NPS Form 10-9003
(Rev. 10-90)

OMB No. 1024-0018

United States Department of the Interior
National Park Service

NATIONAL REGISTER OF HISTORIC PLACES REGISTRATION FORM

1. Name of Property

historic name: **Grand Loop Road Historic District**

other name/site number: 48YE520

2. Location

street & number: **N/A** **not for publication:**

city/town: **Yellowstone National Park** **vicinity:**

state: Wyoming **code:** WY **county:** Park/Teton **code:** 029/039 **zip code:** 82190-0168

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act of 1986, as amended, I hereby certify that this X nomination __ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property X meets __ does not meet the National Register Criteria. I recommend that this property be considered significant X nationally __ statewide __ locally. (__ See continuation sheet for additional comments.)

Signature of certifying official/Title — Date: Nov 10, 2003

State or Federal agency or bureau National Park Service

In my opinion, the property ✓ meets __ does not meet the National Register criteria.

Signature of commenting or other official — Date: Sept. 23, 2003

State or Federal agency and bureau

4. National Park Service Certification

I, hereby certify that this property is: Signature of the Keeper Date of Action

✓ entered in the National Register — Linda McClelland — 12/23/03
______ see continuation sheet

______ determined eligible for the National Register
______ see continuation sheet

______ determined not eligible for the National Register
______ see continuation sheet

______ removed from the National Register
______ see continuation sheet

______ other (explain)

Name of Property	County and State

5. Classification

Ownership of Property: Public/Federal

Category of Property: District

Number of contributing resources previously listed in the National Register: 0

Name of related multiple property listing:
Historic Resources of Yellowstone National Park: Construction of Road System

(See continuation pages for list of structures and features)

Number of Resources within Property

Contributing	Noncontributing	
		building(s)
		sites
9 bridges, 1road	9 bridges	structures
		objects
10	9	Total

6. Function or Use

Historic Functions:

Transportation – Road Related (Vehicular)

Current Function:

Transportation – Road Related (Vehicular)

7. Description

Architectural Classification:

Other: National Park Service
Other: "Park Road" Landscape Architecture
Other: Rustic Style

MATERIALS:
Foundation: earth
stone: granite, sandstone
Walls: stone: granite, sandstone
roof:
Other: wood-log; concrete; asphalt; metal-steel; corrugated metal

Narrative Description:
The Grand Loop Road Historic District is a 140.14 mile road system which provides the primary visitor access to the major points of interest and visitor facilities in Yellowstone National Park. The current alignment of the Grand Loop Road grew from early wagon trails that followed river valleys and lakeshores. During the first 30 years of development, the road was in constant change, but by 1905 the interior road system connecting natural attractions, hotels, and entrance roads had crystallized into the present figure-eight configuration known as the Grand Loop Road. Having been built over many decades with many different standards, techniques, materials, and under many administrators, the Grand Loop Road retains basically the same configuration as it was first built, although some small sections have been abandoned or transformed into scenic roads.

The alignment is the way in which the road moves across the landscape; the curves, straight sections, and roadway movement to the left or right constitute the horizontal alignment; the movement of the roadway up and down hills being the vertical alignment. The alignment of the eight segments of the present Grand Loop Road may be as originally constructed or could be off several hundred yards or more. Although changes have been made to improve the road and to meet weather, natural, and geologic concerns, it is the continuation of the philosophy of design that harmonizes the road with the environment that is important. The Grand Loop Road retains elements of grace in alignment with features constructed of natural materials to a scale compatible with the natural environment, and the roadside vegetation contribute to the natural setting, evoking a feeling of distinction that differentiates it from modern roads.

Originally constructed of earth and rock with wood corduroy and plank road through wetlands and at an 18-foot width, the road was widened and improved drainage systems installed and bituminous surface treatment applied. Landscape details of natural materials such as stone curbing at pullouts, masonry culvert headwalls, guardwalls, retaining walls, and log railing were added to continue the design philosophy of using natural materials. **(See Continuation Pages)**

Name of Property	County and State

8. Statement of Significance

Applicable National Register Criteria: A, B, C

Criteria Considerations (Exceptions):

Significant Person(s): Chittenden, Hiram

Cultural Affiliation: Euro-American

Areas of Significance: Transportation
Landscape Architecture

Period(s) of Significance: 1872-1944 (Criterion A)
1891-1906 (Criterion B)
1883-1944 (Criterion C)

Significant Dates:

Architect/Builder: U.S. Army Corps of Engineers
National Park Service
Bureau of Public Roads

Narrative Statement of Significance
(See continuation pages)

9. Major Bibliographic References

See continuation pages.

Previous documentation on file (NPS):

___ preliminary determination of individual listing (36 CFR 67) has been requested.
___ previously listed in the National Register
___ previously determined eligible by the National Register
___ designated a National Historic Landmark
___ recorded by Historic American Buildings Survey # __________
_X_ recorded by Historic American Engineering Record # __________

Primary Location of Additional Data:

___ State Historic Preservation Office
___ Other State agency
_X_ Federal agency
___ Local government
___ University
___ Other – National Archives, Denver

10. Geographical Data

Acreage of Property: Approximately 1,699 acres; 680 hectares
Refer to 7.5 Minute Quadrangle Maps for UTM Points

UTM References:	Pt	Zone	Easting	Northing

(See continuation pages)

Verbal Boundary Description
The boundary begins and ends at Mammoth Hot Springs at the junction of the Mammoth to Tower segment of the Grand Loop Road, which proceeds in an easterly direction, and the Mammoth to Norris segment of the Grand Loop Road, which heads south. The UTM coordinate for the beginning and ending point is Zone 12, 523579.38 easting; 4980365.00 northing, (NAD 1983). The latitude is 44.97633 and the longitude, -110.70095. The nominated property is a linear area following the current alignment of the Grand Loop Road, in its figure-eight configuration. The boundary extends 50 feet (approximately 15 meters) from the centerline on both the left and right side of the road. The Grand Loop Road extends south from the origin point in Mammoth to Norris Junction; travels in a westerly direction to Madison Junction; extends south to Old Faithful; the turns west to West Thumb; roughly follows the lakeshore north to Fishing Bridge; then northwesterly to Canyon Junction; northeast from Canyon to Tower; then turns west towards Mammoth returning to the origin point; a center section connects Norris Junction and Canyon Junction.

Boundary Justification
The boundary of the Grand Loop Road is drawn to include the road corridor at a sufficient width (100 feet or approximately 30 meters) to include the road, bridges, and the historic features associated with the road.

11. Form Prepared By

name/title: Mary Shivers Culpin, NPS Historian, Retired; amended by Elaine Hale, YNP Cultural Resource Specialist; additional historic documentation by Nancy M. McClure, HAER Historian; edited by Sara Housley, YNP Administrative Support Staff
organization: National Park Service **date:** August 2003
street & number: P. O. Box 168 **telephone:** (307) 344-2156
city or town: Yellowstone National Park **state:** Wyoming **zip code:** 82190-0168

Additional Documentation

(See continuation pages for photographs and maps)

Property Owner

name/title: Yellowstone National Park: National Park Service
street & number: P. O. Box 168 **telephone:**
city or town: Yellowstone National Park **state:** Wyoming **zip code:** 82190-0168

LIST OF CONTRIBUTING STRUCTURES AND BRIDGES

Road Segment	Resource Name	Contributing to District	Year Built	Resource Type
All	Grand Loop Road—Wy-24	Yes	1872-1905	Road Historic District
A-2	Golden Gate Viaduct	No	1977	Concrete Viaduct
A-2	Seven Mile Bridge	Yes	1932	Masonry Bridge
A-4	Gibbon River Bridge #1-- Modern MP20.22	No	1960	Concrete Bridge
B-2	Gibbon River Bridge #2—Wy-29 (Known on Historic American Engineering Record documentation as Gibbon River Bridge No. 1 – Wy-29)	Yes	1938	Masonry Bridge
B-2	Beryl Spring Causeway	No	1962	Timber Structure
B-2	Gibbon River Bridge #3—Wy-30 (Known on Historic American Engineering Record documentation as Gibbon River Bridge No. 2 – Wy-30)	Yes	1938	Masonry Bridge
B-2	Gibbon River Bridge #4-- Modern MP27.83	No	1960	Concrete Bridge
C-1	Gibbon River Bridge #5-- Modern MP34.63	No	1960	Concrete Bridge
C-2	Nez Perce Bridge—Wy-48	Yes	1935	Masonry Bridge
C-4	Firehole River Bridge-- Modern MP48.27	No	1967	Concrete Bridge
D-1	Old Faithful Interchange—Modern	No	1969	Concrete Structure
D-2	Isa Lake Bridge—Wy-31	Yes	1942	Timber Bridge
D-2	Firehole River Bridge #2—Modern	No	1972	Concrete Bridge
F-3	Otter Creek Bridge—Wy-32	Yes	1935	Concrete Bridge

Road Segment	Resource Name	Contributing to District	Year Built	Resource Type
G-4	Tower Creek Bridge—Wy-33	Yes	1933	Masonry Bridge
H-2	Lava Creek Bridge—Wy-34	Yes	1933	Masonry Bridge
H-2	Gardner River Bridge—Wy-7	Yes	1939	Steel Truss
I-1	Gibbon River Bridge—Modern	No	1966	Concrete Bridge

UNNAMED ROAD FEATURES CONTRIBUTING TO NATIONAL REGISTER ELIGIBILITY OF THE GRAND LOOP ROAD

Mammoth to Norris—Segment A

Culverts

Box	A	B	C	D	E	F	G	B/C	K
	181	6	6	4	3			4	

Retaining Walls—5
Stone Flumes--1

Norris to Madison—Segment B

Culverts

Box	A	B	C	D	E	F	G	B/C	K
	57	17	4	2		1	2		

Retaining Walls—5
Retaining Walls with Guard Walls—3

Madison to Old Faithful—Segment C

Culverts

Box	A	B	C	D	E	F	G	B/C	K	Paired
	100									1

Retaining Walls—1

Old Faithful to West Thumb—Segment D

Culverts

Box	A	B	C	D	E	F	G	B/C	K
3	96								

Retaining Walls—1

West Thumb to Lake—Segment E

Culverts

Box	A	B	C	D	E	F	G	B/C	K
11	23			1					

Retaining Walls--3

Lake Junction to Canyon—Segment F

Culverts

Box	A	B	C	D	E	F	G	B/C	K
6	134	1	7	1	5				

Retaining Walls (drylaid)—6
Stone Flumes—3
Stone Curbing
Timber Drainage Structure—1

Canyon Junction to Tower Junction—Segment G

Culverts

Box	A	B	C	D	E	F	G	B/C	K
10	148		3		24				10

Retaining Walls (masonry)—3
Stone Curbing
Stone Flume—1
Stone Swale—1
Log Guardrail—6 segments
Log Curbing

Tower to Mammoth—Segment H

Culverts

Box	A	B	C	D	E	F	G	B/C	K
	145		3					7	4

Retaining Walls—6

GRAND LOOP HISTORIC DISTRICT

The Grand Loop Road Historic District, determined eligible for listing on the National Register in 1994, is one of the properties covered within the Multiple Property Documentation "Historic Resources of Yellowstone National Park, Construction of the Road System in Yellowstone National Park, 1872-1966", accepted by the Keeper of the Register in 1995. The significant characteristics of the park's historic roads, road features, and associated structures are identified in that document.

In 1989 the Historic American Engineering Record (HAER), a division of the National Park Service, undertook a recording project to document the roads and bridges of Yellowstone National Park. This study was the first in a series of HAER documentation projects intended to provide a representative overview of roads and bridges throughout the National Park System. The 1989 HAER team produced drawings of seven historic bridges in YNP along with historical reports on the park's Grand Loop Road system. The photographs of the bridges and road features, taken by HAER photographer Jet Lowe, are included Section 11, Additional Documentation.

The historic context for the Grand Loop Road is provided in detail in *The History of the Construction of the Road System in Yellowstone National Park, 1872-1966 Historic Resource Study Volume I*, completed in 1994 by Mary Shivers Culpin. This document includes a map locating all of the historic bridges on the Grand Loop Road and the entrance roads in Yellowstone National Park.

The historic features contributing to the National Register Eligibility of the Grand Loop Road include masonry box culverts, various types of masonry culvert headwalls, masonry guardwalls, masonry and stacked log retaining walls, stone and log curbing, interpretative kiosks, paved waterways, and timber structures. These features have been documented for each section of road and the documentation submitted to the Wyoming Historic Preservation Office. An additional set of historic features documentation and historic photographs can be found in the archives at Yellowstone National Park.

An "Addendum to Yellowstone Roads and Bridges, HAER No.Wy-24" was begun in 1999 and submitted to the Library of Congress in 2003. The second recording project focused on portions of the Grand Loop that were not studied in detail during the earlier project. This project augmented the 1989 documentation and provides greater understanding of the history and significance of Yellowstone's road system. In keeping with the theme of the project, "Yellowstone Roads: A Cultural Landscape," the drawings and narrative histories of the 1999 HAER documentation efforts centered on the intent of the guardians of Yellowstone to provide access to the natural features that Yellowstone National Park was created to protect. In addition to detailed renderings of specific road features, drawings produced by the 1999 project include graphic illustrations of the evolution of transportation in the park, dominant landscape characteristics of various sections of the park road system, and changes in the design and technology of road construction through time.

The 1989 HAER recording project focused primarily on the Grand Loop Road while the narrative history of the addendum concentrates on segments of the Grand Loop that currently serve as scenic loops or byways. Some of these road segments were part of the original alignment of the Grand Loop Road but have since been bypassed by later additions to the park road system and converted to secondary loops that continue to provide access to distinctive park features. Although many of these scenic drives have been upgraded for modern vehicular traffic, like the Grand Loop Road, they retain their historic character.

As with any road, rehabilitation, repair, and reconstruction of the Grand Loop Road have been on-going. In 1992 Yellowstone National Park began a 20-year road improvement plan for the primary roads and bridges. The program was designed to preserve and extend the life of the roads, and enhance their safety, thus enhancing visitors' experiences. The goal of the current reconstruction program is to provide a 30-foot paved road surface where feasible, with replacement of base material, shoulder reinforcement, and minor horizontal alignment adjustments to provide a safer driving environment. The reconstruction will retain the graceful curves through geometric design rather than earlier methods of mechanically carving the road onto the landscape. Regular on-going maintenance and overlay to deteriorated road surfaces provides temporary improvement to the roads ride-ability. The historic values inherent in the road system, including the characteristics defined in the Multiple Property Document, will be preserved with any adverse impact to the historic landscape minimized.

In order for this to be a workable document, the DESCRIPTION section has been divided into seven sections. A sketch map depicting each segment of road is provided in the "Additional Documentation" portion of Section 11, towards the end of this document. The individual segments are also depicted on the 7.5-minute U.S. Geologic Survey quadrants. The historic description of the roads and bridges can be found in Part 8 - Significance.

MAMMOTH HOT SPRINGS TO MADISON JUNCTION SECTION (Map Segments "A" Mammoth to Norris Junction, and "B" Norris Junction to Madison Junction)

This section of the Grand Loop is 34.12 miles that traverses rolling to mountainous topography with vegetation that ranges from sagebrush covered land, aspen groves, and open meadowland to a transition zone dominated by lodgepole pine with light understory interspersed with sedge grass meadowland and scattered deciduous riparian species.

Within this section of the Grand Loop Historic District, in addition to the contributing road, there are three contributing bridges and four non-contributing bridges.

CONTRIBUTING STRUCTURES

ROAD

As part of the 1986 Parkwide Road Engineering Study, the road between Mammoth Hot Springs and Madison Junction was divided into two major sections for evaluation of condition. The first segment is 20.24 miles that begins at the junction with the North Entrance Road at Mammoth Hot Springs and ends at a point 0.04 mile south of the modern Gibbon River Bridge (0.75 mile north of the junction with Norris to Canyon Road). The remaining section begins at the point 0.75 mile north of the junction with the Norris to Canyon Road and runs to a point 0.17 mile north of Madison Junction. Each of the major sections is separated into segments for description and evaluation.

The first segment, A-1, is 1.81 miles located between milepost 0.00 to 1.81 that had an average daily traffic in 1985 of 3,500 vehicles, projected to increase to 4,300 vehicles in 2005. The roadway width, shoulder-to-shoulder, is currently 22 feet with bituminous plant mix surfacing in poor condition, displaying localized rutting and base failure. The base and the drainage are in fair condition and the pavement has no shoulders. The horizontal and vertical alignments are fair with the roadside slopes vegetated and in good condition. There are no bridges or major structures on this segment.

Segment A-2 begins at milepost 1.81 to 8.24 and extends south for 6.43 miles, with a projected average daily traffic in 2005 of 4,300. The roadway width (shoulder-to-shoulder) is 22 to 27 feet with the condition of the paved surface being fair to good, the road base in fair to poor condition, and surface drainage fair. The shoulder width is from 0 to 3 feet and is in fair condition. The posted speed is 45 mph; the horizontal and vertical alignments are fair and the roadside condition mostly open and in good condition. There is one non-contributing structure, the Golden Gate Viaduct, and one contributing bridge, the Seven Mile Bridge, located on this segment.

From milepost 8.24 to 15.57 segment A-3 extends 7.33 miles and had an average daily traffic in 1985 of 3,500 vehicles with average daily traffic projected for 2005 to 4,300. The roadway width, shoulder-to-shoulder, is 26 to 27 feet with the pavement surface 22 to 24 feet. The bituminous plant mix surfacing is in poor condition with extensive rutting and cracking and the base condition is poor. The drainage is in fair condition, the shoulder width from 0 to 2 feet and the shoulders are in poor condition. The posted speed limit is 45 mph with both the horizontal and vertical alignments good. The roadside condition is fair to poor owing to a “wall" effect created by sharp clearing lines along the road edges in heavy timbered areas. There are no bridges or major structures.

Segment A-4 is 4.67 miles long from milepost 15.57 to milepost 20.24 and has an average projected daily use for 2005 of 4,300 vehicles. The roadway width, shoulder-to-shoulder, is 22 to 27 feet with a paved surface width of 22 to 24 feet. The paved surface is in poor condition with rutting, cracking, and pavement edge breakdown. The base condition and surface drainage is poor. The shoulder width is 0 to 3 feet and in poor condition. The posted speed limit is 45 mph with both the horizontal and vertical alignments good. The roadside condition is fair to poor. In heavily timbered areas, a "wall" effect is created by straight clearing lines along the road edges. Major structures include the modern Gibbon River Bridge #1, just south of the access to the Norris campground.

The second half of Mammoth to Madison road section begins with segment B-1 that extends 4.10 miles from milepost 20.24 to 24.34. The average daily traffic in 1985 was 5,900 vehicles and is projected to increase to 7,200 vehicles in 2005. The roadway width is 30 to 32 feet with a pavement surface width of 30 to 32 feet. The bituminous surfacing condition is fair to good with isolated base failures caused by drainage problems. The sub-grade and drainage condition is fair with the shoulder width of 3 to 4 feet in fair to good condition. The posted speed limit is 45 mph and the horizontal and vertical alignments are good. The roadside condition is fair with narrow clearing limits, and sharp clearing lines create an unnatural "slot" appearance in some areas. There are no bridges or major structures.

Segment B-2, 5.06 miles from milepost 24.34 to milepost 29.40, is currently undergoing reconstruction. The average daily projected use for 2005 is 7,200 vehicles. The roadway width is 30 feet of paved surface. The bituminous surfacing is in excellent condition with the base and drainage also in excellent condition. The shoulder width is 4 feet and the shoulders were reconstructed in 2001-2003. The posted speed limit is 45 mph and the horizontal and vertical alignments are in good condition. The roadside condition is good with variegated, undulating vegetation and widened shoulders extend the view. There are four structures, the historic Gibbon River Bridge #2, Beryl Spring Causeway, the historic Gibbon River Bridge #3, and the modern Gibbon River Bridge #4.

The last segment, B-3, begins in the Gibbon Falls area and is scheduled for reconstruction in 2004. It extends 4.72 miles from milepost 29.40 to milepost 34.12 with an average daily traffic in 1985 of 5,900 vehicles. The first 2 miles has a roadway width of 22 to 26 feet with a pavement surface of 22 to 24 feet and 0 to 2-foot shoulders. The remainder has a 30-foot paved width with 11-foot driving lanes and 4-foot shoulders. The pavement and road base condition of the northern 2 miles is poor. The remainder has been reconstructed with the surface and base in excellent condition. The posted speed limit is 45 mph, with the horizontal and vertical alignments of the reconstructed portion excellent and the remainder satisfactory. Undulating clearing of the reconstructed portion has opened the view and provided a natural looking roadside appearance. There are no modern or historic bridges or major structures.[1]

The historic road features contributing to the eligibility of this segment of road have been surveyed and recorded. The first portion between Mammoth and Norris, Segment A, has 224 historic culverts, five retaining walls, and a stone flume. Segment B, Norris to Madison Junction, has 83 masonry culverts, five stone retaining walls, and three masonry retaining walls topped with guard walls.

CONTRIBUTING BRIDGES

SEVEN MILE BRIDGE

The Seven Mile Bridge, completed in 1932, was designed by the Denver office of the Bureau of Public Roads and built by Stevens Brothers of St. Paul, Minnesota. The bridge carries the Grand Loop Road over the Gardner River 9.5 miles south of Mammoth Hot Springs. The concrete girder bridge with masonry piers and abutments, has three spans with a maximum main span length of 27 feet measured from center of support to center of support. The flanking spans are 23 and 25 feet, respectively. The deck width is 27 feet while the bridge roadway from curb-to-curb is 24.8 feet. The construction cost of the bridge was $150,000.22.[2]

The design load for the bridge was 15 tons. All concrete was class "D" with a maximum aggregate size of 1 1/2 inches. Class "D" refers to the proportion of cement in the mix. All exposed corners were chamfered 3/4 of an inch. The top of the slab has a super-elevation of 1/2 inch per foot. The roadway center line curves to the left 4 degrees 18.7 minutes as one looks south. The slab is 2 1/4 inches thick. Transverse reinforcement at the top and bottom of the slab consists of 5/8-inch deformed bars at 14-inch centers. The 5/8-inch diameter bars bent up over the longitudinal girders are located between the other transverse reinforcement at 14-inch centers also. Longitudinal reinforcement in the slab consists of ½-inch diameter bars at about 10 inches on center.[3]

Seven Mile Bridge has 18 simple, longitudinal, concrete girders arranged in six rows spaced 5 feet 1 inch on center. All girders are 2 feet deep. The outside girders and middle six girders are 1 foot 5 inches wide while the other six girders are 1 foot 1 inch wide. All girders have transverse 5/8-inch diameter stirrups. The spacing between these stirrups in the middle girders ranges between about 8 inches near the piers and abutments to 1 foot 6 inches away from the piers and abutments. The closer spacing near the piers and abutments takes up the additional shear found here. The spacing in the outer six girders is uniform at 1 foot. The girders also have longitudinal reinforcement. In the middle six girders are 8, 1 ¼-inch bars arranged in two rows near the bottom of the stirrups. In the outer six girders are 3, 1 ¼-inch bars and 2, 1-square-inch bars arranged in two rows near the bottom of the stirrups. There are also 2, 1 ¼-square-inch bars at the top of the stirrups in the outer six girders. The remaining six girders have 6, 1 ¼-square-inch longitudinal reinforcing bars arranged in two rows near the bottom of the stirrups. The girders flare downward in a V-shape over the piers and abutments. Hooked reinforcing bars are found in this area.[4]

The form lumber for the exposed faces of the six outside girders was of a single slab per span. This form lumber was sand blasted to expose the full grain of the lumber. A single piece of lumber with the same grain treatment was used for formwork on the outside of the flare V-shaped concrete extension over the piers and abutments. A V-notch made with two pieces of ¾-inch chamfer strip was used to mark the concrete extension from the rest of the girder on its exposed face. All forms were lightly oiled with raw linseed oil.

Transverse stiffeners were employed in this bridge in the form of concrete beams at either end of each span. Over the piers these beams are the same depth as the girders while over the abutments they are seated in the abutment. Over the piers these beams are reinforced with ½-inch diameter stirrups and two ¾-inch diameter bars at the base of the stirrups running the length of the beams. Over the abutments these beams also have reinforcement. The piers and abutments of Seven Mile Bridge carry the bridge on a skew. The super-elevation of the bridge is built into the piers and abutments. A concrete seat measuring 2 feet 6 inches wide X 1 foot deep X 28 feet 3 inches long was laid in the piers which are battered at 1:12. A concrete seat measuring 1 foot 6 inches wide X 1 foot deep X 27 feet long was laid in the abutments which are battered 1:12 towards the stream and 4:1 away from the stream. The wing walls are flared and batter 1:12 on the outside and 3:12 on the inside. They extend between about 10 feet to 20 feet from the abutments.

The guardrail consists of 24-inch diameter wood posts rising from the abutments and piers with two 12-inch diameter posts on each span rising between these larger posts from the slab. The 12-inch diameter logs span on top of these 12-inch diameter posts and frame into the larger post. A wheel guard made of half of a 12-inch diameter log runs at the top of the slab between posts. The guardrail is held together by bolts and threaded rods countersunk and plugged.

GIBBON RIVER BRIDGE AT MILEPOST 25.69

The Gibbon River Bridge, at milepost 25.69, (known on HAER documentation as Gibbon River Bridge No. 1, Wy-29) was completed in 1938, and carries the Grand Loop Road over the Gibbon River, 4.9 miles south of Norris Junction. The bridge replaced a narrow pony-type truss structure built by the U. S. Army Corps of Engineers in 1910. The existing bridge is reconstructed, according to provisions of the Secretary of the Interiors Standards, to provide infrastructure support and replacement of support members while retaining the historic characteristics and appearance of the 1938 construction. The widening of the bridge deck driving surface was necessary to accommodate a wider roadway. The reconstruction of the historic bridge in its existing location, using the same masonry stones to replicate the historically documented pattern, and over the existing piers began the summer of 2001 and will be completed in 2003 with in-kind material replacement of eroded stones on the piers.

The location survey for the bridge was one of the first projects of the Bureau of Public Roads after they assumed responsibility for road and bridge construction in Yellowstone National Park in 1926. The 1927 survey between Norris Junction and Madison Junction successfully designed the new road alignment to fit the location of the existing 1910 Army-built bridges with major improvements to the bridge approaches.

Plans for Gibbon River Bridge No. 1 were completed by the Regional Office of the Bureau of Public Roads, with the National Park Service Division of Plans and Designs contributing the architectural designs. Strong and Grant of Springville, Utah, was awarded the contract on September 25, 1936. Between the end of May and the middle of November 1937, work progressed on the bridge. Test holes for excavations for the abutments and one and two piers revealed that solid rock foundations were available at higher elevations than the plans had indicated. Thus the seal concrete was eliminated. The bridge was completed with the exception of the steel handrails, concrete curb work, four masonry wings, and the painting of the structural steel. On July 3, 1938, the bridge was open to traffic.[5]

The bridge is a steel, I-beam continuous girder type, with span lengths of 35 feet, 40 feet, and 35 feet, constructed on stone masonry abutments and piers with reinforced concrete deck and steel guardrail. The span lengths are measured from center of support to center of support. The structure's length is 110 feet from end of backwall to end of backwall. The deck width was 29 feet 2 inches while the bridge roadway from curb-to-curb was 24 feet. The recent reconstruction widened the bridge deck and driving surface to accommodate a 30-foot roadway surface.

