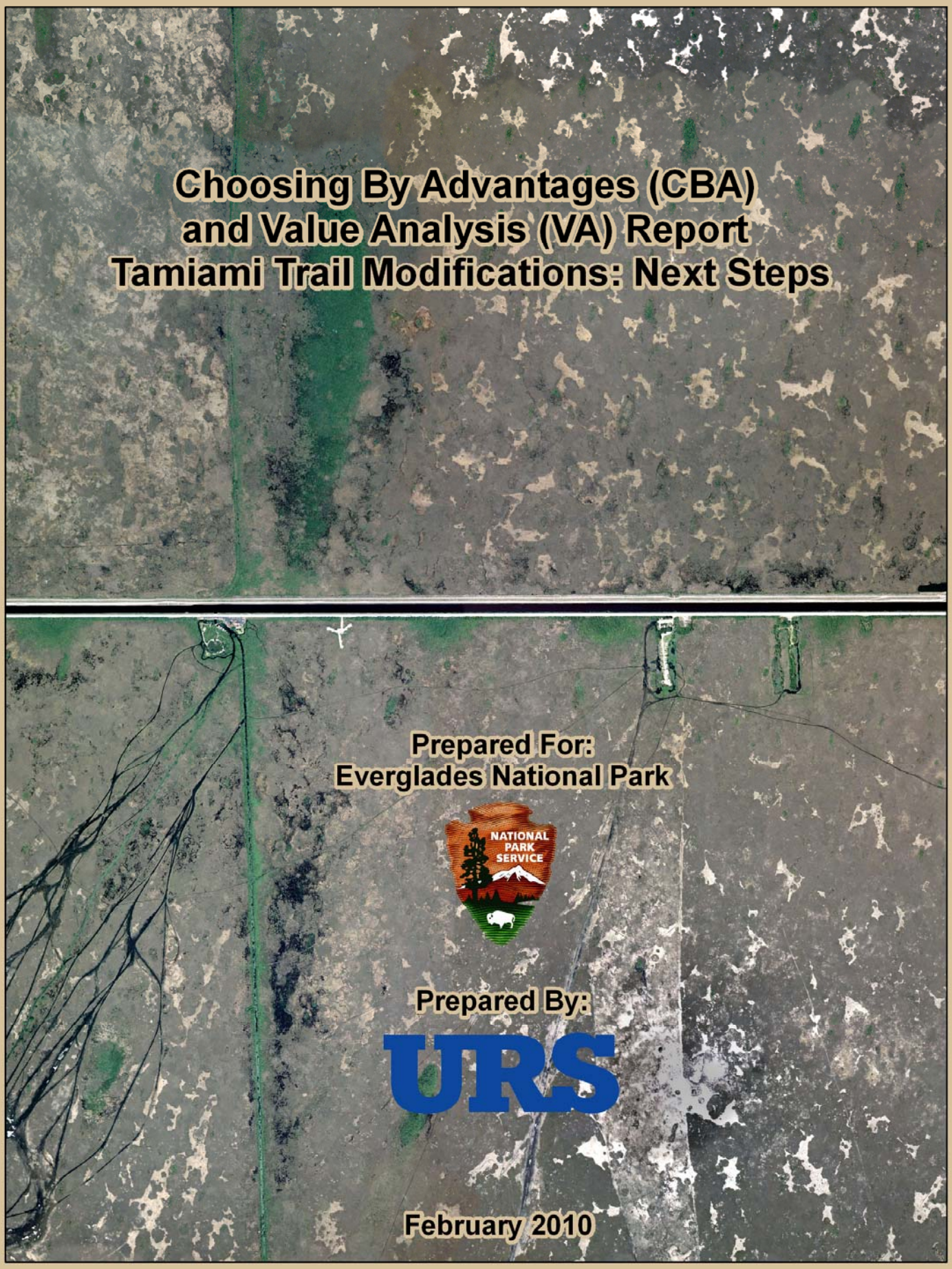
Appendix B
Value Analysis (VA) / Choosing By Advantages (CBA) Report



Choosing By Advantages (CBA) and Value Analysis (VA) Report Tamiami Trail Modifications: Next Steps

Prepared For:
Everglades National Park

Prepared By:

URS

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Choosing By Advantages (CBA) and Value Analysis Report
Tamiami Trail Modifications: Next Steps
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Section 1 Information Phase:

Congressional Guidance – 2009 Omnibus Appropriations Act

The 2009 Omnibus Appropriations Act approved by Congress directed the U.S. Army Corps of Engineers (USACE) to construct modifications to U.S. Highway 41 (Tamiami Trail) that were approved in the 2008 Limited Reevaluation Report and Environmental Assessment (Alternative 3.2.2.a). The 2009 Omnibus Appropriations Act also directed the Department of the Interior National Park Service (NPS) to "immediately evaluate the feasibility of additional bridge length, beyond that to be constructed pursuant to the Modified Water Deliveries to Everglades National Park Project (16 U.S.C. § 410r-8), including a continuous bridge, or additional bridges or some combination thereof, for the Tamiami Trail to restore more natural water flow to Everglades National Park (ENP) and Florida Bay and for the purpose of restoring habitat within the Park and the ecological connectivity between the Park and the Water Conservation Areas" (2009 Omnibus Appropriations Act).

Background and Project History

The Everglades once covered nearly four thousand square miles from Lake Okeechobee to Florida Bay and the Gulf of Mexico. Its original condition clearly showed that it was a flow-way, where shallow water derived from direct rainwater and from wet-season overflows from Lake Okeechobee moved southward as sheet flow, not channelized flow as in rivers and streams. Although the flow direction was understandable based on the slope of the terrain, the most impressive evidence of flow came from the shape of plant communities in the landscape. A directional pattern was observed by early explorers and seen on older aerial photographs to have defined most of the Everglades. The orientation of plant communities – deeper sloughs, sawgrass "ridges," and tree islands with downstream "tails" – is called ridge-and-slough landscape. The Northeast Shark River Slough (NESRS) portion of Everglades National Park was fully part of this landscape. Today, the ridge-and-slough landscape only remains in limited areas of the Everglades, and is highly degraded in NESRS. The following provides background on how these changes happened and why there is a need to restore the area to more historical conditions.

Major alterations of the Everglades began to take effect with flood control efforts in the second decade of the 1900s, initially designed to reduce water levels in Lake Okeechobee. By 1926, six major canals diverted Okeechobee's waters to tide, lowering the lake, and removing much of the Everglades headwaters, affecting even the southern Everglades, home of the future Everglades National Park (established in 1947).

In 1928, the Tamiami Trail and Tamiami Canal were completed. They were constructed completely across the Everglades with regular culverts and some short bridges to accommodate flow. The Tamiami Trail was to become the northern boundary of Everglades National Park. These early alterations of the hydrology of the Everglades had observed effects, noted in a 1938 reconnaissance report for the future national park and in mapping of Everglades vegetation done based on 1940 aerial photographs.

Combined with droughts, notably in the early 1940s, the early drainage system excessively depleted waters of the Everglades, causing major soil fires and impairing freshwater supplies for

people. Alternatively, the hurricanes in 1926, 1928, and 1947 showed the inadequacy of drainage works in protecting developing agricultural and urban lands from overwhelming floods. Of particular interest are the two hurricanes of 1947, which demonstrated that rainfall on the Everglades, without the full overflows of Lake Okeechobee, could still raise waters to excessive depths, estimated to have been six to eight feet deep over vast areas of the central Everglades. Consequently, the Tamiami Trail was overtopped and impassible for weeks. After water had receded enough for an adventure out on Tamiami Trail, an eye-witness account related how the north ends of culverts along the roadway evidenced large whirlpools and water was still flowing over the road.

