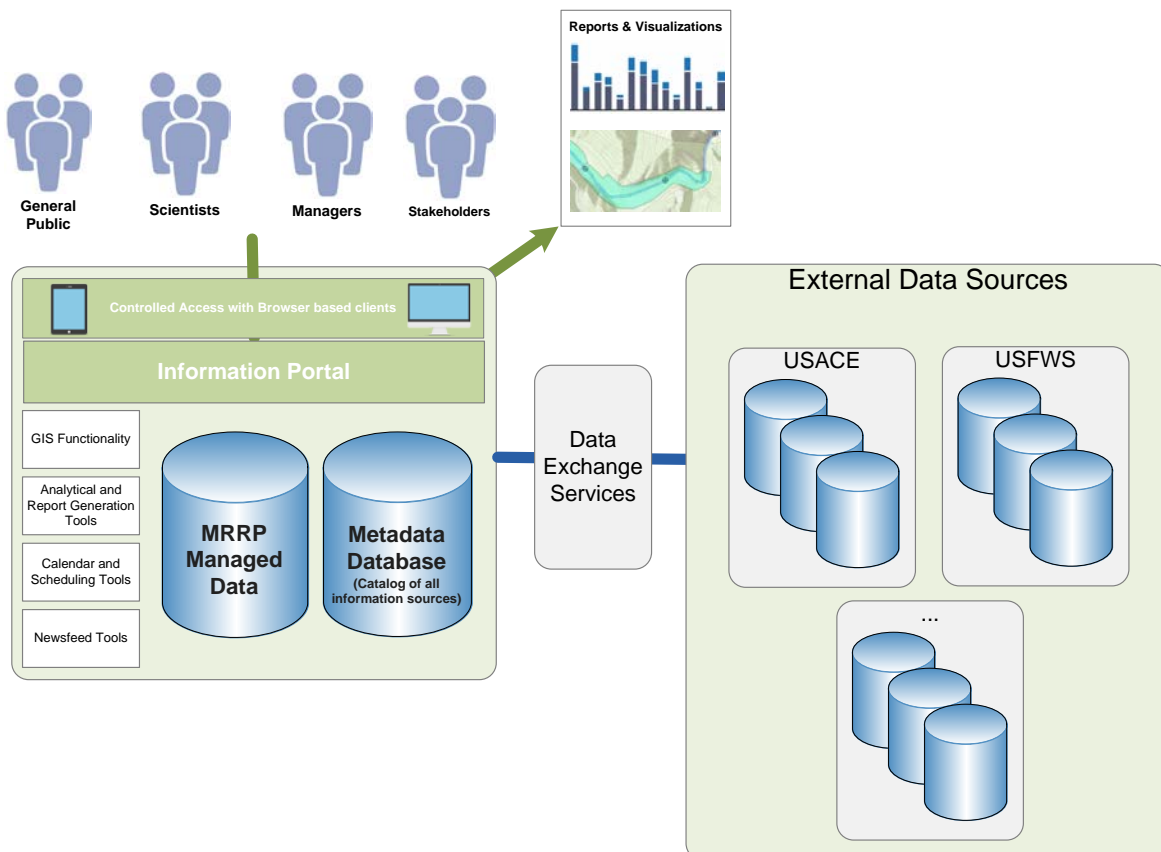


Figure 72. Conceptual Architecture for the MRRP DSS

The key components to note in this architecture are:

1. A single portal to all required information and tools for all user types;
2. Controlled access for certain information and tools based on the requirements of the data and tool providers;
3. The majority of data maintained in systems controlled by the agencies currently generating and managing that data (right side of Figure 72) with a smaller amount of MRRP specific data managed by USACE (left side of Figure 72);
4. Data exchange services based on defined standards to allow direct access to data from the DSS across multiple systems;

5. A comprehensive and searchable metadata database describing data sources and information in all locations; and
6. A variety of user friendly tools to facilitate finding and accessing information in user friendly tabular and map based formats.

6.3.4 Reporting and communication

Data reporting and communication will serve several needs including providing information useful for decision-making as well as fostering understanding of stakeholders and the general public. Each audience has somewhat different needs, and therefore requires different forms of information, with varying levels of detail. These varying needs will be further understood and documented through the user needs assessment in the fall of 2016 (described below in section 6.3.5). It will be important to develop, implement, and periodically re-evaluate a communication plan which considers all of the different audiences, and the diverse forms of reporting that are most appropriate to each audience (e.g., decision-oriented syntheses, annual reports, reporting sessions, science workshops, peer-reviewed reports and journal articles, fact sheets, videos, presentation summaries). The MRRP generates a wide range of communication products, including all of the above.

6.3.4.1 Types of work products

Reporting will include annual reporting of system state such as ESH availability, implementation results (what actions were actually undertaken and to what extent), bird and fish monitoring results, progress toward answering big questions and working hypotheses, effects on HCs, and syntheses of the effectiveness of actions.

Annual and periodic AM reports serve the critical purpose of evaluating effectiveness of management actions toward meeting species objectives, including reporting the status and trends of the three species and their habitats. Annual reports have been very successfully used in the Platte River Recovery Implementation Program (PRRIP)¹, particularly as these reports are accompanied by an annual AM Plan Reporting Session in which the previous year's findings are presented and discussed. AM reports also include a MRRP score card that communicates the status of new learning in relation to

¹ The PRRIP "State of the Platte Report" (e.g., PRRIP 2014) has proved to be a very effective communication tool. The report is organized hierarchically, providing a tabular summary of current understanding of the answers to 11 Big Questions (for decision makers), 3 to 5 page syntheses of evidence for each Big Question and related hypotheses, specific subsections on 'decision implications', recommendations from the PRRIP Independent Science Advisory Committee (ISAC) and responses to these recommendations, and hyper-linked endnotes to all of the primary reports and references used as evidence.

management hypotheses (see Table 68 in section 4.6 for a possible score card approach for synthesizing multiple lines of evidence related to pallid sturgeon action hypotheses).

The AM Report contains recommendations from the Bird, Fish and HC Teams for adjustments to management actions and suggestions for prioritizing research, monitoring assessment and other Program activities in development of the annual MRRP Work Plan. The Annual AM Report is the primary vehicle for summarizing research, monitoring and data analysis results in a manner that ensures new learning is incorporated into MRRP decisions and that these decisions are made based upon the best available science. AM reports will be made available to the Management Team, agency leadership, MRRIC and the ISAP for their review and recommendations. Effecting sharing and maximum transparency of the information used in decision-making will be a key guiding principal in reporting.

The AM Report will also include metrics related to compliance. Any additional reporting needs for compliance with the 2018 Biological Opinion will be determined through close coordination with the USFWS. The 2018 Biological Opinion (USFWS 2018, pages 109-119) describes primary and secondary metrics, as well as decision criteria, for evaluating if Incidental Take has been exceeded. These metrics include apparent survival, abundance, condition, growth rate and reproductive cycling.

To translate scientific information and communicate results and recommendations, a series of work products will be produced. Table 70 outlines the products and identifies various user groups listed as both preparing and receiving work products. Since each user group has a diverse composition and occasional turnover, and a need for documenting past results exists, requiring information transfer both within and between groups. There are also diverse levels of interest in technical information within MRRIC and the general public; providing a hierarchy of linked information (from high-level report cards down to detailed technical reports from which summary information is derived) will permit different users to dive into the details as deep as they'd like.

Table 70. Work product and other forms of information access.

Work Product / Information Access	Purpose/Message	Prepared By	Primary Audience
Online Portal to Raw Monitoring Data	Access raw data and metadata for scientific analyses (e.g., test hypotheses, improve models, assess status and trends) Allow upload of quality-assured data Restrict access to some data	Data providers Research scientists Technical Team Information Management Team	Research scientists Technical Team

Work Product / Information Access	Purpose/Message	Prepared By	Primary Audience
Online Portal to Data Summaries and all Work Products	Status and trends of projects, habitats, species, and HC indicators at various spatial scales Quickly generate maps, graphs and tables for other work products Apply exploratory tools (e.g., Hydroviz) Provide single entry point to other work products	Research scientists Technical Team Information Management Team	Technical Team Management Team Scientific community Bird, Fish and HC Teams Independent Panel MRRIC General Public
Technical Reports	Analysis of monitoring data Modification of conceptual ecological models Evaluation of hypotheses and big questions related to tern, plover and pallid sturgeon population dynamics Reports on effects of actions on HCs	Technical Team	Technical Team Management Team Scientific community, Bird, Fish and HC Teams, Independent Panel MRRIC
Fall Science Meeting	Review initial observations from the field season regarding the system Describe project performance and monitoring Identify analytical needs Serve as an in-Progress Review (IPR) Allow Water Management to provide a briefing on the draft AOP	Management Team Technical Team Research scientists	Oversight Team Management Team Technical Team Bird, Fish and HC Teams Independent Panel MRRIC
Draft and Final AM Report	Annual synthesis of technical reports into messages for decision-makers regarding management action performance (e.g., continue or modify management actions) Links to technical reports Includes MRRP Report Card, which documents answers to big questions and reports on new learning.	Management Team Technical Team	Oversight Team Management Team Bird, Fish and HC Teams Independent Panel MRRIC
Annual AM Workshop	Presents recent findings to be included in the Annual AM Report; allows for interactive dialogue with scientists to better understand findings	Management Team Technical Team Research scientists	Oversight Team Management Team Bird, Fish and HC Teams Independent Panel MRRIC
System-scale AM Evaluation Reports	Report progress towards achievement of programmatic goals, objectives, sub-objectives and targets. Recommendations for adjustments to management actions at Program level.	Management Team Technical Team	Oversight Team Management Team Bird, Fish and HC Independent Panel MRRIC