The design load was 15 tons and the grade of the bridge was 0.00 percent. The slab was 7 ¾ inches thick and is reinforced with longitudinal and transverse bars. The longitudinal bars are ½ inch in diameter at 2-foot centers while the transverse bars were 5/8 inch in diameter at 5 ½-inch centers. Both bars were in layers near the top and bottom of the slab. There were 15 simple steel girders supporting the deck. The girders were 24-inch wide flange (WF) sections weighing 74 pounds per foot. The outer six were encased in concrete with the bottom flange exposed. The girders were transversely braced with 16-inch WF sections weighing 36 pounds per foot over the abutments and piers and with 12-inch channels weighing 20.7 pounds per foot at midspan. These braces were placed in a line over the abutments and piers and in the middle of the span. The girders rest on steel bearing plates 2 ½-inches thick on the abutments and 2 ¾-inches thick on the piers. There were three bearing plates in each assembly.[6]

The plans called for all exposed concrete to be stained with two coats of concrete chemical stain, Xeramic or equal, and the steel rail to be painted with two coats of green paint. The concrete was not stained because the desired color could not be obtained. A third coat of white paint was put on the steel rail to better blend with the unstained concrete.[7]

The guardrail is made of steel bar posts 2 inches X 5 inches set in concrete on 6 feet 8-inch centers. The posts rise 2 feet 3 inches from the curb. The horizontal members of the guardrail are 4-inch channels, weighing 6.25 pounds per foot, which frame into the bar posts near the top and bottom. One-inch-square vertical bars on 8-inch centers run between the channels which cup downwards. The guardrails were replaced during the recent reconstruction with new ones designed to match the existing railing system.[8]

The abutments and piers are masonry on spread footings and rest on firm material. They rise 11 feet 3 inches from the river bed to the girders. The abutments and piers batter 1:12 on the sides running transverse to the bridge and 2:12 on the sides running longitudinally to the bridge. The abutments are U-shaped with wing walls of 34 feet slightly flared.[9]

The reinforcing steel for the 1938 bridge was purchased from the Provo Foundry and Machine Company in Provo, Utah, and hauled to the bridge site by the contractor. Coarse and fine aggregate was taken from near the site. The structural steel came from the American Bridge Company. The cement came from the Idaho Portland Cement Company from Inkom, Idaho.[10]

The bridge, which was completed in July 1938, cost $38,827.63.[11]

During the 2001-2003 reconstruction the abutments and wingwalls were disassembled, salvaging the stone masonry. One-lane traffic was maintained during the removal of the old wingwalls. The new abutments and wingwalls were widened to accept the new 9.2-meter pavement width. The overall deck width is 10.2 meters, allowing room for the curb and rail system. The salvaged stone masonry, with on-site stone supplementing the original, was reconstructed onto the new abutments and wingwalls. The existing stone masonry piers remain in place with a new, protective stone repair collar at the base. Obsidian sand was included in all stone masonry mortar. The new deck is a cast-in-place concrete over steel girders design. The final driving surface over this 33.53-meter long deck is asphaltic concrete. The picket-style steel bridge railing (a modified Oregon 2-tube curb-mounted railing) compliments historic designs and is finished with epoxy paint, Oxford Brown in color. The steel girders were finished with medium-gray epoxy paint (Ameron Amershield #GR-2). The load limit of the modern bridge was adjusted to compensate for modern traffic and the grade of the bridge was retained at 0.00 percent.

GIBBON RIVER BRIDGE AT MILEPOST 26.91

The Gibbon River Bridge, at milepost 26.91, (known on HAER documentation as Gibbon River Bridge No. 2, Wy-30), completed in 1938, carries the Grand Loop Road over the Gibbon River 6.1 miles south of Norris Junction. The location survey for the bridge was one of the first projects of the Bureau of Public Roads after they assumed the responsibility for road and bridge construction in Yellowstone National Park in 1926. The 1927 survey between Norris Junction and Madison Junction successfully designed the new road alignment to fit the location of the existing Army-built bridges with major improvements to the bridge approaches.

Plans for the Gibbon River Bridge No. 2 were completed by the Regional Office of the Bureau of Public Roads, with the National Park Service Division of Plans and Design contributing the architectural designs. Strong and Grant of Springville, Utah, were awarded the contract on September 25, 1936. The Gibbon River has a maximum discharge of 809 cfs .6 miles downstream from Canyon Creek, which is near the bridge.[12]

The 1938 bridge was designed as a concrete deck girder structure with encased steel beams on the outside and masonry piers and abutments. The bridge has three spans with a maximum span length of 39 feet 8 inches. Span length was measured from center of support to center of support. The flanking spans were 31 feet 8 inches. The structure length was, and still is, 104 feet from end of backwall to end of backwall. The deck width was 30.7 feet while the bridge roadway from curb-to-curb was 26 feet. The 2002 widening and reconstruction of the roadway required that the bridge also be widened. The historic 1938 construction was documented, redesigned, and reconstructed according to the Secretary of the Interior's Standards to provide abutment and bridge deck support, provide in-kind repairs to deteriorating stone masonry, and widen the bridge deck to accommodate the wider roadway. The piers were extremely damaged at the waterline from the acidic waters of the Gibbon River. The piers were removed and the masonry stone was salvaged for use on the retaining and guardwall approach to the bridge abutment. A single span concrete bulb-T deck was used to replace the concrete girder deck at the same slant and skew as the original deck. The bridge abutments and deck were widened and reconstructed retaining the historic characteristics and appearance as the 1938 structure.

The design load was originally 15 tons and the grade of the bridge is 0.47 percent going uphill from south to north. The slab was 8 inches thick and reinforced with longitudinal and transverse bars. The transverse bars were 5/8 inch in diameter at 5 ½-inch centers while the longitudinal bars were ½ inch in diameter. There were 15 simple steel I-beam girders supporting the deck, five to each span. The outer six girders were encased in concrete with the bottom flange exposed and the interior web partly exposed on the inside. In the flanking spans the outer girders were 24-inch WF at 74 pounds per foot while the six inner girders were 24-inch WF at 87 pounds per foot while the inner three girders were 24-inch WF at 120 pounds per foot. In the middle span the outer girders were 24-inch WF at 87 pounds per foot while the inner three girders were 24-inch WF at 120 pounds per foot. The girders were transversely braced with I-beam members and channels. These braces were staggered between the girders over the abutments and piers and in the middle of the span. Over the abutments and piers they followed the orientation of the abutments and piers while in the middle of the span they were perpendicular to the girders. The transverse members in the middle of the span were 12-inch channels at 20.7 pounds per foot while over the abutments and piers they were 16-inch WF at 36 pounds per foot. The girders rest on bearing plates on the abutments and piers.[13]

The Gibbon River Bridge's piers were on a skew and the bridge curves 8 degrees 30 minutes to the left as one looks north. This curve creates torsion and increases the stress correspondingly on the girders away from the center of curvature. This difference was not large for multiple girder systems like that found in this bridge. The torsion created translates into horizontal and vertical forces which must be transferred to the girders near the center of curvature. To achieve this, Gibbon Bridge had nearly full-depth cross frames.

The plans called for all exposed concrete to be stained with two coats and the steel rail to be painted with two coats of green paint. The concrete was not stained because the desired color could not be obtained. A third coat of white paint was put on the steel rail to better blend with the unstained concrete.[14]

The guardrail is made of steel posts 2 inches X 5 inches set in concrete on 6 feet 2-inch centers. The posts rise 2 feet 3 inches from the curb. The horizontal members of the guardrail are 4-inch channels weighing 6.25 pounds per foot framing into the bar posts near the top and bottom. One-inch-square vertical bars at 7 5/8 to 8 7/8-inch centers run between the channels that cup downwards.[15] The existing guardrail was replicated and replaced in-kind when the bridge was reconstructed.

The abutments are masonry and have spread footings which rest on firm material. This material is very tightly packed gravel. They rise about 6 feet from the river bed to the girders. The abutments batter 1:12 on the sides running transverse to the bridge and 2:12 on the sides running longitudinally to the bridge. The abutments are U-shaped with wing walls between 16 and 19 feet long, slightly flared.[16]

The reinforcing steel for the 1938 bridge was purchased from the Provo Foundry and Machine Company in Provo, Utah, and hauled to the bridge by the contractor. Coarse and fine aggregate was taken from near the site. The structural steel came from the American Bridge Company. The cement came from the Idaho Portland Cement Company of Inkom, Idaho.

The bridge, which was completed in July 1938, cost $26,604.10.[17]

The reinforcement, widening, and reconstruction of the bridge began the summer of 2001 and will be completed by the fall of 2003. The reconstruction upgrades the load limit, provides abutment support, and widens the deck to facilitate the widened roadway and meet modern traffic standards. The abutments and wingwalls were dissembled, salvaging the stone masonry. One-lane traffic was maintained during the removal of the old wingwalls. The new abutments and wingwalls were widened to accept the new 9.2-meter pavement width. The overall deck width is approximately 10.2 meters, allowing room for the curb and rail system. The salvaged stone masonry, with on-site stone supplementing the original, was reconstructed onto the new abutments and wingwalls. The existing stone masonry piers were removed, the salvaged stone reused on the new abutment and wingwall structures. The existing superstructure was replaced with precast, prestressed deck bulb-T units free-spanning the Gibbon River. The deck is built on a 197.816-meter curve radius and is superelevated at 6.25 percent. The final driving surface over this 33.0-meter long deck is asphaltic concrete. The picket-style steel bridge railing (a modified Oregon 2-tube curb-mounted railing) compliments historic designs and is finished with epoxy paint, Oxford Brown in color.

NON-CONTRIBUTING STRUCTURES

GOLDEN GATE VIADUCT

In 1883 work began on a new route from Mammoth Hot Springs to Gardiner, Montana, through the Golden Gate and the West Fork of the Gardner River. The project was completed in seven months. Twelve hundred and seventy-five pounds of explosives were used and 1300 drilled shots were fired. As a result, 14,000 cubic yards of solid rock was excavated, in addition to a large amount of broken and crushed rock. This dangerous section of road was completed without loss of life or injury. The new road reduced the route by 1 1/3 miles, saving 2 hours to ½ day travel time depending on the type of wagon and load. The reduced ascent of 250 feet to Swan Lake plateau enabled loaded wagons traveling in opposite directions to now pass with relative ease. The near-vertical stone walls of the canyon prevented an excavated roadway, thus a 228-foot wooden trestle carried the roadway. Lieutenant Dan Kingman of the Army Corps of Engineers noted in his report for 1885 that the "natural stone monument at the end of the trestle" marked what "visitors have called the Golden Gate."[18]

Four years after the completion of the road, the wooden trestle was strengthened by placing new timber supports and road-bearer cross beams.

In 1899, the Army Corps' officer Hiram Chittenden described the road:

> . . . through this canyon is mostly cut in side of cliff. For 200 feet it passes over a wooden bridge. This bridge is about fifteen years old and has reached its limit of safety. It will have to be condemned by the close of the season. The situation is such than an accident here would have appalling consequences. It is proposed to put in a series of concrete arches, covered with regular macadam roadway 16 feet wide and a solid parapet 3 feet high. The cost will be in the neighborhood of $10,000. The road through the canyon is in most places too narrow for teams to pass each other, and there are two short turns where the view ahead is abruptly and completely cut off. It is proposed to widen the road so that it shall everywhere be passable by two teams abreast, and to make it much wider at the sharp curves. At the same time the steep grade will be eliminated and the whole made to conform to the grade and approaches of the new bridge. This will be solid rock work and very costly.[19]

The next year, Chittenden felt that the bridge excited "general uneasiness and concern among the traveling public, and although still safe it was felt that its reconstruction could not long be deferred anyway and might as well be taken up at once . . ."[20] Chittenden made a decision to build a concrete structure.

> It was decided to build the new viaduct in a series of arches. The piers were spaced 18 feet from center to center, and were made 3 feet thick and carried down to firm rock. The rise of the arches was fixed at 2 feet; the thickness at the crown at 12 inches and at the springing line at 18 inches. The arch was reinforced with wire netting made of No. 8 B. G. steel wire with meshes 5 X 1 5/8 inches, the long dimension of the mesh being parallel to the axis of the bridge. The netting was placed 4 inches above the lower surface of the arch and extended 3.75 feet on each side of the crown. A parapet wall 42 inches high above the top of the arch was provided on the side opposite the cliff. It was given a thickness of 12 inches at the top and 16 inches at the crown of the arch. To strengthen it further, four pieces of 60 pound steel rail 4 feet long was placed obliquely so as to extend through the concrete. The materials used were Atlas Portland cement, and a natural mixture of gravel and sand found on the Swan Lake flat, 3/4 of a mile from the work. The mixture seemed comparatively free of dirt and was used just as taken from the pit. The proportions of the mixture were on a basis of 1 cement, 2 sand, and 4 gravel.[21]

Most of the time, particularly during the cement work, a gale roared through the canyon, forcing the crews to begin work at daybreak and end about 11 a.m. Besides the wind, the lack of rain created an excessive dust problem. Working in such a restricted area and the ever-present danger of falling from the cliff for 20 to 75 feet made this project a dangerous one. The tourist traffic was rerouted on a temporary road via Snow Pass for four weeks. For about the last month of construction the traffic moved through the canyon.[22]

It was during this construction that the picturesque landmark, the large stone at the entrance to the canyon, received its first instance special treatment.

> One interesting feature of the later work was the removal of the large rock which stood at the entrance to the old bridge and partially blocked the roadway which divided it and the cliff. The changes involved in the new structure necessitated the removal of this rock. As it was the unanimous desire of those familiar with the park that this unique and picturesque feature be retained, the rock was broken off, lifted about 6 feet to the new grade, moved out about 6 feet and down the road about the same distance where it was set up on a new foundation, consisting of a square column of concrete 3 X 3 feet and 24 feet high. The whole foundation was then covered up, so as to remove all evidence of its artificial character. This rock weighed about 23 tons and its removal took place on the steep face of an unstable cliff, it had to be managed with great care. It was done under the

> direction of Foreman Robert Walker, with a force of 4 men. The whole operation consumed 5 days and cost $80.[23]

Upon completion of the 2,000 feet of new roadway, the grades through the canyon were reduced and the newly widened lanes allowed teams to pass one another safely.[24] In 1910, the Golden Gate Viaduct was called the "most notable engineering feature of the whole road system."[25]

For the next few decades, Chittenden's viaduct served the traveling public. In 1926, plans began to be made for its improvement by using National Park Service day forces, but by 1930, a request was made for Bureau engineering. The Bureau recommended a tunnel at station 419 - 420, a viaduct at station 423+10 to 425+95, using sixteen 18-foot spans of steel and reinforced concrete, concrete box and metal pipe culverts with masonry headwalls, masonry retaining wall and hand laid rock embankment. The project was awarded to Morrison-Knudsen Company on October 20, 1932.[26]

The contractor set up camp in a previously occupied camp at the right of station 515 about 1 mile below the end of the work. Frame bunkhouses, an office, and a mess house were constructed. Several tents served as additional bunkhouses. Approximately 55 men worked on this project, which began on October 29, 1932. By the middle of December, excavation of the east portal of the tunnel was finished and the actual tunnel project began.

> Small pioneer tunnels were driven to a distance of 28 feet on each side at spring line and then cross cut at the inside end and the excavation of the roof made, working outward toward the portal. This was done to avoid overbreak and a possible cave in as the rock was badly seamed and shattered. As the rock was excavated, timber lining was placed consisting of 12 x 12 posts and cross members set at 4 feet intervals, with timber logging filling the space behind.
>
> By February 19, 1933, tunnel excavation was completed with the exception of the last seven feet on the upper end. In removing this last seven feet section, a cave in or slide occurred and this portion sheared off, falling onto the road in front of the tunnel. It was necessary at this time for the shovel to move around the point to the outside at upper end of tunnel and load this slide material, but weather conditions were so severe the men could not stand to work there, so all activities were discontinued until the weather moderated.
>
> During the period from December 1, 1932 to February 19, 1933, weather conditions were very severe with considerable snow and extreme cold, the thermometer registering a minimum of 62 degrees below zero at one time, and a high wind blowing almost incessantly through the canyon. Great difficulty was experienced in keeping air lines from freezing up and in getting machinery started in the mornings.

By March 9, 1933, weather conditions had modified sufficiently to permit work to be carried on and excavation was timed on the tunnel. Excavation of the tunnel was completed on March 20, 1933, with a total length of 90 feet as compared with the original planned length of 100 feet.

During the month of May, water from melting snow running into the cracks and crevices above the east portal of tunnel and then freezing and thawing, caused the rock to start working at this point and a few small slides occurred and timbering in the tunnel was observed to be taking considerable weight. Additional posts and braces were set to strengthen the timbering and men were set up to work prying off rock to reduce the weight above the timbering in an attempt to avoid a cave in, but on May 22, 1933, the tunnel caved in resulting in the loss of all except 16 feet on the upper or west end. A change order was issued eliminating the completion of the tunnel from the contract, and the point where the tunnel was originally planned is now to be designated as a quarry site for surfacing and when completed, will be a daylight cut.

After completion of the tunnel excavation on March 20, 1933, work was pushed on the viaduct in order to have the north half ready for traffic when the park opened. Footings for columns were excavated and poured, steel columns set in place and cross girders and reinforcing steel placed. Pouring of concrete was carried on as fast as excavations were made and forms and steel placed. Aggregates for concrete were heated by heaping them on large pipes in which fires were kept burning. Water was heated with a coil and concrete was protected from freezing with canvas covering and oil stoves.

The north half of the viaduct was completed on May 10, 1933, and opened to traffic on May 26, 1933. The south half was completed on July 15, 1933.[27]

The 1933 structural steel-and-reinforced-concrete viaduct consisted of 16 spans (18 feet per span) built over and outside of the Army-built viaduct it replaced. It was independent of the old viaduct for support. The 24-foot-wide roadway extended from stat 423+10 to 425+95. All drainage was accommodated by corrugated metal pipes with masonry headwalls, with the exception of one 4 x 4-foot concrete box culvert with masonry headwall built at station 406+75 in Glen Creek.[28]

The sand came from a pit approximately 5 miles north of the project and the coarse aggregate came from the excavated tunnel material. As part of the project, old roads and old drainage structures were obliterated. The total project was completed on August 16, 1933, for a cost of $115,630.93.

The final surfacing was completed on July 17, 1934, resulting in a 22-foot shoulder-to-shoulder-wide road that had a 4-inch base of 1 ½-inch maximum size aggregate and 1-inch top of 1-inch maximum size aggregate.[29]

Also in 1934, a stone parapet was added at the location of the tunnel and the wall was repaired when it had settled. Excess stone from previous masonry work and stone obtained from the bed of Glen Creek near the foot of Rustic Falls were used in the construction work.[30]

In 1949, the roadway through the Golden Gate Canyon received a bituminous surfacing as part of a larger surfacing project from Mammoth Hot Springs to Firehole Cascades. The project, which was paid from the park's maintenance funds, was awarded to Peter Kiewet Sons Company of Sheridan, Wyoming. The purpose of the project was to "prolong the life of the existing pavement and reduce the cost of maintenance on this section," even though the engineers knew that the road "will ultimately require widening to a higher standard, at which time it will be necessary to widen the shoulders and improve the bituminous pavement."[31]

In 1959, an earthquake centered near the park's western boundary caused considerable damage to the masonry guardrails and embankments near Gibbon Falls, in the Golden Gate Canyon, at Undine Falls and Overhanging Cliff. Much of the guard walls "had fallen off or were cracked in the joints, and embankments had slipped and bulged." In the Golden Gate Canyon, slides blocked the road and portions of the guardrail were lost or damaged to such an extent that replacement of the guardrail was required. Day labor work in the Golden Gate Canyon covered slide removal and scaling, breaking up and relaying the old surface and resurfacing with 2-inch bituminous mat, and replacement of 950.1 linear feet of rustic log guardrail. McLaughlin Construction Company of Livingston, Montana was awarded the contract for the masonry replacement work.[32]

> The contractor's work was described as Rehabilitation and reconstruction of stone masonry guard wall included correction of alignment and elevations, construction of reinforced foundations for all new stone masonry, stabilization of embankments by new reinforced concrete base under bulged sections, and the grouting of slipped embankments above and around such bulged sections. . . The Park granted permission to the contractor to salvage some additional rocks for the masonry from old quarries and storage dumps near Norris Geyser Basin, Midway Geyser Basin, and Undine Falls. . . . For safety reasons work was started in most places by removing old damaged masonry along the road edge above the embankments. New foundations were established along the corrected lines and elevations. The embankment above and around bulges and cavities was stabilized with grout and after curing of the concrete, the bulges down under were excavated and properly repaired. All new guard wall foundations were made to overlap into solid ground or into rock formations, spanning over 80 to 170 feet of existing embankment.[33]

The work was completed during the 1960 season.[34]

In 1977, a new six-span continuous girder bridge with concrete deck replaced the old viaduct. The 327-foot-long, two-lane bridge has a width of 30 feet curb-to-curb and steel-on-concrete base railings, 2 feet 5 inches above the roadway. The bridge is in good condition. Falling rocks in 1984 necessitated the repair to holes in the deck and damage to the stone parapets.[35]The 1977 reconstruction retained the cantilevered aspect of the historic structure.

Due to the rich history and unique aspects of this evolving road structure, HAER documentation (HAER Wy-46) was completed and submitted in the 1995 package. Additional archival photo documentation of the past structures and efforts to maintain the historic feeling of setting for the modern structure was submitted in the "Addendum to Yellowstone Roads and Bridges HAER No. Wy-24" labeled HAER Wy-3.

GIBBON RIVER BRIDGE AT MILEPOST 20.22

The Gibbon River #1, located at milepost 20.22, is a single-span steel girder type with concrete deck. The 52-foot-long bridge, with a deck width of 28 feet, has steel rails which do not conform to current safety standards. The bridge was built in 1960.

BERYL SPRING BRIDGE

The Beryl Spring Bridge, located at MP 26.06, is a ten-span timber causeway bridge built in 1962. The 230-foot-long structure has a deck width of 27.4 feet and wooden rails. The bridge is in good condition, but the original rails and curbs do not meet current safety standards. The 2002 roadway widening and reconstruction project removed the sub-standard rail and viewing platform, replacing these with log railing designed to match the log cribbing associated with the bridge structure. The bridge timbers supporting the bridge deck are deteriorated, some of which were replaced, in-kind, with more extensive support repair planned for the near future.

GIBBON RIVER BRIDGE AT MILEPOST 27.83

The Gibbon River Bridge at milepost 27.83, is a single-span steel girder bridge with concrete deck. The 90-foot-long bridge has a deck width of 28.4 feet and steel rails, which do not conform to current safety standards. The bridge was built in 1960. The current road reconstruction project will apply a stone masonry veneer to the concrete abutments.

MADISON JUNCTION TO OLD FAITHFUL SECTION (Map Segment "C")

This section of the Grand Loop is a 15.57-mile section that traverses rolling to mountainous topography through lodgepole pine forests with light understory, interspersed with sedge grass meadowland and scattered deciduous riparian vegetation. Within this section of the Grand Loop Historic District, in addition to the road, is one contributing bridge and two non-contributing bridges.

CONTRIBUTING STRUCTURES

ROAD

In the 1986 Parkwide Road Engineering Study, this section of the Grand Loop Road was divided into four segments for evaluation of condition. The phased road widening to 30 feet and reconstruction to repair road-base failure of 13.81 miles of this road segment, starting at Madison Junction and ending just north of the Old Faithful Interchange, was completed in 1996.

The first segment begins at milepost 34.12 and ends at 36.70. The roadway width from shoulder-to-shoulder and the pavement or surfacing width is 30-32 feet. The surface type is bituminous plant mix and the surface is in good condition. The shoulder width is 4 feet and the shoulders are in good condition. The posted speed limit is 45 mph. The horizontal and vertical alignments are good. The roadside condition is fair, with vegetation encroaching on roadway restricting the sight distances in some areas due to narrow clearing limits. One modern bridge, Gibbon River Bridge No. 5 is on this segment. The average daily traffic in 1985 was 5,600 vehicles with a proposed average daily traffic for 2005 of 6,800.

Segment 2 covers 5.56 miles between milepost 36.70 and 42.26. The roadway width from shoulder-to-shoulder is 30 feet and is covered with a bituminous plant mix. The surface condition, base, and subgrade condition are good. The shoulder width is 4 feet and the condition is good. The posted speed limit is 45 mph. The horizontal and vertical alignments are good. The roadside condition is generally good with some minor restriction of sight distance caused by encroaching vegetation. This segment transverses prime and unique geological, visual, and thermal natural resources. One historic bridge, the Nez Perce Creek Bridge, is on this segment. There are no other major bridges or structures.

Segment 3 covers two sub-segments, the first is .29 mile between milepost 42.26 to 47.93; the second sub-segment covers 5.38 miles from milepost 42.55 to 47.93. On the first sub-segment, the roadway width from shoulder-to-shoulder is 30 feet and is covered with a bituminous plant mix. The surface condition is good. The base and subgrade condition is good. The shoulder width is 4 feet and the shoulder condition is good. The posted speed limit is 45 mph with exceptions. The horizontal and vertical alignments are good. On the second sub-segment, the roadway paved surface width from shoulder-to-shoulder is 30 feet. The paved shoulder width is 4 feet and the shoulder condition is good. The posted speed limit is 45 mph. The horizontal and vertical alignments are good, having been recently reconstructed. Roadside vegetated areas have been re-established and this segment of road runs through prime and unique geological, visual, and thermal natural resources.

Segment 4 covers 1.76 miles from milepost 47.93 to 49.69. The roadway width from shoulder-to-shoulder is 30 feet. The reconstructed surface is covered with a bituminous plant mix and the condition is good. The base and subgrade are in good condition. The posted speed limit is 45 mph. The horizontal and vertical alignments and roadside condition are good.

The historic unnamed road features along the Madison to Old Faithful section of road were documented to HAER standards (Short Form) and include 100 culverts with masonry headwalls, one set of double culverts, and one riverside retaining wall 600 feet in length.[36]

CONTRIBUTING BRIDGES

NEZ PERCE CREEK BRIDGE

The Nez Perce Creek Bridge carries the Grand Loop Road over Nez Perce Creek 6.5 miles south of Madison Junction. The bridge was built during the reconstruction of the Madison Junction to Old Faithful road section in 1935. The 1996-97 reconstruction and widening of the road to a standard 30-foot width required that the deck of the historic bridge also be widened. The stonework was documented before repairs began, the bridge infrastructure supports were replaced, the deck and abutments were widened on the east side to accommodate the widened roadway, and the stone masonry was reassembled to retain the historic materials and appearance of the 1935 bridge. The bridge was documented to Historic American Engineering Record Standards and is listed as Wy-48.

The bridge is a three-span concrete deck girder-type structure with continuous slab and masonry piers and abutments. The bridge has two spans, one of 25 feet 3 inches and one 28 feet, measured from center of support to center of support. The structure length of the bridge center line, not including the wing walls, is 78 feet 6 inches. The deck width was 27 feet while the bridge roadway from curb-to-curb was 24 feet.[37]

The bridge is on a skew of 45 degrees, so the abutments run about east-west while the bridge runs southeast-northeast. The original design load was 15 tons. All concrete in the bridge is class "D". "D" refers to the amount of cement in the mix. "A" has the highest proportion of cement in the mix and is the strongest concrete. The maximum size of the coarse aggregate is 1 1/2 inches. The curb and three spans were poured in one operation. The slab was 1 foot 3 inches thick and had longitudinal and transverse reinforcing. The curb rises 9 inches above the slab, at a thickness of 1 foot 6 inches. The longitudinal reinforcing bars were near the top and bottom of the slab and were 7 inches on center. The diameters of these bars varied between 1/2 inch and 1 1/8 inches. The transverse reinforcing bars were near the top and bottom of the slab and were 14 inches on center in the middle span. The diameters of these bars varied between 1 inch and 1 1/8 inches. The longitudinal bars were lapped 4 feet at all splice points which occur 6 feet before and after the center lines of the piers.[38]

The guardrail consists of 2 X 5-inch steel bars sunk into a 4-inch X 7-inch X 1-foot 1-inch socket in the curb. Four-inch channels at 6.25 pounds per foot cupping downward frame into the bars near the top and bottom to form horizontal rails. One-inch diameter bars frame vertically between the rails, 8 ¼ inches on center. The rail rises 2 feet 9 inches above the curb.[39] New guardrails built to match the original railing were installed when the bridge was reconstructed and the deck widened.

The abutments and piers spring from spread footings on firm material. The abutments batter 1:12 on the inside and 2:12 on the outside. The abutment has a 1-foot deep concrete seat for the deck slab. The abutments are 3 feet wide at the top. The wing walls batter 2:12 on the inside and 1:12 on the outside. They are 1 foot 10 inches wide at the top. The wing walls extend 16 feet from the abutment. The piers rise approximately 7 feet from the normal water elevation. They batter 1:12 on all sides. The piers have a 2 feet wide X 1-foot deep concrete seat for the deck.[40]

The original estimated material quantities of the bridge were:

Class "D" concrete	110 cubic yards
Reinforcing steel	32,000 pounds
Masonry	264 cubic yards
Steel rail	157 linear feet
Excavation	135 cubic yards[41]

The construction of the 1935 bridge was part of a contract awarded to McLaughlin Construction Company of Livingston, Montana for three bridges--Nez Perce Creek Bridge, Firehole River Bridge at Morning Glory Pool and a footbridge across the Firehole River at Excelsior Geyser.

Excavation work for Abutment No. 2 on began on September 14, 1934 with a crew of eight men. The crew grew to 25 men as excavation work began on the other abutment and the piers. The excavating crews and the masonry crews alternated between the other bridge projects. The crushed aggregate and the stone for the masonry work came from a quarry on the Mary Lake Trail about 1 3/4 miles to the right of Station 513. A roadside pit at Station 370 provided the sand for both the masonry and concrete work. The crews worked until November 9, 1934 completing about 25 percent of the project.[42]

The crew resumed work in June 1935. Prior to the 1934 season's closing, a section of the cliff at the stone quarry had been shot down to provide sufficient stone for immediate resumption of masonry work at the beginning of the 1935 season. However, the shape and size of the stones made it skeptical whether the quarry could provide enough large stones for all three bridges in the project. The decision was made to use the stones for the Nez Perce Creek Bridge, which blended well with the environment, and open another quarry at a point about 1 mile south of Gibbon Falls where the old Mesa Road leaves the Grand Loop Road.