The widespread severity of flooding in 1947 led to the Central and Southern Florida Project for Flood Control and other Purposes (the C&SF Project). The C&SF Project's many constructed features included three water conservation areas to conserve water and provide for Everglades wildlife. Water Conservation Area 3 (WCA-3) was developed with its south-end levee along the Tamiami Trail. Completed in 1963, WCA-3 was divided into two parts – the huge western part was designated WCA-3A and the smaller eastern part became WCA-3B. The parts were separated by a pair of levees; the L-67A and L-67C, which were designed to route water westward. The WCA-3B received relatively little water and gradually deteriorated by the loss of its ridge-and-slough landscape character, while WCA-3A often got too much water, especially in its southern portion because of the natural slope of the terrain, damaging tree islands and important wildlife values. However, much of the signature of ridge-and-slough landscape was retained, especially in central WCA-3A.

WCA-3A was constructed with four control gates along the Tamiami Trail to provide flows into Everglades National Park, and a 9-mile levee was constructed south from the Trail along the east side of the park (the L-67 Extension) to prevent water from moving eastward from the park into NESRS. Until 1989, the park only bordered the Tamiami Trail from the center of the Everglades west to the border with the Big Cypress Swamp at 40-mile Bend – the 10-mile-wide western side of the Shark River /slough. No provision was made to transfer water from WCA-3B to the east side of the Shark River Slough south of the Trail – the NESRS. Some of the land ownership in the NESRS was private, and surface flows reached the area only through culverts connecting with the Tamiami Canal under the Tamiami Trail. NESRS remained over-drained as it had been for many years.

In 1989, Everglades National Park was expanded by adding NESRS, called the "East Everglades Expansion Area" of 107,600 acres. Plans to improve water flows into the NESRS began – a program called Modified Water Deliveries (MWD) or "Mod Waters." While that work was developing, the separate and far broader Everglades restoration initiative, called the "Restudy," began in 1992 and became the Comprehensive Everglades Restoration Plan (CERP) after acceptance by Congress in 2000. Research on flows in the pre-drainage Everglades, using the "Natural System Model" developed for CERP, showed that the eastern half of the Shark River Slough, including the NESRS, had originally carried 65% of the Everglades flows, with only 35% on the western half. Conversely, the routing established by the C&SF Project put 78% of modern flows to the west, and only 22% through NESRS. The intent of the study and project is to find solutions that will allow the full extent of Everglades Restoration to be realized with out the Tamiami Trail being a limiting factor on the flows to and through NESRS that are needed to restore ecological functions in Everglades National Park. As such, the effort is neither CERP nor MWD, but seeks ecological benefits within the context of future CERP projects so that modifications to the Trail will only need to be made once.

Alternatives for water conveyance from the L-29 canal across the Tamiami Trail were first evaluated in a General Reevaluation Report and Supplemental Environmental Impact Statement (GRR/SEIS) in 2003. The 2003 Preferred Plan was a 3,000 foot bridge in

combination with raising the un-bridged roadway segment. In 2005, a revision of the 2003 GRR/SEIS (called the RGRR/SEIS) analysis was performed to re-evaluate the 2003 GRR/SEIS and additional alternatives. Subsequently nine alternatives and the no-action alternative were retained for detailed analysis. The 2005 Recommended Plan was Alternative 14 (two-mile long bridge at the western region of the project area and a one-mile long bridge at the eastern end). The total project cost was estimated at approximately $144 million. A Record of Decision selecting Alternative 14 was signed on January 25, 2006.

However, due to the significant increase in the cost estimate, Congress directed the USACE to re-evaluate the 2005 Recommended Plan as well as develop less costly alternatives. In developing these alternatives, the USACE was directed to increase flows to the Park of at least 1,400 cubic feet per second, without significantly increasing the risk of roadbed failure. USACE prepared a Limited Reevaluation Report and Environmental Assessment (LRR/EA) in 2008 which evaluated 27 options, including no-action and the 2005 RGRR plan (Alternative 14). It was determined that the best performing and most cost-effective plan was alternative 3.2.2.a. This alternative combines a one-mile bridge in the eastern location with raising the stage constraint at L-29 by one foot, to 8.5 feet, and providing road mitigation to this level. The cost for this tentatively selected plan is $225.4 million.

As noted above, Congress directed the USACE to immediately begin construction of Alternative 3.2.2.a. However, construction of this project would provide less than half (1,400 cfs to 1,800 cfs) of the flow volume target contained in the 1992 General Design Memorandum (4,000 cfs). Therefore, Congress also directed the Department of Interior to immediately evaluate the feasibility of additional bridge length, beyond Alternative 3.2.2.a, including a continuous bridge, or additional bridges or some combination thereof, for the Tamiami Trail to restore more natural water flow to Everglades National Park and Florida Bay and for the purpose of restoring habitat within the Park and the ecological connectivity between the Park and the Water Conservation Areas.

Section 2 Functional Analysis Phase:

An interagency team was formed to develop the project objectives, performance measures (PM) and alternatives based on the direction of the 2009 Omnibus Appropriations Act. Based on the Congressional language authorizing this project, the team considered the restoration and/or enhancement of three ecological and hydrological characteristics of the project. These have been selected as Planning Objectives for this project:

- Objective 1: Restore Natural Water Flow to ENP:
  - *Construct additional bridging and road raising of the Tamiami Trail to provide for unconstrained flows to Northeast Shark River Slough (NESRS) and Florida Bay*
- Objective 2: Restore Ecological Connectivity:
  - *Improve ecological connectivity by removing obstructions to sheet flow*
  - *Improve species movements between WCA-3B and Everglades National Park*
- Objective 3: Restore Habitat Within ENP:
  - *Restore slough vegetation and the deep water sloughs*
  - *Restore processes that produce and maintain ridge and slough communities in ENP east of the L-67 Extension*

The interagency team used the benefits analyses in the 2005 TTM RGRR and 2008 TTM LRR as a baseline for selecting performance measures and focused on ways to make adjustments and produce predictions that allowed relative comparisons among the new alternatives.

The team went through the following sequence of steps: screen performance measures from the 2005 RGRR and 2008 LRR that could not be used, create a new velocity performance measure, assign numerical scoring to the qualitative raw values, normalize the scores for easier comparisons and calculate the difference between the with-alternative condition and future without project condition in order to determine the "lift" for each alternative.

These quantified performance measures were then used as part of the Choosing By Advantages (CBA) process to help select the preferred alternative.

Screen Performance Measures

The team considered the 13 performance measures reviewed in the 2005 RGRR, removing the following from further consideration in this study due to the reasons listed below:

A. Average Annual Flow Volumes – no hydrologic data were available for these alternatives.
B. Proportion of area with low flow velocity (<0.1 f/s) discharges within one mile of the Tamiami Trail–no new RMA modeling was available.
C. Distribution of flows, east to west (this is largely affected by lengths of opening(s) in Tamiami Trail) - no new RMA modeling was available.
D. Shift to open water, spikerush marsh and slough communities in NESRS–no hydrologic data was available to review this PM.
E. Risk of ridge and tree island peat burning in NESRS– no hydrologic data was available to review this PM.
F. Invasion of exotic woody plant species- no hydrologic data was available to review this PM.

G. Total abundance of fishes in ENP marshes–the team assembled for this 2009 study was not able to use this performance measure. The performance measure is based on hydroperiods and time since last drydown. No hydrologic data was available to review this PM.
H. Conditions for wading bird foraging and nesting–this performance measure was tied closely to the abundance of fish and thus was also removed.

The team also considered the performance measures which were used in the 2008 LRR that had not been in the 2005 RGRR, removing the following from further consideration in this study due to the reasons listed below:

A. One-in-ten year maximum discharge – no hydrologic data was available for these alternatives.
B. Number of days water depth greater than two feet during wet season peak - no hydrologic data was available for these alternatives.
C. Number of days water depth greater than three feet during wet season Peak - no hydrologic was data available for these alternatives.
D. Average water depth during wet season peak - no hydrologic data was available for these alternatives.