Work Product / Information Access	Purpose/Message	Prepared By	Primary Audience
Periodic Adjustment Mandates	Adjustments requiring immediate attention e.g., unanticipated flow events	Management Team Technical Team	Oversight Team Management Team Bird, Fish and HC Independent Panel MRRIC
Draft and Final Work Plans	Describe the AM activities to be conducted over the next 2 FYs	Management Team Technical Team	Oversight Team Management Team Bird, Fish and HC Independent Panel MRRIC
Fact Sheets for R&D efforts and significant findings	Succinct summaries of progress made on testing key hypotheses, implementing and evaluating actions, key concepts	Technical Team Research scientists	Oversight Team Management Team Bird, Fish and HC Teams MRRIC General Public
Journal Publications	Describe methods, results and implications of research findings Allow for peer review	Technical Team Research scientists	Greater scientific community Bird, Fish and HC Independent Panel
Webinars	Provide an overview of progress on implementation of the AM Plan Obtain feedback	Management Team Technical Team	Oversight Team Management Team Bird, Fish and HC Teams MRRIC
Model Manuals	Provide guidance on how to use publically available models	Technical Team Research scientists	Technical Team Greater scientific community
Science Blogs and Videos	Provide easily understood summaries of recent work (e.g., https://www2.usgs.gov/blogs/csrp/) Engages interest Visualize scale of challenges	Technical Team Research scientists	Oversight Team Management Team Technical Team Bird, Fish and HC Teams MRRIC General Public

6.3.4.2 Product approvals

The USACE has final approval responsibility for products and deliverables of the MRRP and the Division Commander has the final authority on any product approval. Coordination with and, in some cases, review by the USFWS is encouraged prior to broader distribution of products. However, because of the collaborative nature of the

Program and the need to delegate approval for some products to a more appropriate organizational level, the approving entity varies with the specific product and, in some cases, involves signatures from cooperating agencies. The appropriate approval process follows the steps outlined in the MRRP PgMP (see Attachment 10 of Appendix A).

6.3.4.3 *Timing and distribution mechanism for products*

The timing of delivery of information (and various work products) will be driven by three processes: 1) the need for very rapid information to manage water during each year; 2) the ongoing process of learning by the Technical Team and research scientists, which requires rapid access to multiple forms of quality-assured information; and 3) the annual cycle of AM governance (described in section 2.4.2).

6.3.5 **Proposed work plan for developing the MRRP Data Management System (DMS)**

The MRRP has an established Information Data Management team to guide the approach to and stewardship of data management and technology planning for the AM process. The Science lead from the Information Data Management team will lead this effort working closely with the Technical and Bird, Fish and HC teams.

The proposed work plan for the development of the DSS consists of a series of phases, starting with a careful analysis of the needs of data owners and data users, sources of data, and reporting requirements for the MRRP (requirements analysis). A system design phase will follow and will involve evaluation and recommendation of appropriate hardware and software for the DSS that follow USACE information technology guidelines and leverage existing technologies. A framework guidance and content management plan that describe and outline the path forward for DSS development will be completed during this phase. Finally, during the implementation phase we will collaborate with internal and external technical experts to development, support, and host the DSS.

6.3.5.1 *Phase 1. Requirements Analysis*

The requirements analysis includes a research component followed by documentation and review. The overall objective of the requirements analysis is to describe the data, functions, and work products each user group will require, what specific products should be available to them on what time schedule, and how they will interact with the DSS. In the spring of 2016 several groups representing those who generate data, those who process and interpret the information, and those who use the resulting information to make decisions or inform stakeholders were invited to participate in discussions to provide input on the needs of the system.

Several user needs came out from those discussions and are listed below:

- a unified catalogue of existing data including who collected the data, data quality standards, peer review process, data collection protocols, etc;
- improved integration of plover population data with emergent sandbar habitat assessments;
- Streamlined process for updating model parameters for research projects and documenting updates;
- Connection of disparate data sources through distributed databases;
- near real-time planning support for water managers with respect to potential plover nest take;
- Standard data collection for genetics labs and hatcheries and improved dissemination and integration of hatchery-to-hatchery and hatchery-to-river data to integrate and clearly communicate historical and current fish information; and
- provide real time access to complete time series of hydrologic and climate variables from Water Management, for the Technical Team and other scientists;
- Ensure system is tailored to the different user groups and their capabilities

The next step involves utilizing the Technical team to compile a list of information and data needs from the AMP and document the current data management process for each of the datasets. A draft of the list is currently in the works and will be reviewed by the Technical team to ensure accuracy of the information. Upon completion this list will be used to frame further discussions with a range of expected DSS users. The list and further discussions will provide a basis for the framework guidance and content management plans to be completed with Phase 2.

6.3.5.2 Phase 2. System Design

Phase 2 we will involve conducting background research on the capabilities of existing systems to provide examples of different functionality and user interface approaches and identify available systems that could potentially be used as part of the technology for developing the DSS. Several systems have already been reviewed (see Attachment 22 of Appendix A). Existing data and information sources currently relevant to the MRRP will need to be incorporated into the DSS (see section 6.3.6). Members of the MRRP team and information technology experts within the USACE will be engaged for assistance during the design phase.

We will also identify and document barriers to implementation so we can ensure these are addressed as far as possible in the DSS. Some barriers already identified include

data sharing prior to publication, institutional and policy barriers to sharing specific types of data (e.g. endangered species location data), and inconsistent and incomplete data format and data documentation. The Long Term Ecological Research Network (<https://lternet.edu/>) has done considerable work resolving these types of issues and will be a valuable source of information.

Once all information has been gathered for Phase 1 and Phase 2 we will draft a framework guidance document and content management plan document. These two documents will describe requirements for DSS functionality and the path forward for implementation and document and describe all data management processes within the MRRP.

6.3.5.3 Phase 3. Implementation

The implementation phase for the DSS will begin with identifying internal and external technical experts to develop, support, and host the DSS. During this phase we will develop a plan for phasing and scheduling. The schedule will depend on the complexity of the overall design, the priority for different requirements, and budgetary constraints. We will also take into account budgetary and scheduling constraints, and the approach to be taken to the long term management, operation, and maintenance of the DSS.

Decisions in this phase will include:

- priorities for development;
- the use of existing platforms and tools;
- the selection of the development team; and
- hosting options.

The implementation phase is in the very early stages therefore the schedule will change in the future. Design of the DSS is proposed to continue through 2018 with implementation starting in late 2018.

6.3.6 Integrating Existing Data Management Systems

Several technology solutions supporting MRRP monitoring programs are already in place. Fusing newly-developed technology with existing MRRP investments where feasible will provide a foundation for decision support that can grow as priorities shift with the AM process. Suitable technology development to support the dynamic MRRP will be able to evolve over time without having to be rebuilt from scratch when programmatic needs shift. The technology architecture and components will be built to come and go while the rest of the system remains completely operable.

The decision to integrate, migrate, or adapt existing technologies will be based on the needs and priorities of the AM objectives being evaluated. In some cases, it may be sufficient to leverage existing data management assets, particularly if users find that they are working well. In other cases, an adapted or new solution may be required. A phased approach may also be used to gradually shift functionality to newer systems, by first adapting existing systems if source code is available. For legacy commercial products that cannot be modified, migration may be the best option.

Several existing monitoring program data management systems are catalogued below, which were previously developed to provide centralized collection, storage, and dissemination of piping plover and least tern survey data, and pallid sturgeon survey data from the Missouri River Basin. Collectively, these systems also support maintenance of data quality standards for survey data and provision of real time information for decision-making processes.

6.3.6.1 *Least Tern and Piping Plover Data Management System (TPDMS)*

<https://rsgisias.crrel.usace.army.mil/intro/dms.dmsintro.main>

The Tern and Plover Data Management System (TPDMS) was designed to enter, store, maintain, and disseminate data from the Tern and Plover monitoring program. Field data are updated on a daily basis, using ESRI's ArcPad software on Trimble GPS units. Field software provides immediate QA/QC of data in the field. Data storage has been streamlined using an upload process on the website which loads GPS data files directly into the Oracle database via a web interface. The web interface also provides a portal to real time and historic reports, a map interface, data entry modules, and tools for field crews. Built in validation routines and manual approval provide for rigorous data standards and ensure quality data are available for reports and data presentation which can be used by partners and decision makers. The system provides multiple levels of access to the data and information ensuring data integrity. A username and password are required to gain access to the system due to the sensitivity of data on the location of endangered species. Access can be requested online through the website.

6.3.6.2 *Pallid Sturgeon Population Assessment Website (PSPA Website)*

The Pallid Sturgeon Population Assessment Website was designed as a tool for field crews to enter and maintain data for the Pallid Sturgeon Population Assessment Program (PSPAP) and Habitat and Mapping Program (HAMP). Field data are collected electronically using a custom-built MS Access application on Xplore tablets with integrated GPS capability. The field application contains built-in validation routines providing for QA/QC in the field while the data are being collected. The website

provides a portal where files from field computers can be directly uploaded into the Oracle database making it available to users immediately. Tools for field crews and additional validation routines have been built into the PSPA website to further improve data quality. This system is currently only available to field offices collecting the data and to the data administrators. Public content has yet to be developed.

Appendix D to this Plan proposes a substantial revision to the current protocols for population monitoring, which will be reflected in the software used for data collection.