The traffic was not inconvenienced, as the old bridge remained in use throughout the construction period. Upon completion of the new bridge, the old bridge was removed and salvaged. The McLaughlin Construction Company of Livingston, Montana constructed the bridge for a total cost of $16,238.20.[43]

During the 1996-1997 reconstruction the abutments and wingwalls were disassembled, salvaging the stone masonry. One-way traffic was maintained during the removal of the old wingwalls. The new abutments and wingwalls were widened to accept the new 9.2-meter pavement width. The overall deck width is 10.11 meters, allowing room for the curb and rail system. The salvaged stone masonry, with on-site stone from the Nez Perce

Quarry supplementing the original, was reconstructed onto the new abutments and wingwalls. The existing stone masonry piers remain in place. Obsidian sand was included in all stone masonry mortar. The new driving surface over this 24.268-meter deck is asphaltic concrete. The picket-style bridge railing (a modified Oregon 2-tube curb-mounted railing) compliments historic designs and is finished with epoxy paint, Oxford Brown in color. The steel girders were finished with medium-gray epoxy paint. The design load was improved to accommodate modern traffic.

NON-CONTRIBUTING BRIDGES

GIBBON RIVER BRIDGE AT MILEPOST 34.63

The Gibbon River Bridge at milepost 34.63 is a single-span reinforced concrete box beam structure. The 110-foot-long bridge has a deck width of 32 feet and steel rails that do not meet the current safety standards. The bridge was constructed in 1960.

FIREHOLE RIVER BRIDGE AT MILEPOST 48.27

The Firehole River Bridge at Milepost 48.27 is a three-span cantilevered reinforced concrete T-beam bridge built in 1967. The 102-foot-long bridge has a deck width of 28.2 feet and steel rails that do not conform to current safety standards.

OLD FAITHFUL TO WEST THUMB (Map Segment "D")

The Old Faithful to West Thumb segment is a 17.64-mile road that traverses rolling to mountainous topography through lodgepole pine forests with light to moderate understory. Within this section, in addition to the road, there is one contributing bridge, the Isa Lake Bridge, and two non-contributing bridges. This section of the road was determined eligible for listing on the National Register of Historic Places in 1986.

In 1960, more surfacing amounting to $2,192,708.76 was done to the road segment. The road segment continues to be a primary public access road to major points of interest in the park. In 1988, the Federal Highway Administration undertook the reconstruction of this section of road, also known as the "Craig Pass road". The road was widened to a 30-foot road width with a paved surface width of 28 feet (11-foot driving lanes, 3-foot paved shoulders, and 1-foot turf shoulder.)

In addition to the historic Isa Lake Bridge, the road also has three significant stone culverts and headwalls--Herron Creek, DeLacy Creek, and Dry Creek. The road also has 96 stone-faced culverts of different types and sizes. The Herron Creek culvert is a reinforced stone-faced concrete box culvert with 5'4" x 9'0" x 142'0" stone masonry headwalls. The DeLacy Creek culvert is a reinforced stone-faced concrete box culvert measuring 5'4" x 11'3" x 185'0". The Dry Creek culvert is a reinforced stone-faced box culvert measuring 7'4" x 11'3" x 185'0".

The 1985 statistics indicate that approximately 6900 vehicles travel this road daily with a projection for 2005 of 8,500 vehicles.[44]

CONTRIBUTING BRIDGES

ISA LAKE BRIDGE

One of the controversial topics of the Old Faithful to West Thumb segment was the road alignment at Isa Lake and the architectural details of the proposed Isa Lake Bridge. The National Park Service was opposed to the use of a culvert, but requested the construction of a low timber bridge "to preserve the natural existing conditions as near as possible".[45] The decision to construct the bridge was accepted but several years would pass before the final details were worked out and the actual construction took place.

During 1936, the maintenance of a log bridge was discussed in a letter to the Bureau's District Engineer, J. A. Elliot, from J. W. Emmert, Acting Superintendent, in which Emmert pointed out that the drawing No. YELL 3242 had logs located in positions that would promote rapid decay. He proposed a penetration treatment method or the use of redwood logs to prolong the life of the bridge and keep the maintenance costs at a minimum.[46] In September of 1936, the subject of concrete decking and its color was addressed in a letter to Superintendent Edmund Rogers from Ernest Davidson, Regional Landscape Architect. The use of the concrete decking allowed "the bridge to be kept about a foot lower in elevation than if a timber deck were used." The landscape architect recommended that "the road slab be stained with road oil to have a similar color to the adjoining sections of road".[47]

Rogers responded, "that the concrete slab should be stained as suggested . . . in order to avoid any sharp break in color contrast between roadway and bridge." He wrote, "We feel that the missing bridge links on the loop highway are very important and should be pushed along as rapidly as possible."[48]

In 1938, Park Naturalist C. Max Bauer sent a memorandum to the superintendent stating his preference for a "simple type of structure" and that the current plans are too elaborate. He wrote, "I am particularly interested in preserving Isa Lake as nearly as possible like it is at present and any structure which would be any higher than the present fill would seem to me to be objectional."[49]

A September 1940 memorandum to Thomas Vint, NPS Chief of Planning, from Deputy Chief of Planning Thomas Carpenter revealed that a proposed revised location for the road and bridge had been made. The Bureau engineer would be presenting the proposed location of the road and a new architectural plan for the log bridge.[50]

The following June, Carpenter sent a memorandum to Vint telling him that he had addressed Vint's review comments and was enclosing a set of prints of the revised plans (YELL-2050A and YELL-2051A). He stated that almost all the fill shown in connection with the first design had been eliminated. In order to achieve the landscape architects desire "to give the effect that the bridge is crossing the lake and is not the division between two small lakes . . . it has been necessary to go to a length of some 120 feet in the north elevation." This memorandum brought up the discussion of the use of sidewalks. The National Park Service was not in favor of adding sidewalks to the Isa Lake Bridge; the Bureau was. Some compromise was presented by the National Park Service by suggesting that a log curb of 12 inches in width on the northerly side of the bridge would be used for pedestrian traffic. Carpenter felt that the National Park Service may have to agree to the addition of 1 or 2 feet to the width to avoid raising the height of the railings as designed. Carpenter explained that the Bureau planned to place signs on either approach to the bridge "indicating that this would be zoned for slow speed."[51]

Howard Baker, Regional Landscape Architect, responded to the chief of planning in a July 2, 1940 memorandum regarding the sidewalk issue. In response to the Bureau's insistence that "some sort of walk" be on the Isa Lake Bridge, Baker and the park landscape architect surveyed other Yellowstone bridges with sidewalks. He wrote that many of them showed no wear or usage, which "leads me to believe that we can dispense with walks on bridges except in very congested and highly developed areas". He noted that the addition would complicate construction and increase the cost. He closed by writing ". . . I hardly see any necessity for even widening the bridge over the width that is now proposed."[52] Thomas Vint agreed with Baker that the sidewalks should be omitted and that the laying of a 14-inch log down on the deck (to serve as a sidewalk) is inadequate for its purpose and it is an additional place for rot to set in. He suggested an alternative of an 8-inch log supported an inch or so above the deck so that the top of the log is 1 inch above the deck level. Vint agreed that "the additional length of the bridge will help a good deal toward helping the visitor to realize that Isa Lake is one body of water, rather than two. I feel this is particularly important when we point out that the lake is located on the Continental Divide with two outlets--one going to the Pacific and the other to the Atlantic."[53]

The revised plans (YELL 2050A and 2051A) were sent to the Bureau of Public Roads office in San Francisco July 17, 1940 requesting the following:

> 1. The construction of the treated timber is based on the design of "having a bridge which will give the appearance of crossing the lake rather than being a division between two small lakes", thus the National Park Service requests that the bridge width is kept as narrow as possible. The designed top surfacing width was 20 feet on a graded width of 24 shoulder to shoulder. Carpenter points out that National Park Service studies indicated that fitting the bridge to the alignment required the additional width as drawn on the plans in carrying the curvature across the bridge.
>
> 2. The National Park Service agreed with the Bureau of Public Roads that the area should be zoned for low speeds. The National Park Service recommends a speed of 15 miles per hour through the area. He stated that the park administration customarily recommends slower speeds through areas of special interest where people may wish to stop. He wrote that, "Because of this area

being zoned for slow speed it should be possible to design for a minimum of super elevation on the bridge."

3. Again the National Park Service officials suggested that the sidewalks be eliminated for several reasons--it would increase the width; it would make it difficult to maintain the log railings; and it would encourage visitors to cross the bridge in a westerly direction, then cross the road on the inside of a curve--the park felt that the visitor could get an adequate view from the walk around the proposed parking area.

4. National Park Service recommends that the grading and sloping details be carefully carried out. "The cut slopes would be constructed flatter in either direction depending upon the height of the cut, and transition rounding would be introduced in the cut and fill slopes in order to obtain as nearly as possible, slopes with a natural angle of repose which will aid in restoring proposed environment for the lake shores."

5. The National Park Service recommended that topsoil or a type of soil that will readily support vegetation be used to cover any cut or fill slopes.

6. The National Park Service felt that the old road encroached on the lake so the park "would suggest that some removal of this fill should be considered".

Carpenter pointed out that this project was scheduled for the proposed 1941 fiscal year construction season. He asked the Bureau to proceed with the preparation of engineering drawings for the bridge "on the basis of our preliminary architectural plans."[54]

In August, Carpenter wrote Park Landscape Architect Sanford Hill that Dr. Hewes of the Public Roads Administration (formerly Bureau of Public Roads) agreed to the elimination of sidewalks, but proposed to leave the top of the railings 2 feet 4 inches above the bridge deck. Carpenter would have preferred it lower, but believed it would provide a satisfactory design. The plans called for bituminous surfacing for the bridge deck which would "get away from calling attention to the skew at the easterly end of the bridge." Lastly, the Public Roads people and the National Park Service agreed that the simplest location for detouring traffic while the bridge was under construction was a bypass on the south side of the bridge.[55]

By November 1940, the Public Roads Administration was ready to forward the plans to the National Park Service for approval. Their estimated cost for the bridge was $15,000 and the estimated cost for the grading and parking area was $17,000. These estimates did not include surfacing, which was figured into the entire road segment project, estimated at about $125,000.

District Engineer B. W. Matteson wrote that "It is our (Public Roads Administration) understanding that only two parking areas are proposed for improvement on this route--at Kepler Cascades and at Isa Lake." He also wrote that Park Landscape Architect Hill and Superintendent Rogers wanted paved gutter and rolled edges on fills. He requested sketches of these from the National Park Service immediately before the plans had preceded much further.[56]

In response to gutter and parking areas details, Hill sent a memorandum to Carpenter stating that the park engineers "recommended that the gutter design be worked out so that the ditch provides a gutter area for carrying off the drainage. It is suggested that perhaps a 6 to 1 slope could be used to develop a slightly deeper ditch and possibly increase the width of the paved gutter." He proposed the use of a rougher texture on the paved gutter section and that the paved gutter sections be carried through all the cuts because of the existing soil types. Hill recommended that a cobblestone type pavement as a marker be used for the round shoulder and also be used to define the Kepler Cascade and Isa Lake parking areas. Hill pointed out that every guardrail on this road segment had been erected. He stated that "a guardrail was merely suggestion for handling the entire width of fill sections."[57]

In October 1941, Senior Highway Engineer Capes filed a location survey report on the project stating that the survey and final plans for the West Thumb area and the Isa Lake Bridge area were completed during the winter of 1940-41, and that the final plans for the Old Faithful area had been delayed due to the complications of the relocation of concession buildings. The purpose of relocation of the segment was to move the main road farther away from Old Faithful Geyser and thus relieve traffic congestion immediately in front of the geyser. The 1941 report revealed that this segment was now the heaviest traveled section of the Grand Loop. Capes wrote that, "in order to comply with the requirements of the Landscape Architects, it is proposed to construct a timber bridge cross the Isa Lake. Its construction is justified primarily by the sentiment attached to the small lake on the summit of the Continental Divide and to desire to preserve the lake, out of which water flows easterly to the Atlantic watershed and westerly to the Pacific."[58] The report stated that the timber for the construction of the bridge would be secured from a West Coast region source and that "there is no particular inducement for pedestrian traffic across the bridge, no sidewalks should be built."[59]

Capes reported that the Standard Specifications for Forest and Park Highway and Bridge Construction would satisfy most of the projected construction, however, special provisions were necessary for some features--smaller maximum size cover aggregate for sidewalks, barrier stones, pavement guide markers, special log curbing, and the removal of power and telephone lines and the construction of underground systems to replace them.

Shortly after Cape's report was sent, the United States entered World War II. Construction activity in the parks virtually came to a halt during the war years. National Park Service Director Newton Drury advised H. K. Bishop, Chief, Division of Construction for the Public Roads Administration, that the Secretary of the Interior was instructed by the War Production Board to discontinue all projects "costing over $10,000, due to the fact that the aggregate demands of the war program for materials, labor, and transportation are so great as to be jeopardized by a continuance of federal non-war projects."[60] However, the Isa Lake Bridge was completed in July of 1942.

The eight-span timber and log bridge has a maximum span length of 24 feet. Five spans are 24 feet while three spans are 20 feet, measured from center of support to center of support. The bridge is 160 feet in length and has a deck width of 28 feet curb-to-curb. The two-lane bridge has no sidewalks and the deck surface is 5-inch asphalt; the railings are logs, 9 ½ inches in diameter and the bents and pilings are log. The pilings for the trestle piers form a line perpendicular to the bridge center line while the pilings for the trestle abutments form an angle of about 45 degrees with the bridge center line. The abutments are on a line that is nearly north-south. All pilings are capped with an 18-inch diameter cap log. On the outside of the bridge are 22-inch diameter logs spanning longitudinally between cap logs. An untreated deck rests on the cap logs. The guardrail consists of 12-inch diameter log posts rising over the logs that span between the cap logs. These posts are located at the cap logs and at midspan. They support a longitudinal 14-inch diameter log rail which has a top 1 foot 6 inches above the deck.

Originally the plans called for Port Orford cedar pilings treated with salts preservative, but due to the shortage of the cedar, Coast Region Douglas-Fir treated with Wolman Salts was used. The change in wood types resulted in increasing the amount of creosoted bulkhead planks required. The shortage of creosote preservatives also resulted in the use of Wolman Salts for the timber deck.[61]

After the bridge was completed, the remainder of the road project, placing the final surface, finishing the fill slopes, obliterating the borrow pits and the obliteration of the old road, was postponed. The park landscape architects reported that the bridge turned out "very satisfactorily", but "the approach to the bridge from the Old Faithful end is not well designed as the opposite approach. It appears that we have cut the bridge short and filled unnecessarily into Isa Lake."[62]

The bridge required extensive driving surface repair in 1988 due to cracking. A metal plate was placed over the damaged deck area and the deck repaved. Due to the wood materials, moist environment, and increased traffic over the structure, extensive repairs and reconstruction are likely in the near future. The bridge has been recorded to Historic American Engineering Record standards and is listed as Wy-31.

NON-CONTRIBUTING STRUCTURES

OLD FAITHFUL INTERCHANGE

The Old Faithful interchange is a 32-foot shoulder-to-shoulder paved roadway constructed in the mid-1960s. The interchange has a three-span cantilevered reinforced concrete T-Beam, 102-foot-long, two-lane bridge with steel railings and a deck width of 32 feet. A two-span continuous concrete T-Beam bridge, 80 feet in length with a 32-foot deck width curb-to-curb, built in 1969, is near the Biscuit Basin parking area just west of the Old Faithful interchange. The bridge, which is sited over a major hot spring in an active thermal area, has steel tubular rails. The roadway in this area is 62 feet in width from shoulder-to-shoulder. The pavement surface is concrete.

FIREHOLE RIVER BRIDGE NO. 2

Just south of the Old Faithful interchange is Firehole River Bridge No. 2, built in 1970. This bridge is a three-span continuous reinforced concrete T-Beam type. The two-lane bridge is 168 feet 8 3/4 inches in length and has a 28-foot deck from curb-to-curb. The bridge has 3-foot sidewalks on either side. The roadway width in this area is 34 feet from shoulder-to-shoulder with the road surface being bituminous plant mix.

WEST THUMB TO LAKE JUNCTION (Map Segment "E")

This 21.39-mile road traverses rolling to mountainous topography through transition zone vegetation dominated by lodgepole pine with open meadowland in isolated areas. Lacustrine wetland vegetation prevails along portions of this Yellowstone Lake shoreline.

There are no contributing structures other than the road and its historic features. The features contributing to the eligibility of the road were documented to HAER Short Form standards and include 11 masonry box culverts, three retaining walls, 23 masonry culvert headwalls, and one double culvert.

ROAD

The 1986 Parkwide Road Engineering Study divided this road into four segments for evaluation. The first segment begins at the West Thumb bypass and ends at milepost 70.10 (2.77 miles). The roadway width from shoulder-to-shoulder is 30 feet and is in good condition. The shoulder width is 4 feet and the shoulders were in good condition. The horizontal and vertical alignments were good and the roadside conditions were listed as fair to good.

The second segment begins at milepost 70.10 and ends at milepost 73.32. The paved roadway width from shoulder-to-shoulder is 30 feet. The surface condition is excellent having been reconstructed in 2000. The shoulder width is 4 feet and the shoulders are in good condition. The horizontal and vertical alignments are good and the roadside condition is excellent.

The third segment begins at milepost 73.32 and ends at 85.27. The roadway width from shoulder-to-shoulder is 30 feet and the paved surface is also 30 feet. The shoulders are 4 feet wide and in good condition. The horizontal and vertical alignments were good and the roadside condition is good. The roadsides have dense vegetation with sharp clearing lines in some areas. The only major structure on this segment is the modern Bridge Bay Bridge. It is a 234-foot-long, three-span continuous steel stringer with reinforced concrete deck. This modern period bridge is in good condition and a stone masonry veneer was applied to the abutments during road resurfacing in 2000.

The fourth segment begins at milepost 85.27 and ends at 88.72. The roadway width from shoulder-to-shoulder varies from 34 to 38 feet and is in good condition. The paved surface is 30 feet. The shoulder width is 4 feet and the shoulders are in good condition. The vertical and horizontal alignments are good. The roadside conditions were listed as good. The entire road section had an average daily traffic use in 1985 of 5,250 vehicles and the projected average daily use in 2005 is 6,750 vehicles.[63]

LAKE JUNCTION TO CANYON JUNCTION (Map Segment "F")

This 14.99-mile road traverses rolling topography through transition zone vegetation dominated by lodgepole pine with sedge grass meadow and riverine wetland vegetation along the Yellowstone River and tributaries in the Hayden Valley area. In addition to the road, there is one contributing bridge on the road. There are no major non-contributing structures. The historic road features contributing to the eligibility of the road located on the Lake Junction to Canyon Junction section of the Grand Loop Road include six segments of dry-laid stepped retaining wall; three pairs of box culverts; 134 typical culverts with masonry headwalls; one drop inlet culvert; five culverts with flumes; three stone flumes, one segment of stone curbing and one timber drainage structure.

ROAD

In the 1986 Parkwide Road Engineering Study, the Tower Junction to Lake Junction road was divided into several segments for evaluation and description. The first segment begins at Lake Junction at milepost 88.72 and ends at milepost 93.56, near the Mud Volcano. This section of road has a surface width of 23 feet. A bituminous plant mix was applied in 1983. The surface condition is fair. The base and subgrade condition is poor and the drainage condition is fair. There are no shoulders. The horizontal and vertical alignments are good. The roadside condition along this section is poor; narrow and sharp clearing lines obstruct the view from the road and detract from the road's exceptional scenic beauty. In 1985, the average daily traffic was 5,600 vehicles with an anticipated volume of 6,850 vehicles by 2005. There are no major structures on this segment.

The next segment begins at milepost 93.56 and ends in the northerly end of Hayden Valley at milepost 99.65. This section of road has a shoulder-to-shoulder width of 25 feet and is surfaced with a bituminous plant mix. The condition of the surface is poor with extensive broken-down pavement edges. The surface width varies from 22 to 25 feet. The base and subgrade condition is fair and the drainage condition is fair. The width of the shoulders varies from 0 to 2 feet and their condition is poor. The horizontal and vertical alignments are good. The general condition of the roadside is fair and the open roadside does provide the visitors with ideal visibility of the resources. In 1985, the average daily traffic was 5,600 vehicles with an anticipated volume of 6,850 vehicles by 2005. There are no major structures on this segment.

From milepost 99.65 to 103.71 near Canyon Junction, the roadway width from shoulder-to-shoulder ranges from 23 to 25 feet and the shoulder width varies from 0 to 2 feet. The road is covered with a bituminous plant mix and the surface is in fair to poor condition. The base and the subgrade are in fair to poor condition and the drainage is in fair condition. The horizontal and vertical alignments are in good condition. The roadside condition is fair. The Otter Creek Bridge is the only major structure on this section. In 1985, the average daily traffic was 5,600 vehicles with an anticipated volume of 6,850 vehicles by 2005.

CONTRIBUTING BRIDGES

OTTER CREEK BRIDGE

Otter Creek, which had been bridged from the very early days, was listed in Hiram Chittenden's recommendations for improvement of the Yellowstone road system in 1905. He called for the Otter Creek Bridge to be rebuilt with a bridge of shorter spans.[64] In the next comprehensive survey of the road system, Captain Wildurr Willing called for the Otter Creek Bridge to be replaced with a "pile trestle 32' long, consisting of pile bents and wooden stringers."[65] Finally, in 1914, a 26-foot double-span reinforced concrete culvert was built and two years later concrete handrails were added to the structure.[66]

During the 1930s reconstruction of the Lake Junction to Canyon Junction road project, a new Otter Creek Bridge was built. The drawings and plans for the bridge were completed during the winter of 1933 and 1934 and the bridge completed September 25, 1935.[67]

The Otter Creek Bridge is an arched concrete deck girder-type with concrete abutments. The one-span bridge has a maximum span length of 22.5 feet, which is measured from center of support to center of support. The structure length is 68 feet from end of wing wall to end of wing wall. The deck width is 33 feet while the bridge roadway from curb-to-curb is 30 feet wide.[68]

The arched deck is 1 feet 4 inches thick and has a 9-inch high X 18-inch wide concrete curb and is covered with asphalt. The deck slab has 5/8-inch diameter reinforcing bars placed transversely near the top and bottom and 1 1/8-inch diameter reinforcing bars placed longitudinally near the top and bottom. There are 5/8-inch diameter hoops at 1-foot centers facing longitudinally in the curb. The deck has a super-elevation of 1:12.[69]

The guardrail consists of 10-inch diameter log posts, 8 feet 2 inches on center rising 2 feet 1 inch above the curb. They are sunk into an 8-inch diameter pipe sunk about 18 inches into the curb. The rail is an 8-inch diameter log attached with ¾-inch galvanized bolts countersunk on the same side the rail is on, the roadway side. The post is cut back by 2 inches to receive the rail. The rail received two coats of brown stain.[70]

The design load is 15 tons. The abutments batter 1:12 on the outside and are vertical on the inside. They spring from spread footings on firm material. The wing walls are 22 feet 9 inches long. The abutments have ½-inch diameter bars at 2-foot centers running horizontally and ½-inch diameter bars at 1 foot 6-inch centers to 5/8-inch diameter bars at 8-inch centers towards the taller part of the abutment, running vertically. These bars are in two layers near the perimeter of the abutment. The upstream wing walls have horizontal reinforcing bars of ½ inch in diameter at 2-foot centers and the downstream wing walls have the same horizontal reinforcing bars. The upstream wing walls have vertical reinforcing bars ranging from ½ inch in diameter at 18-inch centers to ¾ inch in diameter at 6-inch centers farther away from the abutment. The downstream wing walls have vertical reinforcing bars ranging from ½ inch diameter at 18-inch centers to 5/8 inch in diameter at 6-inch centers farther away from the abutment. Again the bars are in two layers near the perimeter. The wing walls have 9 X 2-foot footings. Most of the footing is towards the inside.[71]

In the 1986 Parkwide Road Engineering Study, the Otter Creek Bridge was found to be in poor to fair condition, with moderate to severe spalling of the concrete.[72] The bridge has been recorded to Historic American Engineering Report standards and is listed as Wy-32.

CANYON JUNCTION TO TOWER JUNCTION (Map Segment "G")

This 18.23-mile road traverses mountainous topography through coniferous forest and low growing arid to semi-arid vegetation dominated by sagebrush and grasses in lower elevations and sparsely vegetated sagebrush covered grasslands in the higher sub-alpine areas. In addition to the road, there is one contributing structure, the Tower Creek Bridge. There are no non-contributing structures. The historic road features located along this segment of the Grand Loop Road include three masonry retaining walls, 10 masonry box culverts, 148 typical masonry culvert headwalls, three culverts with masonry wing walls, 24 culverts with masonry headwalls and stone flumes, 10 culverts with rubble-stone headwalls, six segments of log guardrail, log curbing, stone curbing, a stone flume, and a stone swale.

ROAD

This first sub-segment begins near Canyon Junction at milepost 103.71 and ends at milepost 108.54 at the summit of Dunraven Pass. The road width from shoulder-to-shoulder on this section varies from 22 to 24 feet. The shoulder width ranges from 0 to 2 feet. The surface of the roadway is a bituminous plant mix and it is in poor condition. The drainage is in good condition and the base and subgrade is in poor condition. The horizontal alignment is in fair condition and the vertical alignment is in good condition. The roadside condition is fair to poor, but encroaching vegetation obstructs the view in some locations. In 1985, the average daily traffic was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005. There are no major structures on this section.

The second sub-segment is at milestone 108.54 to 113.44 at the junction of the Chittenden Bridge Road (Route 238). The roadway width from shoulder-to-shoulder is 22 to 24 feet. The pavement or surface width is from 20 to 22 feet. The surface is a bituminous plant mix and the condition is poor. The subgrade or base condition is poor and the condition of the drainage is good. The shoulder width ranges from 0 to 2 feet and the condition of the shoulders is poor. The horizontal and vertical alignments are fair and the roadside condition is fair. In 1985, the average daily traffic was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005. There are no major structures on this section.

The third sub-segment is from milepost 113.44 to Tower Falls at milepost 119.56. The roadway width from shoulder-to-shoulder ranges from 22 to 26 feet and the pavement or surface width varies from 20 to 22 feet. The roadway is surfaced with a bituminous plant mix and the condition is poor. The condition of the subgrade or base is fair to poor and the drainage condition is fair. The shoulder width is from 0 to 2 feet and the condition of the shoulders is poor. The horizontal alignment is poor and the vertical alignment is fair. The condition of the roadside is good. The average daily traffic was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005. There are no major structures on this section.

The fourth sub-segment begins at Tower Falls at milepost 119.56 and ends at the junction of the Grand Loop Road and the Northeast Entrance Road (Route 12). The roadway width from shoulder-to-shoulder is 22 to 24 feet and the pavement or surface width is from 20 to 22 feet. The road is surfaced with a bituminous plant mix and the condition is poor. The subgrade and base condition is fair and the drainage condition is good. The shoulder width ranges from 0 to 1 foot and the condition of the shoulders is poor. The horizontal alignment is poor and the vertical alignment is good. The roadside condition is fair. The average daily traffic in 1985 was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005. The only major structure on this section is the Tower Creek Bridge and the adjacent stonework.

CONTRIBUTING BRIDGE

TOWER CREEK BRIDGE

The initial investigations for the construction of the Tower Creek Bridge were made by the Bureau of Public Roads in 1926. More surveys that settled the exact location of the bridge site were made in 1929 and 1930 by Bureau engineers A. O. Stinson and L. A. Hamilton. Because of the highly specialized work of this project, it was deemed necessary to not include any other work on the contract.

On July 28, 1932, McLaughlin Construction Company of Livingston, Montana received the contract based on the low bid of $19,528.00. Shortly thereafter, the contractor established a camp about 300 feet from the road, opposite station 920 between Tower Junction and the Overhanging Cliff. He also set up a screening plant at the sand and gravel pit on the old road, about a ½ mile from the Tower Creek Campground. As the crews were stockpiling concrete aggregates, stone cutters were quarrying stone for the arch ring and wall facing. The quarrying and facing of the stone required highly skilled men. In addition to these two operations, the excavation began for the footing of the concrete arch abutments and spandrel walls. These three operations required a crew of 20 to 24 men.

The only significant difficulty was keeping the flow of traffic over the old bridge while constructing the new one. A part of one of the abutments had to be removed from the old bridge before the footing for one spandrel wall on the downstream side could be poured. Nevertheless, the work was accomplished without delaying traffic. A change in the aggregate mix had to be made after discovering that the stockpiled aggregate was a different grade than what was being brought in.