Two performance measures from the 2005 RGRR which were revised for the 2008 LRR were used again for this study:

A. Reverse filling in of sloughs changed to “Number of sloughs crossed by each alternative”
B. Flows from L-29 Canal into deep sloughs of NESRS changed to “Flows into NESRS provided via bridge”

The eight performance measures used in this analysis address important characteristics of ENP: connectivity, ridge and slough processes, flows, velocity, wildlife resources, cultural resources and wetlands. These eight performance measures reflect differences among alternative bridge lengths, locations and openings. In addition, all performance measures represent the capability to provide potential benefits of the structural alternatives. Please refer to Section 4 of this report for more detail on these performance measures.

Section 3 Creativity Phase

A total of six Alternatives, (No-Action, 1, 2, 4, 5 and 6) were selected for analysis. These alternative features are discussed below in Section 3.1. Discussion during the Choosing by Advantages (CBA) Workshop revealed that two of the alternatives, 2 and 6, provided important advantages yet, as designed, created potential seepage impacts which were undesirable. Consequently, Alternatives 2a and 6e were added for consideration and are discussed in Section 3.2.

All of the following action alternatives assume the 1-mile eastern bridge (2008 LRR) has been constructed. The lengths of the bridges, transition areas between the bridges and the roadway, and the roadway are separated in the descriptions. Please note that Alternative 3 was eliminated per direction of the USACE.

3.1 Alternative Features:

No Action Alternative:

The No-Action Alternative is authorized by the 2008 Limited Reevaluation Report (LRR) and consists of a 1-mile eastern bridge and elevation of the remaining roadway to allow for 8.5 feet stages in the L-29 Canal. The roadway would not be modified. Although this alternative would not meet the requirements or objectives of the project, it was retained for further evaluation to satisfy the requirements of NEPA.

Alternative 1: 2.2 miles of bridges and remaining roadway elevated:

The bridge configurations include: (1) a 0.56 mile bridge located between the Osceola Camp and the Jefferson Pilot Radio Tower, (2) a 0.45 mile bridge located between the Jefferson Pilot Radio Tower and Everglades Safari Park, (3) a 0.51 mile bridge located between Everglades Safari Park and the Airboat Association, (4) a 0.38 mile bridge located the Airboat Association and the Tiger Tail Camp, and (5) a 0.26 mile ConSpan located between the Coopertown facility and the Radio One Tower.

Alternative 1 would involve creating conveyance openings through Tamiami Trail by removing 2.2-miles of the existing highway and embankment in addition to the one-mile eastern bridge (no-action). The bridges and conspan would create a conveyance opening through Tamiami Trail by removing the sections of the existing highway and embankment. The bridges would be constructed approximately 50 feet south of the centerline of the existing roadway to maintain motor vehicle traffic during bridge construction.The remaining highway embankment would be reconstructed to raise the crown elevation to 12.3 feet, the minimum required based on the design high water of 9.7 feet and the roadway cross section geometry.

Alternative 2a: 3.3 miles of bridges and remaining roadway elevated. The bridge configurations include: (1) a 0.56 mile bridge located between the Osceola Camp and the Jefferson Pilot Radio Tower, (2) a 0.45 mile bridge located between the Jefferson Pilot Radio Tower and Everglades Safari Park, (3) a 0.51 mile bridge located between Everglades Safari Park and the Airboat Association, (4) a 0.38 mile bridge located the Airboat Association and the Tiger Tail Camp, (5) a 0.26 mile ConSpan located between the Coopertown facility and the Radio One Tower, (6) a 0.53 bridge located between the Radio One Tower and the existing one-mile bridge, and (7) a 0.66 mile bridge located between the existing one-mile bridge and the S-334 Structure.

Alternative 2a would involve creating conveyance openings through Tamiami Trail by removing 3.3 miles of the existing highway and embankment. Bridges would be constructed

approximately 50 feet south of the centerline of the existing roadway to maintain motor vehicle traffic during bridge construction... The remaining highway embankment would be reconstructed to raise the crown elevation to 12.3 feet, the minimum required based on the design high water of 9.7 feet and the roadway cross section geometry. Refer to Phase VI for additional information.

Alternative 4: 1.0 miles of bridging and remaining roadway elevated:

The bridge configurations include: (1) a 0.56 mile bridge located between the Osceola Camp and the Jefferson Pilot Radio Tower, and (2) a 0.45 mile bridge located between the Jefferson Pilot Radio Tower and Everglades Safari Park. Alternative 4 would involve creating conveyance openings through Tamiami Trail by removing 1.0 mile of the existing highway and embankment. Bridges would be constructed approximately 50 feet south of the centerline of the existing roadway to maintain motor vehicle traffic during bridge construction The remaining highway embankment would be reconstructed to raise the crown elevation to 12.3 feet, the minimum required based on the design high water of 9.7 feet and the roadway cross section geometry.

Alternative 5: 1.5 miles of bridging and remaining roadway elevated:

The bridge configurations include: (1) a 0.56 mile bridge located between the Osceola Camp and the Jefferson Pilot Radio Tower, (2) a 0.45 mile bridge located between the Jefferson Pilot Radio Tower and Everglades Safari Park, and (3) a 0.51 mile bridge located between Everglades Safari Park and the Airboat Association. The bridges would create conveyance openings through Tamiami Trail by removing 1.5 miles of the existing highway and embankment in addition to the one-mile eastern bridge (no-action). Bridges would be constructed approximately 50 feet south of the centerline of the existing roadway to maintain motor vehicle traffic during bridge construction. The remaining highway embankment would be reconstructed to raise the crown elevation to 12.3 feet, the minimum required based on the design high water of 9.7 feet and the roadway cross section geometry.

Alternative 6e: 5.5 miles of bridges and remaining roadway elevated. This is the maximum bridging option and consists of 5.4 miles of bridges and elevating the remaining roadway. The bridge configurations include: (1) a 2.60 mile bridge located between the Osceola Camp and the Airboat Association, (2) a 0.40 mile bridge located between the Airboat Association and the Tiger Tail Camp, (3) a 1.80 mile bridge located between the Tiger Tail Camp and the existing one-mile bridge, and (4) a 0.70 mile bridge located between the existing 1-mile bridge and the S-334 structure.

The eastern Bridge Access Ramp will be located near Coopertown and the western bridge access will be located near Everglades Safari. The bridges would create a conveyance opening through Tamiami Trail by removing the sections of the existing highway and embankment under the bridges. Bridges would be constructed approximately 50 feet south of the centerline of the existing roadway to maintain motor vehicle traffic during bridge construction. The remaining highway embankment would be reconstructed to raise the crown elevation to 12.3 feet, the minimum required based on the design high water of 9.7 feet and the roadway cross section geometry.

Section 4 Evaluation Phase:

The evaluation factors were developed based on each of the proposed alternatives ability to provide environmental benefits and to minimize cultural resource impacts. An overview of the environmental benefits and cultural resources impacts analysis is provided below.

The Environmental Benefits were evaluated by an ecological sub-team consisting of representatives from five agencies–Everglades National Park (ENP), U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (FWS), Florida Department of Environmental Protection (FDEP), and South Florida Water Management District (SFWMD) in June-October 2009. This sub-team team included engineers, hydrologists, and biologists.

The impacts to Cultural Resources were evaluated by a sub-team consisting of representatives from Everglades National Park (ENP), URS Corporation, and New South Associates in June-October 2009. This sub-team team included engineers, hydrologists, historians, and archaeologists.

Environmental Benefits:

The goal of the environmental benefits analysis was to identify the hydrologic and ecological conditions that would occur for each of the alternatives outlined in Section 3 of this report and develop consistent and quantifiable performance measures in order to compare the alternatives. Subsequently, this comparison resulted in quantitative potential benefits for each alternative.

