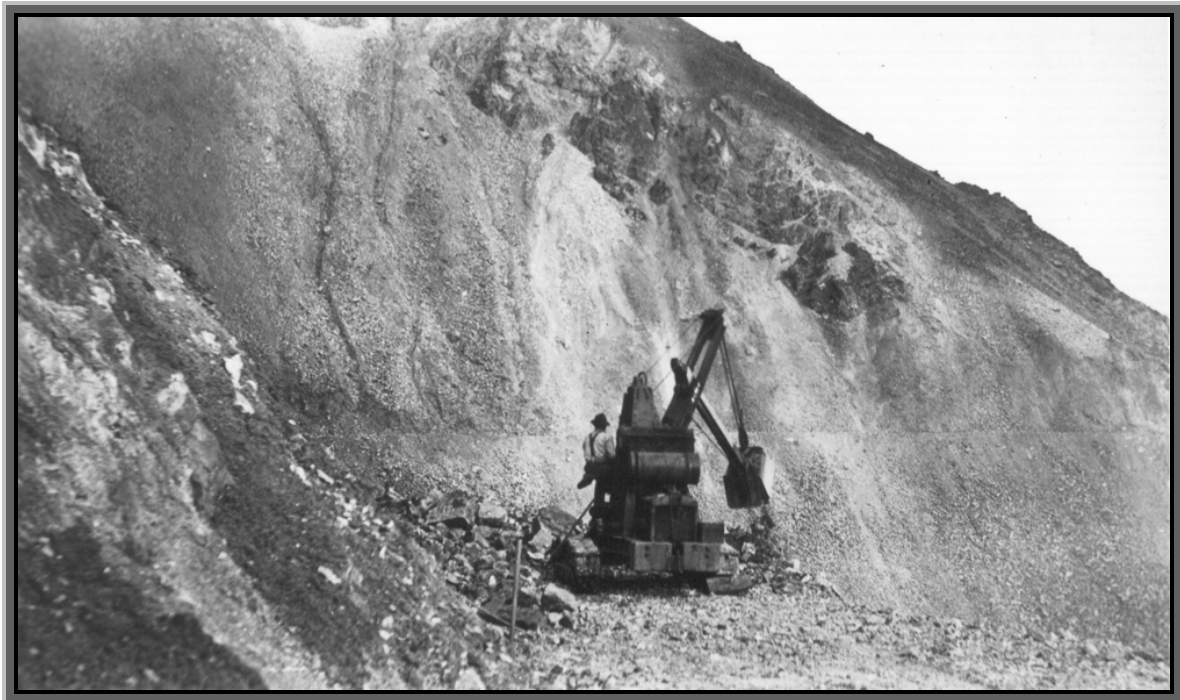


DENALI NATIONAL PARK AND PRESERVE ROAD DESIGN STANDARDS



Edmunds Collection, B88.121.131, Anchorage Museum of History & Art

Polychrome Pass, 1931
(Current Location: Mile 45.5)

1995
Revised 2007

“The first and most important thing to understand in road maintenance is proper shape of the cross section.”

“When proper shape is established and good surface gravel is placed, many gravel road maintenance problems simply go away and road users are provided the best service possible from gravel roads.”

*Gravel Roads Maintenance and Design Manual
FHWA, South Dakota Local Transportation Assistance Program*

“The character of the park road and its relationship with the landscape through which it passes are an integral part of the visitor experience at Denali. The park road changes from a uniform width, two-lane facility to a variable width one lane road with two-lane sections and pullouts. The character of the road is in keeping with the character of the land: a primitive, low-speed road located in a wild and pristine land.”

Definition of Road Character from 1997 Entrance Area and Road Corridor Development Concept Plan

Approved by:

Superintendent, Paul R. Anderson

Date

TABLE OF CONTENTS

SECTION	Page
1.0 INTRODUCTION	1-4
1.1 Purpose	1
1.2 Road Character and Crucial Factors	1-2
1.3 National Environmental Policy Act Compliance	2-3
1.4 Guidelines for Road Design Standards	3-4
2.0 RELATED DOCUMENTS	4-5
3.0 ROAD GEOMETRIC STANDARDS	10-22
3.1 Road Cross-Section Geometry	10
3.2 Roadway Width, General	11
3.2.1 Roadway Width, Maximum	11
3.2.2 Roadway Width, Minimum	12
3.2.3 Control of Roadway Width	12-13
3.2.4 Use of Predominant Roadway Widths in Designed Repairs	13-14
3.2.5 Roadway Width Monitoring	14
3.3 Alignment	14-15
3.4 Design Speed	15
3.5 Grade	16-17
3.6 Clearance	18
3.7 Drainage and Ditches	18-19
3.8 Intervisible Passing Pullouts, Parking Areas and Pulloffs	20
3.8.1 Intervisible Passing Pullouts	20
3.8.2 Parking Areas and Pulloffs	20
3.9 Road Edge Variation	20-21
3.10 Bridges	21
3.11 Signing and Marking	21-22

SECTION	Page
4.0 STRUCTURAL DESIGN STANDARDS	22-28
4.1 Definition of Structure	22-23
4.2 Design Vehicle	23-24
4.3 Average Daily Traffic (ADT) Volume for Design Purposes	24-25
4.4 Load Bearing Section	25-26
4.5 Backslopes	26
4.6 Fill Slopes	27
4.7 Drainage	27
4.8 Use of Geotechnical Products	28

CONTRIBUTORS/CONSULTANTS	29
---------------------------------	-----------

LIST OF FIGURES

Existing Road Cross-Section Diagrams and Definitions	6-9
Road Cross-Section Geometry	10
Horizontal Grades	18

LIST OF TABLES

Table 1, Roadway Widths	14
Table 2, Maximum Design Speed by Sight Distance	16
Table 3, Existing / Maximum Road Grades	17
Table 4, Grade Transition Distance	17
Table 5, Design Vehicle Specifications	24
Table 6, Vehicle Repetitive Loading for Design Purposes	25

Section 1.0

INTRODUCTION

These standards guide repair of the Denali Park Road to work toward achieving the desired service condition for the numbers and size of design vehicle it is presently required to carry. The standards also provide quantitative guidance to the Federal Highways Administration in designing and engineering repair projects for the park road that do not change its unique character. This document identifies which maintenance and repair activities need subsequent management approval and additional National Environmental Policy Act compliance.

Design standards do not constrain maintenance and repair methods, which are covered under the Road Maintenance, Repair and Operating Standards, except to place certain limits on the materials and techniques which may be considered.

The table in Appendix A of this document provides a synopsis of quantitative “character” definitions and design elements and the intent behind them.

Section 1.1 Purpose

The purpose of these standards is to quantify the definition of “Road Character” and bring together in one document the crucial factors which affect the park road. The overall management goal is to preserve the unique character of the Denali Park Road and the visitor experience it provides.

Section 1.2 Road Character and Crucial Factors

Road Character

The Entrance Area and Road Corridor Development Concept Plan and Environmental Impact Statement, approved with a Record of Decision in February 1997, included the statement that “The character of the park road and its relationship with the landscape through which it passes are an integral part of the visitor experience at Denali.” This statement and a qualitative definition of road character were published in Appendix C of the draft plan and environmental impact statement, which was incorporated by reference into the final plan. The full text from this section of Appendix C appears below:

The Denali National Park road serves a variety of functions over its approximately 88-mile length. It provides visitors of all abilities an opportunity to travel by vehicle through and access a rugged wilderness area, observing wildlife interactions in natural habitat as well as outstanding scenery. It provides circulation and access to public and administrative facilities, and it helps meet the ANILCA requirements for a reasonable access to private property in the Kantishna hills.

The character of the park road and its relationship with the landscape through which it passes are an integral part of the visitor experience at Denali. As visitors travel west into the park, they experience a transition in environment from urban to rustic to primitive.