By November, bad weather conditions forced the crew to abandon the project for the season, but not before the concrete, arch ring, and wall facings stones were in place. At that time, most of the parapet wall construction had been completed and the bridge had been backfilled.

On May 24, 1933, the crew resumed building the hand-laid embankment and the masonry wall on the west end of the bridge, installing the curb stones and backfilling the structure. The bridge was completed on June 20, 1933.[73]

The bridge is a 40-foot reinforced concrete arch span with a maximum length of 40 feet. The span length is measured from center of support to center of support. The structure's length is 110 feet from end of wing wall to end of wing wall. Earth material was used in the backfilling between the walls, over the barrel of the bridge, and on the construction of the approach fills. The roadway width from curb-to-curb is 30 feet, with 3-foot sidewalks on either side, extending the length of the spandrel walls. Parapet walls 2 feet 3 inches rise above the elevation of the sidewalks.

Tower Creek Bridge's arch springs from an elevation of 6424 feet and rises 16 feet 2 3/4 inches to the masonry. The arch has two radii. The radius below 9 feet 9 inches above the spring line is 13 feet 5 inches, while above the 9 feet 9 inches above the spring line it is 22 feet 6 inches. The masonry facing on the underside of the arch is 2 inches thick. The arch barrel has concrete 1 foot thick. In this concrete, deformed bars reinforce the arch barrel. Longitudinal arched bars of ¾ inch in diameter are placed near the top and bottom of the concrete arch barrel on 12-inch centers. One-half-inch diameter hoops face longitudinally in the arch barrel and are staggered at 2-foot centers. Transverse bars of ½ inch in diameter are placed near the top and bottom of the concrete arch barrel on 2-foot centers. The concrete in the arch barrel and spandrel walls is class "A". "A" refers to the amount of cement in the mix. "A" is the highest strength for a given aggregate because of the greater cement content.[74]

The spandrels of the arch are also reinforced. The longitudinal reinforcement consists of ½-inch diameter bars at 2-foot centers. The vertical reinforcement consists of 1-inch diameter bars at 6 ½-inch centers going down to ½-inch diameter bars at 1-foot centers near the middle of the arch. The inside of the spandrel walls and top of the concrete arch barrel are membrane waterproofed.[75]

The outside of the spandrel walls are faced with stones a maximum of 2 feet deep to a minimum 1 foot 6 inches deep. The facing stones are carried to solid rock at the abutments. The facing rock is secured with U-shape bars embedded in the mortar joints at one bar to each 5 square feet of wall surface. The ring stones outlining the arch barrel are held by two clamps.[76] Backfilling between walls and over the barrel of the bridge was made with earth material.

The abutments are keyed into solid rock except on the south side where a foundation of large boulders wedged with rock and gravel was used after digging 3 additional feet to find ledge rock. The wing walls extend about 25 feet beyond the abutment. They sit on rectangular footings which were poured at the same elevation as the abutment footings except on the upstream section of the north wing wall which was stepped six times on solid rock. The footings have transverse and longitudinal reinforcing as well as bars bent into the toe of the footing from the vertical part of the wing walls. The concrete in the abutments and footings is class "B".[77]

The stones for the arch rings and wall facings were obtained from a rhyolite quarry about 500 feet right of station 28 on the Tower Junction to Mammoth Hot Springs road. The masonry work on this bridge was under the direction of Camillie, who had constructed the White River Bridge in Mount Rainier National Park. The total cost of the bridge was $22,417.00.[78]

As originally constructed, the bridge is wide enough to accept the 30-foot roadway to be constructed in 2005. During the road reconstruction the bridge will receive in-kind repair to the existing masonry and the drylaid retaining wall adjacent to the structure. The bridge was recorded to Historic American Engineering Record standards and is listed as Wy-33.

TOWER JUNCTION TO MAMMOTH HOT SPRINGS (Map Segment "H")

The 18.20-mile road from Tower Junction to Mammoth Hot Springs traverses rolling to mountainous topography through open sagebrush and grass lands with scattered lodgepole pine and aspen groves. Moderate to dense stands of lodgepole and limber pines are located along the breaks of the Black Canyon of the Yellowstone. In addition to the road, there are two contributing bridges, the Lava Creek Bridge and the Gardner River Bridge. The historic features contributing to the road include six stone retaining walls, 145 typical metal culverts with stone headwalls, three culverts with stone wing walls, seven arched-ope stone culvert headwalls, and four culverts with rubble-stone headwalls.

ROAD

The Mammoth Hot Springs to Tower Junction section of the Grand Loop Road can be described in two segments: from Tower Junction to the entrance of Route 508, Blacktail Deer Plateau Drive, and from Blacktail Deer Plateau Drive westerly to the terminus of the Grand Loop and a junction with Route 11 (North Entrance Road) at Mammoth Hot Springs.

The 8.62-mile long Tower Junction to Blacktail Deer Plateau Drive segment ranges from 22 to 24 feet in width shoulder-to-shoulder with a pavement or bituminous plant mix surface width of 22 to 24 feet. The condition is fair. The base condition is fair and the drainage condition is good. The shoulder width is from 0 to 2 feet and the shoulder's condition is fair. The horizontal alignment is fair and the vertical alignment is good. The roadsides are open and revegetated with minor encroachment of vegetation in some areas. There are no major structures on this segment.

The 9.58-mile long Blacktail Deer Plateau Drive to Mammoth Hot Springs segment has a roadway width of 22 feet. The condition of the bituminous plant mix surface is poor. There are no shoulders. The roadside conditions are generally fair with minor encroaching in some areas. The base condition is fair and the drainage condition is fair. The horizontal alignment is fair and the vertical alignment is good. There are two major structures on this segment, the historic Lava Creek Bridge, and the historic Gardner River Bridge.

In 1985 the average daily traffic over the Tower Junction to Mammoth Hot Springs section of the Grand Loop Road was 2,600 vehicles with an anticipated average daily traffic of 3,200 by 2005.[79]

CONTRIBUTING BRIDGES

LAVA CREEK BRIDGE

Beginning in 1926, plans were being made for the construction of a bridge over Lava Creek. Horace Albright, Superintendent of Yellowstone National Park, sent a proposed plan of the bridge to Daniel Hull, Chief of the Landscape Engineering Division of the National Park Service, for his approval. In turn, Hull submitted two plans to Burt Burrel, head of engineering; he believed that both of the designs disguised the "usual appearance of an I-beam girder bridge." Hull wanted these designs to be considered "more or less standard designs for other spans, not to use I-beams now on hand in Yellowstone National Park."[80] Hull recommended a bridge design based upon a sketch for the Slate Gulch Bridge on the Merced River in Yosemite National Park. The other proposed plan must have required the use of more surplus steel because Hull related to Burrel that "You will notice that in both cases the outside appearance is obtained by shell construction only, and has no real relation to the strength of the structure itself but they are merely for appearance sake."[81]

The survey for a bridge site over Lava Creek in 1930 found two possible locations. One was on a route that "ran on the south side of Lava Creek down the Undine Grade" and it crossed Lava Creek "just below the present Lava Creek Bridge, through the camp ground and along the cliff about 50 feet in elevation below the present road."[82] The other bridge site was "just above the Falls," but the landscape architect pronounced it unsatisfactory as "the road would encroach too closely upon the Falls and that immediate vicinity."[83]

After a visit to Lava Creek in 1932, Park Landscape Architect Kenneth McCarter and the Bureau of Public Roads engineers agreed to a location which crosses "the marsh at the vicinity of the 'beaver dams, followed the present road and crossed Lava Creek at or just below the present bridge."[84]

By September 1932, the Bureau had the plans completed for the Lava Creek Bridge and the contractor, S. J. Groves and Sons, began construction in November 1932. The single-span reinforced slab concrete bridge has a maximum span length of 32 feet, measured from center of support to center of support. The structure length is 76 feet from end of wing wall to end of wing wall. The deck width is 30 feet and the bridge roadway from curb-to-curb is 24 feet wide.[85]

The slab is reinforced with nine longitudinal steel I-beams encased in concrete with their bottom flanges exposed. The outer two I-beams are 14 inch X 95 pound-CB[86] and 20 inch X 55 pound-CB sections while the inner I-beams are 14 inch X 87 pound-CB sections. These I-beams have transverse bracing near their ends in the form of 10 X 20-pound channels connected to the I-beams by 4 X 4 X 3/8-inch angles. Just to the inside of where these channels attach to the I-beams are bearing plates. These bearing plates consist of a sole plate riveted to the I-beam, a middle plate, and a plate sunk into the masonry. For the 14-inch beams, these plates are 10 X ¾ X 1 foot 2 inches, 4 X ¾ X 1 foot 2 inches, and 8 X ¾ X 1 foot 3 inches respectively. For the 20-inch beams, these plates are 10 X ¾ X 8 inches, 4 X ¾ X 8 inches and 8 X ¾ X 9 inches, respectively. There are ½-inch diameter longitudinal bars placed by the I-beams and midway between the I-beams near the top and bottom of the slab. Transverse reinforcement consists of ½-inch diameter bars 12 inches on center near the top and bottom of the slab. The bottom transverse bars are in segments between the I-beams reinforcement.[87]

The guardrail consists of 4 X 4 X 0.2-inch tubing posts 6 feet on center sunk into a 6 X 5-inch well, 1 foot 7 inches, or 1 foot 10 inches on the side without a sidewalk, deep. This tubing and well were filled with concrete after the posts were set and aligned. The tubing posts have cast iron caps. Three inches X 6-pound channels are attached to the posts with angles near the top and bottom to form rails. One-inch diameter bars, 8 ¾ inches on center, frame into the rails vertically.[88]

The abutments batter 2:12 on the outside and are vertical on the inside except at the base where they batter 6:12. The wing walls batter 1:12 on the outside and are vertical on the inside except at the base where they batter 6:12. The east abutment is 10 feet 5 ¼ inches from its base to the deck while the west abutment is 10 feet 6 ¾ inches from its base to the deck. The parapets of the wing walls rise 2 feet 4 inches above the deck. The abutments have a concrete seat to receive the deck. The abutments rest on spread footings on form material. The wing walls are 22 feet in length and are slightly flared.[89]

This bridge was completed in 1933. The estimate of material quantities for the construction was as follows:

Structural steel	27,000 pounds
Reinforcing steel	4,500 pounds
Class "D" concrete	70 cubic yards
Steel handrail	625 linear feet
Masonry	275 cubic yards
Excavation	450 cubic yards[90]

In the 1986 Parkwide Road Engineering Study, the bridge was listed in fair condition. The rails and parapets do not meet the current safety standards. The bridge was recorded to Historic American Engineering Record standards and is listed as Wy-34.

GARDNER RIVER BRIDGE

The 1930 locational survey for the Gardner River Bridge was completed by A. O. Stinson of the Bureau of Public Roads. Stinson ran several different lines and other Bureau engineers provided additional data. After several years of discussion with numerous bridge layouts and estimates, the "high" line was favored over a line crossing the river upstream at a much lower elevation. The choice of the "high" line also concurred with the recommendation of noted landscape architect, Gilmore Clark, of Westchester County Park Development in New York. Clark had proposed a "high bridge", which would be suitable and preferable from a landscape standpoint, as part of his "Mammoth Plan" of 1929.[91]

Several schemes for the architectural treatment of the four-span steel truss bridge with steel towers were done in the National Park Service Branch of Design and Plans, with the preliminary architectural plans signed by Chief Architect Thomas Vint and forwarded to the Public Roads Administration office in San Francisco.[92] While the final designs were being prepared in the western regional office of the Public Roads Administration (formerly the Bureau of Public Roads) in San Francisco under the direction of the Senior Highway Bridge Engineer, H. R. Angwin, test pits were dug at footing locations at the bridge site. These tests provided information for the proper footing elevations and bearing capacities of the foundation material before the substructures were designed. The test holes dug in 1937 were not backfilled, which ultimately saved 568 cubic yards of structural excavation at the time of construction. The final plans were finished in 1938.[93]

In addition to the construction of the Gardner River Bridge, the project also provided for the grading and bituminous surfacing of the approaches, the construction of masonry headwalls, concrete drop inlets, rustic log guardrail, culvert installation, removal of the 1905 Army bridge, and the obliteration of old road scars and trails.

The contract was awarded to Guy James of Tulsa, Oklahoma, in January 1939. James, who had done no work in the park or area, had successfully completed several large bridges in Oklahoma. James sublet the grading and surfacing of the approaches and the road obliteration to Peter Kiewit Sons of Omaha, Nebraska, who had done numerous projects in Yellowstone National Park.

Heavy snow during the winter of 1939 prevented James from starting construction. Nevertheless, equipment and some men began arriving at the end of March. The office and a few men set up at the previously established camp of Peter Kiewit Sons' Company, near the Mammoth Hot Springs campground. Most of the crew lived in Gardiner, hence a mess was not operated by the contractor. The engineering crews were housed in portable houses in Mammoth and a portable 16 X 16-foot building was situated in Mammoth for their office. A testing laboratory and field office was housed in a 10 X 12-foot building at the construction site.

Prior to the beginning of construction, several design features concerned the landscape architects: the color of the railing and the concrete finish. Thomas Vint recommended the same brush-hammer finish as the Firehole River Bridge. He wanted the finish on the two abutments to include both sides and top of the concrete handrails, all exterior wall surfaces, the surfaces of the truss pedestals for bents 4 and 11, and no surface finish for the pedestals in bents 5 to 10, inclusive, but the upper battered portions should be lined with plywood. He requested that no vertical joints other than at corners be allowed and that the horizontal joints be puttied and be spread not closer than 3 feet. All interested National Park Service officials agreed to the color of paint-mixture of Bright Aluminum Industrial Paint made by the Sherwin Williams Company and Light Olive Green Graphite paint made by the Farwell, Ogman, Kirk and Company of St. Paul, Minnesota. Mixture should be approximately five parts of aluminum paint to one part of green graphite paint. There should be two applications of paint over the shop coat.[94]

A local sawmill provided all of the lumber for the form work. Some of the form work was most difficult as the thin abutment walls had different batters on inside and outside. Nevertheless, good lines were obtained on the concrete work. Anchor wires were set into the footings to hold down the forms while pouring the concrete as some of the abutment pedestals had very flat batters. The engineer did not feel the carpenter had done a particularly good job in reading the plans, causing many corrections.

The concrete surfaces were covered with wet burlap during the curing process. All of the water used in the concrete mixing was pumped from the Gardner River by a 2-inch Myers piston-type pump powered by a one-cylinder gas engine set up under the number two span.

The lack of storage space at the bridge site induced the contractor to store the structural steel in the railroad yards at Gardiner. The last steel was placed on September 2 and the last rivet driven on September 27. The Public Roads engineer felt that the rivet job was good and the fabrication good, even though some field reaming had to be done and several of the smaller lateral and splice plates were inaccurately punched and had to have field adjustments.

The painting portion of the contract was felt to have been inefficiently managed. Using a crew ranging from one to four men, instead of a needed 12-man crew, the job was accomplished in three months. In the end, it took the crew several applications to achieve a uniform coverage.

In regards to safety during the construction, the final report noted:

> Despite the size and height of this structure, no extra safety precautions were taken during its erection. Only three or four of the men wore hard hats, and no safety belts were ever used. No fatal accidents occurred. There were several accidents of more or less minor in nature, and one rather serious one. A laborer fell from the scaffolding inside one of the abutments, breaking one ankle and injuring his spine.
>
> Since the contractors on the Gardner River Bridge and two other projects in the Park carried their accident insurance with the same company, a resident safety engineer was stationed in the Park by the insurance company. While the resident safety engineer made every effort to promote safety precautions during the erection of the bridge, few of his suggestions were adopted. Because of this, the contractor was forced to pay an additional premium to retain his policy with this company. Nevertheless, the safety record on the job is commendable, partly creditable to good luck.[95]

The concrete drop inlets, the culverts, and the masonry headwalls were "minor items involving no unusual difficulties or special construction features."[96] The Armstrong Sawmill located about 55 miles north of the project furnished the cut and peeled logs for the guardrail. The hand constructed rails butts had been first soaked in a creosote preservative for four hours, before being immersed for two hours in a cold oil solution. The two applications of the finish coat of Cabot's No. 247 were done on site.[97]

The old 1905 bridge, which became the property of the contractor, was advertised for sale, but to no avail. In the end, the contractor salvaged the steel stringers and wooden flooring, but the rest was sold as scrap. The road obliteration project was considered excellent and was "hardly noticeable even before any growth of vegetation started. Hauling and placing topsoil on the embankments adjacent to the bridge abutments was completed, covering all rocks in the large embankments, which greatly improved the appearance of the area near the bridge."[98]

The most materials used in the construction project were obtained outside of the park. Most of the concrete aggregates and surfacing material came from a supply located 10 miles north of the project and the balance from a source 16 miles away. Location of the correct sand, sand that met certain requirements for soundness, proved to be a difficult task. The sand was finally obtained from five different pits north of the park. The Joe Papish pit did provide some satisfactory sand for concrete without any special treatment. Shortly thereafter, the pit produced sand which had to be washed and this procedure proved to be unsatisfactory. The Cutler pit, which had provided the sand for the Mammoth Development Area project in 1937, proved to be a good quality, however the owner, hearing of the failure of the Papish pit, decided to triple the price for the "good quality" sand, forcing the contractor to look for another source. The next pit, the Wentz pit, initially tested satisfactory, but the engineers found that it failed to pass the sodium-sulphate soundness test. Another pit on the Papish property was tested, but no sand was used. The fifth pit tested out of the park was the McCoy pit which supplied the necessary material to finish the project.[99]

The cement came from a Bureau of Standards pit at Trident, Montana, and the reinforcing and structural steel were fabricated in Oklahoma City, Oklahoma, by J. B. Klein Iron and Foundry Company. The red lead paint was obtained from Sherwin Williams Company and the green paint was furnished by Joseph Dixon Crucible Company.[100]

The bridge project was completed on November 14, 1939 for a total cost of $247,339.36. The park landscape architect found the project to be satisfactory and recommended approval. He asked that the contractor remove all camp buildings by June 1, 1940. The project engineers recommended that:

> . . . future projects involving reasonable large amounts of exposed structural concrete, the use of local timber for form work be prohibited unless it has been air-seasoned for at least six months before use. An even better requirement would be the use of plywood form lining for all exposed surfacing.[101]

The completed Gardner River Bridge has four main spans and six approach spans. The maximum span length is 184 feet. This span length is measured from center of support to center of support. The structure length is 962 feet from end of wing wall to end of wing wall. The deck width is 28 feet while the bridge roadway from curb-to-curb is 25.1 feet wide.[102]

The main bridge is 805 feet long and consists of four riveted steel deck truss spans. Each truss spans 184 feet between support points and cantilevers 11.5 feet at each end over the intermediate supports. The dual trusses are 18 feet on center and have a curved bottom chord resulting in a variable depth of 27 feet at supports to 20 feet at midspan.[103]

A typical 184-foot truss has the following steel members longitudinally. The top chord intersection points are U0, U1, U2, U3, U4, U3', U2' U', and U0'. The bottom chord intersection points are L0, L1, L2, L3, L4, L3', L2', L1', and L0'. Two other points are UA and UA', the intersection points at the end of the cantilevers on the top chord. The steel members spanning between these intersection points are tabulated below.

L4-L3	2 channels 15 inch at 50 pounds per foot
	2 web plates 14 inch X 5/8 inch
L3-L2	2 channels 15 inch at 50 pounds per foot
	2 web plates 14 inch X 5/8 inch
L2-L1	2 channels 15 inch at 33.9 pounds per foot
L1-L0	2 channels 15 inch at 33.9 pounds per foot
U4-U3	2 channels 25 inch at 45 pounds per foot
	2 web plates 14 inch X 5/8 inch
U3-U2	2 channels 15 inch at 45 pounds per foot
	1 cover plate 20 inch X 1/2 inch
U2-U1	2 channels 15 inch at 45 pounds per foot
	1 cover plate 20 inch X 1/2 inch
U1-U0	2 channels 15 inch at 33.9 pounds per foot
U4-L4	10 inch WF at 49 pounds per foot
U3-L3	10 inch WF at 35 pounds per foot
U2-L2	10 inch WF at 49 pounds per foot
U1-L1	10 inch WF at 35 pounds per foot
U0-L0	2 channels at 15 inch at 33.9 pounds per foot
UA-L0	10 inch WF at 49 pounds per foot
U3-L4	10 inch WF at 33 pounds per foot
U3-L2	10 inch WF at 49 pounds per foot
	2 plates 12 inch X 7/16 inch
U1-L2	10 inch WF at 49 pounds per foot
	2 plates 12 inch X 1/2 inch
U1-L0	2 channels 15 inch at 33.9 pounds per foot
	2 web plates 14 inch X 1/2 inch

The steel members are connected by web plates or gussets riveted on. A sway frame at each vertical member between trusses provides for lateral bracing. The span between the bottom chords consists of 2 angles, 3 ½ X 5 X 5/16 inches. Floor beam spans above the top chords are 24-inch WF sections at 74 pounds per foot. Smaller member criss-cross diagonally in the sway frame. The sway frame at U0L0 and its counterpart has larger diagonal members. The floor beams have two exterior stringers of 21-inch WF sections at 59 pounds per foot and two interior stringers of 16-inch WF sections at 40 pounds per foot spanning between them. These stringers are held on by connecting angles and are 7 feet 6 inches on center.[104]

The bridge roadway is reinforced concrete supported on longitudinal steel stringers spaced at 7.5 feet and spanning 23 or 11.5 feet between transverse steel floor beams supported at truss panel points. The roadway is delineated by a 9-inch concrete curb with a steel traffic railing on each side.[105]

The deck has transverse reinforcing bars of 5/8 inch in diameter on the top and bottom of the slab at 11 inches on center. The bottom bars are bent up over the stringers. The longitudinal bars of ½ inch in diameter are also on top and bottom of the slab. They are not continuous over the length of the bridge but span only between floor beams. The concrete slab is 8 ½ inches thick. Reinforcing bars are also bent up into the curb.[106]

The guardrail consists of steel posts 11 feet X 7 inches on center with 6 X 6 X 3/8-inch top plates. Five-inch channels at 11.5 pounds per foot cupping downwards frame into the posts near the top and bottom. Two X 2 X ¼-inch angles frame into these channel rails at approximately 11 inches on center. The guardrail rises 3 feet 6 inches from the curb.[107]

The east approach span measures 82 feet and west approach span measures 75 feet. They are constructed of reinforced concrete cast monolithically to form a "u" shaped abutment including roadway deck, curb parapet, retaining wall and main span bearings. Interior rigid frame reinforced concrete bents, four in each abutment, span 28 feet from side to side and support the concrete deck that spans a maximum of 26.5 feet between bents. All supporting foundations are spread footings on natural soil.[108]

Abutment No. 1, the east abutment, has four interior rigid frame reinforced concrete bents. The other rigid frames are similar except larger if nearer the bridge's main span. The footings of the second rigid frame are spread with trapezoidal concrete above them in vertical section. The right footing, as one looks west, is approximately 10 feet deeper than the left footing. The footings themselves, including the trapezoidal concrete, are approximately 10 feet tall and are made of class "B" concrete. The class of concrete refers to the amount of cement in the mix. Class "A" has the most cement by proportion and is the strongest. A 2 X 2.5-foot concrete beam spans above and between the footings and makes up the bottom chord of the rigid frame. The rigid frame's walls are 2 X 4 feet at their base and batter ½:12 on the inside and ¼:12 on the outside. These walls rise 27 feet 2 inches high and are made of class "A" concrete. The walls were poured in 8-foot tall sections with construction joints between. The top chord of the rigid frame is approximately 5 X 2 feet and is made of class "D" concrete. Reinforced concrete walls and a concrete deck span between the rigid frames. The walls are 1 foot 4 inches thick.[109]

Intermediate supports for the trusses are three riveted steel towers. The tower heights are about 145, 150, and 97 feet. Each tower is 23 X 18 feet at the top and tapers to a wider dimension at bottom. These dimensions are 40 X 57 feet, 41 X 62 feet and 29 X 49 feet. The four legs of each tower are supported on reinforced concrete pedestals with spread footing foundations.[110]

Tower numbers one through three are labeled from east to west. The members of the towers form trapezoidal prisms braced diagonally on all faces. All columns of the towers are made of two channels, 15 inch at 33.9 pounds per foot, and one 12-inch WF section at 65 pounds per foot. All struts of the towers are made of two channels, 8 inch at 13.75 pounds per foot. Finally, all nearly vertical diagonals are made of two angles, 7 X 4 X 3/8 inches. Cross bracing varies between towers and vertically on a given tower. For tower number one, one of the top three prisms are cross-braced with one angle, 3 X 4 X 3/16 inches. The next two prisms are cross-braced with one angle, 4 X 7 X 3/8 inches. The last two prisms are cross-braced with two angles, 5 X 3 1/2 X 3/16 inches. For tower number two, the top two prisms are cross-braced with one angle, 3 X 4 X 5/16 inches. The next two prisms are cross-braced with one angle, 4 X 6 X 3/8 inches. The next two prisms are cross-braced with two angles, 4 X 3 1/2 X 5/16 inches. The last prism is cross-braced with two angles, 6 X 4 X 3/8 inches. Finally, for tower number three, the top two prisms are cross-braced with one angle, 3 X 4 X 5/16 inches. The next two prisms are cross-braced with one angle, 4 X 6 X 3/8 inches. The last two prisms are cross-braced with two angles, 4 X 3 ½ X 5/16 inches. All members of the towers are held together by riveted gusset plates.[111]

Temperature movement for the structure's main span was provided by sliding steel plates in the bridge deck at the center of supports and bottom chord rocker bearing assemblies at the west end of each truss. The bottom chord-bearing shoe at the east end of each truss is fixed against horizontal movement. The tower bearings on the pedestals are entirely fixed shoes.[112]

Foundation data indicates that the material varies from medium clay shale, sandy shale, and caprock at the east abutment to blue shale at the west abutment with hard blue shale at the tower foundations. Design soil pressures used varied from 2 to 5 tons per square foot. The design load was 15 tons.[113]

The maximum height of the bridge is 201 feet above the normal water line of the Gardner River. The alignment of the structure is tangent and on a uniform downgrade from east to west of 2.106 percent.

A parking area was constructed on the west side of the bridge, south of the Grand Loop Road.[114] The bridge was recorded to Historic American Engineering Record standards and is listed as Wy-7.

NORRIS JUNCTION TO CANYON JUNCTION

This 11.57-mile road traverses rolling topography through transition zone vegetation dominated by lodgepole pine with open meadowlands near the easterly and westerly termini. The road is the only contributing structure. There is one non-contributing structure on this road, the Gibbon River Bridge.

ROAD

In the 1986 Parkwide Road Engineering Study, this road section was found to carry 4,700 vehicles daily with a projected daily traffic volume of 5,800 vehicles by 2005. The shoulder, the drainage, and the surface were listed in good condition. The roadway width from shoulder-to-shoulder ranged from 31 to 32 feet. The roadside condition was generally fair. The study reported "Clearing lines form sharp rather than natural road edges. Roadway cut slopes are slightly over-steepened, causing continuing erosion and retarding re-establishment of vegetation." The only major structure on this road section is a modern 22-foot, two-barrel box culvert bridge.[115]

NON-CONTRIBUTING BRIDGE

GIBBON RIVER BRIDGE

The Gibbon River Bridge, built in 1966, is a 22-foot-long, two-barrel box culvert. The deck width is 30 feet. It has no rails. The bridge is in good condition, but there is minor concrete deterioration in the deck.

ENDNOTES

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[3] "Plans for Seven Mile Bridge over Gardner River, 1931," Bureau of Public Roads, U. S. Department of Agriculture.

[4] Ibid.

[5] E. O. Anderson, "Final Construction Report (1936-38) on Grand Loop National Park Highway. 1-B1 Bridges, March 1, 1939," Bureau of Public Roads, U. S. Department of Agriculture, File Box: Roads, North Half of Loop, Yellowstone National Park Archives, Yellowstone National Park.

[6] "Gibbon River Bridge, Station 465+70, Plans, 1-3/4, January 1936," Bureau of Public Roads, U. S. Department of Agriculture.

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[10] E. O. Anderson, "Final Construction Report (1936-38) . . . .".

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[12] U. S. Geological Survey, *Water Resources Data Montana Water Year 1986, Volume I,* Hudson Bay Basin, Missouri River Basin (n. p.: U. S. Geological Survey, 1986).

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[14] E. O. Anderson, "Final Construction Report (1936-38) . . . ."

[15] "Gibbon River Bridge, Station 400+70, Plans . . . ."

[16] Ibid.