Current protocols for requesting data from the PSPAP require a data request for each analysis which must be approved by the PSPAP teams. This step will typically be unnecessary in the future because key analyses and certified information users will be identified ahead of time. Only unplanned analyses from new information users will require additional coordination and approvals from monitoring teams, likely following protocols similar to those currently existing in the PSPAP.

6.3.6.3 *Pallid Sturgeon Collaborative Population Dynamics Model*

This model is described in Jacobson et al. (2016a) and summarized in section 4.1.2.3 and Appendix D of this SAMP. The EA team has developed and deployed a version of the model online as a proof of concept (see https://mcolvin.shinyapps.io/pallid_sturgeon/). A basic version of the model will be deployed on the web, permitting users to explore the outcomes of different actions and hypotheses over 50-year time periods, and incorporating random variation to reflect uncertainty in both environmental conditions and functional relationships. The Technical Team will use a combination of the web based tool and a local application which permits greater complexity in various attributes (e.g., spatial resolution, stochastic replication, individual based models, time horizon), although if the online model is hosted on an internal server, then various constraints may be reduced.

6.3.6.4 *USFWS National Pallid Sturgeon Database (NPSDB)*

https://www.fws.gov/moriver/pallid/pallid_search.cfm

The purpose of the National Pallid Sturgeon Database is to compile, store, and disseminate all data on pallid sturgeon captures, across the range of the species, to support recovery efforts. The database is also used to record stocking data for the pallid sturgeon propagation program. An online tool has been developed to provide access to simple recapture histories of individual fish based on PIT tag number. More complete datasets are shared with programs such as PSPAP on an annual basis after the data from all programs have been compiled.

6.3.6.5 *Pallid Sturgeon Genetics Data*

All entities involved in pallid sturgeon monitoring and research are required by the USFWS to collect genetics samples from pallid sturgeon lacking identifiable hatchery marks. Genetics samples are sent to several different labs depending on analysis needs. These data are recorded on a standardized genetics datasheet which is included with each sample and stored and maintained by the respective genetics lab. Information on the capture location, ancillary information, and the genetics sample ID are incorporated into the NPSDB. Genetics information is valuable for many purposes, including relating surviving offspring to their parents.

6.3.6.6 *Hydrologic Engineering Center River Analysis System HEC-RAS*

<http://www.hec.usace.army.mil/software/hec-ras/>

This software allows the user to perform calculations of one-dimensional steady flow, 1 and 2-dimensional unsteady flow, sediment transport, mobile bed movement, water temperature and water quality. HEC-RAS is a foundational tool used to support geomorphic calculations for both bird and fish habitat applications, as well as to support estimates of effects on human considerations.

6.3.6.7 *Hydrologic Engineering Center Reservoir System Simulation*

<http://www.hec.usace.army.mil/software/hec-ressim/>

The Reservoir System Simulation (HEC-ResSim) software (developed by the U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center) is used to model reservoir operations at one or more reservoirs for a variety of operational goals and constraints. The software simulates reservoir operations for flood management, low flow augmentation and water supply for planning studies, detailed reservoir regulation plan investigations, and real-time decision support. HEC-ResSim can represent both large and small scale reservoirs and reservoir systems through a network of elements (junctions, routing reaches, diversion, and reservoirs) that the user builds. The software can simulate single events or a full period-of-record using available time-steps. HEC-ResSim is a decision support tool that meets the needs of modelers performing reservoir project studies as well as meeting the needs of reservoir regulators during real-time events, to minimize impacts on human considerations.

6.3.6.8 *Missouri River Basin Water Management Information*

The MRBWM office maintains a public website at www.nwd-mr.usace.army.mil/rcc. This site contains information concerning System regulation. The website includes

forecasted reservoir levels and dam releases as well as historic data in both tabular and graphic formats. It contains user-friendly, clickable maps to observe graphical streamflow and System project data. The MRBWM office performs streamflow forecasting at select locations and these results are provided for comparison to the official NWS forecast. The NWS forecasts are available as a link from the MRBWM website. The website contains both normal monthly new releases and special news releases concerning other significant items that occur on an unscheduled basis. In addition, the USACE produces numerous public reports on a daily basis that provide continual updates of the System's status, recent activities and changes in regulation of reservoirs. These reports are available to the public on the MRBWM website or by email.

6.3.6.9 *Comprehensive Sturgeon Research Project (CSRP)*

CSRP datasets describe the locations, movements, physiological indicators, and genetics of individual monitored fish, as well as ancillary data related to water temperature, water quality, habitat availability, and habitat use. The bulk of the data reside in two datasets housed at the USGS, Columbia Environmental Research Center, Columbia, MO: 1) The Sturgeon Information Management System (SIMS), and 2) the Missouri River Hydroacoustic Habitat Dynamics System (MRHHDS). More information on these databases is available in Jacobson et al. 2015a. Access to these datasets can be arranged through requests to the chief of the River Studies Branch, USGS–CERC, Columbia, MO.

6.3.6.10 *Pallid Sturgeon Research literature database*

The Pallid Sturgeon Effects Analysis team has created an Endnote™ database (Thomson Reuters New York, New York) with links to literature cited in the EA reports. This database is meant to be an archival record of information sources and will be sharable among agencies and scientists working on pallid sturgeon recovery, subject to applicable copyright laws. This database contains literature citations for scientific information relevant to understanding pallid sturgeon population dynamics, Missouri River physical and chemical processes, riverine ecology, flood plain ecology, and other native and nonnative species. The Endnote™ database and library assembled for the pallid sturgeon EA is limited to sources cited in the EA documents; however, a larger database and library is maintained by USGS–CERC, which contains records related to river processes, native, and endangered species.

6.3.6.11 *Physical Habitat Assessment Data*

Physical survey data is available from both the Kansas City and Omaha districts Hydrology and Hydraulic Branches. Data include bathymetry surveys, sediment-sample collection, acoustic Doppler current profiles, and two-dimensional hydrodynamic

models. The Kansas City district has developed a software package called Cross Section Viewer which was designed for storage and retrieval of cross section data.

6.3.6.12 *Water quality data*

Currently water quality data are collected by each district. Specific needs for water quality data have been described in Chapter 4 of this plan, and in Appendix K.

6.3.6.13 *USGS National Water Information System*

<http://waterdata.usgs.gov/nwis>

The USGS National Water Information System provides access to water-resources data collected across the nation, including the Missouri River basin. The USGS investigates the occurrence, quantity, quality, distribution, and movement of surface and underground waters and disseminates the data to the public, State and local governments, public and private utilities, and other Federal agencies involved with managing water resources. Information available through this site include surface water, groundwater, water quality, and water use data.

6.3.6.14 *Monitoring of Emergent Sandbar Habitat*

Data that accounts for ESH characteristics are collected and available through the MRRP ISP. Datasets include satellite imagery, remote sensing habitat classifications generated from satellite imagery, ESH accounting summary datasets, and habitat quality line intercept data. Imagery data are stored on a local GIS server and also provided to the Omaha district GIS Service Center for storage and dissemination. All other datasets are stored on local servers with the ISP and are available on request.

6.3.6.15 *Moriverrecovery.org*

The moriverrecovery.org website is the public portal to the MRRP. It provides access to current status of the MRRP, the Missouri River basin model, tribal and MRRIC links, MRRP documents library, and background information on all MRRP implementation, planning, monitoring, and research projects. A mapping component provides for spatial exploration of the basin. It is envisioned that this website will provide a mechanism for timely sharing of monitoring and research results to the public.

6.4 Quality assurance and quality control

A complex process will be required to collect, organize and rapidly assess all of the data required to support the MRRP SAMP. That complexity in turn requires a systematic process for data QC, to ensure that decision-makers and stakeholders have confidence that the data used to support decisions are scientifically sound, of known and documented quality, and suitable for their intended use. This process must include the means to determine whether the data fully meet standards and what to do if they do not.

The Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) provides instructions for preparing Quality Assurance Project Plans (QAPPs) for any environmental data collection operation (IDQTF 2005). A QAPP is a formal document describing in detail the QA/QC, and other technical activities that must be implemented to ensure that data and related analyses satisfy stated performance criteria, how performance measures are verified and validated and how to proceed if there are any limitations in the data that prevent attainment of the required level of accuracy.

The MRRP QAPP (see Appendix I) was developed to address system-wide and project-specific environmental monitoring QA/QC, including data collection, analysis, and archiving activities, throughout the entire AM cycle, activities which are summarized in section 6.1. All agencies and contractors involved in environmental data acquisition during MRRP implementation are required to adhere to the provisions of the QAPP. The information presented in the QAPP (or referenced therein) serves as the basis of the quality system for all monitoring activities conducted during MRRP implementation and details QA/QC requirements, including establishing data quality objectives and guidance for data management. Also included are procedures and references for biological, hydrologic, geomorphic and other relevant sample collection, laboratory methods, and data assessment protocols.

The QAPP will be updated and refined periodically to strengthen the QA program. All agencies, contractors, etc., involved in environmental data acquisition during MRRP implementation are required to adhere to the provisions of the QAPP. A biennial Quality Assurance Review (QAR) will be conducted by an independent entity to provide MRRP management and stakeholders with an assessment of the state of data quality for MRRP. The goals of the QAR are to identify practices that contribute to data quality, identify data quality problems and best management practices, report on the activities of the AM Teams, and recommend improvements to the quality system for MRRP monitoring. As such, when specific data quality issues are discussed in this report, a less-than-perfect assessment is meant to identify an opportunity for continuous process improvement, not failure.