The road itself is part of this transition. The first 15 miles of road, to Savage River, is a dual purpose facility. It must efficiently handle large volumes of traffic traveling in and out of the park and between various facilities in the entrance area. It provides the visitor an opportunity to see and experience the park resources without the need to interface with the public transportation system. It also serves as a conduit for vehicles traveling into the more remote areas of the park.

The next segment of the road, between the Savage and Teklanika Rivers, is a transition zone. The driving surface changes from pavement to gravel. Efficient traffic flow is not the only function of the road; allowing the visitor to experience the landscape is of increasing importance.

West of the Teklanika River, the landscape and the road change. Rolling terrain gives way to steep mountains and rugged canyons. The park road changes from a uniform width, two-lane facility to a variable width one lane road with two-lane sections and pullouts. At this point, the landscape and the character of the road become integral parts of the park experience. The sinuous path emphasizes the dramatic terrain. Engineered structures such as bridges are used only as necessary to protect the resource or preserve the road. Signs and related items are kept to a minimum. The character of the road is in keeping with the character of the land: a primitive, low-speed road located in a wild and pristine land.

Crucial Factors in Maintaining Road Character

The continued preservation of the unique character of the Denali Park road and the visitor experience it provides depends on the following four interrelated factors. Compromising or eliminating any one of these crucial factors from the road standards will result in that factor driving a change to the character of the park road and visitor experience.

1. Safety will be an integral component of road character. Denali National Park staff will strive to repair and maintain road structure within the standards outlined in this document to support the chosen design vehicle and provide safe passing situations through a series of intervisible passing pullouts.
2. Visitor transportation vehicles of all road users will be limited to a design vehicle size that can safely travel the existing park road and that the road can structurally support.
3. The number of vehicles using the park road will continue to be limited by the park's general management plan and regulations implemented in June 2000.
4. Rules of the Road, which allow safe meeting and passing of vehicles and which were referenced in the June 19, 2000 Special Regulations will continue to be in effect.

Section 1.3 National Environmental Policy Act Compliance

The Denali National Park Road Maintenance, Repair and Operating Standards (March 2005) describe the routine preventative maintenance activities and the repair and operating procedures employed to achieve the physical condition of the Denali Park Road

described by the *Park Road Design Standards*. The *Maintenance Standards* describe goals, methods, and the limits of these activities. The *Maintenance Standards* include target levels toward which routine maintenance and repair activities are directed and **quantitative** limits that these activities cannot exceed.

Park road projects that exceed the limits of the *Maintenance Standards* will be designed and engineered following the *Denali National Park Road Design Standards* to preserve the unique character of the Park Road. All such projects will be subject to National Environmental Policy Act (NEPA) review. Projects that are confined to the existing road structure footprint (see definition) are generally considered as categorically excluded activities under NEPA. Other projects within the existing road area of disturbance (see definition) may also be considered as categorically excluded. Categorically excluded projects are not considered major federal actions and have no measurable impacts on the environment and require no further environmental review. Projects such as significant grade raises, or other projects that are outside the existing road area of disturbance such as road realignment, major alteration of backslopes, construction of parking areas and pullouts, and bridge replacement will require additional environmental review under NEPA, most likely with an environmental assessment and/or environmental impact statement.

Section 1.4 Guidelines for Road Design Standards

The following guidelines are the basis for these road design standards.

1. Long-term protection of the environment through which the road passes, particularly the physical terrain it rests on and influences.
2. A park road which changes from a paved, all-purpose roadway at the park entrance to a dirt and gravel roadway beyond the Savage River and which telescopes smaller in dimension by section and distance while transitioning the visitor experience from one of developed facilities to one of wilderness discovery through a sense of time, distance and isolation.
3. Adherence to the “items that help define the character of the road beyond MP 30” as defined in the 1994 Road System Evaluation, pages 2 and 3 and referenced on page 269 of the 1996 *Draft Entrance Area and Road Corridor Development Concept Plan*, Appendix C. In summary:
 - The road winds a sinuous path over dramatic terrain.
 - The road and repairs to the road conform to surrounding topography and not overcome or overpower it.
 - Adjacent terrain dictates variable road width and grade.
 - Engineered structures such as bridges, retaining walls and piles are used only when necessary to protect the resource or preserve road alignment.
 - Native materials are used in construction where possible.
 - The driving surface is gravel.
 - Signs and related items are kept to a minimum.

4. Sufficient minimum roadway surface width, intervisible passing pullout location/geometry and sufficient stability in the road structure to allow safe travel, meeting and passing of two design vehicles during the visitor season all along the park road. This guideline takes into account the fact that road stability is highly variable during the year because of subgrade moisture and frost, which limit the season during which safe structural stability is obtainable.
5. West of Teklanika River, the park road changes from a uniform width, two-lane facility to a variable width one-lane road with two-lane sections and intervisible pullouts that are easily reachable by vehicles in a yielding situation.
6. Linking the crucial factors affecting road character as described above to these standards.

Section 2.0

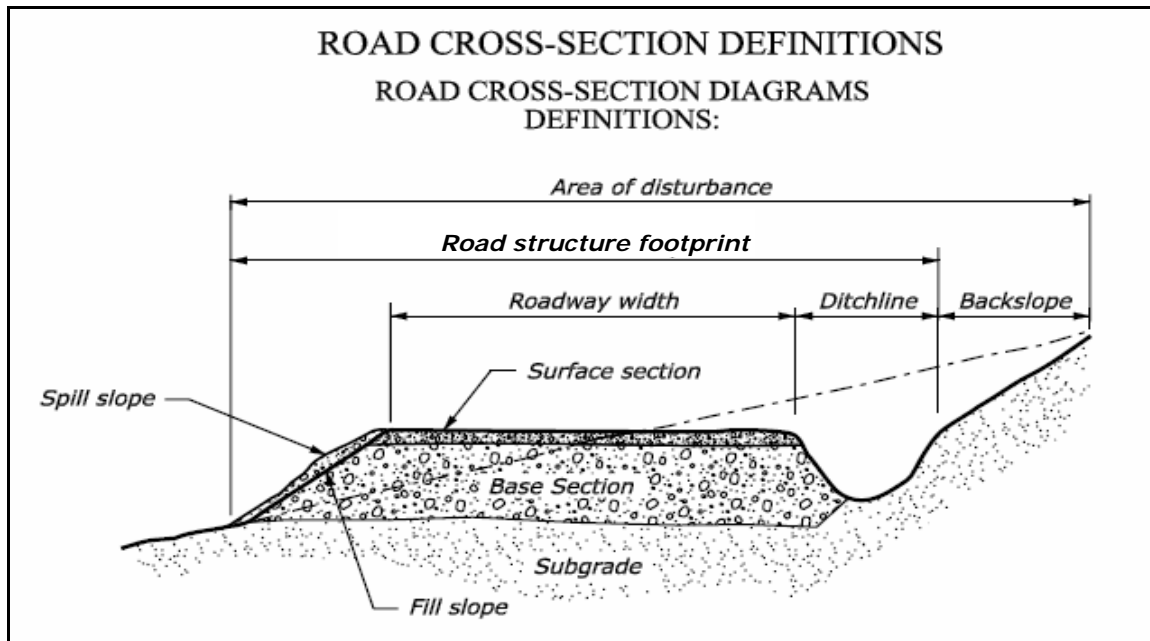
RELATED DOCUMENTS

TECHNICAL

- Denali National Park Denali Park Road Geotechnical Report No. 06-03, Federal Highways Administration, 2003.
- Denali National Park Road Maintenance, Repair and Operating Standards, 2005.
- Denali National Park Road Systems Evaluation, 1994.
- American Association of State Highway and Transportation Officials, A Guide for Design of Pavement Structures.
- Alaska Department of Transportation Highway Preconstruction Manual, 1992 edition.
- California Department of Transportation Road Design Guide Manual, 1992 edition.
- Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects.
- Standard Specifications for Public Works Construction.
- Manual of Uniform Traffic Control Devices.
- Draft Denali National Park Sign Manual.
- National Park Service Sign Manual, 1988 edition.
- National Park Service Park Road Standards, Federal Highways Administration, 1984 edition.
- U.S. Forest Service Road Design Guide for Secondary Roads.
- AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads, 2001.
- Federal Highways Administration "Gravel Roads" Maintenance and Design Manual, LTAP-02-002, 2000 edition.