The sub-team used a variety of sources of information during its analysis. These included historical photos and surveys produced before Tamiami Trail was constructed in the 1920s, data on flows through Tamiami Trail bridges and culverts in the 1940s, and current topographic information. The team referred to analyses contained in the USACE 2003 General Reevaluation Report (GRR) for TTM, the associated 2003 FWS Coordination Act Report (CAR), the May 2005 Draft Tamiami Trail Alternative Optimization Report prepared by the ENP, the USACE 2005 Revised General Reevaluation Report (RGRR) for TTM, and the USACE 2008 Tamiami Trail Modifications Final Limited Reevaluation Report (LRR). Please refer to these earlier reports for additional information.

The interagency team used the benefits analyses in the 2005 TTM RGRR and 2008 TTM LRR as a baseline for selecting performance measures, discussed in Section 2 of this report, and focused on ways to make adjustments and produce predictions that allowed relative comparisons among the new alternatives.

An operational plan was not developed for this project. Full realization of benefits is dependent upon an operational plan that utilizes the structural capacity of the alternatives. Most of the performance measures quantify “potential” benefits that would occur once an operational plan is defined and executed. Although there has been a description of operational intent within the main report, these performance measures were limited to where the Sub-team felt there was adequate scientific data to support an analysis.

The following sections identify the final suite of performance measures that were used to develop the Factors and Attributes for the CBA Workshop**.**

Performance Measure Descriptions

This section presents a brief description of each of the eight performance measures–what they represent, how they were developed, the input information, units of measure, targets and the methods of calculation or estimation of values.

1. Potential connectivity of Water Conservation Area 3B (WCA-3B) Marsh and NESRS as percent of total project length.
2. Number of sloughs crossed by each alternative.
3. Flows into NESS provided via bridge.
4. Difference between Average Velocity in Marsh and Average Velocity at Road.
5. Reduction in wildlife mortality.
6. Impacts to Tamiami Trail as a Cultural Resource
7. Impacts to Historic Properties
8. Impacts to Wetlands

PM-1: Potential Connectivity of WCA-3B Marsh and NESRS as Percent of Total Project Length

This performance measure describes the potential connection between WCA-3B and NESRS if the L-29 Levee is removed under a future project. It is calculated by dividing the length of bridge opening in miles by 10.7 miles, the length of the longest possible bridge that could be constructed in the project area.

A 100 percent value indicates full *potential* connectivity and is the target. Note that this marsh to marsh connectivity would also require degrading the L-29 Levee that encloses the WCA-3 impoundments. Degrading L-29 is not authorized under this project.

Table 1: Potential Connectivity of WCA-3B Marsh and NESRS as Percent of Total Project Length

Alternative	Bridge Length (miles)1	Connectivity Performance Measure Score
No-Action	1.0	9%
1	3.2	30%
2a	4.3	40%
4	2.0	19%
5	2.5	23%
6e	6.5	61%

[1] Includes the length of the proposed bridging from the proposed alternative and the one-mile bridge from the No-Action Alternative.[1] Opening lengths are slightly shorter than bridge lengths. The difference between opening lengths may vary between alternatives based on inclusion of conspans and down ramps.

PM-2: Number of Sloughs Crossed by Each Alternative

This performance measure is related to the alignment of the bridge with existing degraded sloughs south of Tamiami Trail. Since the Tamiami Trail was constructed, sediment has accumulated in the sloughs downstream of the road. Situating a bridge directly upstream of the degraded slough would maximize the potential for storm flow velocities to maintain the sloughs through removal of the accumulated organic sediment. The length of the bridge has relevance only to the extent that it can encompass more sloughs within its flow cross-section.

The method used for estimating the number of sloughs crossed is based on the premise that the locations of the 19 sets of culverts were placed to match natural flow-ways. McVoy states in his swales report (McVoy, et al. in review, Pre-Drainage Everglades Landscapes and Hydrology, page 58) that the locations of the 19 sets of culverts were "apparently placed to match the natural flow ways." The performance measure is evaluated by counting the number of culverts that each bridge alternative crosses. Culverts located in the approach areas were not counted. The target for this performance measure is 19, the total number of culverts under Tamiami Trail. This method differs from the 2005 and 2008 USACE Tamiami Trail analysis of this PM, in which the HAED data was used to estimate the number of sloughs crossed by Tamiami Trail. Due to the locations of the alternatives in this study, the subteam felt that the culverts were a better method to estimate the number of historic sloughs crossed by each alternative.

Table 2: Number of Sloughs Crossed by Each Alternative

Alternatives	Bridge Length (miles)2	Number of Sloughs Crossed
No-Action	1.0	1
1	3.2	5
2a	4.3	6
4	2.0	2
5	2.5	4
6e	6.5	10

PM- 3: Flows into Northeast Shark River Slough Provided via Bridge

While the existing culverts provide a hydraulic connection to the deeper sloughs existing within NESRS, the capacity is not commensurate with the amount of flow expected in these deeper sloughs during both high and low flow conditions. Preferential flow through these deeper sloughs is even more pronounced during drier times.

The eastern portion of Shark Slough (from the L-67 extension to the L-31N Levee) varies in elevation from about 5.6 feet National Geodetic Vertical Datum (NGVD) to 7.2 feet NGVD. Without the obstruction of Tamiami Trail, the preferential flow path from this varying elevation would be in the deeper sloughs. The distribution of flow within NESRS would become more

[2] Includes the length of the proposed bridging from the proposed alternative and the one-mile bridge from the No-Action Alternative.

uniformly distributed (from west to east) as depth increases and the relative depth differences reduce.

Average and High Flow Conditions

The stages in NESRS range from about 4 feet NGVD (about two feet below ground surface) to 9 feet NGVD with a median stage of about 7.5 feet NGVD. Ground elevations vary along the Trail. The median stage of 7.5 feet NGVD results in an average water depth of about 1.1 feet with a maximum depth of about 1.9 feet and a minimum depth of about 0.3 feet.

The increased connection provided by the bridge aligned with deeper portions of NESRS, facilitates increased flow where it should occur preferentially. When the water level is less than 0.5 foot above the ridges, most of the flow occurs in the deeper sloughs. It is important for water to be rapidly delivered to these deeper sloughs, commensurate with this capacity, during wet periods. Rapid water delivery will produce higher velocities desirable for the redevelopment and maintenance of open water vegetation in these sloughs. This assessment assumes that sheet flow is based on the following equations:

Manning Equation; $Q = (u/n)\ A\ Rh^{(2/3)}\ (hf / L)^{(1/2)}$
A depth dependent Manning n ($n = \sim d^{0.77}$)

Where:

A = Cross Section Flow Area = W * d
W = Flow Width
d = Flow Depth
P = Wetted Perimeter
R = Hydraulic Radium = A/P = (W * d) / W ~ d

Dry Conditions

The importance of these connections during drier periods is increased by the fact that both the existing condition and the expected range of the "with project" conditions (Tamiami Trail Bridge in conjunction with revised operations) are drier than the desired conditions as represented by the Natural System Model (NSM)[3]. The increased connection that a bridge provides as compared with culverts in terms of capacity and connectivity (sheet flow with low velocity versus higher flow volume through a narrower culvert) is expected, for the same water availability, to have the following effects:

- Better distribution of the water; high water levels with more natural recession rates and less abnormal dry conditions as the limited water available will be able to reach these sloughs.
- May reduce unnatural predation around the culverts due to their limited area.

[3] The Natural System Model depicts the hydrologic response of the pre-drained system to rainfall and other hydrologic conditions of the period from 1965 through 1995. It does not depict the conditions of the pre-drained Everglades system, although there is a misconception that it does; such data does not exist (1999 *Final Integrated Feasibility Report and Programmatic Environmental Impact Statement*, a product of the *Central and Southern Florida Project Comprehensive Review Study*, also known as the *Restudy*).