6.4.1 Basic Principles for Quality Assurance

AM of the MRRP will require many decisions that will be made on the basis of information available at that time. The following principles (consistent with the principles described in section 6.1) will help ensure that those decisions are made using the best information possible, and serve to guide the development of the QAPP and its periodic review and improvement.

Quality. Information quality is integral to every step of the AM cycle. The AM Teams should employ appropriate practices to ensure quality during the creation, collection, maintenance and dissemination of data and other information. Any information used for decision-making should be thoroughly reviewed by expert staff and appropriate levels of management. Both internal and external review and approval policies and procedures should ensure, to the extent practical, that disseminated information and data are accurate and timely, appropriate for consumption, uncompromised and useful to decision-makers, stakeholders and the public.

Objectivity. The MRRP AM Program relies upon information that is accurate, clear, complete and unbiased both in its content and in its presentation. The relevant subject matter experts and appropriate levels of management should review information before it is disseminated, among other things, to evaluate whether the information is accurate, reliable and unbiased, including an assessment of collection, generation, and analysis of relevant information and data. The review also should consider the presentation of the information to ensure that it is put in the proper context and presented in a clear, complete and unbiased manner. The sources of data used in decision making should be identified so that decision makers, stakeholders and the public can assess for itself the objectivity of those sources. This includes adequate disclosure about underlying data sources, quantitative methods of analysis and assumptions used, to facilitate reproducibility of the information according to commonly accepted scientific or statistical standards by qualified third parties. Periodic external reviews or audits of information should be conducted to ensure that it is objective.

Utility. Information and the appropriate form and vehicle for its presentation and dissemination should be evaluated by relevant subject matter experts, along with appropriate levels of management, to ensure its usefulness to the intended purpose. This includes ensuring that the information is organized, written, and summarized in a manner that facilitates its understanding and use by the intended audience. The information also should be reviewed to ensure its timeliness and continuing relevance for the intended audience.

Integrity. The AM Program should ensure necessary precautions for information security pursuant to the Computer Security Act of 1987, the Government Information Security Reform Act of 2000 and the Security of Federal Automated Information Resources, OMB Circular A-130 (February 8, 1996). The protective measures should cover the following information resources: sensitive data, software, hardware, physical facilities and telecommunications. The information security measures should assure that the information system has a level of security that is commensurate with the risk and magnitude of the harm that could result from the loss, misuse, unauthorized disclosure or improper modification of the information contained in the system. Information which should not be made public (e.g., the specific locations of bird nests or sacred tribal sites) must be kept secure.

6.4.2 Data Quality Objectives (DQOs)

Data Quality Objectives (DQOs, described in section 6.1) define the type, quality, and quantity of data needed to make defensible decisions when implementing the AMP. They identify the requirements for a field investigation and the limits on tolerable error rates. They also indicate the intended end use of the data, including decisions that may be made based on the information generated.

Additional DQOs may be required for specific projects or studies not envisioned at the time of developing the AMP, or for which the necessary information to develop DQOs did not exist. In those cases, and when reviewing and updating existing DQOs as new information becomes available, the AM Teams should rely upon the seven-step process outlined in Guidance for the Data Quality Objective Process (EPA 2006), summarized in section 6.1.1.1.

The DQO process has both qualitative and quantitative components. The qualitative steps encourage logical and practical planning for environmental data collection activities, while the quantitative steps use statistical methods to design a data collection operation that will efficiently control the probability of making an incorrect decision. Although the quantitative steps of the DQO process are important, investigators and decision makers may choose not to apply statistics to every environmental field investigation. In some cases, the team may utilize only the qualitative steps of the DQO process during the investigation planning phases to generate authoritative data.

6.4.3 QAPP organization and content

The QAPP has been prepared for use by entities involved with implementing the environmental monitoring and assessment components of the MRRP. These include program managers, project personnel, agency representatives and private consultants involved in designing monitoring plans, preparing contractual statements of work for monitoring activities, and reviewing or validating data. Contractors involved in data gathering activities, such as field measurements, observations or examinations, calibrations, and data analyses may also utilize the QAPP to determine program, sampling, and analytical protocols and requirements.

The MRRP QAPP is a project-specific plan organized to address four basic elements, as required by the Uniform Federal Policy (IDQTF 2005):

- Project Management and Objectives
- Measurement and Data Acquisition
- Assessment and Oversight
- Data Review

All QAPPs must address all elements detailed in the UFP-QAPP Manual (IDQTF 2005). In some cases, certain elements do not apply to the MRRP. In those cases the requirement is addressed with a simple statement of why the information is not relevant. Although Appendix I is the QAPP for the MRRP, some of the requirements are found elsewhere in the AMP or in other external documents. In those cases, the information is cross referenced in the appendix and details the information in the plan and its location.

6.4.4 QAPP implementation responsibilities

Each agency, contractor, consultant, and individual involved with MRRP monitoring must share responsibility for maintaining knowledge of the QA/QC program and for adhering to the procedures identified in the QAPP. However, the ultimate responsibility for implementation of the QA/QC program rests with the ISP.

The ISP, working and coordinating with the various AM Teams, is charged with implementation and oversight of the MRRP QA/QC program and will ensure that monitoring adheres to the QAPP. The ISP is responsible for dealing with QA issues, establishing a mechanism for distribution of quality system information and changes, and ensuring data meet or exceed the DQOs of the AMP. Some of the ISP responsibilities with respect to the AMP include the following:

- Developing and implementing data review criteria
- Conducting audits of field and laboratory activities
- Performing QA reviews of monitoring data
- Implementing laboratory and field performance evaluation (PE) programs to assess consistency among entities involved in the data collection activities
- Producing biennial Quality Assessment Reports and submitting them to management and MRRIC
- Developing Quality Management Plans for the AMP and associated annual quality assessment reports
- Coordinating governmental and commercial laboratories to ensure adequate training, coordination, and consistency in laboratory and field procedures
- Initiating/conducting systems audits, performance audits, and corrective actions
- Reviewing new and alternative methods and requests for sample modifications
- Conducting data verification, validation, and quality assessment as needed
- Coordinating training for these functions and making sure the guidelines are followed and any deficiencies are corrected.

Standardized monitoring/data collection methodologies, sampling schemes, laboratory analytical methods, and QA and reporting procedures for each of the monitoring parameters will be agreed upon and used by all participating investigators in the program for collecting, processing, and managing data. Any changes in methods during the implementation of the plan, once approved, will be documented. The ISP will also interact with the MRRP Management and MRRIC Work or Task Groups to review and comment on all data-related technical specification; ensure that a proper data QA/QC process will be in place, particularly for data acquisition contracts; and review contract Statements of Work (SOWs) for monitoring.

6.4.5 Alternative Procedures or Variances

To maintain a level of standardization and consistency and to help ensure verifiable data quality, adherence to QAPP provisions is critical. However, the intention of QAPP is not to be restrictive, but rather to encourage agile responses to identified challenges, as well as to stimulate the creation of new methods and innovations. Proper approvals, including those of any regulatory agency, if deemed necessary by the ISP, are required prior to implementing a variance from the QAPP. Variances may involve the use of alternate laboratory or field procedures, QA/QC elements, and data validation or data management procedures. Variances may be driven by project limitations, a need for enhancements or improvements, such as better technology, or for experimental or research purposes. The QAPP details processes that will be used for review and approval of variances for water quality monitoring and analysis; alternate biological, ecological, and hydrologic procedures; and remote sensing procedures and protocols. The ultimate

goal of the variance process is to ensure that the proposed alternative procedure or method will produce data of a quality appropriate to the study's objectives, and consistent with MRRP data gathering activities.

6.5 Reporting and Communications

Reporting and communicating the activities of the MRRP, progress toward objectives, knowledge gained from monitoring, assessment and research activities, and decisions regarding future program activities is essential to the adaptive management of the program. Additionally, the ESA emphasizes the necessity for "reporting requirements... for determining whether [incidental take permit] terms and conditions are being complied with" (section 10(a)(2)(B)(v)).

The USACE is working with the USFWS and the MRRIC on the development of a data management and communications system for the MRRP. Reporting and communications requirements and processes will be refined as part of that effort, and through the normal engagements fundamental to the MRRP and described in Chapter 2. This section outlines considerations and provides guidance on these topics so as to shape early reporting and communications activities under the 2018 BiOp.

6.5.1 Reporting

The MRRP generates two primary reports on a recurring basis, the Annual AM Report and the Annual Update to the Strategic Plan. Additionally, the program generates a number of technical reports and studies under the direction of the ISP or as part of the planning and design of projects, collects and evaluates data, and prepares materials for MRRIC and the public. Requirements for each vary, will likely evolve over time to better fulfill program needs, and are subject to relevant policies.

6.5.1.1 USACE Annual Reporting in Compliance with the 2018 USFWS Biological Opinion

The 2018 BiOp is complex because the USACE Proposed Action has a long duration and includes both immediate actions and a Science and Adaptive Management Plan to test hypotheses, determine most effective actions, assess impacts of actions and propose changes in management of the Missouri River system. The USACE Proposed Action analyzed in the recent consultation fits the description of a mixed programmatic action because it includes immediate actions and anticipates (through the Science and Adaptive Management Plan) future actions that will be subject to section 7 consultation, if necessary.

As future actions are further defined the consultation requirement under 7(a)(2) may be triggered even though those future actions are intended to benefit the likelihood of survival and recovery of listed species. As described in the 2018 BiOp, the most appropriate and efficient way to review future actions is as part of an annual reporting and review. Such an annual report represents an examination from the action agency of how the past activities aligned with the action proposed under the consultation and identify proposed changes or additional actions for the immediate future. To insure consistency with the framework of the programmatic consultation, the USFWS will use that opportunity to assist the USACE in satisfying any needed additional compliance with 7(a)(2). This is likely to take the form of a statement or document of consistency with the framework and conclusions of the 2018 BiOp and a statement of exemption of take as necessary.