PLANNING

- Denali National Park Environmental Assessment for Road Corridor Development Concept Plan, 1982.
- Road Rehabilitation Environmental Assessment, 1982.
- Denali Park Road Corridor Development Concept Plan, 1983.
- Denali National Park Road Improvement Study, Federal Highways Administration, 1984.
- Denali National Park General Management Plan, 1986.
- Denali National Park Gravel Acquisition Plan, 1992.
- Denali National Park Road Systems Evaluation, 1994.
- Draft Denali Park Road Plan, 1996.
- Denali National Park Final Entrance Area and Road Corridor Development Concept Plan, 1997.
- Environmental Assessment for Dust Abatement Activities on the Denali Park Road, 1999.
- Denali National Park Gravel Acquisition Plan, 2003.



FULL BENCH: The subgrade cut supporting the road structure is fully excavated into the existing topography, with no fill sections underlying the road surface other than constructed base sections.

PARTIAL BENCH: Called “cut and fill”. Only a portion of the road surface, usually 50% or more, is supported by a bench cut into the native slope and the rest is supported by a section of constructed aggregate fill over-lying the native slope. Partial bench construction may structurally overload native slopes.

AREA of DISTURBANCE: As it pertains to the Denali Park Road; the disturbed, or previously disturbed, area of ground associated with and directly adjacent to the existing road structure which contains berms, original ditches, original road features or other obvious road related disturbance. Cutback brush is not considered disturbance.

ROAD STRUCTURE FOOTPRINT: The area the road structure covers, measured horizontally. Always extends from the toe of the fill/spill slope to the backslope edge of the ditchline at the road level. If structural stability is at risk, footprint can extend from the toe of the spill slope to the upper edge of the backslope.

ROADWAY WIDTH: The surface portion of the road from the breakpoint of the outside edge to the breakpoint into the ditch. It is that portion of the road that appears as useable road surface to a vehicle driver and would reasonably be considered to be used in normal driving and yielding. It excludes: 1) The sloped portions of the outer road edge or ditch edge in excess of 6% slope; 2) The areas of unconsolidated nonsurface-grade materials at the road edges.

TRAVEL SURFACE WIDTH: On the paved section of the road, the pavement will be considered the travel surface width. This term does not apply to the unpaved section of the road.

DITCHLINE: The drainage ditch width, measured from the edge of the roadway horizontally to the backslope. Nominally not less than 1.5 times the ditch depth.

BACKSLOPE: The slope constructed in the native terrain in-slope to the ditchline to accommodate the road bench and achieve both native slope stability and design-speed stopping sight distance. Usually steeper than the native slope angle of stability.

SURFACE SECTION: That portion of the roadway cross-section that consists of surfacing aggregates. Nominally 4" thick. Sections less than 2" thick have no structural value.

SPILL SLOPE: The outer slope created by the overboarding of surface and slide materials during maintenance, repair, traffic and weather activities. Spill slopes are unconsolidated, may be supported by vegetation and are inherently unstable. They can be over-steep, cause structural overloading of the underlying native and fill slopes and create an unsupported false road edge that appears to be part of the structural driving surface.

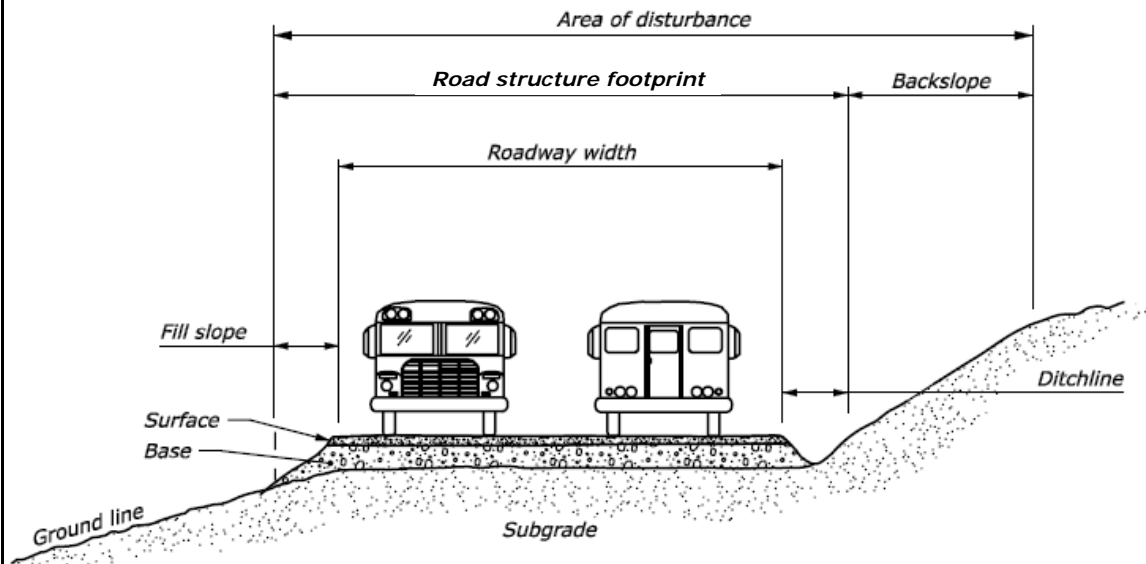
FILL SLOPE: The segment of the road structure that is fill rather than bench supported base or surface material; often refers to the face slope of the fill section

BASE SECTION: That portion of the roadway cross-section that consists of constructed coarse base aggregates, fully compacted to 95% density. Sections less than 6" thick have no structural value.

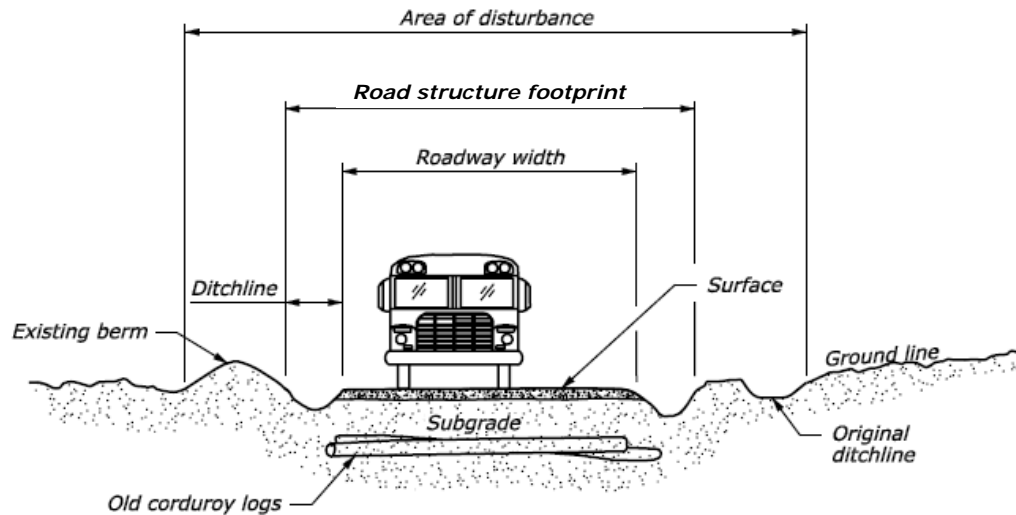
SUBGRADE: Refers to all subgrade soils, including weathered bedrock. (Generally, the park road is constructed on a native soil subgrade and little if any constructed sub-base exists, especially west of Savage River)

GROUNDLINE: The line contour of the native ground in cross-section prior to any road construction disturbance.