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[19] Hiram Chittenden, *Improvement of the Yellowstone National Park, Including the Construction, Repair and Maintenance of Roads and Bridges. (Annual Report of the Chief of Engineers for 1899,* Appendix EEE) (Washington D.C.: Government Printing Office, 1899), 10.

[20] Hiram Chittenden, *Annual Report Upon the Construction, Repairs, and Maintenance of Roads and Bridges in the Yellowstone National Park and Construction of Military Road from Fort Washakie to Mouth of Buffalo Fork of Snake River, Wyoming and Erection of Monument to Sergeant Charles Floyd in the Charge of Hiram Chittenden, Captain, Corps of Engineers, Being Appendix FFF, III, and JJJ of the Annual Report of the Chief of Engineers for 1901,* (Washington D.C.: GPO, 1901), 3778-3779.

[21] Ibid.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Maurice Eldridge, "Touring Yellowstone Park on Government Highways," *World Today,* November 1910.

[26] E. O. Anderson, "Final Construction Report (1932-1933) Project E 1-A4 Grading Mammoth Hot Springs-Norris Junction, Grand Loop National Park Highway, Yellowstone National Wyoming," Office of Maintenance Division, Yellowstone National Park.

[27] Ibid.

[28] Ibid.

[29] E. O. Anderson, "Final Construction Report (1933-1934) on Project NR 1-A1, A3, A4, A5 Surfacing, Grand Loop Highway, Yellowstone National Park, Wyoming, January 11, 1935."

[30] C. F. Capes, Bureau of Public Roads, letter to Roger Toll, Superintendent of Yellowstone National Park, 17 July 1934.

[31] E. O. Anderson, "Final Construction Report (1948-1949) on Grand Loop National Park Highway - Wyoming, Project 1-A, B, C-1 Reseal, Yellowstone National Park, State of Wyoming, February 8, 1950," Office of Maintenance Division, Yellowstone National Park.

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[33] Ibid.

[34] Ibid.

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[36] Ibid.

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[39] Ibid.

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[46] J. W. Emmert, Acting Superintendent, Yellowstone National Park, letter to J.A. Elliot, Bureau of Public Roads District Engineer, 14 February 1936.

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[48] Edmund Rogers, Superintendent, letter to Ernest Davidson, 10 September 1936.

[49] Max Bauer, Park Naturalist, memorandum to Superintendent Edmund Rogers, 23 August 1938.

[50] Thomas Carpenter, Deputy Chief of Planning, National Park Service, memorandum to Thomas Vint, Chief of Planning, National Park Service, 7 September 1939.

[51] Thomas Carpenter, Deputy Chief of Planning, National Park Service, memorandum to Thomas Vint, Chief of Planning, National Park Service, 24 June 1940.

[52] Howard Baker, Regional Landscape Architect, memorandum to Thomas Vint, Chief of Planning, National Park Service, 2 July 1940.

[53] Thomas Vint, Chief of Planning, National Park Service, memorandum to Thomas Carpenter, Deputy Chief of Planning, National Park Service, 8 July 1940.

[54] Thomas Carpenter, Deputy Chief of Planning, National Park Service, letter to Dr. L. I. Hewes, Chief of Western Region Public Roads Administration, 17 July 1940.

[55] Thomas Carpenter, Deputy Chief of Planning, National Park Service, memorandum to Sanford Hill, Park Landscape Architect, Yellowstone National Park, August 1940.

[56] B. W. Matteson, Public Roads Administration District Engineer, letter to Superintendent Edmund Rogers, Yellowstone National Park, 13 November 1940.

[57] Sanford Hill, Resident Landscape Architect, Yellowstone National Park, memorandum to Deputy Chief of Planning, National Park Service, 28 November 1940.

[58] C. F. Capes, "Location Survey Report (1939-40) on General Loop 1-D Bridge Design; 1-D1, D2 Improvements, Yellowstone National Park, Wyoming," Office of Maintenance Division, Yellowstone National Park, 3-5.

[59] Capes, "Location Survey Report (1939-40) . . ." 5.

[60] Newton Drury, Director, National Park Service, letter to H. K. Bishop, Chief, Division of Construction, Public Roads Administration, 31 October 1942.

[61] E. H. Cowan, "Final Construction Report (1941-1944) on Grand Loop National Park Highway, Project 1-D1, D3 Bridge and Bituminous Surfacing (Partially completed; contract cancelled due to war emergency) Yellowstone National Park, State of Wyoming, November 25, 1944," Office of Maintenance Division, Yellowstone National Park.

[62] "Monthly Narrative Report for September 1942, Yellowstone National Park."

[63] U. S. Department of Transportation, Federal Highway Administration, Western Direct Federal Division, *Parkwide Road Engineering Study . . . .*

[64] Hiram Chittenden and John Mills, *Annual Report Upon the Construction, Repair, and Maintenance of Roads and Bridges in the Yellowstone National Park and the Road Into Mount Rainier National Park* (Washington D.C.: GPO, 1905) 2818.

[65] Wildurr Willing, "Report of Inspection of Bridges in the Yellowstone National Park, made September 24, 25, and 26, 1909, with recommendations by request of Capt. Wildurr Willing, Corps of Engineers, U. S. A."

[66] *Annual Report of the Superintendent of National Parks to the Secretary of the Interior for the Fiscal Year Ended June 30, 1916* (Washington D. C.: Government Printing Office, 1916) 32. The records indicate that no other bridges were constructed until the 1930s project.

[67] "Otter Creek Bridge Plans, January 1934," Bureau of Public Roads, U. S. Department of Agriculture. Frank Mattson and Robert Hall, "Report to the Chief Architect for the Period August 26 to September 26, 1935."

[68] "Bridge Inspection Report, Otter Creek Bridge, August 6, 1986," U. S. Department of Transportation, Federal Highway Administration, Western District Federal Division.

[69] "Otter Creek Bridge Plans, January 1934."

[70] Ibid.

[71] Ibid.

[72] U. S. Department of Transportation, Federal Highway Administration, Western Direct Federal Division, *Parkwide Road Engineering Study* . . . .

[73] H. E. Dalton, "Final Construction Report 1932-1933 on Project 1-G2, Bridge Accounts No. 1475, Yellowstone National Park, Wyoming, April 9, 1934," Office of Maintenance Division, Yellowstone National Park.

[74] "Tower Creek Bridge Plans, October, 1931," Bureau of Public Roads, U. S. Department of Agriculture.

[75] Ibid.

[76] Ibid.

[77] Ibid.

[78] Ibid. "Monthly Narrative Report, Yellowstone National Park, Bureau of Public Roads, District No. 3, August 31, 1932."

[79] U. S. Department of Transportation, Federal Highway Administration, Western Direct Federal Division, *Parkwide Road Engineering Study* . . . .

[80] Daniel Hull, letter to Burt Burrel, 15 February 1926.

[81] Ibid. In a July 24, 1990, telephone call to Yosemite National Park, Mary Shivers Culpin found that the Slate Gulch Bridge over the Merced River is not extant. In fact, Slate Gulch is outside of the boundary of Yosemite National Park.

[82] "Monthly Narrative Report, October 31, 1930, Yellowstone National Park, District No. 3."

[83] Ibid.

84 Kenneth C. McCarter and Frank E. Mattson, Jr., "Report of Kenneth C. McCarter, Asst. Landscape Architect, and Frank E. Mattson, Jr., Landscape Architect, July 18-23, 1932." File Box: L-56, Yellowstone National Park Archives, Yellowstone National Park.

85 "Bridge Safety Inspection Report, Lava Creek Bridge over Lava Creek. U. S. Department of Transportation, Federal Highway Administration, Western Direct Federal Division, July 7, 1985."

86 The standard bridge design manual for 1893-1952 provides designations for steel beams that identify the company that rolled the steel beams (rolling mills). "CB" designates Carnegie Brothers Company, limited, which was established in 1881.

87 "Lava Creek Bridge Plans, U. S. Department of Agriculture, September, 1932."

88 Ibid.

89 Ibid.

90 Ibid.

91 C. F. Capes, "Final Survey Report (1937) 1-H3 Bridge Investigation and Design, Grand Loop Highway, Yellowstone National Park, Wyoming," File Box: Roads. Grand Loop. 1931-42. 1971, Yellowstone National Park Archives, Yellowstone National Park.

92 "Monthly Narrative Report to the Chief Architect of the National Park Service through the Superintendent of Yellowstone National Park, October 27, 1936," Yellowstone Box 10: National Archives and Records Center, Denver, Colorado.

93 J. Wayne Courter, "Final Construction Report (1939) on Grand Loop Highway, Project 1-H3, Grading, Bridge, and Bituminous Surfacing (Gardiner [sic] River Bridge) Yellowstone National Park, State of Wyoming, May 14, 1940," Office of Maintenance Division, Yellowstone National Park.
Capes, "Final Survey Report (1937) . . . ."

> Actual field work on determining foundation conditions was started May 24 and completed July 1, 1937. A total of 23 test pits were dug, in nearly all cases to a formation that was considered satisfactory footing, then a jackhammer and drill steel were used to determine that there were no soft spots within a reasonable depth below that elevation.

Due to the rugged nature of the terrain, it was impossible to use the truck extensively except on six of the holes near the river. Hence, it was necessary to resort to hand hoisting on the deeper holes on the sidehill. A maximum of 17 laborers were employed during this work.

Due to the hard and complex nature of the soil encountered, it is felt that excellent progress was made by the crew. As the work progressed it became apparent that a test hole at each footing for the towers would be required due to the variable nature of the hard shale strata. At the abutments where the pressures are undoubtedly lower, the formation, while somewhat variable, did not indicate that it would be necessary to dig pits at all footings, hence only typical pits were dug. A previous shale movement or slip was encountered in Test Holes T1-A2 and T1-B2, and exploration carried deep enough to assure getting foundations below the material causing this slip.

This series of explorations should complete the necessary foundation investigations for the layout as submitted for the 4-span layout, and hence no further expenditure need be anticipated except for removing the timber covers placed over the holes to facilitate future inspection and filling pits if it should be necessary. . . .

There were 155.5 feet of jackhammer drill holes, and 370.6 feet of dug pits, or 620 cubic yards of material excavated. The unit cost would then be $1.72 per foot for jackhammer drill holes and $7.48 per foot for dug pits, or $4.48 per cubic yard of material excavated.

Recommended foundation pressure and elevation for bottom of footings are shown on each of the accompanying detail shoots for the respective pits and are based on the actual soil conditions encountered. The location of investigation pits was based on the 4-span bridge layout suggested and tentatively selected for construction by the Landscape Division of the Park Service.

In contemplation of early construction, the test pits were temporarily covered with plank in order to facilitate inspection by prospective bidders and also effect economy in actual structure excavation in building the bridge. Inasmuch as construction apparently is indefinitely deferred, it probably will be advisable to backfill the pits to avoid disintegration by exposure to the elements of the materials proposed for foundations.

[94] Thomas Carpenter, letter to L. I. Hewes, 1 August 1938. L. Hewes, letter to Mattson, no date shown. Thomas Carpenter, letter to L. I. Hewes, 28 July 1938.

[95] Courter, "Final Construction Report (1939) . . . ."

[96] Ibid.

[97] Ibid.

[98] Ibid.

[99] Ibid.

[100] Ibid.

[101] Ibid.

[102] "Bridge Inspection Report, Gardner River Bridge, July 28, 1987," U. S. Department of Transportation, Federal Highway Administration, Western Direct Federal Division.

[103] "Gardner River Bridge Inspection Report, October 1976," Sverdrup & Parcel and Associates, Inc.

[104] "Gardner River Bridge Plans, August 1938," Bureau of Public Roads, U. S. Department of Agriculture.

[105] "Gardner River Bridge Inspection Report . . . ."

[106] "Gardner River Bridge Plans, August 1938 . . . ."

[107] Ibid.

[108] "Gardner River Bridge Inspection Report . . . ."

[109] "Gardner River Bridge Plans, August 1938 . . . ."

[110] "Gardner River Bridge Inspection Report . . . ."

[111] "Gardner River Bridge Plans, August 1938 . . . ."

[112] "Gardner River Bridge Inspection Report . . . ."

[113] Ibid.

[114] Courter.

[115] U. S. Department of Transportation, Federal Highway Administration, Western Direct Federal Division, *Parkwide Road Engineering Study . . . .*

The Grand Loop Road is significant on the national level, under Criterion A, as the first large-scale designed national road system built at a time when road building was a new concept. The logistics and techniques devised by the U.S. Army Corps of Engineers to construct the road in remote, difficult mountainous terrain were both bold and unique. Under Criterion A, at the state level, the Grand Loop Road is important in the development of the entrance roads and the park's gateway communities. Engineering Officer, Hiram Chittenden, in charge of constructing the road, is significant on a national level, under Criterion B for his visionary role in the development of the road system in Yellowstone National Park, for his role in the development of the design philosophy of National Park Service roads, as well as his important contributions to the history of the American West. Under Criterion C, the Grand Loop Road represents the continuing design philosophy that blends the road with the natural setting and lies lightly on the land. The use of natural materials to construct the historic bridges harmonizes the manmade features with the surrounding environment. The Grand Loop Road Historic District is associated with the Historic Context – *Construction of the Road System in Yellowstone National Park, 1872 – 1966*, and the *Addendum to: Yellowstone Roads and Bridges, HAER No. WY-24* under the Multiple Property Listing "Historic Resources of Yellowstone National Park: Construction of the Road System in Yellowstone National Park." The historic district has examples of two of the identified property types – roads and bridges, both of which retain sufficient integrity of feeling, design, location, and setting to impart to the visitor the qualities of a "park road."

CRITERION A

NATIONAL LEVEL

At the national level of significance, the planned road system in Yellowstone National Park is the first, large-scale designed planned system giving people access into the "scenic splendors" in the country. While the plans and designs for Central Park precede Yellowstone National Park by approximately 16 years, the scope of the project and the size differ significantly. The first superintendent, Nathanial P. Langford, envisioned this scheme long before anything of this magnitude had been executed anywhere else in the country. One of the significant considerations is the early configuration providing accessibility to the major geologic and scenic wonders is almost a mirror image of the extant system.

In addition to the significance of the concept, this undertaking was important because it was constructed in an isolated region at a time when road building across the country was in its infancy. Even after the railhead reached the park boundary, the difficulty of transport and the logistics of building a road system covering this very large, geologically challenging region with challenging climatic conditions makes the construction effort momentous.

The system also represents the important role of the Army Corps of Engineers in the development of the park. Before the turn of the twentieth century, there was no national road system. Road districts within states and a few states built the public roads. The federal government had been responsible for the roads in Washington D.C., the roads to government posts (which in most cases were no more than trails), roads on military reservations, and for building the road system in Yellowstone National Park. Since the park covers more than 3,400 square miles, it is reasonable to suggest that the park road system was one of their most ambitious road projects. Captain Dan

Kingman of the Army Corps of Engineers established the first road standards for a park in 1883; he also is credited with setting the philosophy for roads in a wilderness setting.

The techniques devised for building a road through a sensitive area such as a park were in many cases the result of collaboration between the Bureau of Public Roads engineers and the landscape architects of the National Park Service. Their techniques and philosophy were adopted not only in other parks, but in some state highway departments.[1]

Although segregated as a separate property type for documentation purposes, the bridges in the park are a part of the road system, thus the significance applies to the bridges.

STATE LEVEL

The configuration of the road system in Yellowstone National Park was important toward the development of the surrounding towns and approach roads to the park.

CRITERION B

NATIONAL LEVEL

U.S. Army Corps Engineering Officer Hiram Martin Chittenden is considered significant under Criterion B at a national level for his vital and innovative role in the development of the road system in Yellowstone National Park, for his role in the very early recognition of Yellowstone's place in history in the United States, for his other important historical contributions to the literature of the American West, and for his role toward the development of the design philosophy which the National Park Service later adopted for its roads and building programs.

Hiram Chittenden, who graduated third in his West Point Class of 1884, arrived in the park for a short period, 1891-1893, to supervise the Army Corps' construction of the road system. His most important accomplishment for that period was the completion of the Old Faithful to West Thumb route and on to the Grand Canyon via the Lake Hotel area.[2] Poor funding, scheduling, and lack of funds hampered any real achievements for his first stay in the park, but he was immediately recognized as "zealous, untiring, and remarkably efficient." When he was transferred in the spring of 1893, Acting Superintendent Anderson expressed his unhappiness with Chittenden's transfer, "The unfortunate relief of Lieutenant Chittenden last spring has been a most serious blow to road building here. He was greatly interested in his work, tireless in his attention to it, and ably equipped for it."[3]

For the short period that Chittenden spent in the park, he developed a sense of the importance of Yellowstone in American history. He researched the area history and while stationed in Louisville, Kentucky, and Columbus, Ohio, he wrote *The History of Yellowstone Park*, published in 1895.

Chittenden was called back to the park in 1899, at the urgency of Senator Thomas Carter of Montana and Mr. Huntley, one of the park's concessionaires. General Wilson of the Army Corps of Engineers asked him to return to the park "to take full charge of the Park, including the Superintendency" to which he replied, "No Superintendency", but "I would like to be placed in charge of the road work." It was during his second period in the park, 1899-1906, that Chittenden heavily influenced the road program, the park appearance, and philosophy.[4]

Immediately upon returning, Chittenden took on the construction of the very important Mammoth Hot Springs to Golden Gate section. Chittenden selected a location and invited the Cavalry officers in charge of park administration to take a look. "They had to go on foot because the ground was so rough and as we clambered through the mass of rocks which is now known as Silver Gate they unanimously declared that it was a fine location for scenery but impossible to build." Chittenden inquired if that was all they had to say and then proceeded to build it to his specifications. The following year, Chittenden built the Golden Gate Viaduct that replaced the rickety wooden trestle built in the 1880s. Chittenden felt that the construction of the viaduct was the "most difficult piece of work I executed while I was in the Park."

The 200-foot Golden Gate Viaduct was a series of eleven concrete arches, built into the cliff wall on the inner side. The work was carried out under extraordinary working conditions.[5] The site was described in a Livingston, Montana, newspaper as

> The execution of this work was one of extraordinary difficulty. This arose first from the conformation of the canyon and its influence upon the winds, which prevailed during the entire season. The canyon is practically the small end of a funnel, which gathers up the wind on the plateau above and conveys it to the lower country. The wind was high nearly every day during the work. At times, it attained the force of a gale with sufficient power to pick up stones half an inch in diameter. When it came to mixing the concrete it was found almost impossible to conduct the work during the middle of the day. The dust and cement filled the eyes and lungs of the workmen in spite of goggles and handkerchiefs. On this account men kept constantly quitting, not withstanding increased pay for concrete work, and their places had to be filled with new and inexperienced men.[6]

Prior to this time, and with his experience with the appropriations for construction of the roads and the inefficient distribution, Chittenden formulated a plan for the completion of the 300-mile road system. He pressed for a one-time appropriation of $300,000, which he felt would be sufficient to complete the system. Chittenden envisioned the need for two types of appropriations, one for construction and one for maintenance. He pointed out in his reports to Congress that the only time real progress was made on the system was in 1891 when two appropriations for a combined total of $120,000 were used to construct 60 miles of road. Chittenden should be attributed with giving maintenance a major place in the budget and in the daily operations of the park.

During this time, Chittenden built the first east entrance road, including the construction of the first Fishing Bridge. He shifted a dangerous section of the Gardiner to Mammoth Hot Springs road to the east side of the Gardner River. He worked on the south entrance road into the Teton Forest Reserve. Chittenden felt that it was time to "perfect and embellish the road system." He proposed to clear all dead and down timber for the distance of 100 feet and to thin the living trees to allow grass to grow among them to encourage the game that frequented the area. He planned to rebuild the retaining walls with fine masonry and position strong guardrails at the most precarious points. The slopes and cuts would be thoughtfully aligned and, where possible, small watercourses would be carried along the routes. Chittenden felt that "In these and other ways the roads will themselves be made one of the interesting features of this interesting region."

Other important engineering feats of Chittenden's were the construction of the North Entrance Arch, the Yellowstone River Bridge, and the Mount Washburn Road. Captain Chittenden felt that the heavily traveled, highly visible northern park entrance at Gardiner, Montana, deserved an impressive entrance gate. The Northern Pacific Railway's train station, designed by Robert Reamer, had been completed adjacent to the park boundary on the western edge of Gardiner and a new route into the park was scheduled for construction. Chittenden, who called Reamer "an architect of great originality and particularly skillful in adapting his work to natural surroundings," believed that with the completion of the train station, the time was right to further improve the north entrance with a compatible entrance arch.[7] Reamer had submitted a draft design which Chittenden disliked. At a conference in the United States Commissioner Judge John Meldrum's office, Chittenden proposed new suggestions for a design which was finally accepted. The arch was dedicated in the attendance of President Theodore Roosevelt in 1903. The monumental arch, with the definite Army Corps of Engineers' detailing, stands as a fitting memorial toward their significant work in the park.[8]

Of the nine important bridges built in the park during 1903, the most impressive and certainly most significant was the Melan arch Chittenden Bridge over the Yellowstone River, above the Upper Falls. The steel and concrete bridge was completed with great difficulty; however, Chittenden felt that its location merited an artistic design because of its prominent location. For many years the idea of a bridge in this location had been contemplated, but lack of funds prevented its construction. Chittenden spent considerable time on site selection. Not wanting to introduce an artificial structure at the most desirable and obvious site, the brink of the Upper Falls where the gap narrows to 50 feet, Chittenden chose a 120-foot span between two jutting rocks, about ½ mile above the Upper Falls at the rapids, with the roadway at the center being 43 feet above the low water in the river. Despite the volcanic rhyolite rock being of inferior quality for construction, Chittenden stated, ". . .still from the fact that it has resisted for an indefinite geological period the action of the river, it must have considerable stability." Including dangerous rapids just below, Chittenden had many obstacles to overcome. One of the most serious was the construction of the framework and related framing. All of the rough material was cut locally, but the finer lumber came from the Pacific Northwest. Using a small dynamo connected to the rock-crusher engine and a temporary plant to provide artificial light, the crews were able to complete the concrete work by working around the clock.[9] A detailed description of both the bridge and the construction of the bridge, a sketch plan of the working site, illustrating the gravel piles, the sluices for washing sand, the cement and crushed rock storage, the dynamo, the boilers and the working camp can be found in *Engineering News,* January 4, 1904. The article is entitled "Reinforced Concrete Arch Bridge over the Yellowstone River, Yellowstone National Park," by Hiram Chittenden.[10]

The bridge held a special place in Yellowstone history and it was not without a fight that the bridge was removed in 1961. In 1947, A. W. Burney, the Assistant Chief of Development for the National Park Service, called it one of "significant interest because it is one of the first reinforced concrete arch bridges of this type (Mylan [sic] Arch) constructed in this country. It was designed by and erected under the supervision of Captain Hiram M. Chittenden, Engineer Corps, U.S. Army." Burney recalled that an article from *The Railway and Engineering Review*, dated September 5, 1903, also described its design and construction.[11]

By 1959, the Melan arch Chittenden Bridge had been condemned, but a movement arose to have the bridge retained. General J. A. Code, who was a first assistant to the head of the Signal Corps during World War II, stated "That bridge should be retained as a memorial to early bridge building in America. It should be closed to vehicular and foot traffic. There isn't a bridge in the world that can compete with it in beauty and unique setting."[12]

For the next two years, efforts were made to preserve the bridge and build its replacement in a different location. However, the final decision was made to replace the 1903 bridge with a new bridge on the same site. In a letter to General Chittenden's family, Lemuel Garrison, Superintendent of Yellowstone National Park, wrote

> . . .there have been further developments concerning construction of the Chittenden Memorial Bridge. These developments demand additional respect of General Chittenden's engineering prowess. The site he selected for his bridge is not only the best, but is also the most logical site for a bridge across the Yellowstone River. As Mr. Scoyen wrote you, a site upstream was selected for the Chittenden Memorial Bridge, but as engineering data accumulated it became increasingly clear that costs for a bridge there would be staggering. The more the problem was studied, the more Bureau of Public Roads engineers and our own experts realized that the site selected by General Chittenden is the only logical site to construct the new bridge. Accordingly, we will remove the old bridge this summer and immediately start construction on the new. A plan has not yet been approved for the new bridge, but I can tell you that we will try to do. We will erect a reinforced concrete arch which we hope will be as fine a contribution to contemporary bridge design as the original was to earlier concepts of bridge design. This is a high standard of achievement, but we will do our best. We will not attempt a slavish copy of Chittenden Bridge. It is unique and any copy would detract from the value of the original by not measuring up to its beauty and grace. I know General Chittenden would use the results of modern engineering research in designing the bridge if he were to tackle the job today, and, somehow I don't think he would approve of copying a previous design. . . . I think, however, that a new bridge of clean design similar to that General Chittenden built, on the site he selected, and named Chittenden Memorial Bridge will be a most fitting tribute to that fine engineer. We will place there a memorial tablet whereon all may read of General Chittenden and why we honor him.[13]

Another major engineering feat was the construction of the road over Mount Washburn, where Chittenden found that the presence of solid rock on most sections of the road made construction very difficult and slow. Ten years after its completion, Franklin Lane, the Secretary of the Interior, wired the retired General Chittenden to announce that in an August 2, 1913 ceremony, the road over Mount Washburn had been dedicated and christened the Chittenden Road.[14] An immediate response came from the Chief Geographer, R. M. Marshall, who was responsible for changing the name on the newly published maps. In a letter to General Chittenden, he stated "There can not be too much Chittenden for me in this world, geographically."[15]

Finally in 1959, General Chittenden's contributions were honored by the park changing the road signs from "Mt. Washburn Road" to read "Chittenden Road to Mt. Washburn."[16]

Chittenden's accomplishments to the history of the American West included not only the first comprehensive book on the history of the park--still one of the classics of Yellowstone literature, but several other major works.

In regard to *The History of Yellowstone National Park*, which was Chittenden's first book, the author had the privilege to be able to explore the region, examine its history, and perceive its place in the country's history. After its 1895 publication, Chittenden continued to revise it, with other editions being published. Finally in 1913, he alerted his publisher that considering the state of his health, he thought that the 1913 revision would be last. He still pondered over geographic issues like whether the use of the Spanish spelling for "Canon" should be changed to "Canyon".[17]

The other classics of Western American history that he authored were the *American Fur Trade of the Far West*, *History of Early Steamboat Navigation on the Missouri River*, and the collaborative work with Alfred T. Richardson, *The Life, Letters, and Travels of Father Pierre Jean de Smet.* In addition to these works, he also authored *War or Peace*, *Flood Control*, and *Letters to an Ultra-Pacifist.*

Chittenden's writings have been praised by his contemporaries and later historians. Frederick Jackson Turner characterized the *American Fur Trade of the Far West* as "excellent" and admitted that the book's map showing the western fur trade posts "furnished the basis for the map of western posts and trails in (Turner's) *Rise of the New West.*" Grace Lee Nute characterized the fur trade history as remaining "the best general account available." Ray Billington found the fur trade history "the most useful work on the fur trade."[18]

Chittenden's accomplishments related not only to Yellowstone National Park and his literary efforts. After leaving Yellowstone for the Pacific Northwest, he continued with engineering projects. Besides serving as the President of the Port Commission of Seattle, he supervised the construction of the docking and terminal facilities, he was active in many other water or flood projects on the West Coast, and most importantly he was responsible for the design and construction of the locks which raised the seagoing vessels 19 feet from Puget Sound to Lake Washington. At the time of their construction, they were the fourth largest locks in the world. In 1956, President Dwight Eisenhower signed a bill in which the locks were named the "Hiram Chittenden Locks."[19] The locks were listed on the National Register of Historic Places on December 14, 1978.

Hiram Chittenden is listed in both the *Dictionary of American Biography* and *A Biographical Dictionary of American Civil Engineers, Vol. II.*

At the dedication of the Chittenden Memorial Bridge in Yellowstone National Park on August 9, 1963, Chittenden was described as

> at least a triple threat to man. He had three distinguished careers with national and lasting recognition in each--engineering, history, and conservation. As if these weren't enough to keep him busy, he became a student of international affairs, writing one book and a number of articles in this field. There was a book of poetry along the way, and the design of two monuments to attest to his artistic nature. As an engineer, he left his major marks here in Yellowstone, and in Seattle where the Chittenden Locks identify his contribution to the Port of Seattle. But it was here in Yellowstone that his greatest engineering accomplishments were made in a national sense. Thus he sensed when summing up his career he said: `My work in the Yellowstone Park will stand out as perhaps most important in the construction line of anything which I have accomplished. . . . It was in the fullest sense a labor of love. . . . In every important respect the Yellowstone Park has so far fulfilled the expectation of its founders and has justified the wisdom of its creation.'[20]

SEE CRITERION C FOR CHITTENDEN'S CONTRIBUTION TOWARD THE DEVELOPMENT OF THE DESIGN PHILOSOPHY.