The Annual Adaptive Management Report along with a submittal letter/document represent the USACE annual reporting requirement in compliance with the 2018 BiOp. A description on progress towards meeting the pallid sturgeon, interior least tern, and piping plover sub-objectives as well as calculations for determining take as defined in the Incidental Take Statement are provided in the Annual AM Report. Information on the progress towards achieving the fundamental objectives for the pallid sturgeon, interior least tern, and piping plover as well as information on incidental take is documented in the Annual AM Report. The following list of topics are included in the AM Report and/or summarized in the submittal document as part of the annual review and reporting process:

1. **USACE Proposed Action including Adaptive Management** –This section includes a list of site-specific projects that were covered under the BiOp in the past year, any proposed changes for future years, and any changes from what is described in the BiOp. It also provides a brief description, or reference to, actions or studies that were conducted in the previous year. Discussion on any planned studies or actions that were not conducted is also included. Additional recommendations or “lessons learned” on improving the processes described in the AM plan or suggestions to improve coordination among both agencies should be described in this section as well.
2. **Conservation Recommendations** –Section 18 of the 2018 BiOp provides conservation recommendations for the USACE to consider during project implementation. Although these actions are discretionary, USACE discusses what opportunities may or may not exist to implement these actions when funding or situations allow.

3. **Section 7(a)(1) Conservation Plan** –The proposed action included a section 7(a)(1) conservation plan for a variety of ESA listed species in Kansas City and Omaha Districts. Although these actions are discretionary, USACE discusses what opportunities may or may not exist to implement these actions when funding or situations allow. USACE and the Service will meet annually (December) to discuss any conservation recommendations or Section 7(a)(1) activities that have been implemented the prior year and plans for possible implementation in the following year. To capture these discussions, detailed and expanded meeting minutes will be taken. These expanded minutes will be part of the annual review process used by the USFWS as the statement or document of consistency with the framework and conclusions of this BiOp is prepared.

Table 71 summarizes the actions implemented in the reporting year as part of the Proposed Action. Changes or potential changes to the Proposed Action are described in the reporting documents by addressing the following questions:

1. Have any changes to the Proposed Action Occurred in Reporting Year?
2. Are there changes proposed for the following reporting year?
3. What processes in the Adaptive Management plan did not go well and need improvement?
4. Describe how the coordination process between the USACE and USFWS and if improvements are needed?

Section 18 of the 2018 BiOp provides conservation recommendations for the USACE to consider during project implementation. Although these actions are discretionary, USACE should discuss what opportunities may or may not exist to implement these actions when funding or situations allow. Table 72 summarizes the status regarding the conservation recommendations included in Section 18 of the 2018 BiOp.

Section 7(a)(1) of the ESA directs Federal Agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a Proposed Action on listed species or critical habitat, to help implement recover plans, or to develop information. Table 3 summarizes the actions implementing as part of the Section 7(a)(1) plan.

Table 71. USACE Proposed Action (Actions Completed in 20XX)

Operations & Maintenance of the Bank Stabilization and Navigation Project	
Types of O&M	# Implemented in Reporting Year
Routine Maintenance of Existing Rock Filled Structures	
Revetments	
Dikes	
Sills	
Crossing Control Structures (Kickers)	
Changes to the Footprint of Structures	
Landward Dike Extensions	
Riverward Dike Extensions	
Hardpoints	
Construction of New Dikes	
Piles	
Structure Lowering	
Least Tern and Piping Plover Management Actions	
Action	Description of Implementation
Mechanical ESH Creation	XX acres of ESH were created at RM XX, RM XX, etc.
Vegetation Management	XX acres were treated with herbicide via aerial spraying
Predator Management	
Human Restriction Measures	
Flow Management to Reduce Take	
Nest and Chick Relocation	XX nests and XX chicks were relocated
Pallid Sturgeon Management Actions	
Propagation and Augmentation	
Spawning Habitat	
Interception Rearing Complex	
Adaptive Management (Studies Completed in Reporting Year 20XX)	
Completed Study	Category
	Choose an item.
	Choose an item.

Table 72. 2018 BiOp Conservation Recommendations Annual Reporting Form

Conservation Recommendations	Status of Conservation Recommendation
Coordinate pallid sturgeon monitoring efforts and information with those entities working on the Mississippi River.	Choose an item.
Continue to pursue completion of fish passage at Intake Dam on the Yellowstone River as authorized by WRDA (2007).	Choose an item.
Implement recovery actions for pallid sturgeon, piping plover, interior least tern, and other listed species, in coordination with the Service, as identified in the most recent recovery plans for those species.	Choose an item.
Consider sturgeon and sicklefin chub when implementing project actions, research, and monitoring. Gathering data on these species will inform future listing decisions.	Choose an item.
Support the collection of data (i.e. contaminant hazards) necessary for the development of a risk assessment for pallid sturgeon.	Choose an item.
Support studies to increase the accuracy of estimations of piping plover annual survival rates.	Choose an item.
Determine whether it would be feasible to manage flows to create shoreline habitats, backwater areas, inter-sandbar channels, and ephemeral pools and whether engineered habitats may be designed, located, and constructed to maximize the likelihood of creating these habitat components.	Choose an item.
Increase gravel and cobble on areas of mechanically created sandbars and consider removal of gravel from areas that may function as sinks for nesting plovers.	Choose an item.
Consider the potential to address shortcomings in remote sensing data (i.e. habitat quality) to suitable nesting habitat for piping plovers is estimated with sufficient accuracy.	Choose an item.
Adaptive management priorities should be assigned to monitoring and to analysis of the Missouri River ESH targets based on modeling that considers the entire piping plover population unit, including birds on river segments, reservoirs, and alkali lakes.	Choose an item.
Adaptive management priorities should be assigned to develop a monitoring scheme to understand the immigration between alkali lakes and piping plover habitats in the Northern Region to properly inform habitat targets.	Choose an item.

Table 73. Section 7(a)(1) Conservation Plan Annual Reporting Summary.

Conservation Strategy	Summary of Implementation
Identify opportunities to operate the System to benefit listed species.	
Support the Pallid Sturgeon Propagation and Augmentation Program in addition to the Biological Assessment Proposed Action.	
Identify opportunities to maintain the BSNP in a manner that could contribute beneficially to aquatic habitat.	
Prioritize lands for acquisition that contribute to meeting pallid sturgeon habitat requirements when consistent with BSNP Fish and Wildlife Mitigation Program authority.	
Consider Indiana bat and northern long-eared bat habitat needs in planning of site-specific habitat development for Mitigation Program lands.	
Evaluate potential for levee modifications at existing and future mitigation sites.	
Determine if there is potential to operate the Kansas River projects in a manner that would increase benefits to native species.	
Avoid adverse impacts to gray bat, Indiana bat, and northern long-eared bat while maintaining District projects.	
Coordinate, communicate, and cooperate among entities responsible for conserving pallid sturgeon, least tern, and piping plover.	

6.5.1.2 Strategic Plan

The MRRP employs a rolling, 5-year Strategic Plan (SP) for implementation of the management actions, research, monitoring, assessment, and associated engagements needed to meet the MRRP goals and objectives. It includes the current fiscal year (CFY) and the following 4 years. The SP follows and builds upon the Science Update Process (see Section 2.4.3), and conforms to the constraints of the USACE Civil Works Budget Process. Annual updates to the SP include adjustments to the CFY and the following year (FY+1) necessary for program execution, but the emphasis is on development of the FY+2 program needs for budgeting purposes and planning for upcoming years (FY+3 and FY+4). A key element of the SP is the risk management related to potential program adjustments and identification of priority needs for opportunistic/accelerated implementation.

An initial draft of the SP was prepared in 2018 to test and evaluate the strategic update process. Feedback from the exercise will be used to refine the content and scope of the SP in the future. In general, the SP should provide a multi-year accounting of the Program that:

- 1) Identifies anticipated program activities and contingencies, including
 - Project implementation
 - Research
 - Monitoring and assessment
 - Governance, collaboration, administration, reporting, etc
- 2) Articulates the rationale for program direction
- 3) Prioritizes a listing (and possibly prioritization) of major activities
- 4) Documents decisions
- 5) Highlights programmatic decision-relevant uncertainties that could affect program direction and composition, as well as any appropriate contingency plans or other risk management strategies

6.5.1.3 *Technical Reports and Research Results*

The ISP establishes requirements for studies and research reports developed in support of the MRRP. These requirements are discussed in Attachment x of Appendix A.

6.5.2 Communications

A wide variety of communications directly or indirectly take place as part of the MRRP. These are essential to the programs success in a variety of ways; they ensure PDTs, managers and senior leaders are making decisions based on the best available information, they convey intent to the entities involved in the program, and they ensure transparency with MRRIC and the public.

General requirements and responsibilities for communications are described in the PgMP (see Attachment 10 of Appendix A). Specific requirements will be addressed as the MRRP develops its data management and communications plan, and will be outlined in future revisions to this SAMP.