Evaluation Procedure

Considering each bridge location, the benefits of different bridge lengths and locations were assessed. A representative "marsh capacity" was estimated on 200 foot wide intervals using the United States Geological Survey (USGS) helicopter ground elevations and Manning's "n" based flow equation used in the South Florida Water Management Model (SFWMM). The location of each bridge was then used to calculate the marsh capacity directly connected by a bridge opening. This marsh capacity for the bridge was then divided by the marsh capacity of the approximately 11 mile wide NESRS from the L-67 Extension to the L-31N Levee (NAD83 horizontal coordinates from 763,500 to 821,250) and expressed as a percentage.

Table 3: Flows into Northeast Shark River Slough Provided via Bridge

Alternative	Bridge Length (miles)[4]	Flows into Northeast Shark River Slough Provided via Bridge
No-Action	1.0	10%
1	3.2	35%
2a	4.3	50%
4	2.0	26%
5	2.5	29%
6e	6.5	64%

PM 4: Difference between Average Velocity in Marsh and Average Velocity at Road

The objective of this project is to allow for "unconstrained" flows to ENP, while providing flow velocities at the bridges approaching velocities seen in the freshwater marsh. The total bridge capacity must pass the greatest anticipated flows without exceeding the maximum allowable stage in the L29 canal. For this project the Tamiami Trail will be improved to allow for a maximum stage in the L29 canal of 9.7 feet. Hydrologic Engineering Center - River Analysis System (HEC-RAS) was used to evaluate the 6 alternatives (including "no action"), plus a 10.7 mile bridge, using steady flow water surface profiles. HEC-RAS allows for simulation of multiple bridge and culvert openings by solving the one-dimensional energy equation. Energy losses were computed using a depth-varying Manning's n-value, and contraction/expansion coefficients. The models show that all six proposed alternatives can pass the maximum anticipated flows (6,200 cfs) at the 9.7 foot design stage.

Results for computed velocities at the bridges and in the marsh, and the normalized performance measure scores, are shown in Table-4. Performance measure scores are based on a percent increase in flow velocity at bridges over marsh velocity. Scores are normalized on a scale of 0 to 1, and represent lift above base conditions (the no-action alternative).

[4] Includes the length of the proposed bridging from the proposed alternative and the one-mile bridge from the No-Action Alternative.

Table 4: Difference between Average Velocity in Marsh and Average Velocity at Road

Alternative	Average velocity 200' blw bridge (ft/sec)	Normalized PM Score
No-Action	0.34	0.0
1	0.14	0.7
2a	0.10	0.8
4	0.20	0.5
5	0.16	0.6
6e	0.08	0.9

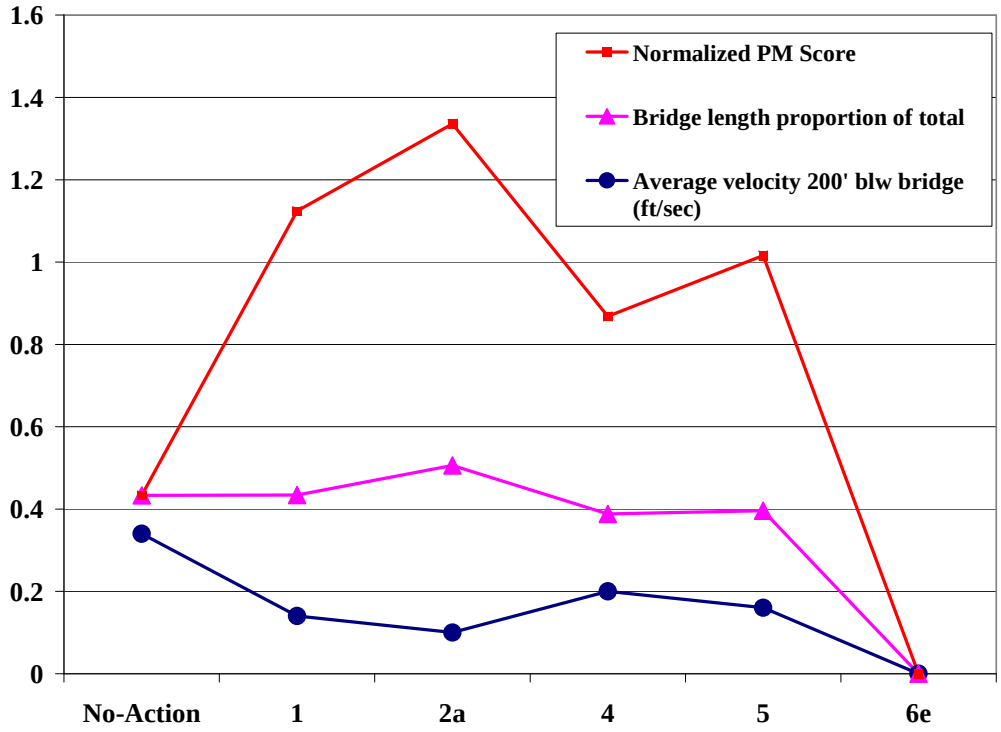


Figure 1: Average velocity 200' downstream of bridges, Bridge length proportion of total distance and normalized PM Scores for the Tamiami Trail alternatives.

PM 5: Reduction in Wildlife Mortality

This performance measure is based on average mortality data from the FWS for the Tamiami Trail. The data describe an average of 261 deaths per mile of road per year and assume that this rate applies to the entire 10.7 mile long project area.

The deaths of small animals from collision with automobiles would continue to occur on the sections of Tamiami Trail that would be connected to the adjacent marsh and canal. The deaths would not occur on the bridged sections of Tamiami Trail because there would be no connection between the road surface and the marsh and canal habitat of the animals. The animals would not easily reach the road surface in these sections and then be at risk of being hit. However, because the L-29 canal and levee are not eliminated and because conditions may be artificially deep under the bridge, limited bridging (e.g., one mile) may simply redirect animals to cross at other sections of the unbridged Tamiami Trail.

The performance measure presents the numbers of deaths that would be avoided because of the presence of the bridge(s). It is calculated by multiplying 261 deaths per mile per year by the total length of the bridge(s) in miles. A short bridge would only result in a small reduction in mortality while a bridge that spans the entire project area would produce the maximum value of 2,737 deaths per year avoided (Table 5).

Table 5: Reduction in Wildlife Mortality

Alternative	Total Bridge Length (miles)[5]	# Average Annual Deaths Avoided
No-Action	1.0	261
1	3.2	835
2a	4.3	1,122
4	2.0	522
5	2.5	653
6e	6.5	1,697

PM 6: Impacts to Tamiami Trail as a Cultural Resource

Elements of the Tamiami Trail are susceptible to adverse affect due to destruction of the roadway to construct bridges or install ConSpans. This factor was evaluated in terms of how much of the highway would be removed by the Alternatives under consideration. There would be an advantage of one alternative over another if less roadway was removed (See Table 6).

[5] Includes the length of the proposed bridging from the proposed alternative and the one-mile bridge from the No-Action Alternative.

. **Table 6 – Miles of Highway Affected/Protected**

Alternative	# of Resources Adversely Effected (Miles of Highway)	# Miles Protected
No-Action	1.0	9.7
1	3.2	7.5
2a	4.3	6.4
4	2.0	8.7
5	2.5	8.2
6e	6.5	4.2

PM 7: Impacts to Historic Properties

The historical resources analysis considered three cultural recourses eligible for the National Register of Historic Places (NRHP); 1) Tamiami Trail itself, 2) The private Airboat Association of Florida property, and 3) The Coopertown commercial property. The analysis also considered the Osceola Camp, Access to the Osceola Camp was not provided however it is potentially eligible for the NRHP..

Though the Airboat Association of Florida has been determined eligible for listing in the National Register for Historic Places, the archaeological testing to determine if remains over 50 years old were present did not encounter any such remains. Additionally, the buildings at this facility are farther south from the highway and will not experience direct adverse effects by any of the alternatives discussed earlier.