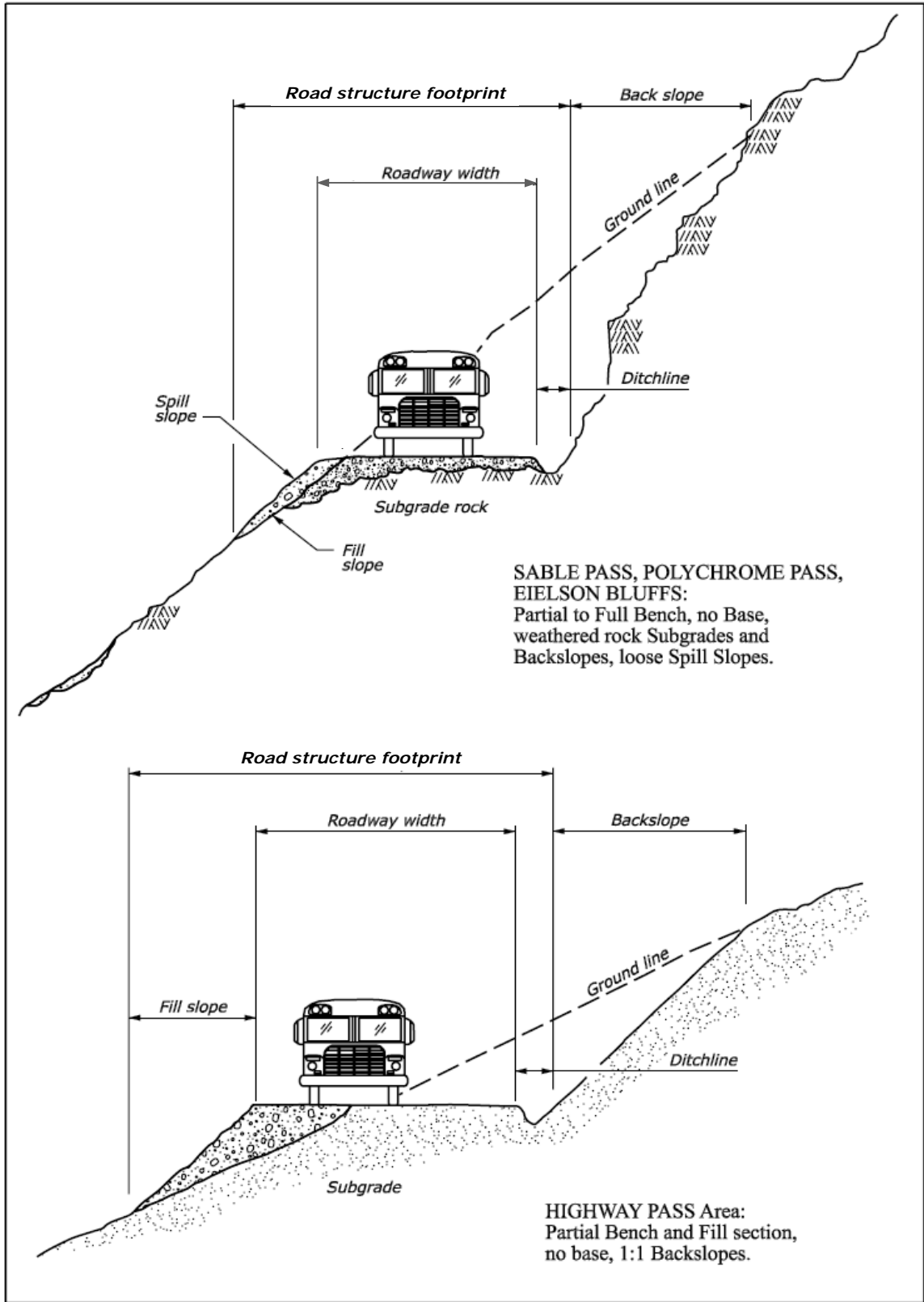
EXISTING ROAD CROSS SECTION DIAGRAMS



EAST of TEKLANIKA BRIDGE:
Full Bench with constructed Base section, 1V:1.5H Backslopes.



IGLOO FOREST / WONDER LAKE Section:
Native Subgrade cut, no Base, may have
old corduroy buried in Subgrade,
drainage allows Subgrade saturation.



Section 3.0

ROAD GEOMETRIC STANDARDS

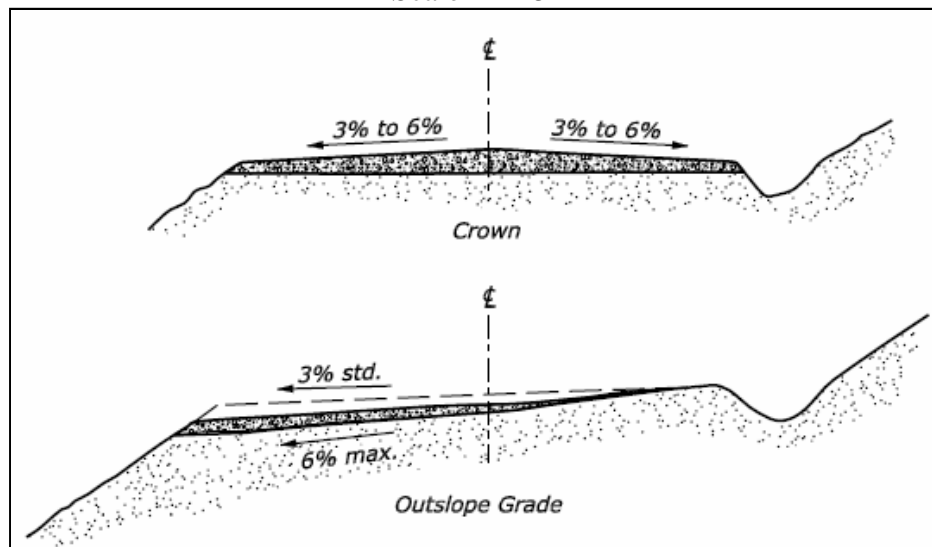
Section 3.1 Road Cross-Section Geometry

Road repairs and maintenance will be directed toward the following standards for road cross-section geometry:

1. Road surface: either crowned (3 to 6%, with 3% typical) or gently outsloped or insloped (3% to 6%) as required for surface drainage on a particular section.
2. Superelevations in horizontal curves: should not exceed 6%.
3. Fill and spill slopes (downslopes) will be no steeper than 1V:1.5H (or angle of repose for the type of structurally sound material being used) and no flatter than 1V:2.5H. Areas with high natural spill slopes (Sable Pass, Polychrome Pass and Eielson Bluffs) that exceed the 1V:1.5H standard and where meeting the standard would require massive projects will be exempt from this standard as long as the spill slope consists of rocky cliffs and/or material that is stable at higher fill slope angles.
4. Fill and spill slopes exceeding 1V:1.5H due to vegetation holding spill material will be corrected.
5. Foreslope (transition from road surface to ditch bottom) will be flatter than a 1V:1.5H slope.
6. Backslope angles will be based on the inherent shear angle for the particular soil under normal spring runoff moisture loading (generally angle of repose). Exceptions apply and are listed under section 4.5, Backslopes.

Road Cross Section Geometry

Scale 1" = 5'



Section 3.2 Roadway Width, General

Between the paved and unpaved sections of road there is a difference between roadway width and travel surface width. The 14.9 miles from the park entrance to the Savage River has constructed shoulders averaging 2 feet wide and will be maintained as such. The travel surface width in this segment will be the pavement width. The unpaved section of road does not have constructed shoulders, only a road edge, therefore travel surface width does not apply.

On the unpaved sections of the roadway, the roadway width will be the controlling factor for designed and constructed repairs. Maintenance and repair projects will be directed toward the goal of ensuring that as much of the roadway width as possible will adequately support the full weight of the design vehicle when stopped.