CRITERION C

STATE LEVEL

Under Criterion C, the road system in Yellowstone National Park represents the continuing design philosophy first recognized by the Army Corps of Engineers and then later expounded upon by the landscape architects of the National Park Service. The road system has evolved into an historic landscape. The use of the road has remained the same, however a historic landscape is not static but always changing to meet the needs of visitors, to improve with advancing technology, and to meet weather, geologic, and other concerns. The landscape that one sees today does not exist exactly as it was first constructed. The road alignments, width of roads, surfacing materials, guard walls and guardrails, culverts and traffic patterns have changed and been altered many times. Yet it is the continuation of the philosophy of design that is most important. The designed features such as the guardrails or guard walls, the culverts, embankments, and designed pullouts are considered as part of the system and impart to the visitor a feeling of "blending with nature." The continuation of the earlier design philosophy in most cases has produced a modern park road system that evokes a high degree of feeling that one is traveling through a wild, natural setting. Many historic components of the earlier system are extant, e.g., bridges, culverts, guard walls and guardrails.

As the first designed road system for a national park or other reservation, the Grand Loop Road served as a model for other park areas. The consistent concern from Captain Dan Kingman in 1883 through the work of the landscape architects of the National Park Service, demonstrates the National Park Service's role as a leader in the landscape architecture field. The use of native materials compatible with the landscape and the concern for scarring or excavation has been a model for state park systems. Moreover, techniques used by the National Park Service were adopted by some state highway departments. In an article entitled, "America's Park Highways," the Deputy Chief Engineer of the Bureau of Public Roads, L. I. Hewes, cites the importance of the philosophy of the National Park Service and its influence across the country:

> In all the work in the National Parks, the Bureau of Public Roads has been guided in its design by the Landscape Division of the National Park Service. . . . The influence of the park landscaping methods has been felt by the bureau's entire organization and has resulted in better looking roads outside the parks. The highway departments of the Western states have been influenced by the results achieved on the park roads, and there has been a noticeable improvement during the last few years in the appearance of the roads constructed by the states themselves.[21]

In addition to Dan Kingman's setting the first park road standards, he also instilled a philosophy of wilderness road construction. Chittenden followed Kingman's thoughts showing his concern for man's imprint on the park. In addition to his concern for the siting and the artistic development of the Yellowstone Bridge, Chittenden wrote

> As a general policy, the extension of the system should be restricted to actual necessities. The Park should be preserved in its natural state to the fullest degree possible. While it is true that highways are the least objectionable of all forms of artificial change in natural conditions, still they should not be unnecessarily extended, and the great body of the Park should be kept inaccessible except on foot or horseback. But a road once found necessary should be made as perfect as possible. So far as it may detract from scenery, it is far less objectionable as a well-built work than if left in a rough and incomplete state. The true policy of the government in dealing with this problem should therefore be to make the roads limited in extent as will meet actual necessities, but to make such as are found necessary perfect examples of their class.[22]

Soon after the NPS resumed the responsibility for the construction of the roads in Yellowstone, a national landscape engineering office was created and the earlier philosophy was continued. As part of the cooperative agreements with the Bureau of Public Roads, the NPS landscape architects controlled the appearance of the road system and all landscaping details. By the 1930s, standardized plans for guardrails, guard walls, and culverts were on the shelf. Another standard that marked a park road was the flattening and rounding of the slopes and cuts. In 1935 and 1938, the design philosophy was expressed in the publication of two books by Albert Good, *Park Structures and Facilities* and *Park and Recreation Structures*.

One other area of significance for the Yellowstone roads was the association with the nationwide roadside improvement program under the leadership of Mrs. John D. Rockefeller. It would be difficult to pinpoint any particular resource in the park to that association, but the work done in the park as a result of that program was very important to the park's appearance and to the morale of the park employees, who gained more pride from their work.

Under Criterion C, the bridges can represent the National Park Service's design philosophy of harmonizing the manmade features with the surroundings. The bridges are the resources on the road system which maintain the best integrity and clearly represent the works of the landscape architects of the National Park Service.

For the most part, the Grand Loop Road retains sufficient integrity of Feeling and Design of the physical attributes of the National Park Service design philosophy to impart to the visitor the qualities of a "park road." The configuration of the Grand Loop retains sufficient integrity of location for it is to be as pertinent to the early 21st century visitors as it was to the late 19th century visitors--to be afforded access to the major "scenic wonders and geologic features of the Park."

HISTORY OF GRAND LOOP ROAD

THE DEVELOPMENT OF THE "GRAND LOOP" CONCEPT

Yellowstone's first superintendent, Nathaniel P. Langford, recognized the unique responsibility that the federal government had assumed in setting the area aside. In his annual report for 1872, Langford wrote, "here, the grandest, most wonderful, and most unique elements of nature are combined, seemingly to produce upon the most stupendous scale an exhibition unlike any other upon the globe...Our government, having adopted it, should foster it and render it accessible to the people of all lands, who in future time will come in crowds to visit it." Langford proposed a carriage route to convey visitors to "all the great points of interest," but he was unable to secure the necessary funding to develop existing trails into roads.

Langford's successors further developed his general proposal for a road system to carry tourists to the natural features of the park. Philetus W. Norris, superintendent from 1877 to 1882, continued explorations of the area and began a road-building program designed to provide access to the scenic areas of Yellowstone. Although Norris has been criticized for the poor quality of his roads, many of which were later rerouted or rebuilt, his general layout of roads set the precedent for the Grand Loop system that circulated visitors through the park.

In 1883, the U.S. Army Corps of Engineers assumed responsibility for the construction of roads in Yellowstone. The work of the Corps from 1883 to 1918 laid the foundation of the road system and rout that is essentially still in use today. Under Lt. Dan C. Kingman, assigned to Yellowstone in 1883, the "belt line," or Grand Loop, envisioned by Langford and Norris, began to take definite shape. By 1905, the Corps, then under the leadership of Maj. Hiram M. Chittenden, had completed the Grand Loop and the improvement or construction of four of the five entrance roads. The northeast entrance road, built by private enterprise in the early 1870s to reach the Cooke

City mines, was not comprehensively improved by the government until 1935, though minor repairs were made from time to time to fix washouts and other localized problems. After completing the Grand Loop, the Corps of Engineers focused on improving the existing roads rather than building new roads. In 1918, when the National Park Service functionally assumed control of the administration of Yellowstone, engineers and landscape architects of the service took over responsibility for road construction and maintenance. They, too, concentrated on improving the road system already in place.

The Grand Loop of Yellowstone National Park carried tourist traffic through "Wonderland" to view the geothermal and scenic features the park was created to preserve for the people's enjoyment. During the early history of Yellowstone, the typical traveler was well-to-do, with leisure time to spend on a five to six day tour of the park aboard a transportation company's stagecoaches, staying at park hotels along the way. Most arrived at the North Entrance, having taken the Northern Pacific Railroad's park branch line to its terminus at Cinnabar, Montana, or, after 1903, Gardiner. A stagecoach, or "tally-ho," then took tourists to Mammoth Hot Springs where they readied themselves for their tour. While most visitors stayed on the main stagecoach tour, they could also hire surreys or horses for more extensive exploration of the more remote areas of the park.

On the usual route of the tour on the Grand Loop, visitors departed Mammoth Hot Springs in four-horse, eleven-passenger coaches, heading south toward the geyser basins. They traveled first to Norris Geyser Basin, then to the Lower and Upper Basins and Old Faithful. Until construction of the Old Faithful Inn in 1903-1904, coaches backtracked from Old Faithful to the Lower Geyser Basin for the night before pushing on to the West Thumb of Yellowstone Lake. From there, travelers continued along the lake shore to the outlet of the Yellowstone River, then along the river to view the Grand Canyon of the Yellowstone. Until the completion of the section of road between the Canyon and Tower Falls, coaches then took the Norris-Canyon Cutoff back t the Norris Geyser Basin, and backtracked north over their earlier route to return to Mammoth Hot Springs. Even after roads over Dunraven Pass and Mount Washburn completed the loop to eliminate the need for backtracking, many continued to follow the earlier route because of the steep grades and the late opening of the new roads.

Although the majority of tourists followed this pattern, there were some variations during the early years of the p ark. Some chose to avoid the hotels, traveling with organized camping companies that maintained tents and tent cabins in select locations along the Grand Loop. The most prominent of these outfits was the Wylie Permanent Camping Company, which popularized this alternative as "The Wylie Way." Other tourists, known as "sagebrushers," toured the park on their own, camping along the way. Some visitors used other entrances to the park. The West Entrance became popular after the Utah and Northern Railroad extended a narrow gauge line to West Yellowstone in 1908. Still others traveled by rail to Cody, Wyoming and came into the park via the East Entrance after completion of the East Entrance road in 1903.

The opening of the park to automobiles on 1 August 1915 dramatically altered the experience of travel in Yellowstone. Cars rapidly displaced the horse-drawn stagecoaches. Independent motorists began touring the park and the main transportation company quickly replaced its conveyances with buses, or "auto stages," as the relatively small open touring vehicles were known at the time. The automobile eventually had a democratizing effect on tourist traffic as more and more Americans became able to afford their own cars by the 1920s. It also affected a shift from public to private transportation for the majority of visitors, especially once interstate highway networks were improved after World War II. The increasing speed of travel shortened the average stay of each visitor and allowed the park to eliminate some of the service establishments that had been placed at intervals mandated by the slower stagecoach schedule. The changing modes of transportation and increasing numbers of visitors had significant impacts on the park, particularly on the roads, which had not been designed for automobile traffic and were gradually resurfaced and otherwise "improved" throughout the twentieth century.

HISTORY OF THE SEGMENTS OF THE GRAND LOOP ROAD

For the reader's convenience, the Grand Loop has been divided into seven sections and two subsections:

- MAMMOTH HOT SPRINGS TO MADISON JUNCTION
- MADISON JUNCTION TO OLD FAITHFUL
- OLD FAITHFUL TO WEST THUMB
- WEST THUMB TO LAKE JUNCTION
- LAKE JUNCTION TO TOWER JUNCTION
  - TOWER JUNCTION TO CANYON JUNCTION
  - CANYON JUNCTION TO LAKE JUNCTION
- TOWER JUNCTION TO MAMMOTH HOT SPRINGS
- NORRIS JUNCTION TO CANYON JUNCTION

MAMMOTH HOT SPRINGS TO MADISON JUNCTION

During Superintendent Philetus Norris' first year in Yellowstone in 1877, he proposed a route or bridle-path from Mammoth Hot Springs to the Firehole River region via the Gardner Falls and the Gibbon River which would connect the only two entrances to the park, the west and north. This proposal was part of a larger scheme that included the construction of a wagon road from Mammoth Hot Springs to Henry's Lake via the Tower Falls, Mount Washburn, Yellowstone Falls, Lake Yellowstone, Firehole Basin, and exiting the park on the older western route into the geyser basin region. Norris felt that the wagon road would connect almost all of the major points of interest. In addition, another bridle-path was proposed from the Stillwater River to the Upper Geyser Basin via the Clark's Fork mines, Soda Butte, through the petrified forests to Amethyst Mountain, Pelican Creek, the outlet of Lake, Shoshone Lake, and on to Old Faithful in the Upper Geyser Basin. Norris also planned to build facilities at Mammoth Hot Springs.

Upon arriving in the park the following year with the first congressional appropriation of $10,000, Norris' priorities for building facilities and beginning the construction of the wagon road were changed due to the previous year's conflict with the Nez Perce Indians and a continual threat from the Bannock Indians. Instead, Norris began construction of the first permanent road from the Mammoth Hot Springs to the Lower Geyser Basin. Completion of the road would facilitate the movement of military from Fort Ellis, Montana, to Henry's Lake in Idaho or Virginia City, Montana, and of course, would be used by the ever-increasing number of visitors to the park.[23]

Prior to his explorations for appropriate routes, Norris viewed possible routes from the top of Sepulcher Mountain. He could spot the route that he had taken in 1875 and he visualized a route to the south through the park via Gibbon Canyon, Firehole Basin, the continental divide, and on to the Tetons. For the portion of the road to the Firehole region, he knew construction through the canyons could prove difficult and dangerous, but it appeared to be the most straightforward and practical wagon route.[24] Furthermore, the presence of huge masses of obsidian in the Obsidian Cliff area posed problems for road construction.

In the survey of the road section immediately south of Mammoth Hot Springs, Norris located three possible routes from Mammoth Hot Springs to the plateau near Swan Lake. One route, the longest and most precipitous, followed the Gardner Canyon over the pass via the Osprey Falls and Rustic Falls to the plateau (this later became the Bunsen Peak Road); another route, which had a more gradual grade but also had a sheer wall section to be transversed, was the opening created by Glen Creek on to Swan Lake; the third and chosen course was the most direct route, but with steep grades, through Snow Pass above the hot spring terraces. A visitor described this first section through Snow Pass as "So steep is the climb that if the tail-board of a wagon falls out . . . the whole load is promptly dumped out in the road. A good road, though, a longer one, might have been built over the same ground."[25]

From the flat area near Swan Lake to the Obsidian Cliff area no great construction difficulties were encountered; however, penetrating the "glass mountain," Obsidian Cliff, took ingenuity. Norris described his technique:

> Obsidian there rises like basalt in vertical columns many hundreds of feet high, and countless huge masses had fallen from this utterly impassable mountain into the hissing hotspring margin of an equally impassable lake, without either Indian or game trail over the glistening fragments of nature's glass, sure to severely lacerate. As this glass barricade sloped from some 200 or 300 feet high against the cliff at an angle of some 45 degree to the lake, we . . . with the slivered fragments of timber thrown from the height . . . with huge fires, heated and expanded, and then, . . . well screened by blankets held by others, by dashing cold water, suddenly cooled and fractured the large masses. Then with huge level steel bars, sledge, pick and shovels and severe laceration of at least the hands and faces of every member of the party, we rolled, slid, crushed and shoveled one-fourth of a mile of good wagon-road midway along the slope; it being, so far as I am aware, the only road of native glass upon the continent.[26]

Leaving the "glass mountain," the 1878 road followed in a southeasterly direction to Lake of the Woods, Solfatara Creek and into the Norris Geyser Basin. Norris' road proceeded through Elk Park, Gibbon Meadows into the Gibbon Canyon. At an approximate point where the Gibbon River flows in a westerly direction, the road left the canyon in a gap between cliffs and traversed pine-covered slopes connecting with the Madison Junction to Old Faithful road south of the present-day Madison Junction.

During 1879, Norris supervised improvements to the grades at Obsidian Cliff, in the Norris area and into the Gibbon Canyon. He found spanning the Gibbon, Firehole, and Madison rivers or their creeks and streams could prove to be very interesting. He wrote "Few of the anomalous features of the LAND OF WONDERS are of greater scientific interest or of more practical value than the placid, uniform water-flow in its hot spring and geyser-fed rivulets and streams." Because these water courses are generally "broad, shallow, grassy and flowers carpeted to the water's brim, . . . with long stretches of flowing grass and occasional hot spring pools in the channels, . . . with overhanging turfy banks," Norris decreased the need for some bridges by cutting a slope through the turf forming a very good and permanent ford. Instead of a bridge, he placed "long, limber poles and foot-logs, only a few inches above the low stage of water."[27]

The following season, bridges were built to span the Gardner and Gibbon rivers, including costly long causeways, turnpikes, and grades along the Norris Fork of the Gibbon River. An extension of the road to the Forks of the Gardner River was finished and a road "through the eastern branch nearly half-way through its terrible canon, necessitated a grade of over 1,000 feet within two miles."[28] In 1882, the new superintendent, Patrick Conger, who accomplished little in road construction, was responsible for the substantial bridge over the Gardner River. The construction was supervised by Captain E. S. Topping. The bridge, which was 12 miles south of Mammoth Hot Springs, was built in two weeks. The 96-foot-long structure had abutments built well out into the river on both sides. The center pier and the abutments were constructed of log in a V-shaped configuration, pinned at the corners and filled with rock above the high water mark. The bridge was covered with hewn logs, 5 inches thick.[29] Mr. Topping and his crew built and repaired culverts and crossways, removed rocks and boulders, and still Conger wrote "Our road is still in a mountainous and rugged country, requiring much labor and expense before it can be said to be a good road." In his appeal for more appropriations for road work, he described the situation:

> . . .when you consider the extent of the territory and the great natural obstructions that have to be encountered, it seems to me it must be evident, . . . the amount heretofore placed at the disposal of the Secretary of Interior `for the protection and improvement of Yellowstone National Park' is entirely inadequate . . .. But to proceed with our road we have to pass over some very high hills to reach the valley of the main Gibbon, where we encounter a wide low bottom called the Geyser Meadow, a place where it will require a large amount of labor to make a good road. After passing the meadow our road enters the Gibbon Canon and follows the river down several miles, close on the edge of the stream, crossing the same three times in as many miles over difficult and dangerous crossings in time of high water. After passing through this canon our road gains the highlands, by a steep grade along the side of the mountain on the south side of the river. We soon come to the great falls of the Gibbon where the river plunges over a perpendicular precipice of 75 feet, which in the stillness of the evergreen forest that covers this country renders the scene as enchantingly beautiful as `fairyland'.[30]

Army engineer Lieutenant Dan Kingman, who assumed the responsibility for road construction in the park in 1883, found this section of road to be the most heavily traveled and in the worst condition. His largest work crews reported there the middle of October 1883 when there were heavy snowfalls of 18 to 30 inches. With the exception of a 3-mile stretch in the Gibbon Canyon, this 40-mile section was widened and straightened, boulders and stumps removed, and slopes reduced. They built frequently spaced turnouts and a new ford, repaired existing bridges, and covered the corduroy sections with sod and earth. The work on this section cost approximately $6300 or $170 per mile.[31]

In 1885 major changes were made to the Mammoth Hot Springs to Firehole Basin area. Substantial bridges were completed, one over the Gardner River at the ford, one over the Gibbon River at the lower ford, and one over the Gibbon River at the third crossing.

The 4 ½-mile Mammoth Hot Springs to Gardiner via Golden Gate and the West Fork of the Gardner River, which was started in 1883, was completed in a 7-month period. Twelve hundred and seventy-five pounds of explosives were used and more than 1300 shots in drilled holes were fired. As a result, 14,000 cubic yards of solid rock were excavated in addition to a large amount of broken and crushed rock. This dangerous section of road was completed without any loss of life or injury to anyone. The completion of this section reduced the route south by 1 1/3 miles and the time to many areas in the park from 2 hours to a half-day, depending on the type of wagon and load. The reduced ascent of 250 feet to Swan Lake plateau enabled loaded wagons traveling in opposite directions to now pass with relative ease. The near vertical stone walls of the canyon prevented an excavated roadway, thus a 228-foot wooden trestle carried the roadway. Kingman noted in his report for 1885 that the "natural stone monument at the end of the trestle" marked what "visitors have called the Golden Gate."[32]

Kingman established a road camp near the Norris Geyser Basin in order to begin work on the new road between the geyser basin and Beaver Lake, where it would connect with the old road at the head of the lake. The poorly located old road ran in an easterly direction south of Beaver Lake before entering the woods near Lake of the Woods, and then the road followed Solfatara Creek and crossed the Continental Divide near the confluence of rivers near Norris Junction. Due to excessive snow depths and heavy timber, the snow covered the road well into May. The poor subsurface drainage caused by the heavy clay soils and the "saucer-like shape" over the Continental Divide produced "horrible conditions" for travelers. Kingman noted that it was not uncommon "to see a team lying in the mud, tangled in their harness and floundering about in almost in inextricable [sic] confusion while the drivers looked on in despair." Consequently, Kingman had sought a new route that would provide more exposure to the sun, better drainage and soil conditions. The 7 miles of new road, completed by the middle of October, cost $6269.80. Before the close of the 1885 season, the crews replaced "a long and rather unsafe structure built of poles" with a "single span King-post truss of 30 feet" combined with a causeway, over the Gibbon River near the Norris Geyser Basin.[33]

In 1887, the wooden trestle through Golden Gate was strengthened by placing new timber supports and road-bearer cross beams. A log and pole temporary bridge had to be placed over Obsidian Creek at the ford due to the unusually high runoff. Lieutenant Kingman's replacement, Captain Clinton Sears, proposed building 7 miles of new road from Swan Lake Flats to Beaver Lake, a new road between Norris Basin and Gibbon Canyon which would complete the 6-mile gap, and build a new road from Gibbon Canyon to the Firehole Basin. With a small appropriation for 1888, he was able to build a road from Norris Hotel across the Gibbon Meadow connecting with the road into Gibbon Canyon and a 7-mile stretch from Obsidian Cliffs northwards.[34]

In 1889, a king and queen post-truss through span of 40 feet were built over the Gardner River at the south end of Swan Lake Flats. It had a trestle span of 20 feet, a roadway width of 14 feet, and a height above low water of 6 ½ feet. An 86-foot-long trestle bridge with a 13 feet 8-inch width roadway between guardrails, and 5 ½ feet above the low water, was built over the Gibbon River in the canyon. The engineers felt that a trestle bridge could be safely built because the river, which has many hot springs in its bed, would not receive ice build-up. Thus at the end of 1889, the following bridges were in service on the Mammoth Hot Springs to Madison Junction road:

1. three spans of 33 feet over Gardner River--no truss
2. three spans of 32 feet over Gardner River--King post
3. trestle of 224 feet--Golden Gate
4. one span of 14 feet over West Gardner--no truss
5. two spans of 40 feet and 20 feet over Gardner River King and queen post
6. one span of 32 feet over Obsidian Creek--King post
7. one span of 16 feet over Obsidian Creek--no truss
8. one span of 32 feet over Obsidian Creek--King post
9. One span of 34 feet over Gibbon River--King post
10. one span of 20 feet over slough at Norris--no truss
11. two spans of 40 feet over Gibbon River--Queen post
12. trestle 75 feet over Gibbon River--Queen post
13. one span of 24 feet over Gibbon River--no truss
14. one span of 24 feet over Gibbon River--no truss
15. one span of 20 feet over Gibbon River--no truss[35]

During 1890, one of the two major projects in the park was the construction of retaining walls in the Gibbon Canyon area.[36] In 1895, the Army completed another bridge over the Gibbon River at an old ford, near the mouth of the canyon.[37] The next major road projects for this section would be a part of Captain Hiram Chittenden's 1900 multi-year plan for completion of the Grand Loop Road.

Among Chittenden's proposals was a new widened road through Golden Gate Canyon, including a new bridge to replace the wooden trestle around the cliff, raising 3 miles of road 2 or 3 feet in Gibbon Canyon and cutting out 1 mile of dangerous grades, and constructing 4 miles of new road down the Gibbon to connect with the western entrance road.[38]

About 1 mile of the original wagon road along the Gibbon River Canyon remained in 1900. The road had two very steep grades, one of which had a sharp curve at the bottom right at the river's bank. Chittenden found this particular stretch to be most dangerous as the failure of brakes or any other emergency might bring a team and wagon into the river. He called the road through Gibbon Canyon "one of the most pleasing in the park. It runs immediately along the bank of the river and is of easy grade. Unfortunately it is not built high enough above the river to make it safe. The river at every heavy flood goes clear over the road and has washed it out twice in the past six years." By 1903 the two bad grades had been cut out, 1 mile of new road had been constructed and a new steel bridge with concrete abutments had been built. During the winter of 1902, rock was hauled on sleds for about a mile to be used in the construction of the new heavy retaining wall on the newly reconstructed section of road about a ½ mile below Gibbon Falls.[39]

In 1904, a worn-out bridge in the Gibbon Canyon was replaced with a small 45-degree skew span. The following year the bridge over the Gibbon near Norris Junction was reconstructed and a steel truss was built over the Gardner River at the 7-mile post (Seven Mile Bridge).[40] Chittenden completed the construction work on the Golden Gate during 1902.[41]

Before Captain Chittenden left Yellowstone to begin supervision of the roads in Mount Rainier, he made the following recommendations for improvements to the Mammoth Hot Springs to Madison Junction road:

> . . . great care should be taken in widening the road through the "Hoodoos" to prevent the destruction of unusual rock formations. "It will be better to let the right of way have an irregular alignment--being narrower in some places than in others--than to sacrifice this peculiar formation in order to get a uniform width throughout. . . . it would be better to require all teams to come to a walk there than to remedy the defect by blasting out those picturesque rocks.
>
> Forested areas at Apollinaris Springs, a point 8 ½ miles from headquarters, Crystal Springs, and at mileposts 13, 14, and 17 miles out should be cut back on the east side about 30 feet to expose the snow to the sun. However, if these forests contained fine specimens of trees, the stands should be preserved. The Apollinaris Spring, Kepler Cascade, Mud Geyser and other coach unloading platforms should be rebuilt and extended to a length of 100 feet.
>
> The first hill just beyond the Growler can probably be brought to the adopted grade of 8% by a small amount of cutting and filling and no relocation of the old road is deemed necessary. The second hill just beyond the first milepost can probably be dealt with better by going around it to the south. A personal reconnaissance of the ground indicates the entire practicality of such a line. If built, it should leave the present road at the foot of the first hill near the Minute Man Geyser and rejoin near the foot of the second hill at the beginning of the tangent across Elk Park.
>
> The maintenance of the retaining wall along the Gibbon River between Elk Park and Gibbon Meadow can probably be avoided advantageously by putting the road back farther into the rock. If the wall is retained it will have to be relaid in mortar.[42]

First Lieutenant Ernest Peek, who replaced Hiram Chittenden, agreed with Chittenden's earlier suggestion of building all stone drywalls in the park, and in 1907, began repairs on the drywalls near Gibbon Falls. In order to efficiently coordinate the work on this section, he established a number of road camps including one near Obsidian Cliff and one near Beryl Springs. The camps had floored and frame tents.[43] In 1908, Peek requested sufficient funds to purchase three bridges, including two for the Gibbon River, but his request was not honored. Thus very little major work occurred, but road surfacing was carried out from Silver Gate to the 5-mile post across from Swan Lake Flats. Near Crystal Spring, "considerable work was done on the roadside in order to deepen the ditches and give the road a good high crown." Surfacing was also done on the Norris to Fountain road from 2 ½ to 2 ¾ miles. The 25-foot bridge at Obsidian Cliff and the 15-foot bridge at Apollinaris were each replaced by fills with 4-foot culverts. At Obsidian Cliff, the road was raised over 2 feet to improve the grade and it was also straightened. A fill of a foot was also made at Apollinaris.[44]

In 1909, Army Captain Willing conducted an inspection of the bridges in the park that stated condition and made recommendations for improvements. On this section of the road, Willing found:

> Bridge No. 2 across the Gibbon River, 5 5/8 miles south of Norris Station---The present structure consists of one wooden span with two wooden approaches, and was built in 1895. The timber in the bridge is sawed pine lumber, which at present is in a decaying condition, some of the floor beams being broken and held in place by props. The structure is in an unsafe condition, and it is recommended that it be replaced by two 50' low truss, pin connected steel spans, resting on two concrete abutments and one concrete center pier.
>
> Bridge No. 3, Gibbon Canon Bridge, across Gibbon River, 7 miles south of Norris---The present structure is a trestle bridge 80' long, built 1891, of sawed pine timber which is in a decaying condition. It is recommended that this bridge be replaced by an 80' low truss, pin connected steel span, resting on concrete abutments. As the bridge crosses the stream, at an angle of about 45 degrees, it will be necessary to make this bridge askew.
>
> Bridge No. 4, Gibbon Canon Bridge, across Gibbon River, 9 miles south of Norris Station. The present bridge consists of two piers in the stream, two abutments of logs, and log stringers spanning the space between these piers. It was built in 1892, is 65' long is in shaky and decaying condition. It is recommended that it be replaced by a 65' low truss, pin connected steel span, resting concrete abutments. It will be necessary that this bridge also be built askew as the road crosses the river at an angle of about 45 degrees.
>
> Bridge No. 5, across the Gibbon River at Wylie's Lunch Station. The present structure consists of one pier in the middle of the stream, and two log abutments with log stringers spanning the space between. The bridge was built about eight

years ago and is in a fair condition, but two light in construction for the travel it has to carry. It is recommended that it be replaced by a 40' steel plate girder span, resting on concrete abutments.