There is no information to indicate that the 5-acre Osceola Camp, which is within the Everglades National Park, is eligible for the NRHP, but evaluation of the property is incomplete because of lack of access. For the purposes of this analysis, the camp was considered potentially eligible and impacts were considered. Potential impacts from the proposed project would be outside the existing fence that separates the camp from the highway and are expected to result in only a minor impact to any historic values that the camp might have.

The Coopertown property could be adversely affected by increasing the roadway height, which would require additional right-of-way at the base of the embankment and loss of usable ground in the adjacent properties. Constructing a bridge in front of the property also could adversely affect their visual setting or degrade access. This factor was evaluated according to the level of impact on the properties, as cultural resources, which could be expected from the Alternatives under consideration. If all the Alternatives affect the properties, as cultural resources, to the same degree, there is no advantage to be realized. If there is a difference in the amount of property affected or the location of the properties affected then the lower amount of impact would be considered an advantage for that attribute and Alternative (See Table 7).

Table 7 – Historic Property Impacts

Alternative	Total Bridge Length (miles)	Airboat Association	Osceola Camp	Coopertown
No-Action	1.0	No Impact	No Impact	No Impact
1	3.2	Minor Impact	Minor Impact	Moderate Impact
2a	4.3	Minor Impact	Minor Impact	Moderate Impact
4	2.0	Minor Impact	Minor Impact	Moderate Impact
5	2.5	Minor Impact	Minor Impact	Moderate Impact
6e	6.5	Minor Impact	Minor Impact	Major Impact

PM 8: Impacts to Wetlands

A wetlands assessment was conducted for this project to assist in the CBA process. This evaluation was meant to assess the permanent effects (both impacts and benefits) to the functional value of wetlands resulting from the construction-related activities of the project. This evaluation did not assess any potential long-term benefits to wetlands that could result from implementation of the project with a future operational plan.

In Florida, wetland impacts are typically assessed through the Uniform Mitigation Assessment Method (UMAM), which was developed by the Florida Department of Environmental Protection and the state Water Management Districts and has been adopted for use by the Florida offices of the USACE. A UMAM-type tabletop analysis was performed to assess the effects to the functional value of wetlands. With this method, the wetland functional value is scored both prior to implementation of the project and after the project. This method takes into account the value of the landscape, the hydrological characteristics of the area, and the vegetation community composition. Since an official UMAM has not yet been conducted for this project, average UMAM scores that were completed for another similar project, the Tamiami Trail Pilot Spreader Swales project, within the project area, were used for this analysis. Scores for all vegetated areas prior to project implementation were 18.5/30. Scores for vegetated areas that will be located in the bridging footprints were scored 11/30 after project implementation to account for the functional loss of wetland value to these areas. Areas within road raising, roads and bridging approaches were scored as a 0/30 following project implementation. For areas that were previously road that are converted to wetlands, these areas were scored 0/30 prior to project implementation and 11/30 following project implementation.

For this analysis, the Geographic Information Systems (GIS) layers depicting the project construction features were intersected with the Land Use Land Classification layer to estimate the amount of permanent effects to wetlands. This acreage was then multiplied by the average UMAM score to assess the effects to the functional value of the wetlands prior to project implementation. The scores were then summed. Next, the effects to wetlands were assessed in the post project implementation conditions. These scores were then summed. The scores were then combined to assess the overall effects to wetlands both prior to and following project implementation. ***Table 8*** below shows the results of the UMAM-type analysis prepared for this project. The “UMAM” score below was calculated per the following equation:

Permanent wetland effects = [UMAM score (after project) x wetland acreage] - [UMAM score (before project) x wetland acreage)]

Table 8 – Wetland UMAM Scores

Alternative	Total Bridge Length (miles)	UMAM Score
No-Action	1.0	-42.1
1	3.2	-588.4
2a	4.3	-507.9
4	2.0	-593.6
5	2.5	-572.7
6e	6.5	-194.4

Note: The least negative number represents the least amount of permanent wetland impacts.

Selection of Final Factors for CBA Workshop

The CBA team created a list of factors and attributes from the original lists of project performance measures. The sub-teams then evaluated whether information had been developed and was available to document the attributes and determine whether there was an associated advantage. The CBA guidance specifically states that a factor should be used only when there are discernable differences between the alternatives. This process resulted in the selection of 8 factors and attributes that were carried forward to the CBA workshop. A list of the 8 factors selected along with the list of the fundamental factors that were initially considered but subsequently dismissed is provided below.

Factors Selected:

1. Potential Ecological Connectivity - Length of opening over the targeted 10.7 mile stretch
2. Potential Marsh Flow -Marsh velocity over the targeted 0.05ft/sec
3. Potential Number of Sloughs Re-connected – Number of sloughs re-connected over 19
4. Potential Sheet Flow – Percent target achieved in 200-foot increment
5. Potential Reduction in Wildlife Mortality – Highest number of road kills avoided/year
6. Prevent Loss of Cultural Resources (Highway) – Number of miles of highway protected
7. Prevent Loss of Cultural Resources (Property) – The degree of impact over the targeted zero impact
8. Net Wetland Effects – Permanent wetland effects with highest net score obtained from Uniform Mitigation Assessment Method UMAM score.

Factors Considered but Dismissed:

- **Regional effects (e.g., ability to reduce water levels in southern WCA 3):** No discernable differences between alternatives, since this project does not contain an operational plan. While greater capacity to move flows from WSS to NESRS should optimize future capabilities to improve ecological conditions in WCA-3 (reduce deep-ponding areas) and NESRS, this factor is outside the scope of this project.

- **Threatened and Endangered (T&E) Species**: No discernable differences between alternatives regarding their impact on or ability to protect T&E species, since addressing these concerns is required for all alternatives equally.
- **Socio-economic:** The USACE completed this review and, similar to the recreation factor, did not believe there would be discernable differences between alternatives. ENP was given authority to purchase the commercial airboat properties in the 1989 Act and all other businesses will continue to have access to their properties with all alternatives equally.
- **Compatibility with CERP and Pre-CERP Projects:** No discernable differences between alternatives, since all alternatives were deemed compatible with CERP and Pre-CERP projects.
- **Safety:** No discernable difference between alternatives, since all alternatives would be required to provide a required level of safety.
- **Recreation**: No discernable difference since the ENP Superintendant has committed to providing the same level of recreation to all the alternatives.