Note: Currently, west of the Teklanika River, in some areas, the outer edge of the road surface may be structurally unreliable for 2 to 3 feet back from that edge, and the inner (ditchline) edge may be structurally unreliable for 1 to 2 feet back from the ditch edge. The reliable travel surface may be 3 to 5 feet narrower than the full visible surface. Repair projects will be directed toward improving this situation.

Road repairs and maintenance will be directed toward the following standards for general roadway width:

1. Roadway widths will be variable and will be dictated by terrain and grade and design vehicle geometry.
2. The width of the base of the road structure footprint will be based on the safe structural limits of the footprint, reflected in the angle of fill slopes and cut slopes.
3. To the greatest extent possible allowed by the terrain, the road will be a full bench construction to minimize the width of the road structure footprint at its base. In no case should constructed fill slopes be steeper than 1V:1.5H (34 degrees) or gentler than 1V:2.5H (22 degrees), and fill slope materials will be selected to conform to those limits.

Section 3.2.1 Roadway Width, Maximum

Road repairs and maintenance will be directed toward the following standards for maximum roadway width:

1. Roadway widths per segment will not exceed general maximum roadway widths shown in Table 1 except for random previously existing widths west of Teklanika River Bridge (mile 37 excluded).
2. Where a section of road exceeds a segment's standard it may be narrowed to meet the standard.

Section 3.2.2 Roadway Width, Minimum

Road repairs and maintenance will be directed toward the following standards for minimum roadway width:

1. Roadway widths per segment will not be narrower than the minimum allowable road surface widths shown in Table 1.
2. Minimum allowable roadway widths will not be less than is safely adequate for the design vehicle type allowed on that particular segment (i.e., unrestricted 2-way traffic or controlled passing 2-way traffic).
3. The minimum safely adequate roadway width on any segment will be 16' except for short anomalies where all of the following conditions are met:
 - Adequate intervisible pullouts exist.
 - Fill slope depths make achieving minimum segment width impracticable or impossible.
 - Backslope heights or materials are such that achieving the minimum 16' width is impracticable or would result in unacceptable visual impacts.
 - Sufficient structural stability exists for a safe travel surface width within 2' from the fill slope edge and 1' from the ditch edge. In these areas the absolute minimum road surface width will be 14'.

3.2.3 Control of Roadway Width

The following standards will control and limit widening work on the park road:

1. Existing roadway widths and extent of road structure footprint will be retained except when the standards for minimum designated segment width, road edge variation, ditch widths, and intervisible pullouts cannot be met.
2. In areas between intervisible pullouts (see Section 3.8 Intervisible Passing Pullouts), where outer road edge variation standards (see Section 3.9 Road Edge Variation) cannot be met, widening to the minimum extent necessary to achieve the road edge variation standards can occur. Exceptions will be in very low speed areas (example: Polychrome Pass) where it is impossible or impractical to achieve this standard due to the extreme fill depths required.
3. A road section between intervisible pullouts can be widened to the maximum designated segment width in those limited areas where intervisible pullouts must be spaced so closely that they become impractical for maintenance activities or safe traffic management. Site specific corrections would be used first rather than employing extensive sections of widening to a uniform two lane width. This use of intervisible pullouts and other site specific corrections rather than systematic widening is the approach that was endorsed by the 1997 DCP/EIS and preceding road repair planning for improving vehicle passing and general road safety.
4. In designed repairs, existing ditches may be filled to the degree necessary as a means to meet standards for ditch design (width = 2.5 times proper drainage

depth), road edge variation and minimum roadway widths as long as the resulting roadway width gain does not exceed the segment's allowed maximum and additional disturbance is not created beyond the road structural footprint. This activity is allowed during road maintenance activities as long as the existing roadway width in the location does not increase and additional disturbance is not created beyond the road structural footprint.

5. Oversteepened road edges that do not meet fill slope angle standards (see Section 4.6 Fill Slopes) would be laid back or reconstructed until standards are achieved. The objective would be to first accomplish the work within the existing structural footprint if possible, or then within the existing disturbance limits by concurrently filling any ditches that do not meet standards to regain the width that may have been lost during the edge repairs.
6. Any fill slope road edge width variation that is still beyond standard limits after the preceding edge and ditch repairs have been completed would be corrected by widening the indented area outward to the minimum extent necessary until it tapers into surrounding road widths in a manner that meets the road edge variation standard and roadway structural standards (see Section 3.9 Road Edge Variation and Section 4.4 Load Bearing).
7. In those remaining locations that are below minimum designated segment widths, widening would be accomplished by the method that causes the least disturbance while still achieving important safety standards for roadway width and road edge variation. Exceptions are in very low speed areas (example: Polychrome area) where it is impossible or impractical to achieve this standard due to the extreme fill depths required.

Section 3.2.4 Use of Predominant Widths in Designed Repairs

The following standards will guide the use of predominant widths in designed repairs:

1. Roadway width ratios of the completed project will generally simulate the ratios of pre-existing road width within the proposed repair section.
2. Widths of the section to be repaired will be inventoried and assigned into 2' increment width classes so that the linear distance and percentage of occurrence of each width class within the section can be established for the section proposed for repair. Center points of the width classes will be 16', 18', 20', 22', and 24.'
3. A designed repair using these center points will place each width class present in the pre-repair inventory in their preexisting proportions and in locations where they would best fit first within the road structure footprint if possible or then within the existing area of disturbance.
4. Whenever it can be done first within the road structure footprint, or then within the existing area of disturbance, roadway widths between intervisible pullouts or

other prominent terrain features such as large fill slope or corners will be designed to stay within one width class to simplify subsequent road maintenance and monitoring efforts. Existing pullouts would be excluded from the width inventory formula. They will be established and sized based on the pullout standard.

3.2.5 Road Width Monitoring

The goal for road width monitoring will be to inventory road width on a 3 year cycle, using the best available technology, as part of the Federal Highways Administration Roadway Inventory Program. This inventory will provide an ongoing photographic record of the park road and its features. Denali National Park and Preserve has requested that the program provide a quantitative inventory of roadway width dimensions. With improvements to the software it is hoped that it will be available in future inventories.

**TABLE 1
ROADWAY WIDTHS**

ROAD SEGMENT	MAXIMUM GENERAL ROADWAY WIDTH	MINIMUM ROADWAY WIDTH*
Entrance to Savage River	24' to 28'	24' to 28'
Savage River to Teklanika River	24' to 28'	24' to 28'
Teklanika River to Tattler Creek	24'	20'
Tattler Creek to East Fork	24'	18'
East Fork to Toklat River	24'	16'
Toklat River to Eielson V.C.	24'	18'
Eielson V.C. to Grassy Pass	22'	16'
Grassy Pass to Kantishna	22'	16'

*Minimum widths may be narrower in select locations meeting certain criteria. See Section 3.2.2, Roadway Width, Minimum for an explanation.

Section 3.3 Alignment

Road repairs and maintenance will be directed toward the following standards for road alignment:

1. To comply with road character definitions, both horizontal and vertical alignments will be maintained as presently existing. Abrupt changes in vertical

alignment resulting from periodic and/or continuing sub-grade deformation will be repaired following a parabolic arc which retains a smooth grade transition throughout the replaced section.

2. Where slope failures necessitate horizontal realignment in order to retain the road (for example, realignment is the only effective alternative) such realignment will conform to the site topography and maintain the sinuous character of the road.
3. The vertical alignment for all road segments will, by its constraint of stopping sight distance, limit the maximum vehicle speed on the particular road segment.
4. The horizontal alignment for all road segments will, by its constraint on turning radius, safely accommodate the design vehicle.

Section 3.4 Design Speed

The maximum design speed, and the existing posted speed limit, is 35 miles per hour on both the paved and gravel sections of the road. Existing posted speed limits are lower in some areas.

Maximum design speed set by the stopping sight distance for particular road sections is shown in Table 2. All maximum design speeds assume a dry and properly maintained road surface providing good friction characteristics. Excessive soil moisture, loss of aggregate or aggregate filler, rain and other factors can make maximum safe speed considerably less than the design speed.