References Cited

- Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS) 2015. Report to the Secretary of the Interior. March 30, 2015. 86 pp. (accessed 12/10/15 from: https://nccwsc.usgs.gov/sites/default/files/files/ACCCNRS_Report_2015.pdf)
- Allen, Craig R. and Gunderson, Lance H., "Pathology and failure in the design and implementation of adaptive management" (2011). Nebraska Cooperative Fish & Wildlife Research Unit -- Staff Publications. Paper 79. <http://digitalcommons.unl.edu/ncfwrustaff/79>
- AMPV5 Summary. 2016. Summary of the Draft MRRP AM Plan V5. Prepared by the Missouri River Recovery Adaptive Management Team for the Missouri River Recovery Implementation Committee. September 12, 2016. Available online at <https://community.apan.org/wg/mrric/m/meetings/172537>
- Atkinson, Andrea J., et al. Designing monitoring programs in an adaptive management context for regional multiple species conservation plans. US Geological Survey, Western Ecological Research Center, 2004.
- Barber, M.C., ed. 1994. Environmental Monitoring and Assessment Program: Indicator Development Strategy. EPA/620/R-94/XXX. Athens, GA. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory. Available online here (very long URL)
- Bennett S., G. Pess, N. Bouwes, P. Roni, R.E. Bilby, S. Gallagher, J. Ruzyski, T. Buehrens, K. Krueger, W. Ehinger, J. Anderson, C. Jordan, B. Bowersox and C. Greene. 2016. Progress and Challenges of Testing the Effectiveness of Stream Restoration in the Pacific Northwest Using Intensively Monitored Watersheds, *Fisheries*, 41:2, 92-103, DOI: 10.1080/03632415.2015.1127805. <http://dx.doi.org/10.1080/03632415.2015.1127805>
- Bonneau, J. and C. Kruse. 2016. Charter for evaluation of skinny pallid sturgeon observations on the Lower Missouri River. Submitted to the Effects Analysis Team 2/16/2016. 2 pp.
- Buenau K, Cullinan V, Vernon C, and Huber C. 2015. Science Information to Support Missouri River Piping Plover and Least Tern Effects Analysis. Pacific Northwest National Laboratory Richland, Washington. 10 pp.
- Buenau K.E. (2015), Modeling to Support the Development of Habitat Targets for Piping Plovers on the Missouri River. PNPL-24287, Pacific Northwest National Laboratory, Richland, WA.

- Buenau K.E., Hiller T.L., and Tyre A.J. (2014), Modeling the effects of river flow on population dynamics of piping plovers (*Charadrius melodus*) and least terns (*Sternula antillarum*) nesting on the Missouri River, *River Res. Applic.*, 30, pages 964–975, doi: 10.1002/rra.2694
- Burkhardt-Holm, P. and K. Scheurer. 2007. Application of the weight-of-evidence approach to assess the decline of brown trout (*Salmo trutta*) in Swiss Rivers. *Aquatic Sciences*. 69: 51-70.
- Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) - Marmorek, D.R., M. Porter, D. Pickard and K. Wieckowski (eds.). 2007. Snake River Basin Pilot Study: Volumes 1 and 2. Prepared by ESSA Technologies Ltd., Vancouver, B.C. on behalf of the Columbia Basin Fish and Wildlife Authority, Portland, OR. 2007. 47 pp. <https://groups.nceas.ucsb.edu/monitoring-kb/7-revise/Volume-1-FINAL.pdf> Volume 2 (232 pp.) available online at: http://s3.amazonaws.com/zanran_storage/www.cbfwa.org/ContentPages/16142024.pdf
- Corsello, M. "System-of-Systems Architectural Considerations for Complex Environments," IEEE SYSTEMS JOURNAL, pp. 312-320, 2008.
- DeLonay, A.J., Chojnacki, K.A., Faulkner, J.D.A., Candrl, J.S., and Combs, D.K., 2015, Comparative studies of the initiation of drift behavior by three sturgeon species in an experimental stream [abstract], 2015 North American Sturgeon and Paddlefish Society Annual Meeting: Oshkosh, Wisconsin, North American Sturgeon and Paddlefish Society <http://www.nasps-sturgeon.org/media/33336/NASPS%202015%20Abstracts%20in%20Alphabetical%20Order.pdf>
- DeLonay, A.J., Chojnacki, K.A., Jacobson, R.B., Albers, J.L., Braaten, P.J., Bulliner, E.A., Elliott, C.M., Erwin, S.O., Fuller, D.B., Haas, J.D., Ladd, H.L.A., Mestl, G.E., Papoulias, D.M., and Wildhaber, M.L., 2016b, Ecological requirements for pallid sturgeon reproduction and recruitment in the Missouri River: A synthesis of science, 2005-2012: U.S. Geological Survey, Scientific Investigations Report 2015-5145, 224 p. <https://pubs.er.usgs.gov/publication/sir20155145>
- DeLonay, A.J., Jacobson, R.B., Chojnacki, K.A., Braaten, P.J., Buhl, K.J., Eder, B.L., Elliott, C.M., Erwin, S.O., Fuller, D.B., Haddix, T.M., Ladd, H.L.A., Mestl, G.E., Papoulias, D.M., Rhoten, J.C., Wesolek, C.J., and Wildhaber, M.L., 2016a, Ecological requirements for pallid sturgeon reproduction and recruitment in the Missouri River: Annual report 2013: U.S. Geological Survey Open-File Report 2015–1197, 99 p. <https://pubs.er.usgs.gov/publication/ofr20151197>
- Diefenderfer, H. L., G. E. Johnson, R. M. Thom, K. E. Buenau, L. A. Weitkamp, C. M. Woodley, A. B. Borde, and R. K. Kropp. 2016. Evidence-based evaluation of the cumulative effects of ecosystem restoration. *Ecosphere* 7(3):e01242. 10.1002/ecs2.1242

- Diefenderfer, H.L., R.M. Thom, G.E. Johnson, J.R. Skalski, K.A. Vogt, B.D. Ebberts, G.C. Roegner and E.M. Dawley. 2011. A Levels-of-Evidence Approach for Assessing Cumulative Ecosystem Response to Estuary and River Restoration Programs. *Ecological Restoration* Vol. 29, Nos. 1–2, 2011, pp. 111-132
- Doyle M, Murphy D, Bartell S, Farmer A, Guy C, Palmer M. 2011. Missouri River Recovery Program, Independent Science Advisory Panel Report on Spring Pulses and Adaptive Management. U.S. Institute for Environmental Conflict Resolution and Oak Ridge Associated Universities, Third Party Science Neutral.
- Duit, A. and V. Galaz. 2008. Governance and Complexity—Emerging Issues for Governance Theory. *Governance: An International Journal of Policy, Administration, and Institutions*. 21 (3): 311–335.
- EPA (United States Environmental Protection Agency). 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4. Office of Environmental Information, Washington, DC. Available online at: <http://www.epa.gov/sites/production/files/2015-06/documents/g4-final.pdf>
- Ferrell, J. 1993. Big Dam Era. Omaha, NE: U.S. Army Corps of Engineers, Missouri River Division. Greig, L.A., D.R. Marmorek, C. Murray, and D.C.E. Robinson. 2013. Insight into enabling adaptive management. *Ecology and Society* 18(3): 24. Available online: <http://www.ecologyandsociety.org/vol18/iss3/art24/>
- Fischenich et al. 2017. Habitat Assessments in Support of the Missouri River Recovery Program Effects Analysis; Hydrogeomorphic Team Integrative Report. ERDC Technical Report EL TR-17-XX. Vicksburg, MS: US Army Engineer Research and Development Center.
- Fischenich J, Tripe J, Meier D, Pridal D, Givson S., Hickey J, and Econopouly T. 2014. Models, Data and Literature to Support Habitat Analyses for the Missouri River Effects Analysis. U.S. Army Corps of Engineers. Vicksburg, MS. 80 pp.
- Fischenich, C., et al. 2012. The application of Adaptive Management to ecosystem restoration projects. EBA Technical Notes Collection. ERDC TN-EMRRP-EBA-10. Vicksburg, MS: U.S. Army Engineer Research and Development Center. www.wes.army.mil/el/emrrp.
- Fischman, R.L., and Ruhl, J.B., 2016. Judging Adaptive Management Practices of U.S. Agencies. *Conserv Biol*. 2016 Apr;30(2):268-75. doi: 10.1111/cobi.12616. Epub 2015 Nov 2.
- Fish and Wildlife Service and the National Marine Fisheries Service. 1998. **Endangered Species Act Section 7 Consultation Handbook**. Fish and Wildlife Service and the National Marine Fisheries Service. Endangered Species Act Section 7 Consultation Handbook. 315p.