Bridge No. 7, at the mouth of the Gibbon River, near the junction with Firehole River. The present bridge consists of one wooden span with approach at one end, resting on wooden piers and abutments, total length 66'. This bridge was built in June and July, 1896, and is also in the advanced state of decay and is unsafe. It is recommended that this bridge be replaced by a 65' low truss, pin connected steel span, resting on concrete abutments.[45]

During 1909, the road between mileposts 8 and 15 was ditched and crowned and the road was raised about 1 ½ feet at the culvert fill across Willow Creek. The ruts caused by heavy traffic and water were filled with surfacing material.[46] In 1911, the road from Gardiner to Norris Junction was re-graded and 21 miles of the road was graveled. Also that year, the engineers recognized the need to replace a section of the dry, rubble wall along the Gibbon River.[47] During the winter of 1912, Captain Knight recommended that additional dry rubble guard walls be built on the outside edges of curves through the Golden Gate. He suggested the road along the Gibbon River between points 8 and 9 be raised 2 feet for 1 ½ miles to keep it from overflowing in the spring and that sections of the dry rubble retaining walls be rebuilt.[48] He also felt that the old, crumbling retaining wall between Norris and Fountain should be replaced and that the narrow road should be widened.[49]

In 1914, gravel was placed over the middle 8 to 10 feet of the Golden Gate to Swan Lake Flats road to bring up the crown and fill in the wagon ruts. The gravel, which was taken from a pit just east of the 4 milepost was loaded through a trap by drag scrapers. It took approximately 1/4 yard of gravel per linear foot of road.[50] Some of the old bridges on the Mammoth Hot Springs to Madison Junction were replaced during the year. A 40-foot two-span reinforced concrete bridge was built over the Gibbon River, 7 miles from Norris, and one 65-foot single-span girder and slab constructed bridge was built over the Gibbon near the confluence with the Firehole River. A 40-foot steel arch bridge was built over the Gibbon River near the Wylie Camp, 17 miles from the West Entrance. More reconstruction of stone retaining walls was done in the Gibbon Canyon and the road crews built a barn in the Gibbon Meadows camp, a cabin at the Beaver Lake camp, and two "public-comfort houses" in the Norris Geyser Basin.[51]

No major road projects occurred on this section of the Grand Loop Road for a few years. Shortly after the National Park Service was created, Secretary of the Interior Franklin Lane visited the park. During his inspection of the road system, he recognized a safety and visual problem in the Gibbon Canyon, the growth of small trees along the road. He found that the trees obstructed the view of the river and in turn made for dangerous driving. He also felt the removal of a few trees at the Gibbon Falls would "afford a better view of the falls." Other comments of condition on this section were "On top of hill on main road two miles from Mammoth, a number of very bad and hard rolls and bumps. Two serious holes, more than half way across Swan Lake Flats. Bridges were constructed at Upper Gardner River, Willow Creek and Gibbon River at Norris, below and above road levels. Road at Roaring Mountain in poor shape. Road Norris to Fountain down the Gibbon Canyon very rough, full of large chuck holes and broken culverts. Also contains one or two improvised log bridges where culverts have been washed out. Wylie Gibbon Camp over Mesa Road to Firehole River, about four very bad chuck holes that could be filled with little expense."[52]

During 1921, a new steel and concrete bridge was placed over the Gibbon River near Norris and wooden mess halls were built at Madison Junction and at Gibbon Meadows.[53] For the next few years, small allotments financed minor road projects, mostly accomplished on short sections at the end of the season. In September 1927, a crew composed of men and teams from disbanded work groups began a grading project along the Gibbon River. The 1928 appropriation provided sufficient funds for work for a complete season. Foreman John Benson established a temporary work camp at milepost 17 on May 17, 1928 in order to begin the heavy steam shovel work in rock cuts and to arrange detours for traffic. Later the camp was moved to Norris Junction to continue the project which was finally finished in May 1929.

In June 1930, Foreman O. A. Weisgerber established a camp at the old Beaver Lake road camp in order to begin work on the Bijah Springs-Obsidian Cliff section. A dangerous curve was reconstructed near milepost 15, and between the Gardner River crossing and the Glen Creek crossing, the crews were stalled by underground springs which required the installation of subdrainage. Material from a rhyolite slide north of Obsidian Cliff was used for a rock sub-base. An Osgood gas shovel, which had been moved up the Gibbon River-Norris Junction section, was used on this section. The next section mostly required light cuts in the existing roadway and side cuts to straighten and widen the road. On this section, the banks were sloped up to an 8 or 10 feet cut on a 1 ½ and a 2:1 slope. It was felt that the slopes, which would present a pleasing appearance, would also suffer less erosion from heavy runoff and the vegetation would take root easily. Upon completion of the excavation of this segment, the shovel removed rhyolite material from a pit behind the Norris Ranger Station for use as a light coating material for surfacing. The camp was dismantled in November.[54]

In October 1929, when the weather became too bad to work in the interior of the park, the crews resumed work on 600 feet of road in the Mammoth Lodge area. Most of the project was in-fill, but the additional rough fill material needed was obtained from the demolished concrete grainery near the Tower Falls and Mammoth Hot Springs junction and from abandoned concrete flumes near the Mammoth Lodge. The removal of these structures was part of the Landscape Division's plan for the Mammoth area. The rough fill was covered by material obtained from the road slopes above the Mammoth reservoir and the finer material for surfacing came from the pit on Capitol Hill. In addition to the road construction, the old wooden sidewalk and the continuing gravel walk to the Mammoth Lodge was replaced with a stone curb sidewalk. The new sidewalk was described as

> a stone curb walk, 2412 feet in length, and with an emulsified asphalt surface. Curbing, of locally quarried sandstone, is twelve inches wide and with a clear face of eight inches on the street side. Width of walk between curbs is five feet, an overall width of seven feet. The space between curbs was filled to within three inches of the top with any available material. Above this was spread two courses of grade size gravel, each coat being sprayed with a penetrating coat of Bitumen and

> rolled to a true cross section. A final coat of fine native sand was then broomed into the surface, giving a natural gray finish to the walk.[55]

After the Bureau of Public Roads assumed the road construction and improvement responsibilities for the park in 1926, the Mammoth Hot Springs to Madison Junction road was considered as a major project. However, adequate funding for location surveys was not received until 1929 and 1930, and as earlier stated, the lower segment of the section was constructed by National Park Service day laborers. The location survey for the Mammoth Hot Springs to Obsidian Cliff segment was made during the fall of 1930. At that time, additional funds were requested for more investigation of the Golden Gate and for designs for a new viaduct.

A better route south from Mammoth Hot Springs was investigated. However, an improvement to the existing route through Golden Gate was deemed more advisable than the old route through Snow Pass and/or Bunsen Peak, or a preliminary proposal by the park's engineering department of following a higher location through Golden Gate Canyon toward Mammoth Hot Springs through the Hoodoos. The National Park Service's Landscape Division did not approve of cutting a new route.

The Bureau of Public Roads' proposed route followed the older Army road from Mammoth Hot Springs south except at the Gardner River crossing and the Obsidian Creek crossing, where it moved approximately ¼ mile eastward for a distance of about ¾ mile.

The 18-foot standard roadway design by the Bureau of Public Roads was used on this road segment. The design provided a surfaced roadway with 3-foot shoulders on each side, both on fills and cuts. Three-foot standard ditches, 1 foot deep with 2:1 slopes into the ditch, from the shoulder, were provided for sections in cuts. The cut slopes were designed for slopes 1:1 or flatter in common material as specified by the Landscape Division of the National Park Service. For the use of materials other than common, the cut slopes were designed at slopes thought to be stable for the particular material, except that all cuts 4 feet were designed with 1:1 slopes. The fill slopes were all designed at 1 ½:1.

The Bureau called for the use of corrugated, galvanized metal pipe culverts with cement rubble headwalls for the minor drainages and for reinforced concrete box culverts with cement rubble headwalls for creek crossings. They also recommended the construction of a reinforced concrete structure 75 or 80 feet long of two or three spans at the crossing of the Gardner River at station 233+50.

In assessing the Golden Gate Viaduct situation, the Bureau found the present viaduct below the grade of the located line and too narrow and thus, a new viaduct was necessary. In order not to incur further scarring, a wider and slightly higher structure was needed. They recommended cement rubble retaining walls on either end of the viaduct and the respective length of the wall. The new reconstruction would also require a tunnel approximately 100 feet in length.

Finding snow conditions worse in the Swan Lake Flats area, snow fences were suggested to control the conditions on the flats. The Bureau did not project possible snow conditions at either entry to the tunnel, but they did try to consider snow problems on the route in case of possible winter use of the road.

A sand and gravel pit on Swan Lake Flats was approved for concrete aggregate material, but its conspicuous location limited the amount that could be extracted from it.[56]

Following the completion of the location survey, the Denver office of the Bureau of Public Roads designed the road and also the plans and specifications for the Seven Mile Bridge over the Gardner River. The Bureau's plans designated grading and draining on an 18-foot 1930 standard roadway width. Concrete box culverts and corrugated metal pipe were designed for drainages; tile drain and rubble drains were planned for wet and swampy areas.

Following the advertisement for bids in the *Rocky Mountain News*, Denver, *The Billings Gazette*, Billings, Montana, and the *Salt Lake Tribune*, Stevens Brothers of St. Paul, Minnesota was awarded the contract with a bid of $140,126.65 or 73 percent of the engineer's estimate. The contractor, who was awarded on August 5, 1931, set up camp immediately and began construction work on August 13.

Three camps were used for this contract. During 1931, the camp near station 55, or near Apollinaris Springs, was used, then moving the camp to station 300 at Swan Lake Flats in October 1931. For the remainder of the construction time, a camp near station 515 was used. These camps consisted of portable cabins positioned on wheels for cook houses, office and bunkhouses, and tents to accommodate extra crews. The average daily crew working on the project was 57 men using the following equipment:

3 - "60" Caterpiller tractors
2 - Hydraulic Bodies
2 - Hydraulic Fresnos
1 - Concrete mixer
1 - Hydraulic Bulldozer
1 - Hydraulic scarifier
1 - Elevating Grader
14 - Teams with dump wagons
1 - 1 1/4 yard gas shovel
4 - 3 ton dump trucks
4 - 1 ton trucks
1 - Grader, 12' blade
1 - Compressor
1 - Small electric light plant[57]

One of the partners of the firm, C. R. Stevens, served as superintendent of the project. Using mostly long-time firm employees, he also hired common labor locally. The foreman was paid $140 per month; skilled laborers,

$100 to $140 per month; and common laborers, $55 per month. The contractor gave a $45 per month subsistence sum.

During 1931 season, grading began at a point south of Obsidian Cliff and in 2 ½ months had progressed to station 245 near the crossing of the Gardner River, but cold weather forced the crews to move toward the other end of the project near Mammoth. Prior to shutting down for the winter, all concrete work had been done, the Seven Mile Bridge had begun, some masonry work finished, and the drainage projects completed as the grading progressed.

The contractor started the 1932 season on May 12 with shovel and dump trucks working in the Hoodoos. Extensive blasting was required to break up and loosen the huge wedged rocks, then more blasting was needed to break the rocks into manageable sizes for hauling. Grading continued on the project until August. The Seven Mile Bridge was completed; pipes, head walls, and rubble drains were completed as grading permitted, and an old road was obliterated. The old road, from station 465 to station 496, required tearing out old retaining walls, cutting of the old shoulders, and hauling out the waste material. The new road approximately paralleled the old road.

Two concrete box culverts were installed, one 8 X 6 feet at station 64, the Obsidian Creek crossing, and one 8 X 4 feet at station 369, the Glen Creek crossing. Corrugated metal pipes with masonry headwalls were installed over the other drainages. Tile and rubble drains and rock sub-base were installed in the swampy ground in areas of springs. The project required the installation of 1922 feet of tile drain and 5955 feet of rubble drain.

The types of material the grading crews faced throughout the project were varied. From just south of Obsidian Cliff to near the Glen Creek crossing, the cuts were through solid rock, loose rock, gravel, muddy swamps and common earth. From the Hoodoos to the end of the project at the Mammoth Terraces, cuts were through solid rock and very large loose rocks, with some common earth and gravel toward the end. Since the park required that all borrow pits should not be visible from the road, some difficulty was experienced in finding suitable material with a reasonable hauling distance.[58]

The engineering crews occupied three portable cabins built by the contractor at the National Park Service's Beaver Meadow maintenance camp during 1931, then moving to Mammoth Hot Springs until the end of the project. In addition to retracing the center line and cross-sectioning the entire project, staking culverts and drains, the engineers placed concrete center-line markers at intervals of approximately ½ mile over the entire project. A light palliative oil treatment, 4000 gallons per mile, was applied to the entire project to aid in the dust nuisance and serve as an interim measure until a surface course of crushed rock or gravel was applied. The project was completed by September 6, 1932 for a total cost of $136,810.94. [59]

Several landscape architecture issues were identified during 1932. During Landscape Architect Mattson's inspection of the guardrail between Mammoth Hot Springs and Norris in July, he objected to the use of the dark stain. The Bureau attributed the use of the stain as the result of competitive bidding, but he was willing to work with the park to achieve a desired effect. After discussing the use of oil to thin the stain, Mattson was assured that the stain would bleach to a lighter shade. However, in discussing the staining of the guard rail at Madison

Junction, he "asked them not to stain the guardrail at Madison Junction until it was complete and then use every effort to obtain the original desired color."[60]

Vista clearance and guardrail installation was also considered by the park landscape architects in their July report:

> sta. 93 --work will be done under road contract to provide turnout when waste material is cleaned up
> sta. 122--Road ditch to be filled making 10 ft. dalite available for distance of 100 ft. No guard rail required. Few trees to be selected and removed.
> sta. 125--Dalite already available between sta. 124 and sta. 126 needs oil surface and 150 ft. guard rail. Some trees to be removed.
> sta. 150 to 151--some trees to be removed-no turnout no guard rail required. Vista will be available while autos are in motion.
> sta. 160--remove numerous matured trees at edge of meadow for vista. No parking required, no guard rail.
> sta. 173 to 175--This location is on the outside of a curve. It would require considerable yardage to fill three feet deep and ten feet wide. Guard rail would be required.
> sta. 185--Several dead trees and a few mature trees to be removed. No parking or guard rail.[61]

Upon the completion of the Mammoth Hot Springs to Obsidian Cliff segment, the short steel Seven Mile Bridge which the new road bypassed was removed by park crews then the old road obliterated. The new road location required the removal of 5460 feet of telephone lines. The 18-wire system was relocated through a 16-foot right-of-way in a wooded area.[62]

In October 1933, John McLaughlin of Great Falls, Montana was awarded the surfacing contract for the 11.99 miles of road between Obsidian Cliff and Mammoth Hot Springs. Upon receiving the contract, McLaughlin set up camp about 600 feet to the right of station 520, a site that had been used by two previous contractors. McLaughlin purchased the frame buildings that the other contractors had used for cook house, office, and bunk houses. He completed the camp by adding tents for use as additional sleeping quarters.

The crews began quarrying the widened heavy cut through solid rock in the Golden Gate between stations 418 and 421. The rock, obtained from the high cliffs, was blasted, put through a primary crusher and then stock piled to the left of station 409 at Swan Lake Flats.[63] The crews worked through the winter in order to avoid the traveling public during the visitor season. By the beginning of May 1934, sufficient rock was stock piled and some surfacing had begun. By July 17, the project was complete.

The finished roadway had a 22-foot shoulder-to-shoulder width, a 4-inch base of 1 ½-inch maximum size aggregate and 1-inch top of 1-inch maximum size aggregate. The earlier grading contract had graded the road on the 1929 standard, but on this project the super elevation on all curves conformed to the 1932 standard. The surfacing courses consisted of rhyolite. At the conclusion of the project, a palliative oil treatment was applied. A plant mixed oil course was scheduled for application during the summer of 1935.[64]

In October of 1934, Taggart Construction Company received the oiling and seal coat bid for $99,836. This project covered 36.29 miles of road, with 11.99 miles receiving a plant-mix oiled material and 24.29 miles receiving a seal coat. The contractor established his camp approximately 1000 yards left of the gravel pit that was to provide the surfacing material at station 255. A frame cookhouse was constructed, portable tents were used for bunkhouses, and a portable building on wheels served as the office. The project required the services of about 65 men. A Pioneer Duplex crushing and screening plant was placed at the gravel pit which was approximately 1000 feet left of station 260. The crushed and screened material was stock piled nearby.[65] The project began on May 15, 1935.

Upon the completion of oil matting, the crews built masonry guardrail, performed cut slope treatment, cleaned up any slide material, obliterated old roads and borrow pits, placed top soil and planted approximately 275 trees of which 28 died. Parking areas were constructed near the Beaver Dams at station 100, at Apollinaris Spring and Roaring Mountain. The Beaver Dams parking was considered by the engineers to be a "pleasing and useful asset to the road."

The project, which extended from Mammoth Hot Springs to the Firehole Cascades was completed on September 30, 1935. With the exception for the needed construction and/or replacement of four bridges over the Gibbon River, "The smooth, wide highway, with easy curves and grades, should add greatly to the comfort and safety of the increasing volume of tourists who come to visit Yellowstone National Park each year".[66]

No other major work was completed on the road until 1948 and 1949 when the road received another bituminous seal coat surface. The project, which was classified as a maintenance project and funded from park funds, was awarded to Peter Kiewit Sons' Company of Sheridan, Wyoming for a cost of $77,250. The park hoped that this treatment would extend the life of the existing pavement and lower the cost of maintenance on this road section. The crushed and screened material was stockpiled at locations along the route; however, the bituminous material was trucked in directly from a refinery at Cody, Wyoming. Most of the equipment and supplies were brought in from West Yellowstone or Gardiner, Montana. In order to transport the crushing and screening plant over the Madison River Bridge, the bridge had to be reinforced with the addition of eight temporary timber bents. The project was completed on August 2, 1949.[67]

The next major road project between Mammoth Hot Springs and the Firehole Cascades was the construction of the Norris Junction bypass, a project initiated by the National Park Service's Mission 66 program for FY65. The 6.32-mile-long project channelized the intersection for the Grand Loop Highway and the Norris-Canyon Cutoff. The new alignment intended to provide a bypass of the Norris Museum and the Norris Geyser Basin and reduce the traffic congestion in that area.

The plans for this bypass were designed in the Region 9 Federal Highway Projects Office during the winter and spring of 1964-65. Both aerial and ground survey methods were used in siting the new alignment and automatic data processing equipment was used in its design. The mainline roadway was designed for a 38-foot graded width with 5 ½ inches of base. The upper 1 ½ inches of base were bituminous stabilized with a surface width of 30 feet. The two spurs road leading off the bypass were graded to a 32-foot width with a 5 ½-inch base of which the top 1 ½ inches were bituminous stabilized with a surface width of 24 feet. The shoulders were defined by cover aggregate resulting in a travel way of 22 feet on the main road and 20 feet on the spur roads. A 12-degree maximum curve, a 5.4-percent maximum grade, and minimum horizontal and vertical sight distances of 250 feet and 240 feet, respectively, were other design features.

The contract was awarded to R. J. Studer and Sons of Billings, Montana who submitted the low bid of $817,815. During May of 1966, subgrading began in an unstable, marshy area across from Elk Park, then moving on to a soaked peat bog near the Gibbon River. In addition to the grading operation, corrugated metal culvert pipe, vitrified clay culvert pipe, and perforated corrugated metal pipe underdrains were installed. Drop inlets, headwalls, and concrete curb and gutters were installed in October of 1966. By the end of October 1966, the old road had been obliterated in the Norris Geyser Basin area, the areas of the old Gibbon River bridge, and the old Norris Junction. Seeding was done in one procedure with a 1,200-gallon capacity tank hydroseeder, seed, fertilizer, and green-dyed wood cellulose mulch. The one operation covered approximately 1/4 acre.

The guide posts treatment was changed from chemonite or greensalt to pentachlorophenol which produced a brown rather than green color. Other landscape details required the coloring of visible portions of concrete box culverts to be the same color as the curbs and gutters, and the removal of downed trees along part of the route. The crushed aggregate, from a pit sited to the left of station 1362+50 on Route 12, the Northeast Entrance road, came from an alluvial deposit and from a highly disturbed rhyolite formation next to the alluvial deposit. A pit at Corwin Springs, Montana provided the concrete aggregate and the cement came from the Ideal Cement Company at Three Forks, Montana. Almost all of the corrugated metal pipe, which was spot welded, came from the Bethlehem Steel Corporation. The contractor completed the project on November 7, 1966.

Upon its completion, the route now provided safer passage through this area. In the past, a common complaint and worry to park officials was the reduced visibility caused by the steam blowing across the road from the geyser basin. The cars, which were pulled off on the road's shoulder for better viewing of the geyser basin, also caused a safety hazard. One recommendation the officials made at the time of the project was that the roadway receive a high type bituminous surface at some time in the future to replace the 1 ½-inch thick plant-mix base which had been applied as a temporary measure.[68]

MADISON JUNCTION TO OLD FAITHFUL SECTION

As early as 1873, a road had been completed from Virginia City, Montana to the Lower Geyser Basin, via the Madison Canyon. Gilmer Sawtell, who catered to park visitors at his hotel on Henry's Lake in Idaho, built the west entrance road and named it The Virginia City and National Park Free Road.[69] Four years later, the second superintendent of the park, Philetus Norris, proposed in his first report to the Secretary of the Interior, the construction of a wagon road connecting the "wonders" of the park which included a route connecting

Yellowstone Lake through the geyser basins and exiting on the west side. As a result of the Nez Perce conflicts during the summer of 1877, the construction of a road from the headquarters at Mammoth Hot Springs southward to the Lower Geyser Basin became the highest priority construction project. This completion of the section of road would facilitate the movement of the military from Fort Ellis, Montana to Henry's Lake in Idaho or Virginia City, Montana, and, of course, be used by the ever increasing number of visitors to the park.[70]

In 1880, improvements were made to the Firehole River road including opening a road into the Midway Geyser area.[71] The following year, two footbridges were constructed over the Firehole in the Upper Geyser Basin. The next major work took place after the U.S. Army Corps of Engineers assumed responsibility for road construction in 1883. At that time, the roads in the park were described as "barely passible and are daily growing worse. Just Sunday a lady was thrown out of the carriage and badly hurt at Fire Hole River. Between the 2 fords on Gibbon River, my wagon was turned over sideways and my wife thrown out. . . . The roads are terribly worn down on one side which makes it difficult to keep in a wagon."[72] Under the direction of Lieutenant Dan Kingman, a new bridge was built over the West Fork of the Firehole and some stretches of corduroy road were repaired and ruts filled. Finding Mammoth Hot Springs to the geyser basins the most heavily traveled path in the park, he also noted that it had the most serious natural obstacles and thus the "worst" in the park.

Kingman constructed a new road between the Firehole River and Upper Geyser Basin, as the old, poorly located road would be very costly to improve. The "unnecessarily long" and old road crossed a "kind of geyser swamp" in some places and crossed soils of a "black obsidian sand" in others.[73] As the road neared the Upper Geyser Basin, the alignments of the old and new roads were almost the same. The new route, which cost a total of $6,042.53, reduced the three to four hour travel time from the Marshall Hotel at the Forks of the Firehole River to the Upper Geyser Basin to one hour. Kingman described it as "well built" and said that the bridges and culverts had "substantial character". He further describes it as "sensibly level, and as the roadbed is mostly composed of gravel that packs well, it is a very pleasant road to drive over."[74]

The first trestle bridge built in the park crossed the Firehole River above Hell's Half Acre. Kingman felt that this bridge was well suited to the unusual conditions of the locality, "enormous quantity of hot water that this river received it never carried any ice, and as its discharge is remarkably uniform (there is hardly a difference of a foot between high and low water) it bears little or no drift wood." The trestle bridge, costing $400, was covered with 4-inch hewed planks.[75] In 1889, 3.5 miles of new road had been built along the Firehole River above the Upper Geyser Basin, and two bridges, in addition to the trestle bridge, had been built--a two-span of 36 feet each over Firehole River, no truss, and a one-span of 38 feet over the Firehole River, no truss.[76] In 1892, Lieutenant Hiram Chittenden urged the rebuilding of "the worst, most tedious, and least interesting drives in the park," the road from the Gibbon Falls to the Lower Geyser Basin.[77] In 1894, a new road was completed from a point on the old road near Gibbon Canyon south across the flats toward the Firehole and also connecting with the road west down along the Madison River. At the same time, a bridge spanning the Firehole River near Excelsior Geyser was built permitting teams to cross the river at this point and join the main road in the edge of the woods opposite.[78] The next year the new road had been extended to Nez Perce Creek. In 1897, a new bridge was built over the Firehole near the Riverside Geyser and a new footbridge built over Firehole River near Biscuit Basin.[79]

During the first few years of the twentieth century, several bridges were built along this section. In 1903, a new steel truss bridge, whose material came from the American Bridge Company, was built over the Firehole River, ½ mile above Excelsior Geyser.[80] More bridge construction and reconstruction occurred during 1905 and 1906. In 1905, a steel truss bridge was built over Nez Perce Creek and two wooden bridges were reconstructed, one on the old road from the Lower Geyser Basin to Excelsior Geyser, and the other just above the Upper Geyser Basin. During 1906, the wooden bridges over the Firehole River on the old freight road near the Fountain Hotel and over the Firehole River above the Upper Geyser Basin were reconstructed. "An attractive footbridge of rustic design was constructed over the small stream between the Castle Geyser and Old Faithful Inn".[81]

In 1907, the Army engineer supervised the repair of many of the park's wooden bridges and the replacement of some bridges with culverts. On this road section, a new wooden abutment was built at the bridge over the Firehole River on the Fountain to Upper Geyser Basin road and tile culverts were laid at 7 7/8 miles on the Norris to Fountain section.[82] The following year, new decking was laid on two bridges spanning the Firehole River, one crossing being near the Riverside Geyser and the other on the Upper Geyser Basin to West Thumb at the junction with Spring Creek. One 12-inch corrugated sheet iron culvert was placed at 9 ½ miles on the Norris to Fountain road.[83]

In 1909, a bridge inspection was done for all of the park bridges. The bridges on this section of road were described as follows:

> Bridge No. 9, across the Firehole River at Riverside Geyser, Upper Geyser Basin. The present bridge consists of a two-truss wooden span on wooden piers and abutments. This bridge is entirely too light for the service required at this point. It is located at one of the most important points in the Park, and in addition to the vehicle traffic, is at times loaded with sightseers viewing the Geysers. It is recommended that, owing to the importance of the bridge, and its location, it should be made an attractive appearing structure, and further recommended that two 32' plate girder spans with curved effect underneath be used resting on concrete piers and abutments, and that the roadway be 20' in width so as to accommodate the sightseers without interference with the vehicle traffic.
>
> Bridge No. 8, across the Firehole River at Hell's Half Acre, near Excelsior Geyser. This bridge was built in 1895, of white pine lumber, and consists of two spans with one pier in the center of the stream and two abutments. It is now in a decaying condition and its factor of safety is so much reduced that it should be removed at once. It is recommended that it can be replaced by two 50' low truss, pin connected steel spans and concrete pier and abutments.

As part of the inspection report on the bridges in the park, it was recommended that plans be drawn for a reinforced concrete bridge to be constructed over the Firehole River near Riverside Geyser. Captain Wildurr Willing of the Corps of Engineers felt that since this was one of the most visited areas in the park, it was necessary that the bridge be of an aesthetic design.[84] However, because of costs, a 65-foot steel arch bridge was built was built by the Minneapolis Steel and Machinery Company in 1911. As late as 1923, the 1911 bridge was still in use.[85]

Not many major changes or improvements were made to this road section after the Army left the park and the newly created National Park Service assumed the road construction program.