**TABLE 2
MAXIMUM DESIGN SPEED BY SIGHT DISTANCE**

EAST OF TEKLANIKA RIVER						
INFLUENCE OF SIGHT DISTANCE TO NEXT CREST OR CURVE ON DESIGN SPEED*						
*Values from Exhibit 3-76 in 2001 "Geometric Design of Highways and Streets"						
Where the sight distance to the next crest or curve is ...	Under 80'	80'	115'	155'	200'	250'
The speed limit should be (in MPH)	10	15	20	25	30	35
WEST OF TEKLANIKA RIVER						
INFLUENCE OF SIGHT DISTANCE TO NEXT CREST OR CURVE ON DESIGN SPEED*						
*Values from Exhibit 12 in 2001 "Guidelines for Geometric Design of Very Low-Volume Local Roads" are doubled to determine two-way, one lane road sight distances.						
Where the sight distance to the next crest or curve is ...	Under 130'	130'	190'	250'	330'	410'
The speed limit should be (in MPH)	10	15	20	25	30	35

Section 3.5 Grade

Road repairs and maintenance will be directed toward the following standards for longitudinal grades:

1. Maintain existing grades (see Table 3), including grades resulting from repairs as discussed in Section 3.2.
2. Maximum allowable grades are a function of the road surface material (cohesion and friction characteristics), the torque load induced by the vehicle tires on that material, and the length of grade section. Grades should not exceed the upper limits of the grade ranges shown in Table 3.

**TABLE 3
EXISTING / MAXIMUM VERTICAL ROAD GRADES**

ROAD SEGMENT	GRADE RANGE	
	Minimum to maximum	Average
Entrance to the Savage River	0.5 to 11 %	av. 3 %
Savage River to Teklanika River	0.5 to 9 %	av. 2.7 %
Teklanika River to Tattler Creek	0.5 to 7 %	av. 2 %
Tattler Creek to East Fork	1 to 13 %	av. 4.9 %
East Fork to Toklat River	0.5 to 16 %	av. 3.3 %
Toklat River to Eielson V.C.	5 to 15 %	av. 4 %
Eielson V.C. to Grassy Pass	0.5 to 12 %	av. 3.9 %
Grassy Pass to the North Boundary *	1 to 12 %	av. 2.2 %
North Boundary to Kantishna	0.5 to 13 %	av. 3 %

* Includes Wonder Lake Campground Road.

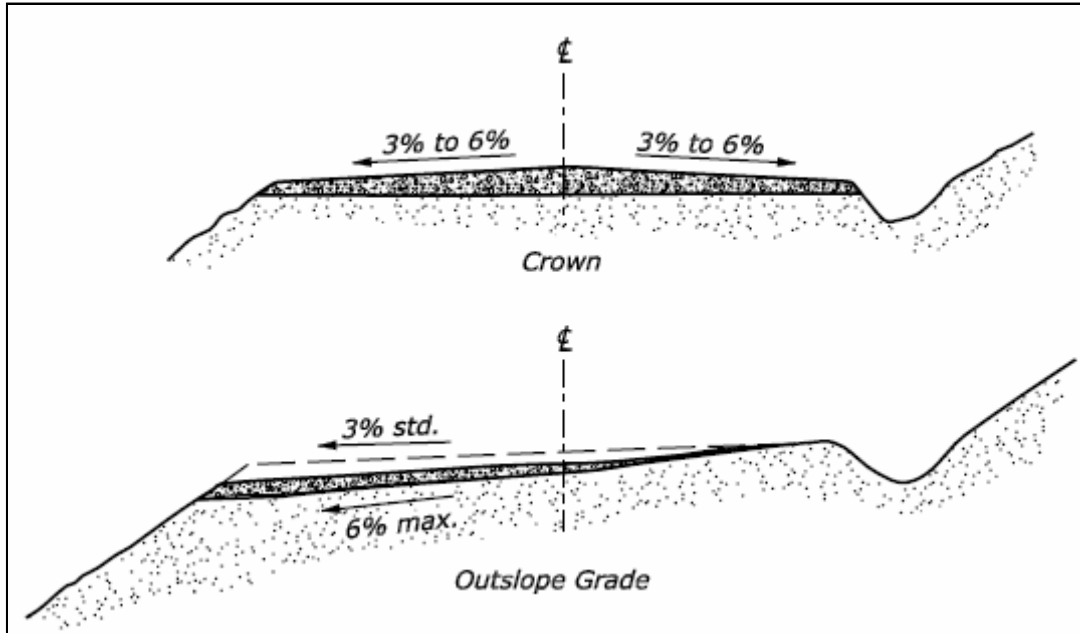
- Maintenance and repair activities will result in grade changes being made over the linear distances shown in Table 4 to control traffic induced road damage.

**TABLE 4
VERTICAL GRADE TRANSITION DISTANCE**

Design Speed in MPH	GRADE CHANGES IN PERCENT					
	2	5	7	10	12	15
10	10'	25'	35'	50'	60'	75'
15	15'	40'	55'	80'	95'	120'
20	20'	50'	70'	100'	120'	150'
25	40'	100'	140'	200'	240'	300'
30	60'	150'	210'	300'	360'	450'
35	80'	200'	280'	400'	480'	560'

- The horizontal grades of the road will be as described in Section 3.1, Road Cross-Section Geometry. Road surface will be either crowned (3 to 6%, 3% typical) or gently outsloped or insloped (3% to 6%) as required for surface drainage on a particular section.
- Superelevations in horizontal curves should not exceed 6%.

Horizontal Grades



Section 3.6 Clearance

Road repairs and maintenance will be directed toward the following standards for clearance:

1. Vegetation will be controlled to maintain the stopping sight distance established by road alignment and design speed (Table 2) and/or sign sight distance, to preclude physical contact by vegetation with any vehicle properly using the road, prevent or eliminate oversteep road edge slopes and prevent damage to the road structure or impedance of drainage.
2. Standard clearance widths and height assume a maximum 3-year cycle of vegetation control (i.e. each section of road receives control work at least once every 3 years), and that revegetation growth rates are slow enough that clearance is not compromised in less than 3 years.
3. Where growth rates dictate, the control cycle will be shortened if feasible, rather than enlarging the clearance limits. See the park's Road Maintenance Standards for brushing and clearing specifications.

Section 3.7 Drainage and Ditches

The ditch dimension standard (number 4) is an element that authorizes road work that alters road width in specific locations. Road repairs and maintenance will incorporate the following standards for drainage and ditches:

1. Drainage, which is primarily a function of site topography and soils, will be adequate to manage water flow type and volumes affecting the road structure, including within the subgrade section of the road structure footprint, without adversely affecting the road or the adjacent terrain.