- Forbes, V.E. and P. Calow. 2002. Applying Weight-of-Evidence in Retrospective Ecological Risk Assessment When Quantitative Data are Limited. *Human and Ecological Risk Assessment* 8(7): 1625-1639.
- Galat, D.L., Berry, C.R., Gardner, W.M., Hendrickson, J.C., Mestl, G.E., Power, G.J., Stone, Clifton, and Winston, M.R., 2005, Spatiotemporal patterns and changes in Missouri River fishes: American Fisheries Society Symposium, v. 45, p. 249–291.
- Green, O.O., L. Schultz, M. Nekoro, and A.S. Garmestani. 2015. Chapter 7: The Role of Bridging Organizations in Enhancing Ecosystem Services and Facilitating Adaptive Management of Social-Ecological Systems. Pages 107-122 in C.R. Allen and A.S. Garmestani (editors). *Adaptive Management of Social-Ecological Systems*. Springer Publishing.
- Greig, L. A., Marmorek, D. R., Murray, C., & Robinson, D. C. E. (2013). Insight into enabling adaptive management. *Ecology and Society*, 18(3), 24. <http://dx.doi.org/10.5751/ES-05686-180324>
- Gunderson and Light 2006. Adaptive management and adaptive governance in the everglades ecosystem. *Policy Science* 39:323–334
- HAMP SOP Author 2015? Missouri River Habitat Assessment and Monitoring Program (HAMP) Standard Operating Procedures, 2015
- Hillman, T.W. 2004. Monitoring strategy for the Upper Columbia basin. Draft Report. Prepared by Tracy W. Hillman, BioAnalysts, Inc. Eagle, Idaho. Prepared for Upper Columbia Regional Technical Team, Upper Columbia Salmon Recovery Board, Wenatchee, Washington. February 1, 2004.
- Hillman, T.W. 2006. Monitoring strategy for the Upper Columbia basin. Draft Report. Prepared by Tracy W. Hillman, BioAnalysts, Inc. Eagle, Idaho. Prepared for Upper Columbia Regional Technical Team, Upper Columbia Salmon Recovery Board, Wenatchee, Washington. Available online at: <http://www.colvilletribes.com/media/files/UCB%20Monitoring%20Strategy%202008-01-06.pdf>
- Intergovernmental Data Quality Task Force (IDQTF). 2005. Uniform Federal Policy for Quality Assurance Project Plans. Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs. Washington, D.C. DTIC ADA 427785
- ISAP (Independent Science Advisory Panel) 2015. ISAP Evaluation of MRRMP v3 AM Plan and Pallid Level 3 Actions. Nov. 9, 2015. 24 pp.
- Jacobson, R. B., & Galat, D. L. (2008). Design of a naturalized flow regime on the Lower Missouri River. *Ecohydrology*, 1(2), 81–104.

- Jacobson, R.B., Annis, M.L., Colvin, M.E., James, D., Welker, T.L., and Parsley, M.J., in review, Missouri River pallid sturgeon effects analysis integrative report 2015: U.S. Geological Survey, Scientific Investigations Report 2015-xxxx, 218 p.
- Jacobson, R.B., Annis, M.L., Colvin, M.E., James, D., Welker, T.L., and Parsley, M.J., in press, Missouri River Scaphirhynchus albus (Pallid Sturgeon) Effects Analysis—Integrative Report 2016: U.S. Geological Survey, Scientific Investigations Report 2016-xxxx, 275 p.
- Jacobson, R.B., Annis, M.L., Parsley, M.J., James, D.A., Colvin, M.E., and Welker, T.L., 2016a, Scientific information to support the Missouri River pallid sturgeon effects analysis: U.S. Geological Survey, Open-file Report 2015-1226, 78 p. <http://pubs.er.usgs.gov/publication/ofr20151226>
- Jacobson, R.B., Parsley, M.J., Annis, M.L., Colvin, M.E., Welker, T.L., and James, D.A., 2016b, Development of working hypotheses linking management of the Missouri River to population dynamics of Scaphirhynchus albus (pallid sturgeon): U.S. Geological Survey, Open-file Report 2015-1236, 33 p. <https://pubs.er.usgs.gov/publication/ofr20151236>
- Jacobson, R.B., Parsley, M.J., Annis, M.L., Colvin, M.E., Welker, T.L., and James, D.A., 2015b, Development of conceptual ecological models linking management of the Missouri River to pallid sturgeon population dynamics: U.S. Geological Survey, Open-File Report 2015-1038, 47 p. <https://pubs.er.usgs.gov/publication/ofr20151038>
- K. Blann, S. Light, J.A. Musumeci. Facing the adaptive challenge: practitioners' insights from negotiating resource crises in Minnesota. F. Berkes, J. Colding, C. Folke (Eds.), Navigating Social–Ecological Systems, Building Resilience for Complexity and Change, Cambridge University Press, Cambridge (2003), pp. 210–240
- Keeney, R. L. (1982), Potential Research Topics in Decision Analysis. *Decision Sciences*, 13: 547–550. doi:10.1111/j.1540-5915.1982.tb01180.x
- Keeney, R.L., Gregory, R.S., 2005. Selecting attributes to measure the achievement of objectives. *Operations Research* 53, 1-11.
- Krentz, S., R. Holm, H. Bollig, J. Dean, M. Rhodes, D. Hendrix, G. Heidrich, and B. Krise. 2005. Pallid Sturgeon Spawning and Stocking Summary Report (1992 – 2004). Available online: <http://www.fws.gov/mountain-prairie/fisheries/missouriRiverFWCO/pallid%20spawning%20and%20stocking%20summary%200512.pdf>

- Light, S.S. (2001). Adaptive ecosystem assessment and management: the path of last resort? In M. Jensen (Ed.), *A guidebook for integrated ecological assessment*. New York, NY: Springer-Verlag.
- Loftin, M. K. 2014. Truths and governance for adaptive management. *Ecology and Society* 19(2): 21. <http://dx.doi.org/10.5751/ES-06353-190221>
- Marmorek, D. D. Pickard, A. Hall, K. Bryan, L. Martell, C. Alexander, K. Wieckowski, L. Greig and C. Schwarz. 2011. Fraser River sockeye salmon: data synthesis and cumulative impacts. Technical Report 6. The Cohen Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River. 363 pp. Available online: <http://www.watershed-watch.org/wordpress/wp-content/uploads/2012/01/Exh-1896-NonRT-.pdf>
- MRRIC 2011. "Development and Implementation of Adaptive Management Strategies - MRRIC Engagement Approach". Approved by MRRIC on February 15, 2011
- MRRIC 2014. "Human Considerations (HC) Objectives and Performance Metrics"
- MRRIC. 2014. Missouri River Recovery Implementation Committee Charter. Revised 2014. 13 pp.
- MRRIC. 2016. Missouri River Recovery Implementation Committee. FINAL Operating Procedures and Ground Rules. Amended November 2016. 20 pp.
- Murphy, D.D., and Weiland, P.S., 2011, The route to best science in implementation of the Endangered Species Act's consultation mandate: The benefits of structured effects analysis: *Environmental Management*, v. 47, no. 2, p. 161–172. [Also available at <http://dx.doi.org/10.1007/s00267-010-9597-9>.
- National Academy of Sciences. 2003. Policy and Procedures on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports. May 2003. Available online at: <http://www.nationalacademies.org/coi/index.html>
- National Research Council (NRC). 2002. *The Missouri River Ecosystem: Exploring the Prospects for Recovery*. Washington, D.C.: National Academies Press.
- Nie, M.A., and Schultz, C.A. 2012. Decision-Making Triggers in Adaptive Management. *Conservation Biology*, Volume 26, No. 6, 1137–1144
- Normand, S.L., McNeil, B.J., Peterson, L.E., and Palmer, R.H., 1998, Eliciting expert opinion using the Delphi technique: identifying performance indicators for cardiovascular disease: *International Journal for Quality in Health Care*, v. 10, no. 3, p. 247-260.

Office of the Deputy Under Secretary of Defense for Acquisition and Technology, Systems and Software Engineering, "Systems Engineering Guide for Systems of Systems," Washington, 2008.

Pallid Sturgeon Recovery Team. 2008. Pallid Sturgeon (*Scaphirynchus albus*) Range Wide Stocking and Augmentation Plan. Prepared for the Region 6, US Fish and Wildlife Service, Denver, CO.
Available online: http://www.fwspubs.org/doi/suppl/10.3996/022012-JFWM-013/suppl_file/10.3996_022012-jfwm-013.s8.pdf

Peterman R.M., D. Marmorek, B. Beckman, M. Bradford, N. Mantua, B. Riddell, M. Scheuerell, M. Staley, K. Wieckowski, J. Winton, C. Wood. 2010. Synthesis of evidence from a workshop on the decline of Fraser River Sockeye. June 15-17, 2010. A Report to the Pacific Salmon Commission, Vancouver, B.C., 123 pp. + 35 pp. of appendices. Available online:
<http://www.psc.org/pubs/FraserSockeyeDeclineWorkshopReport.pdf>

Porecca, A.P., W.D. Hintz, G.W. Whitley, N.P. Rude, E.J. Heist, J.E. Garvey. 2015. Establishing ecologically relevant management boundaries: Linking movement ecology with the conservation of *Scaphirynchus sturgeon*. Canadian Journal of Fisheries and Aquatics Sciences. 10.1139/cjfas-2015-0352

PRRIP 2014. Platte River Recovery Implementation Program Adaptive Management Plan (AMP). 2013 State of the Platte Report. 91 pp. Available online at:
<https://www.platteriverprogram.org/PubsAndData/ProgramLibrary/March%204%202014%20FINAL%20PRRIP%202013%20State%20of%20the%20Platte%20Report.pdf>

Puget Sound Partnership 2008. Notes from Science Panel Briefing Material for April 16, 2008 Discussion with Science Panel. Downloaded on 04/16/16 from URL:
<http://www.psp.wa.gov/downloads/SP2008/041508/11AdaptiveManagementAccountability.pdf>

Randall, M., M. Colvin, K. Steffensen, T. Welker, L. Pierce, and R. Jacobson. 2016. Assessment of Adult Pallid Sturgeon Fish Condition, Lower Missouri River: Application of New Information to the Missouri River Recovery Program. Draft Report. Sept. 9, 2016. 44 pp.