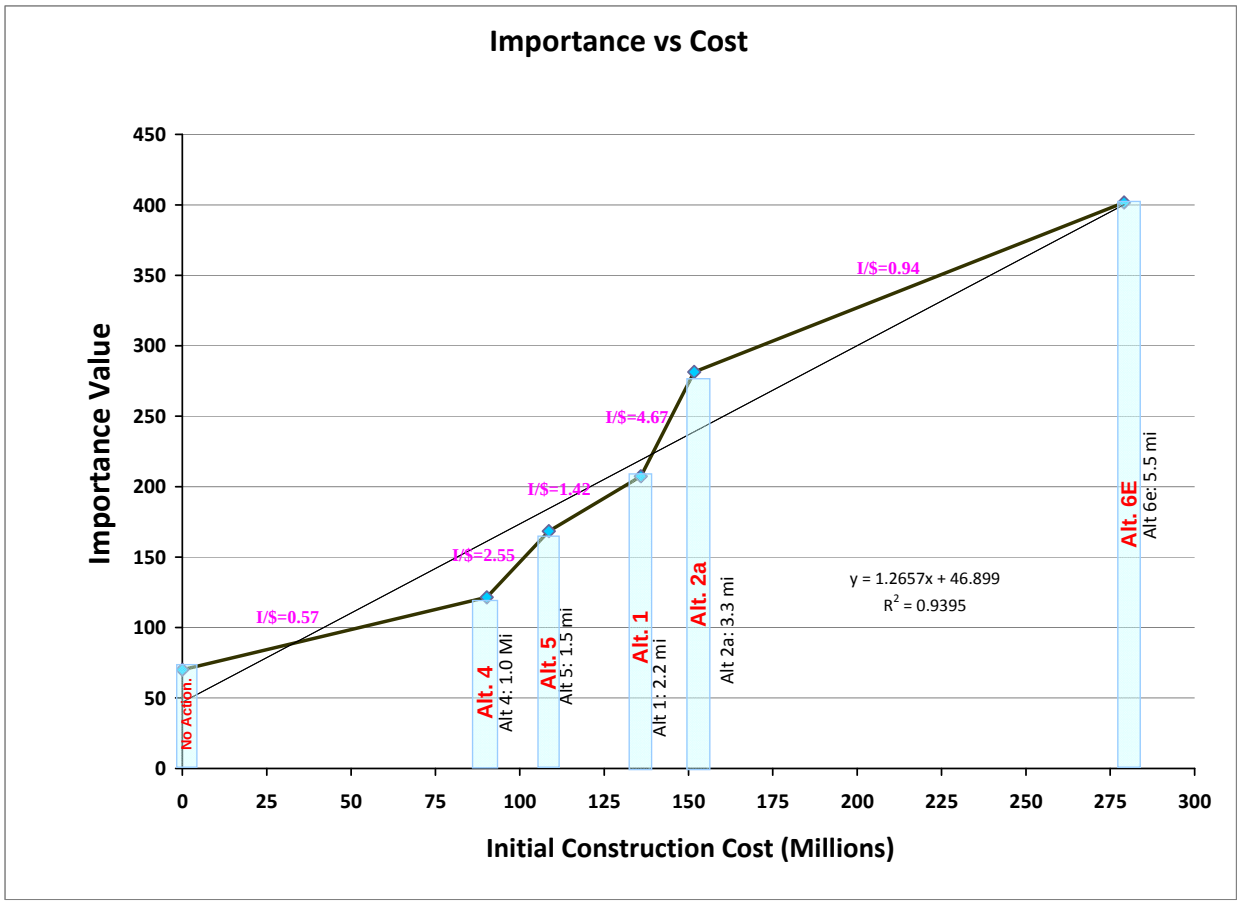
The CBA evaluation matrix for the Tamiami Trail Modifications: Next Steps Project Alternatives is included as Appendix A.

The Factors were selected by the inter-agency/tribal team based on the project objectives. Next, the sub-teams assigned attributes to each Factor. The team then determined and underlined the least preferred attribute for each Factor. The advantage for each attribute was then determined by subtracting the value of the least preferred attribute from the other attributes under each Factor. The team then identified and circled the Most Important Advantage for each factor for all Alternatives.

Once the advantages were determined and the team identified the least preferred and most important advantage for each factor, the workshop participants rated the relative importance of each of the advantages. The first step of this process was to select the ***paramount advantage*** – the most important of all the advantages. Selecting the paramount advantage was achieved by following a Defender-Challenger process that divided the task into a series of small comparisons.

The paramount advantage was assigned an importance score of 100, which was entered adjacent to the description of that advantage in the matrix. After selecting the paramount advantage the workshop participants weighed all the other advantages on the same scale of importance. The subsequent comparisons were of the relative importance of the advantages. When the importance of each advantage was decided and represented by a score, the importance scores were totaled for each alternative – the total importance.

Project cost is another factor. The amount of money is an attribute of the alternative but was not given an importance score. The process of comparing the cost attributes was performed by determining if an increase in project cost is coupled with an increase, a decrease, or no change in the importance of the advantages. The answer was in the ratio of importance score to dollar cost (I/$). As part of the CBA workshop, a simple value analysis (VA) was conducted by comparing the construction costs of the alternatives with the total importance score of each of the alternatives as shown below.


Importance vs Cost
Importance Value
Initial Construction Cost (Millions)
450
400
350
300
250
200
150
100
50
0
0
25
50
75
100
125
150
175
200
225
250
275
300
I/$=0.57
I/$=2.55
I/$=1.42
I/$=4.67
I/$=0.94
No Action.
Alt. 4
Alt 4: 1.0 Mi
Alt. 5
Alt 5: 1.5 mi
Alt. 1
Alt 1: 2.2 mi
Alt. 2a
Alt 2a: 3.3 mi
Alt. 6E
Alt 6e: 5.5 mi
y = 1.2657x + 46.899
R2 = 0.9395

Section 5 Development Phase:

The CBA team determined that of the factors that were most closely associated with the purpose and objectives of the project, the advantages of the “Sheet Flow”’ Factor were more important than the advantages of the other factors. Also, the team agreed that the most important or Paramount Advantage was represented by the most equitable distribution of overland flow over the 10.7 mile corridor length based on the topographic relief and location of proposed bridges in each alternative. Other important advantages were determined to be conditions in which 1) the greatest ecological connectivity was present, 2) alternatives which reconnected the greatest number of sloughs to restore the ridge-and-slough landscape, 3) and conditions which would pass water from north to south at a velocity closest to natural marsh conditions (0.05 cfs).

Section 6 Recommendation Phase:

The alternative that provides the most value for the Tamiami Trail Modifications was determined to be alternative 6e, which provides the greatest length in bridging along the corridor. See Appendix A for the CBA matrix and the chart showing the ratio between the importance of advantages and cost for each alternative.

Please note that the analysis does not include life cycle costs such as long term maintenance.

Section 7 Implementation Phase:

The USACE will construct the one-mile long bridge identified as Alternative 3.2.2.a in the 2008 LRR/EA within the three year limit imposed by Congress. The Department of Interior expects to complete a Report to Congress (evaluation of the feasibility of additional bridge length to achieve hydrological and ecological improvements) within the one year time allotted by Congress. After the required public review period for the Draft Environmental Impact Statement, it is anticipated that a Final Environmental Impact Statement (FEIS) and Record of Decision (ROD), which may or may not reflect the recommendation of this report, will be approved and be published in the Federal Register per the compliance requirements of the National Environmental Policy Act (NEPA). Implementation of the project included in the ROD will depend on available funding.

Section 8 CBA Study Team Members:

The following table lists the CBA study team members that were present during the CBA workshop conducted on November 4, 2009.

Name	Agency/Firm
Bruce Boler	NPS (Everglades National Park)
Dave Sikkema	NPS ENP
Alicia Logalbo	NPS ENP
Gregg Reynolds	NPS ENP
Brandon Gamble	NPS ENP
Dan Levy	URS Corporation
Keith Stannard	URS Corporation
Lilian Flank Maggi	URS Corporation
Valerie Chartier	URS Corporation
Thom Rounds	URS Corporation
Ernie Clarke	US Army Corps of Engineers (USACE)
Kevin Whittmann	USACE
Susan Conner	USACE
Donna George	USACE
Gwendolyn Nelson	USACE
Amy Swiecichowki	Everglades Partners Joint Ventures
Ingar Hansan	Florida Department of Environmental Protection
Barbara Culhane	Florida Department of Transportation
Mary Terry Vilches	Florida Department of Transportation
Kevin Palmer	U.S. Fish and Wildlife Service

Note: A representative from the Miccosukee Tribe of Indians (Joette Lorion) was present as an observer during the CBA workshop.

Section 9 Summary of Improvements, Cost Savings, and Study Costs:

The results of the CBA workshops revealed that Alternative 6e provided the most value when compared to the other alternatives evaluated. Alternative 6e provides the greatest bridge length (5.5 miles) and comes closest to the Congressional mandate stated in the 2009 Omnibus Appropriations Act.

Estimated costs for this study were approximately $20,100. This is based on the consultant's salaries and travel. Most of the NPS and Eco-Study-team participants are base funded. There was no donated time.