2. Drainage system design will accommodate and mimic adjacent natural drainage patterns to the greatest extent feasible without sacrificing road stability.
3. Drainage systems will be installed and maintained in a manner that matches surrounding roadway width on either side of the structure while also achieving the established standard for road edge tapers.
4. In designed repairs, existing ditches may be filled to the degree necessary as a means to meet standards for ditch design (width = 2.5 times proper drainage depth), road edge variation and minimum roadway widths as long as the resulting roadway width gain does not exceed the segment's allowed maximum and additional disturbance is not created beyond the road structural footprint. This activity is allowed during road maintenance activities as long as the existing roadway width in the location does not increase and additional disturbance is not created beyond the road structural footprint.
5. Cross culverts will be sized and located to handle maximum water volumes for the particular location. Surface drainage culverts will be extended from the inner edge of the ditch bottom to daylight in the downslope below the road, will be downsloped not less than 4% or more than 8%, and will be placed at the angle to the ditchline axis that allows for water diversion from the ditch without siltation or ponding at the culvert inlet. A culvert downslope grade should not be less than the road surface outslope grade. Road repairs will insure that at least 12 inches of gravel are placed above the culverts to protect them from the weight of vehicles using the road.
6. Catch basins at culvert inlets will have a radius of at least 2 times the culvert diameter to allow for effective change in direction of water flow from the ditch to the culvert. Culvert outlet channels may be hardened with emplaced rock, buried gabions, half culverts or geoblocks if necessary to prevent slope scarring or destabilizing erosion from normal culvert flows. Culvert material may be galvanized steel, aluminum, concrete, HDPE (high density polyethylene) or other composite material.
7. Bridge and culvert crossings of streams will be designed, installed and maintained to preserve natural flow regimes, physical and biological stream characteristics, and the free passage of native fish. In particular, the sizing, configuration and placement of in-stream culverts will ensure the preservation of suitable hydraulic conditions to allow normal fish passage to continue unimpeded.
8. Subsurface drains will be site specific in design to provide for enhancing the structural stability of the road section without reducing the structural stability of the adjacent natural slopes. They may include deep pipe drains, French drains, curtain drains and permeable section drains, as necessary to match the soils hydrology and mechanics of the particular location.

Section 3.8 Intervisible Passing Pullouts, Parking Areas and Pulloffs

3.8.1 Intervisible Passing Pullouts

Intervisible passing pullouts are defined as a clearly visible and easily reachable widened road section used by vehicles to yield and pass while one vehicle is stopped. These pullouts are important to safely managing the meeting and passing of vehicles on narrow sections of the park road. The following standards will guide installation, maintenance and repair of intervisible passing pullouts:

1. To be clearly visible and easily reachable from one pullout to the next they would be placed approximately 300' to 700' apart in areas where the roadway width is less than 24'. Areas of road with a roadway width of 24' do not need intervisible passing pullouts. Construction of additional intervisible passing pullouts and repair of existing passing pullouts that are inadequate for safe passing may be necessary.
2. Location of new passing pullouts will take advantage of terrain and minimize disturbance as long as sight distance can be achieved. Passing pullouts will provide a total roadway width of not less than 24 feet and will be a minimum of 75 feet long, including tapers. Existing passing pullouts may remain as currently configured unless they are inadequate for safe passing.
3. All passing pullouts will be designed to meet the same structural criteria as the road.

3.8.2 Parking Areas and Pulloffs

Parking areas are defined as areas which vehicles can pull into and park completely off the road travel surface. Pulloffs are defined as widened road sections onto which a bus can pull and be completely off the road travel surface. Maintenance and repair projects will be directed toward the following standards:

1. Parking areas will conform to existing configuration and size.
2. Pulloffs will conform to existing configuration and size and by definition will not be less than 10 feet wide or more than 12 feet wide.
3. All parking areas and pulloffs will be designed to meet the same structural criteria as the road.

Section 3.9 Road Edge Variation

This element in the standards deals with road repair work which may alter road width to correct deficiencies in specific areas. To avoid abrupt road width transitions and improve overall road safety, maintenance and repair projects will incorporate the following standards:

1. Any change in general roadway width will not be shorter than a ratio of 1' in 10'.

2. Transition tapers to and from pullouts will not be shorter than a ratio of 1' in width to 10' in length. This proposed taper standard may or may not provide enough smooth transition for the general road, especially if the transition narrows the road. Field monitoring will be conducted and the standard may be changed in the future if necessary.

Section 3.10 Bridges

Repair and maintenance work on bridges will be guided by the following standards:

1. Bridges will conform to the minimum load bearing capacities required by the heaviest vehicle allowed on the road, such as 90,000 pound crawler dozers and 150,000 pound GVW (gross vehicle weight) tractor trailers.
2. Bridge capacity and condition is determined by inspection every 2 years by Federal Highways Administration bridge engineers.
3. Bridge replacements will conform to existing structures in type, surface width and function unless less obtrusive structures would suffice or structural safety requirements cannot thereby be met.
4. At the time any bridge needs replacement, esthetic treatments to produce a more rustic appearance will be explored.

Section 3.11 Signing and Marking

The goal of signing and marking of the park road is to provide appropriate traffic control, safety and information in a timely manner. The Manual on Uniform Traffic Control Devices (MUTCD), as supplemented by the National Park Service Sign Manual and Denali National Park Sign Manual, contains details regarding design, location and application of road signs and markings as they apply to park roads in Denali National Park. They will supply primary guidance for signing and marking standards.

Park-specific standards include:

1. Signing will be kept to a minimum on the restricted access portions of the road.
2. The number and location of signs and markers will be the minimum required for safety based on traffic regulatory and informational needs, accident history, NPS law enforcement input, and the input from Denali road savvy NPS staff and trained bus drivers.
3. Signs and markers will be installed to blend with and compliment local terrain characteristics to the greatest extent practical.
4. Traffic control and informational signs will be installed at 5 feet above the height of the road surface and 5 feet beyond the road edge as per Manual on Uniform Traffic Control Devices (MUTCD) requirements. The sign backs and posts may

be painted brown and posts will be breakaway and meet MUTCD and NPS sign standards.

5. Markers (such as mile markers) if installed will be installed according to the DENA Sign Plan.
6. Construction and temporary signing will meet all applicable safety requirements, with the exclusion of painting sign backs, and will have a breakaway post design.

Section 4.0 STRUCTURAL DESIGN STANDARDS

For structural design purposes the park road to Teklanika River Bridge (MP 31.3) will be considered to fall within the “Rural Recreational and Scenic Roads” functional class as defined by the American Association of State Highway and Transportation Officials (AASHTO).

The park road west of Teklanika River Bridge will be considered to fall within the “Very Low-Volume Local Road” (less than 400 vehicles a day) functional class as defined by AASHTO.

See Table 6 for a further breakdown and estimated number of season days.

Road structural standards and designed repairs will be based on the design vehicle size, **the projected average traffic volume per segment per day**, design speed (current speed limits) and road surface/subgrade soil conditions. Where feasible, subgrade soil design capacity will assume 30 percent of saturation in moisture content. The goal for structural capacity of the full roadway width is to make it structurally sound for safe stopping and passing of the design vehicle in a way that will not alter the road character.

Section 4.1 Definition of Structure

The road structure is defined as the load bearing road section, consisting of the surface, the constructed base (if any), and the subgrade soils, and including the downslope whether it is natural terrain or a fill/spill slope. Additionally, the constructed backslope is a structural element which, while not load bearing, must account for the structural stability of the ground in which it is cut.

Standards for the physical road structure provide for safely adequate load carrying capacities and slope stability while retaining the existing road character. These standards are driven by road character limitations which will determine the design vehicle and repetitive loading characteristics of the road. Note: This is the reverse of the normal design process.

Structural standards assume the normal ground conditions encountered within a summer operating season of approximately 110 days, and do not attempt to overcome the seasonal subgrade weakening caused by spring runoff saturation and frost activity.

For structural design purposes, the park road construction history can be viewed in 4 distinct categories:

1. Road has constructed base and surface aggregate sections, and an asphalt pavement (Park Entrance to Savage River).
2. Road has a predominantly constructed base and surface aggregate sections (Savage River to Teklanika River).
3. Road consists of a constructed surface aggregate section on native subgrade soils which are relatively stable (generally Teklanika River to Grassy Pass, although sections of Category 4 road exist within this segment).
4. Road consists of a constructed or applied surface aggregate section on native subgrade soils which may be unstable (generally Grassy Pass to Kantishna, although sections of Category 3 road exist within this segment).

Section 4.2 Design Vehicle

For use in structural standards, the design vehicle is the predominant heavy vehicle the National Park Service approves for use in transporting visitors on the park road, not the heaviest vehicle which may travel the road. Mass transportation vehicles larger than the design vehicle are not approved for use on the Denali Park Road in transporting visitors or guests.