RECOVER. 2004. Quality Assurance Systems Requirements (QASR) Manual. Comprehensive Everglades Restoration Program. (accessed 12/12/15 from:
http://www.evergladesplan.org/pm/program_docs/qasr.cfm;))

RECOVER. 2009. Monitoring and Assessment Plan. Comprehensive Everglades Restoration Program. (accessed 12/12/15 from: http://141.232.10.32/pm/recover/recover_map_2009.aspx0)

- Rhoads, B. L., Wilson, D., Urban, M. L., & Herricks, E. E. (1999). Interaction between scientists and nonscientists in community-based watershed management: Emergence of the concept of stream naturalization. *Environmental Management*, 24, 297–308.
- Ridenour, C.J., C.J. Wrasse, H.A. Meyer, W.Doyle, T.D. Hill. 2012. 2011 contingency sampling report- Variation in fish assemblages among four habitat complexes during a summer flood: implications for flow refuge. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 39p.
- Rijke, J., R. Brown, C. Zevenbergen, R. Ashley, M. Farrelly, P. Morison, S. van Herk. 2012. Fit-for-purpose governance: A framework to make adaptive governance operational. *Environmental Science and Policy*. 22: 73-84.
- Roni, P., T. J. Beechie, C. E. Jordan, G. R. Pess. 2012. Basin scale monitoring of river restoration: recommendations from case studies in the Pacific Northwest USA.
http://www.nwfsc.noaa.gov/assets/4/911_03262014_091848_Roni.et.al.2012-AFSS-78.pdf
- Shaffer, TL, MH Sherfy, MJ Anteau, JH Stucker, MA Sovada, E Roche, MT Wiltermuth, DA Buhl, and CM Dovichin. 2013. Accuracy of Missouri River Least Tern and Piping Plover Monitoring Program: Considerations for the Future, U.S. Geological Survey, prepared in cooperation with the U.S. Army Corps of Engineers U.S.G. Survey, Reston, VA.
- Sheriff, S.L., Renken, R.B., and Treiman, T.B., 2011, Missouri River public use assessment: Final report: Missouri Department of Conservation, 285 p
- Sheskin, D. J. 2007. Handbook of parametric and nonparametric statistical procedures, fourth edition. Chapman & Hall/CRC, Boca Raton, Florida.
- Sims, S. A., and J. Pratt Miles, editors. CAMNet fifth annual rendezvous, adaptive governance in the face of environmental and social change, April 16-17, 2011, Antioch University, Keene, NH. Summary. Collaborative Adaptive Management Network (CAMNet), Dillon, Ohio, USA.
- Steffensen, K. D., M. A. Pegg, and G. Mestl. 2013. Population prediction and viability model for pallid sturgeon (*Scaphirhynchus albus*, Forbes and Richardson, 1905) in the lower Missouri River. *Journal of Applied Ichthyology* 29:984-989.
- Trinity River Restoration Program, ESSA Technologies Ltd. 2009. Integrated Assessment Plan, Version 1.0 – September 2009. Final report prepared for the Trinity River Restoration Program, Weaverville, CA. 285 pp. http://odp.trrp.net/FileDatabase/Documents/IAP_1.01.pdf

- Tyre, A. J., B. Tenhumberg, M. A. McCarthy, and H. P. Possingham. 2000. *Swapping space for time and unfair tests of ecological models*. **Australian Journal of Ecology** 25:327–331.
- U.S. Bureau of Reclamation (Reclamation). 2015. Appendix E – Lower Yellowstone Passage Project Monitoring and Adaptive Management Plan. Report Reference: BOR-0000084
- U.S. Bureau of Reclamation and U.S. Army Corps of Engineers (Bureau and USACE). 2015. Intake Diversion Dam Modification Lower Yellowstone Project, Montana. Final Supplement to the 2010 Final Environmental Assessment. Available online: http://www.usbr.gov/gp/mtao/loweryellowstone/EIS/2015_ea.pdf
- Upper Basin Pallid Sturgeon Propagation Committee. 2005. Upper Basin Pallid Sturgeon Propagation Plan. Available online: <http://www.fws.gov/mountain-prairie/endspp/protocols/PallidPropagation2005.pdf>
- USACE 2000a. Missouri River Main Stem Reservoirs - Releases Needed to Support Navigation. MRBWMD Technical Report 2000-A. USACE Northwestern Division, Missouri River Basin, Water Management Division
- USACE 2000b. Planning Guidance Notebook. US Army Corps of Engineers Engineer Regulation ER 1105-2-100. Headquarters, USACE. Washington, DC.
- USACE. 1999. Digest of Water Resources Policies and Authorities. Engineer Pamphlet EP-1165-2-1. US Army Corps of Engineers. Washington D.C. 381 pp
- USACE. 2000. Missouri River Main Stem Reservoirs - Releases Needed to Support Navigation. MRBWMD Technical Report 2000-A. USACE Northwestern Division, Missouri River Basin, Water Management Division
- USACE. 2000. Planning Guidance Notebook. US Army Corps of Engineers Engineer Regulation ER 1105-2-100. Headquarters, USACE. Washington, DC.
- USACE. 2004.
- USACE. 2006. Missouri River Mainstem Reservoir System Master Water Control Manual. USACE Northwestern Division
- USACE. 2007. Missouri River Mainstem Reservoir System - System Description and Regulation. USACE Northwestern Division, Missouri River Basin, Water Management Division

- USACE. 2010. Water Resources Policies and Authorities – Civil Works Review Policy. Headquarters, U.S. Army Corps of Engineers. Washington, DC.
- USACE. 2014. Draft Framework for Human Considerations Objectives and Performance Metrics and Associated Modeling/Methodology (USACE 2014)
- USACE. 2015. Full citation unknown. Drawn from MRRMP-EIS, referenced in Section 4.2.5.1
- USACE. 2015. Missouri River Mainstem System 2015-2016 Annual Operating Plan
- USFWS 2000. Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. 385 pp.
- USFWS. 2003. U.S. Fish and Wildlife Service 2003 Amendment to the 2000 biological opinion of the operation of the Missouri River main stem reservoir system, operation and maintenance of the Missouri River bank stabilization and navigation project and operation of the Kansas River reservoir system. USFWS, Washington D.C.
- USFWS. 2007. Pallid sturgeon (*Scaphirhynchus albus*) 5 year review summary and evaluation. U.S. Fish and Wildlife Service. Denver, Colorado. Available online: http://www.fws.gov/mountain-prairie/missouririver/Pallid_Sturgeon_5-year_review_June%202007.pdf
- USFWS. 2013. Interior least tern (*Sternula antillarum*) 5-Year Review: Summary and Evaluation. Jackson, Mississippi. 75 pp.
- USFWS. 2015. Planning Aid Letter from Mr. Casey D. Kruse (USFWS) to Ms. April Fitzner (USACE), entitled “Regarding the Missouri River Recovery Management Plan Lower Missouri River Pallid Sturgeon Framework, Targets and Decision Criteria”. Nov. 2, 2015. 2 pp.
- USFWS. 2015. U.S. Fish and Wildlife Service. Recovery Plan for the Northern Great Plains piping plover (*Charadrius melodus*) in two volumes. Volume I: Draft breeding recovery plan for the Northern Great Plains piping plover (*Charadrius melodus*). 132 pp.
- USFWS. 2015. Planning Aid Letter from Mr. Casey D. Kruse (USFWS) to Ms. April Fitzner (USACE), entitled “Regarding Task B3 in the Missouri River Recovery Program FWCA Scope of Work – FY 2015”. Nov. 2, 2015. 8 pp.
- USFWS and USACE 2015. Lower Missouri River Pallid Sturgeon Framework, Targets and Decision Criteria. Nov. 2, 2015. 18 pp.

- USFWS. 2016. Establishing piping plover and least turn targets for development of the U.S. Army Corps of Engineers Missouri River Recovery Management Plan. Denver, Colorado. 30 pp.
- USFWS. 2016. Recovery Plan for the Northern Great Plains piping plover (*Charadrius melodus*) in two volumes. Volume I: Draft breeding recovery plan for the Northern Great Plains piping plover (*Charadrius melodus*) 132 pp. and Volume II: Draft revised recovery plan for the wintering range of the Northern Great Plains piping plover (*Charadrius melodus*) and Comprehensive conservation strategy for the piping plover (*Charadrius melodus*) in its coastal migration and wintering range in the continental United States. Denver, Colorado. 166 pp.
- Walters, C.J., J.S. Collie and T. Webb. 1988. Experimental Designs for Estimating Transient Responses to Management Disturbances. *Can. J. Fish. Aquat. Sci.* 45: 530-538.
- Water Resources Reform and Development Act of 2014. Public Law 113-121.
<https://www.gpo.gov/fdsys/pkg/PLAW-113publ121/pdf/PLAW-113publ121.pdf>
- Wiens, J.A. and K. R. Parker. 1995. Analyzing the effects of accidental environmental impacts: approaches and assumptions. *Ecol. Appl.* 5(4): 1069-1083.
- Wildhaber, M.L., DeLonay, A.J., Papoulias, D.M., Galat, D.L., Jacobson, R.B., Simpkins, D.G., Braaten, P.J., Korschgen, C.E., and Mac, M.J., 2011, Identifying structural elements needed for development of a predictive life-history model for pallid and shovelnose sturgeons: *Journal of Applied Ichthyology*, v. 27, no. 2, p. 462-469. doi: 10.1111/j.1439-0426.2011.01731.x.
- Williams, B. K., and E. D. Brown. 2012. Adaptive Management: The U.S. Department of the Interior Applications Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. 120 pp.
- Williams, Byron K., Robert C. Szaro, and Carl D. Shapiro. 2007. Adaptive management: the US Department of the Interior technical guide. US Department of the Interior, Adaptive Management Working Group, 2007.
- WRDA 2007. H.R.1495 - Water Resources Development Act of 2007 (Public Law 110-114) on Congress.gov (Library of Congress)