Appendix A

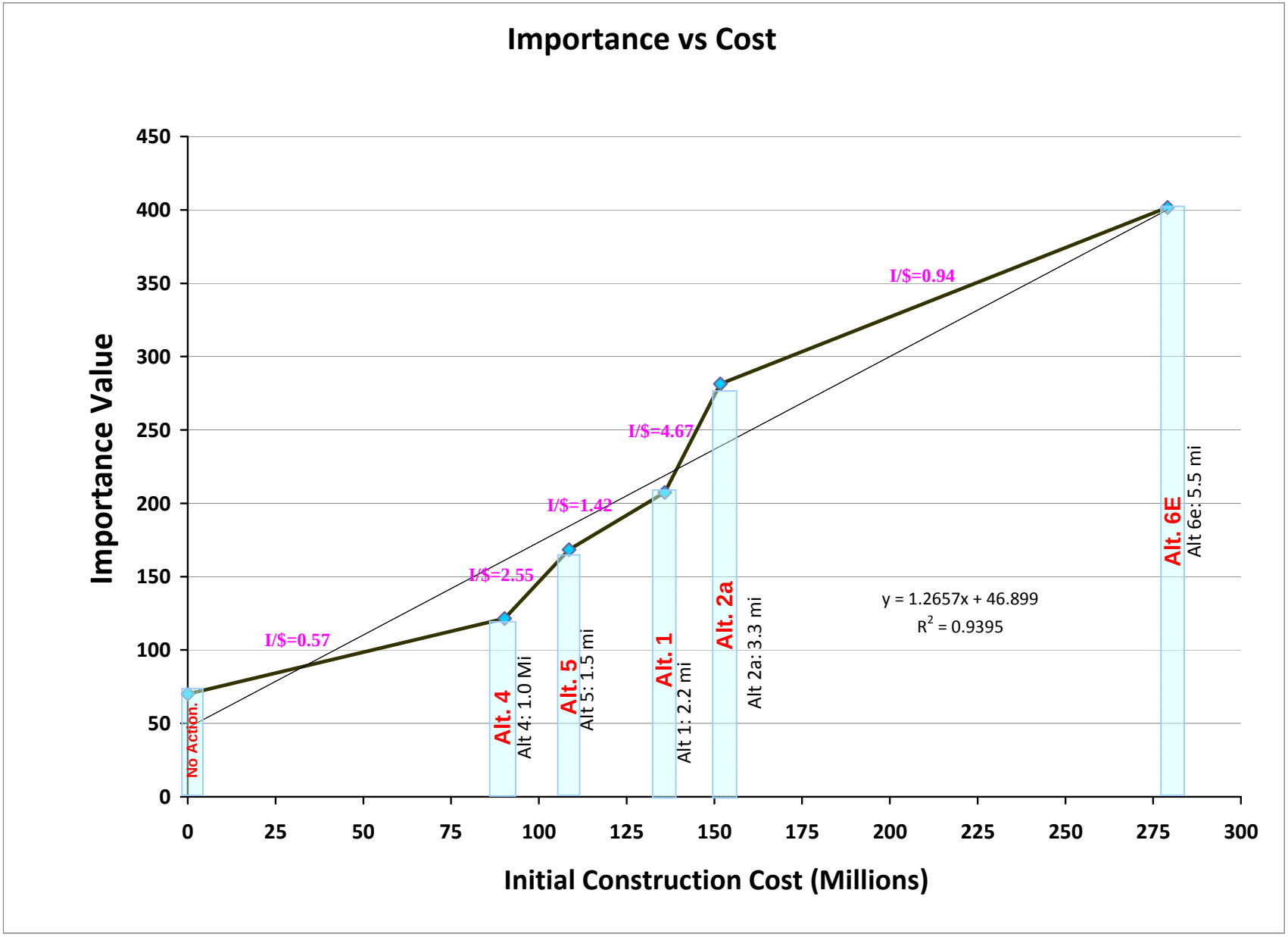
Evaluation Matrix

Everglades National Park
Tamiami Trail Modifications: Next Steps
Draft Environmental Impact Statement
Choosing by Advantages Workshop November 4, 2009

		Project Alternative (includes No Action: 1-mile eastern bridge)											
Factor	**Factor Measure (Metric)**	**No Action**	**Importance**	**Alt 1: 2.2 mi**	**Importance**	**Alt 2A: 3.3 mi**	**Importance**	**Alt 4: 1.0 mi**	**Importance**	**Alt 5: 1.5 mi**	**Importance**	**Alt 6E: 5.5 mi**	**Importance**
Factor 1-Potential Ecological Connectivity													
Attributes	Length of opening (miles)	1.0		3.2		4.3		2.0		2.5		6.5	
Advantages	Target: 10.7 miles	0	0	2.2	36	3.3	54	1.0	16	1.5	25	5.5	90
Factor 2-Potential Marsh Flow													
Attributes	Marsh velocity (ft/sec)	0.34		0.14		0.10		0.20		0.16		0.08	
Advantages	Target: 0.05 ft/sec (lowest velocity or largest difference)	0	0	0.20	54	0.24	65	0.14	38	0.18	48	0.26	70
Factor 3-Potential Number of Sloughs Reconnected													
Attributes	# Sloughs reconnected	1		5		6		2		4		10	
Advantages	Target: 19	0	0	4	40	5	50	1	10	3	30	9	90
Factor 4-Potential Sheet Flow													
Attributes	Percent target achieved in 200 ft increment	10		35		50		26		29		64	
Advantages	Target: Highest score indicates lowest deviation	0	0	25	46	40	74	16	30	19	35	54	100
Factor 5-Potential Reduction in Wildlife Mortality													
Attributes	Species mortality (# of roadkills avoided/year)	261		835		1122		522		653		1697	
Advantages	Target: Highest # of roadkills avoided/year	0	0	574	12	861	18	261	5	392	8	1436	30
Factor 6-Prevent Loss of Cultural Resources - Highway													
Attributes	# Resources adversely effected (Miles of Highway)	1		3.2		4.3		2.0		2.5		6.5	
Advantages	Target: Highest # of Miles Protected	5.5	15	3.3	9	2.2	6	4.50	12	4.00	11	0	0
Factor 7 - Prevent loss of cultural resources - Historic Properties													
Attributes	Degree of Impact	No Impact		Moderate Impact		Moderate Impact		Moderate Impact		Moderate Impact		High Impact	
Advantages	Target: No impact	No impact	25	Less Impact	10	Less Impact	10	Less Impact	10	Less Impact	10	0	0
Factor 8- Net Wetland Effects													
Attributes	Permanent wetland effects [UMAM score (after project)*wetland acreage] - [UMAM score (before project)*wetland acreage)]	-42.1		-588.4		-507.9		-593.6		-572.7		-194.4	
Advantages	Target: Highest net score: wetland benefits (road removal only) -wetland impacts	551.5	30	5.2	0	85.7	5	0.0	0	20.9	1	399.2	22
Importance Score Sum	**To be determined**		**70**		**207**		**281**		**121**		**168**		**402**
Alternative ID			**No Action**		**Alt 1: 2.2 mi**		**Alt 2A: 3.3 mi**		**Alt 4: 1.0 mi**		**Alt 5: 1.5 mi**		**Alt 6E: 5.5 mi**
Total Construction Costs (Millions $)			**0**		**135.9**		**157.5**		**90.2**		**108.6**		**279.1**

xxx **Least Preferred Attribute**

Most Important Advantage


Importance vs Cost
Importance Value
Initial Construction Cost (Millions)
450
400
350
300
250
200
150
100
50
0
0
25
50
75
100
125
150
175
200
225
250
275
300
I/$=0.57
I/$=2.55
I/$=1.42
I/$=4.67
I/$=0.94
No Action.
Alt. 4
Alt 4: 1.0 Mi
Alt. 5
Alt 5: 1.5 mi
Alt. 1
Alt 1; 2.2 mi
Alt. 2a
Alt 2a: 3.3 mi
Alt. 6E
Alt 6e: 5.5 mi
y = 1.2657x + 46.899
R2 = 0.9395