Consistent with the 1997 *Entrance Area and Road Corridor Development Concept Plan*, the design vehicle as defined in this section will not be used in the Visitor Transportation System on the Eielson Visitor Center to Wonder Lake section of road until that section meets the standards for minimum width, road edge variation and intervisible pullouts.

**TABLE 5
DESIGN VEHICLE SPECIFICATIONS**

Design Vehicle Specifications	
Bus, Forward Control	
Maximum GVWR	36,200 pounds
Maximum Width	96" (8')
Maximum Length	483" (40' 3")
Maximum Height	132" (11 feet)
Maximum Wheelbase	288" (24 feet)
Maximum Turning Radius*	40 feet 5 inches

Vehicle dimensions represent design vehicle body length including bumpers and vehicle body width excluding mirrors.

*Maximum, instead of minimum, turning radius is provided as vehicles with turning radius larger than 40' 5" may require a change in road character.

Section 4.3 Average Daily Traffic Volume for Design Purposes

While repair designs will be based on the design vehicle and ADT (Average Daily Traffic), it should be understood that larger vehicles including tractor trailers and road maintenance dump trucks also use the road in limited numbers.

**TABLE 6
VEHICLE REPETITIVE LOADING FOR DESIGN PURPOSES**

ROAD SEGMENT	Approximate Season in Days	ADT Passes per Day 2003 ¹	ADT Design Range
		All Traffic	
Entrance to Savage River	200	> 400	Greater than 400
Savage River to Teklanika River	150	268 ²	Less than 500
Teklanika River to Tattler Creek	120	180	Less than 400
Tattler Creek to East Fork	120	180	Less than 400
East Fork to Toklat River	120	180	Less than 400
Toklat River to Eielson V.C.	110	86	Less than 400
Eielson V.C. to Grassy Pass	100	77	Less than 400
Grassy Pass to Kantishna	100	77	Less than 400

Notes for Table 6:

¹ These figures derived from Savage Entrance Station database and assume all vehicles travel round trip so database numbers were doubled. Additional in-park work traffic originating at Toklat and Wonder Lake was liberally estimated at 15% of the Savage Database numbers for all sections. Totals were divided by season days in column 2.

² These figures are for all traffic within the 120 season between Memorial Day and approximately mid-September. Shoulder season adds another 30 days of light traffic.

Section 4.4 Load-Bearing Section

Maintenance and repair projects will work toward the following standards for load-bearing section of the road:

1. The cumulative capacity of the subgrade soils, base section (if used) and surface section must support the ADT Design Range during the bus operating season.
2. During the bus operating season, in areas where the cumulative capacity of the road structure fails to equal the designed load placed on that particular section, repairs will be made until adequate structural load bearing capacity is achieved.
3. Downslopes, in particular fill slopes, will be considered part of the load bearing structure and will conform to the geometric standards in Section 3.1.

4. When factors such as spring thaw and saturation render the standard impossible to achieve, traffic will be restricted as necessary for safety and to achieve road stability.
5. A surface section with a minimum of 4” depth adds strength to the overall road structure. The park road will have a surface section of crushed gravel (or other suitable aggregate meeting the spec for D-1) 4” to 6” deep except in areas where geogrids are used directly under the surface section for strength and stability. In these areas the minimum depth of the surface section will be 8”.
6. Dust palliatives may be used as approved by the 1999 *Environmental Assessment for Dust Abatement Activities on the Denali Park Road* to bind and stabilize gravels in the surface to add additional structural strength and reduce the loss of fine materials through dusting.
7. The bearing and shear capacity of weak subgrade soils may be strengthened through use of geotextiles, geogrids or geoweb, and/or interdiction and diversion of subsurface and surface infiltration water.
8. The thickness of constructed base may be minimized where feasible through the use of geotextiles, geogrids, geoweb, or other appropriate bridging membranes, and/or applications of aggregate fillers, palliatives and binders.
9. Obtaining the maximum cohesion capacities on untreated gravel and native soil surfaces may not be possible. Since substandard cohesion capacity contributes directly to accelerated washboarding, potholing and gravel loss, efforts will be made to achieve 100% capacity by means which will not alter the road character, including use of binders (see Section 4.8 Use of Geotechnical Products) and modification of tire pressures.
10. The use of exposed slope retaining structures which alter existing road character, such as earthwall, binwall, cribwall, gabions, and sheetpiling, is generally precluded by this standard. However, instances may arise where using such a structure may improve traffic safety and/or prevent damage to the road structure or adjacent resources.
11. Structural grade raises up to 18” may be applied to mitigate or eliminate overflow ice or other problems as long as the additional base width required does not go beyond the area of disturbance. However, instances may arise where grade raise beyond this standard is needed and/or disturbance beyond the existing area of disturbance is required to accomplish a grade raise.

Section 4.5 Backslopes

Backslopes (for example cut slopes) are not load bearing, but are structural in their need to achieve stability relative to normal gravity and lubrication influences. Maintenance and repair projects will incorporate the following standards:

1. Existing backslopes which are not failing will be considered stable.
2. Where backslope failure occurs, or where natural slope failure into the road requires establishment of a backslope, the backslope angle will be based on the inherent shear angle for the particular soil under normal spring runoff moisture loading. In general the newly constructed backslope will extend horizontally from the ditchline up to 2 times the width of the roadway. Where the angle of stability dictates that a wider footprint is necessary, the backslope will be cut to meet the natural slope line at the 2 -times-roadway width margin, and if safely possible (road sections with ditches deep and wide enough to allow catchment and detainment of material) slope stability will be allowed to occur through natural gravitational failure over time.
3. Locations that don't meet a segment's maximum allowable width or that don't have ditches deep or wide enough to catch and hold shedding backslope material may exceed these standards as part of a designed project.
4. Efforts to stabilize downslopes and backslopes with revegetation and with geotextiles or fiber mats will be encouraged. The Division of Resource Management will prepare and implement site specific revegetation plans, including plans to monitor project sites in the years after the work is completed.

Section 4.6 Fill Slopes

1. Fill and spill slopes (downslopes) will be no steeper than 1V:1.5H (or angle of repose for the type of structurally sound material being used) and no flatter than 1V:2.5H. Areas with high natural spill slopes (Sable Pass, Polychrome Pass and Eielson Bluffs) that exceed the 1V:1.5H standard and where meeting the standard would require massive projects will be exempt from this standard as long as the spill slope consists of rocky cliffs and/or material that is stable at higher fill slope angles.
2. Fill and spill slopes exceeding 1V:1.5H due to vegetation holding spill material will be corrected.

Section 4.7 Drainage

While surface and subsurface drainage directly influences the structural capacity and stability of both load-bearing sections and their adjacent natural or constructed slopes, it also directly influences road geometry. Therefore both the structural and geometric standards are discussed in Section 3.6.

Section 4.8 Use of Geotechnical Products

As discussed in Section 4.4, use of geotechnical products such as fabrics, geocellular confinement, geogrids and other appropriate fillers, binders and palliatives is desired and encouraged in repair and construction projects on the park road. Use of these products reduces the demand for extraction of mineral material resources within the park and conserves those resources used in repair and maintenance of the park road.

Contributors/Consultants

Denali National Park and Preserve

Elwood Lynn, Assistant Superintendent for Operations

Brad Ebel, West District Roads Supervisor

Tim Taylor, East District Roads Supervisor

Mike Shields, former Chief of Maintenance

Joe Durrenberger, Park Engineer

Bill Friesen, Former Roads Foreman, Auto Shop Supervisor

Dutch Scholten, Chief of Maintenance

Joe Van Horn, Wilderness Program Manager

Steve Carwile, Compliance Program Manager

Mike Tranel, Chief of Planning

Adrienne Lindholm, Park Planner

Federal Highways Administration

Betty Chon, Project Manager

Steve Chapman, Design Quality and Safety Engineer

Tori Brinkley, Highway Safety Engineer

Reuben Johnson, Design Team Leader

Malcolm Ulrich, Engineering Geologist

Susan Pobar, Project Designer