The new director did suggest the completion of the Firehole Cutoff road.[86] The 4-mile-long freight road, which paralleled the main road between the Fountain Soldier Station and the Excelsior Geyser, was closed in 1917 due to its unsafe condition of the wooden truss bridge over the Firehole River about 1 mile from the soldier station. A new 50-foot bridge was built as a replacement and a 40-foot bridge over Nez Perce Creek was reconstructed.[87] And in 1921, a new footbridge was constructed over the Firehole River near Castle Geyser.[88]

Prior to the next major construction program initiated after the Bureau of Public Roads took over the roadwork in Yellowstone in 1926, the Firehole River Road south of the Firehole Cascades for 3.5 miles was widened for two-way traffic.[89] The work began in May 1925 in the immediate vicinity of the Firehole Cascades and a camp was set up near the cascades. By the middle of July, 5,160 cubic yards of excavation had been removed by hand and team labor. Of the total, 4,400 cubic yards was of solid rock. The crews installed approximately 150 feet of drainage culvert. The cost of the 1.5-mile project was approximately $6,000. In 1926, Director Mather reported that the work along the Firehole River between Madison Junction and the Firehole Cascades was "constructed on the highest standards of any used in the National Park Service" as "the beauty of the canyon justifies the very great attention that is being given to details of wall and fill construction."[90] The 1926 project, which involved widening a 1.5-mile section of the road in very narrow places and new construction for 1.5 miles, had originally been started by the Army engineers, but abandoned in 1916. This project required the assistance of 1 foreman, 1 cook, 1 flunkey, 1 compressor operator, 2 Jackhammer men, 1 powder man, 1 grade man, a 14-horse teamster, 2 2-horse teamsters, 1 axe man, 1 blacksmith, 6 laborers, and 3 teams. The project required the excavation of 360 cubic yards of common material, 820 cubic yards of loose rock, 2,945 cubic yards of solid rock and the installation of 120 linear feet of 12-inch CMP (corrugated metal pipe) culvert in place and 24 linear feet of 18-inch CMP culvert in place. All excavated material was used on the project. "Neither the amount of material nor the nature of the country would permit fills on a naturally stable slope and all embankment was constructed with hand placed fill or rubble wall on slopes of 1/4:1/2:1."[91]

Work also began on a new bypass road at Fountain Paint Pots as the old road was widened and improved to become a short loop road. The necessary fill material was hauled from the cut at the 7 milepost, about 1 ¼ miles distant. About half of the construction in this section was through sandy material which required a binder to create a stable surface. A sharp curve above the Firehole River Bridge at Excelsior Geyser was widened by the excavation of 600 cubic yards of solid rock. The borrow for the material on this project came from a pit near Firehole Lake. The project was finished in July 1930. A total of 2.16 miles of road had been built and 196 linear feet of 18-inch CMP culvert had been installed.[92]

Shortly thereafter, the crews began lessening the curvature and widening the grade on a sharp curve at a point 5 miles north of Old Faithful. This project required the hand excavation of about 475 cubic yards of material which was then used to widen the grade from 18 to 24 feet, both at the curve and a distance of 200 feet on either end. All of the excavation was through a sand-clay formation, thus no additional surfacing was required. It was finished with an application of oil.[93]

In 1930, the realignment of the Norris Junction to Madison Junction road resulted in the abandonment of two steel bridges across the Gibbon River approximately 9 ½ miles below Norris Junction. It was proposed that both would be removed; however one bridge, which served the old stage road (Mesa Road) to the Firehole Cascades, was still needed as diverted traffic used this route while the new road was being completed. The other Gibbon River Bridge, a steel arch bridge with concrete floor, constructed in 1913 at a cost of $4,010, was dismantled and reassembled over the Firehole River on the Fountain Freight Road. This relocated bridge replaced an unsafe timber bridge. This bridge has since been removed.[94]

In an inter-bureau conference held in San Francisco in 1931, the National Park Service requested a reconnaissance survey be completed for the road between Firehole Cascades and Old Faithful. The average daily traffic during that period was about 600 vehicles per day with about 10 percent of the total being trucks and busses. The survey found that the first 2.5 miles from Madison Junction to the Firehole Cascades, which had been reconstructed by day labor of the National Park Service and surfaced by the Bureau of Public Roads in 1931, to be in satisfactory condition. Thus most of the survey was for the remainder of the road. The park requested the feasibility of rerouting the main road via the Firehole Lake, the east end of Biscuit Basin and Black Sand Basin. They also felt that if this was not desirable then they wanted loops built in these areas. The fairly recently built bypass of the Fountain Paint Pot proved to have reduced the interest at this point, thus the park desired a rerouting that would produce a closer approach. Within ten days, the survey crew recommended many slight variations from present alignment, flattening of curves, reducing curvatures, and widening the present road. It was estimated that approximately ten culverts would be needed for every mile. The width of the road from shoulder-to-shoulder should be 28 feet for the main roads and 22 feet shoulder-to-shoulder for the proposed loop roads. The four bridges on the project were considered too narrow and too light of construction to carry the average daily traffic load, and therefore should be replaced.[95]

The location survey for this project was completed in 1932 and the Morrison-Knudsen Company of Boise, Idaho was awarded the grading contract on July 17, 1934, for the low bid of $188,216.10. The contractor began establishing his camp at Goose Lake on July 19, 1934. The camp had frame buildings which facilitated 125 men. Family members were provided for at a camp just across the creek from the main camp. The engineers camp consisted of two 16 X 16 portable houses and two tents and was located at Riverside Geyser.

Work began immediately and closed for the season on December 26 with 84 percent of the project completed. The 1935 season began in May and with 95 percent of the project finished by September 9 when the contractor closed down for the year.

By the end of the 1935 construction season, the road had been graded to a minimum width of 28 feet at the recommendation of the National Park Service. The Bureau of Public Roads standard for that time was a 26-foot roadway, shoulder-to-shoulder. The bridge construction was handled by separate contracts. All cross and side drainage structures were corrugated metal (1,898 linear feet) and vitrified clay pipes (4,254). Since many of the drainages are through areas of unusual chemical composition, vitrified clay pipe was preferred. The 271 cubic yards of rock for the masonry work was obtained at a quarry at a point where the Mesa Road leaves the Grand Loop Road between Gibbon Falls and Madison Junction. Because of the superior condition of the subgrade, it was deemed possible for traffic to move over the road for a season or two until the final surfacing is done.[96]

Concurrently with the road construction project, a bridge contract was awarded to McLaughlin Construction Company of Livingston, Montana for the construction of the Nez Perce Creek Bridge, the Firehole River Bridge and a footbridge over the Firehole River at Excelsior Geyser. Work began in 1934 and the bridges were completed on September 6, 1935. Following the completion of the bridges, the park felt that "great improvements" had been made in the roadways. The use of 4:1 slopes on low embankments was preferable, however, that combined with not diverting branch streams left:

> some undesirably conspicuous culvert headwalls especially on the road recently completed between Madison Junction and Old Faithful. It is believed that a change in design of culvert headwall is desirable and that an improvement in appearance can be readily obtained. One plan would be to move the headwalls closer to the road shoulder, to bevel the projecting corner, and to provide 90 degree wingwalls on the same slope as the embankment. Another method would be to bevel the end of the culvert and protect the bank by hand placed embankment or by masonry laid flush with the surface of the embankment. While the masonry of large bridges adds to the attractiveness of the roadway it seems to be undesirable to make the headwalls of small culverts conspicuous and the more invisible they can be the better the appearance of the roadside.[97]

Another landscape issue identified with this section's bridge work was the type of curbing desired. The park felt:

> that a concrete curb is more serviceable than a masonry curb. It is, however, suggested that the appearance of wingwalls would be improved by making the wingwalls all of masonry including a masonry curb rather than introducing a concrete curb as a portion of a masonry wall. A single course of masonry above a concrete curb does not give the appearance of being adequately bound into wall.[98]

Both the newly constructed Nez Perce Creek Bridge and the Firehole River Bridge have the combination of the concrete curb with the masonry walls.

The next major project on this road section was the relocation of approximately 2 ½ miles of road between a point on the Grand Loop Road immediately north of Madison Junction to a point on the Grand Loop Road near the

Firehole Cascades. The old road, which is along the Firehole River through a narrow canyon, was first constructed by the Army engineers, but abandoned in 1910 because of construction costs and the very heavy character of the work. In 1925, National Park Service day labor forces resumed construction on the section and it was eventually surfaced by the Bureau of Public Roads in 1931. The 1938 preliminary location survey proposed the construction of a new bypass road to alleviate the serious bottleneck imposed by the narrow road through the Firehole Canyon. The engineers specified that the new bypass be built on the same standards as the rest of the Grand Loop Road. Upon completion, the old road could be used as a scenic drive.[99] This report resulted in preliminary plans; however, the construction did not occur for several years. In 1949, a 38-mile chip-sealing project on the Mammoth Hot Springs to Firehole Canyon road, and a grading and base surfacing project in the Firehole Canyon began.[100]

Many improvements, such as widening the roadways and bituminous surfacing, were made on the Madison Junction to Old Faithful section during the 1960s. A number of remnants of old roads were obliterated and the scenic loop roads were resurfaced and improvements made to the shoulders. Rock work was repaired after the 1959 earthquake.[101]

OLD FAITHFUL TO WEST THUMB

Army Engineering Officer William Craighill became the first person to survey the Old Faithful to West Thumb route. Not knowing the precise route that the road would take, Craighill had the crews working from each end. Before the road was completed, Craighill was replaced by a significant figure in the park's history, Lieutenant Hiram Chittenden.

One of Chittenden's first assignments was to complete Craighill's project, the construction of the road from Old Faithful to West Thumb. In 1891, Congress required that the route be built by the shortest practicable route.[102]

Thus, Chittenden's recommended route, which closely paralleled today's road, did not skirt Shoshone Lake as Captain Kingman proposed, but instead crossed Isa Lake and crossed the Continental Divide twice. According to a Yellowstone National Park historian, Aubrey Haines, Chittenden discovered that the crew on the Old Faithful end were following the old Norris trail. "That was Mr. Lamaratine's idea of locating a road--to follow a trail with all its irregularities and excuses of gradients, regardless of what improvements could be made by something of a survey." Haines wrote that "Chittenden found it necessary to do the locating himself, working alternately at the two ends of the line with a hand level, a five foot staff, and the assistance of two laborers."[103] The road, completed during the summer of 1892, is one-third shorter than Kingman's proposed route via Shoshone Lake.[104]

In 1891 or 1892, a pole bents and stringers trestle bridge was constructed to span a ravine 1 ½ miles from West Thumb, and the Log Cabin Bridge across Heron Creek was built. The Log Cabin Bridge consisted of "two piers built up of logs resembling a log cabin, hence its name. There are also two wooden abutments. The spaces between the piers are spanned by stringers of white pine logs."[105]

In 1908, a new, small bridge was built on the flat near DeLacy Creek, and repairs were made to the bridges over Heron Creek and DeLacy Creek.[106] In 1909, Engineering Officer Wildurr Willing made a thorough inspection of the bridges in the park. He recommended that the trestle bridge 1 ½ miles from West Thumb be replaced with a low-truss, pin-connected steel span, 60 feet in length, which would rest on concrete abutments. He called for the replacement of the Log Cabin Bridge with a 60-foot steel arch span with steel approaches at either end. Due to the fact that at one end of the bridge the road makes a sudden turn, that end had to be widened "so as to permit the four-horse teams to swing onto the bridge with ease". Another trestle bridge, 60 feet in length and constructed of pole bents and stringers, which spanned a ravine 1 mile west of West Thumb, was scheduled to be replaced by a 4-foot culvert pipe.[107] It was replaced in 1913 by a concrete culvert and earthfilled wooden crib.[108] In 1912, a road assessment was conducted to determine the suitability, from an engineering standpoint, of the system for the introduction of automobile traffic in the park. The Army Corps officer, Captain Knight, concluded that it would be better if the existing system were reconstructed than creating a separate system for motorized vehicles as some had suggested. Not much work was done on the Old Faithful to West Thumb Road but a 25-foot-long bridge had been constructed in 1911 (exact location not known).[109] In 1915, three concrete culverts from 4 to 6-foot spans had been built along Spring Creek and the foundation for three more, plus several galvanized culverts had been put in along the road segment. These replaced older wooden ones.[110]

Intensive reconnaissance surveys of this segment were completed by Worth Ross in 1927 and by A. C. Stinson in 1934 at the request of Superintendent Roger Toll. Toll urged for a speedy completion of the survey with expectations of going into construction the following year. Records for 1934 recall that this segment, which was, and is, an integral part of the Grand Loop system, was the "lowest type and poorest main road in the Park."[111] The Bureau of Public Roads engineers felt that the road was far below the standards of the roads elsewhere in the park. During 1934, the road was being traveled by approximately 250 cars daily, whereas the approximate daily use for other segments was 500 cars daily. These figures were based on records of previous years indicating 50,000 cars entering the park during the 100-day season. Officials felt that the low usage of this segment was no doubt due to the one-way traffic regulations and the poor condition of the road.

A $10,000 allotment for the 1934 survey was approved; the survey began July 5, 1934. The 15-man crew completed the staked line survey on October 22, 1934. Later, an additional $4,000 was approved for the survey project. The surveying crew found the crooked and narrow one-lane road following "most of the devious windings of the water courses, which it employs in the ascent to and descent from the two crossings of the Continental Divide. The road employs a great many sharp curves and a few sketches of excessive grades . . .".[112] The road width varied from 12-15 feet to 18-20 feet. The wider width sections were found in the flatter country and also at the beginning of the ascent to Craig Pass which also has some of the rockiest sections of the route. Less rocky country, but very crooked alignment, was found in the lower section of Dry Creek, while the upper section of Dry Creek was described as "rolling hilly country of less rugged nature." The descent road from the second Continental Divide crossing to West Thumb ranged from gentle to very steep slopes as one neared Yellowstone Lake. The survey team reported that the earlier work had been designed to incorporate a "fine view" of Yellowstone Lake at one of the very sharp curves and further down the road, an overlook was built for a view of Duck Lake, a spring-fed lake lying between the bluffs and Yellowstone Lake.

At the conclusion of the survey, the Bureau of Public Roads made seven different proposals, some of which proposed similar alignments, but proposed different methods to overcome specific problem areas. The selected proposed route was a compromise between the National Park Service, who imposed strict guidelines concerning landscape, design, vistas, and the use of the segment for interpretation, and the Bureau of Public Roads whose aim was to find the most suitable ground for a modern highway. The 1934 survey report recommended some new road construction, some incorporation of the earlier road, and the use of a 24-inch culvert as an equalizer between the two lakes (Isa Lake) with the road running on the left side of the first lake and the right side of the second lake. It proposed parking spaces at Shoshone Point for views of Shoshone Lake and the Teton Mountains, and at Mount View where selected clearing would provide fine views of mountain peaks and Yellowstone Lake. Other vistas considered on this segment were views of Flat Mountain at the south end of Yellowstone Lake, the Trident in the southeastern section of the park, and views of Yellowstone Lake. The report stated, ". . . This is a magnificent and worthwhile view (Yellowstone Lake) and should be preserved". The engineer admitted that another approach to West Thumb was more favorable and less expensive but "does not develop this view, and, although occupying better exposure, results in probably a little less satisfactory alignment."[113]

The proposed route would eliminate 2.7 miles off the earlier route. The length of the 1934 route was 17 miles, and crossed the Firehole River and four creeks. The report recommended concrete box culverts for the creeks, and all remaining drainage should use corrugated, metal pipes, or in high erosion areas, paved inverts for some of the pipes. The park afforded one of the major concessionaires, W. M. Nichols, President of Yellowstone Park Hotel Company, to comment on the proposed new alignment. He suggested that the old section through the Spring Creek Canyon, which he considered "one of the prettiest short trips on the Loop", might be also retained as a one-way east bound road. He stated that "As for our own buses, it would make a delightful trip, because, as you know, the buses have their tops down most of the time, and people can view scenery even in a narrow canyon like Spring Creek.[114]

Prior to the 1934 survey, the discussion of road width was an important topic and one of disagreement between the Bureau of Public Roads and the National Park Service. In a 1931 letter, the Bureau's District Engineer discussed the construction width, shoulder-to-shoulder, for all sections of the Grand Loop Road. The National Park Service reacted by telegram and called it "a matter of over-design". After several conversations and the Bureau's reason for the greater width, the 28-foot width was accepted and some projects proceeded using the 28-foot standard. In a February 12, 1934 letter from Superintendent Toll to the Director of the National Park Service, Toll questioned whether a recognized agreement on the 28-foot width existed.[115] The previous 24-foot accepted standard for all parks was raised to 28 feet for the Grand Loop Road and to 26 feet for the entrance roads.

By 1936, ten years after the initial road survey, 200 miles of the park road system had been improved to a drain and grade standard. Approximately 100 miles had been base-course surfaced, which consisted of crushed rock, and spread the full width of the graded section to a compacted thickness carrying from 4 to 9 inches depending on subgrade conditions. Approximately 50 miles had a bituminous treated surface which was 20 feet wide with a 2 ½-inch minimum compacted thickness with a seal coat and a wearing surface of stone chips. This treatment was the desired ultimate completed surfacing for all of the roads. Approximately 30 miles was under construction for bituminous surfacing; 19 major bridges including the new Golden Gate Viaduct were either completed or near completion. With approximately 60 percent of the project completed, the total cost, including 1936 work in progress, was $7,000,000. However, the Old Faithful to West Thumb segment was not completed.[116]

Refinements of the details and revisions of the 1934 report and recommendations began almost immediately after the publishing of the report. In fact, in the published report, the author acknowledges the cooperation of Superintendent Toll, but indicates that they had "less effective' cooperation with the Landscape Division of the National Park Service.[117] Perhaps this "less effective" cooperation is a sign of the importance of the Landscape Division's input toward the completion of the park's road system to park standards. One of the requests from Sanford Hill, Resident Landscape Architect, was that "the cleanup of old logs and down timber along the small creeks and particularly along Isa Lake be held to the minimum. We feel that the cleanup along these streams would tend to destroy a natural condition, and also destroy a natural check on erosion."[118]

Very early in the park road development history, the concern for visual quality, interpretive values, and the limited destruction to the landscape is evidenced in U. S. Army Corps of Engineers Captain Kingman's standards and it was continued throughout the periods of the 1920s, 1930s, and 1940s. The landscape architects in the Branch of Plans and Design of the National Park Service collaborated with the engineers of the Bureau of Public Roads during the survey, and throughout the planning and design stages of construction. The park's resident landscape architect monitored the actual construction and supervised the development and construction of landscape features. Among the examples throughout the park of a landscape architect's input are the roadside pullouts, trails, and the rounded cut and fill slopes and other special design features. "The rounding of tops of cut slopes and the flattening of cut and fill slopes in earth material" had long been standard practice for the National Park Service road design. In the Rocky Mountain West, the state highway departments adopted the same practice. Another landscape problem was the rehabilitation of abandoned roads, a problem that existed on the Old Faithful to West Thumb segment. The problem was addressed by reversing the construction procedures and "placing the materials from fills back into the cuts and attempting to reestablish the original contour and topography of the terrain."[119] In wooded areas, much tree planting was done and in barren areas, the old roads were covered with duff and topsoil to promote vegetative cover and prevent erosion.

Travel on this segment of the Grand Loop had increased to nearly 1,200 cars daily. The new alignment, at a point just east of Isa Lake, followed the old road, swinging north, crossing Herron Creek, and down to DeLacy Creek crossing on a high fill to Shoshone Point. A parking area was constructed at Shoshone Point to enable the visitors to experience the beautiful view of Shoshone Lake with the Teton Mountains as a backdrop on the horizon. From the parking area, the new road followed the older road until leaving the old alignment and headed to Dry Creek continuing in a southeasterly direction along the west slopes of Dry Creek and DeLacy Creek basins to the rim of the Continental Divide then the descent into the West Thumb. As the road descends on a combination of tangent and very light curves, the mountains to the east become visible. As the road passes through a triple compound curve to the right, one would see Yellowstone Lake just before reaching West Thumb. This view was intended to take in not just Yellowstone Lake, but the lake's islands and the Absaroka Range. It was during this approximate time that the steel Herron Creek bridge was removed and culvert work was done at DeLacy Creek. Log guardrails were constructed on both segments. At one point on the road the landscape architects had a hand-placed embankment tree well put around a lodgepole pine tree just on the edge of the road.[120]

The grading project continued from 1935 to 1938 with contractors under the supervision of the Public Roads Administration completing the job. Combined with the final costs on the surfacing which was completed in July 1941, the total for the 17.083 miles was $359,949.75 or approximately $21,000 per mile. At its completion, the engineers recommended centerline striping over the entire 17 miles with double-line striping for curves. The engineers felt that the maintenance work would be reduced if the gutters were paved and other roadside measures taken. The engineers felt that "No unusual or difficult engineering problems were encountered . . . ."[121]

In 1944, the road project was considered 67 percent finished with some miscellaneous minor work and the bituminous surfacing yet to be completed.

By 1945, seeding of the roadsides had been completed, but the planting of trees, as specified in the contract, had not been done. The contract called for an unspecified number of 2-year-old pine and fir seedling stock trees and an additional number of trees up to 8 feet in height. The National Park Service felt that some natural reseeding of lodgepole pines had already begun and that any transplanted stock would have to come from within the park.[122]

In 1947, work on completing the surfacing of the road continued. Using material from the following sites, McLaughlin, Incorporated of Great Falls, Montana began work on June 15, 1947:

Plant mix aggregate --Stockpile at Dry Creek pit 4 ½ miles east of project.
Cover aggregate ------Stockpile at Old Faithful-originally produced from Basalt rock slide 2 ½ miles east of West Yellowstone
Concrete aggregate ---Sand from pit left of Sta. 342, Sec. 1-C2, Gravel from Yellowstone River at Livingston
Topsoil --------------Pit on old road 5 ½ miles east of project.
Liquid Asphaltic -----Rusky Oil Company refinery, Cody, Wyoming.
C.G.S.M. Pipe --------Armco pipe from Hardesty Manufacturing Company, Denver, Colorado

When the project was completed the following materials were stockpiled for use by the maintenance crews:

1850 tons plant mix -- at Dry Creek pit
165 tons 2 inch base course - at Dry Creek pit
700 tons 3/4 inch cover aggregate - at Dry Creek pit
85 tons 3/8 inch cover aggregate - along road 6 miles east of Old Faithful, and at Old Faithful power house.[123]

The new contractor used the same road camp, which was approximately at the midway point of the project, the previous contractor, Peter Kiewit, had used in the early 1940s.

The road was considered the heaviest traveled in the park carrying between 3,100 and 3,800 vehicles per day during July and August.

Part of this final work was the surfacing and finishing of the parking area on the east side of Isa Lake Bridge. The finished work included a boulder pavement guide marker between the traffic lane and the parking area. The guide marker at the Kepler Cascade parking area, completed at the same time, was a black, 1-inch chip material.

During the 1950s, 1,000 linear feet of log guardrail was replaced with guide posts.[124] The entire road section was rebuilt in the late 1980s.

WEST THUMB TO LAKE JUNCTION

One of the prominent features of this road section is the geologic feature, the Natural Bridge. In Philetus Norris' survey for possible routes in this area, he found the bridge to be his answer for bypassing the sandy spits, ponds, and numerous gullies near Bridge Bay. The bridge showed evidence of its use as a long-time game trail and Norris felt that as soon as funds became available, he would prepare the bridge for tourist use. In his 1880 report to the Secretary of the Interior, Norris described the area:

> What is now the bridge was once the brink of a cataract nearly one hundred feet high, over a ledge of peculiarly hard, durable, variegated trachyte upheaval to the vertical across the stream. Directly across this ledge countless ages of erosion have formed first a shallow, trough-like channel; then, or simultaneously with this channel, a vertical orifice, several feet long by one foot wide, between the strata, some two feet from the brink. There is farther upstream . . . one of the finest archways I have ever seen, has about ten feet of stone support for a carriage way above, and about thirty feet of waterway beneath. The chasm is fully spanned by the bridge, which, by measurement, I found to be twenty-nine feet long, and including the above mentioned vertical orifice, ten feet high above the top of the arch, and forty-one feet to the bedrock of the chasm, which, at this point is a rapidly deepening cascade. As the two outside layers of the vertical orifice, as well as the ancient channel, can readily be filled or floored with timbers. . . . this route will be one of the most traveled, and this natural bridge one day be crossed by thousands of pilgrims to this wonderland.[125]

Historical records indicate that the road across the Natural Bridge was not built by Norris and the travelers continued to use the Mary Mountain route to Yellowstone Lake until 1891 when a road followed the shore for much of the way from West Thumb to the lake outlet. In 1895, Captain Anderson completed a road from the Lake Hotel to the Natural Bridge.[126] In 1899, Hiram Chittenden began to plan the construction of 8 miles of road across the peninsula to replace the 12 miles of road built in 1891. The 1891 road that followed the shore had been severely eroded by the lake and had been abandoned and the portion that passed through the wooded section had been constructed over uneven and rough ground. Chittenden believed that this road was "the most monotonous drive in the park"[127] and that the road he planned would reduce the distance by 4 miles, it would be a better road and that the road would offer the visitors a view of the Natural Bridge. Chittenden estimated that the new road would cost approximately $2,000 per mile or a total of $16,000. In 1902, the new road was "put over the mountain by way of the natural bridge and the knotted woods" and the old section along the shore was abandoned.[128] In 1908, the road was surfaced and ditched and the 1909 report listed the road as in "very good condition."[129]

In 1923, the route from Lake Junction to West Thumb was evaluated again. The National Park Service's engineering division found:

> the existing road between Arnica Creek and Bridge Bay passes over high divide, necessitating a hard climb on one side and an equally difficult descent on the other. This 9 miles section is entirely void of scenic attractions and is a difficult piece of road to maintain because of steep grades and the absence of water for sprinkling. It is proposed to reconstruct the old original road along the shore of the lake, making an attractive drive on practically a water grade, and abandon the present road over the hill. . . . This crew (Cosey's Crew) is now moving to West Thumb to rebuild the log bulkhead along the lake shore. They should also place culverts and make fills in places of the three log bridges between West Thumb and Arnica Creek.[130]

Two years later, this section of road was included as part of the first three-year improvement program with the intentions for this portion to be completed in 1925. In a letter to the Director, Mr. Albright described the project

> I have discussed this project very thoroughly with our engineers and we have reached the conclusion that we can do this work cheaper by force account. If this was a case of constructing an entirely new road, there would be no question but what is ought to be done by contract. However, it is purely a matter of reconstruction. The old original road between Thumb and Lake Hotel followed the Lake shore quite closely as you note from old maps. In 1901 this road was abandoned when the cut-off road was built across the mountains. This cut-off road was apparently built to shorten the distance, but in order to make the change it was necessary to construct a highway with grades running up to 16%. The road possesses no scenic qualities whatever, has many sharp turns and narrow places where cars cannot pass and as I have just stated a maximum grade 18%. When the old road was abandoned in 1901, it was usable for several years, apparently was used; however, gradually the culverts and bridges which were of wood decayed and for the past twenty years the road has been impassable except to saddle horses and pedestrians. I have been over the road several times and there are many miles that are in excellent condition today; all these stretches of road will require widening and installation of drainage structures which, under our plans, will be galvanized iron culverts of proper sizes. We expect to do away with the two or three bridges by putting in culverts and making fills. In three places the road will be realigned in

> order to give better scenic effects of Lake Yellowstone, but these stretches are short.[131]

By 1926, the reconstruction of the 11-mile stretch along Yellowstone Lake between Bridge Bay and West Thumb replaced the steep, narrow, and uninteresting section that went over the hill. A ¾-mile section at Bluff Point had been widened.[132] Major landscape improvements were made to this section as part of the parkwide road cleanup project funded by John D. Rockefeller, Jr.[133]

The road which had been brought to the standard of the other main park roads, with the exception of side drainages, was oiled in 1928, and a new 2-inch oil top placed upon it during 1931. The 1931 oiling expedited the necessity for improvements to the side drainages to lower the water table under the road to avert corrugation from capillary action.[134]

In 1935, a field survey was completed for this road section, however no more major work was done until the Mission 66 period other than replacing 1,500 linear feet of guardrail with guideposts.[135] The Final Construction Report for work on this section during 1960-61 listed the project as

> The major improvement on this project begins at the Natural Bridge Road, approximately four miles south of Lake Junction, at Station 888, elevation 7753, and extends northerly 3414.82 feet to Station 922, elevation 7759. At Station 894+50, the road crosses the inlet to the Bridge Bay Lagoon on a 237 feet 8 inches three-span steel welded plate girder structure. All of the main improvement in on new alignment except for the last 200' to 300' on the north and where a tie is made to the existing Grand Loop Road. Immediately to the south, the project abuts the Bridge Bay-Arnica Creek project, which is now under construction. To the north of the project is a section extending to Lake Junction, approximately 3 miles long, which is still unimproved to Mission 66 standards.[136]

Other work completed on the project was the construction of spur roads, one extending 2,000 feet to the west end of the Bridge Bay Lagoon and another extending 400 feet to a future lake front parking area for fishermen's use. By the end of 1963, Long Construction Company of Billings, Montana had completed the work totaling $861,986.23. This section of road had received clearing, grading, an emulsified stabilized base course, a wearing surface of plant mix base course, bituminous and concrete curbs for traffic and water control, and a box culvert on Bridge Creek. The old Gull Point by-pass section was converted to a fishermen access and the construction of the Lake by-pass was begun in late 1969.[137]

LAKE JUNCTION TO TOWER JUNCTION

The first superintendent of Yellowstone National Park, Nathanial P. Langford, planned the present circuit system (the Grand Loop Road) soon after taking his position in 1872. His idea for a route through this section of the park called for the wagon-road to follow the Yellowstone River northward from its outlet to the Yellowstone Falls, past Mount Washburn and on to Tower Falls. Then Captain William Jones' 1873 survey for a wagon-road route from Camp Brown in northwestern Wyoming to Fort Ellis, Montana, recommended that the route follow the Upper Yellowstone River, via Yellowstone Lake, to Tower Junction and on to Gardiner, Montana through Mammoth Hot Springs.[138] The park received no appropriation until 1878, and by that time, the second superintendent, Philetus Norris, had to use the first appropriation for the construction of the road from Mammoth Hot Springs. However, Superintendent Norris, who spent part of 1878 exploring this section of the park, described the difficulties of finding a suitable route:

> From the falls of Tower Creek I explored its canon and the canon and valley of Antelope Creek above it, the timbered plateau between them, and also that between the latter and the Grand Canon. I found the latter very elevated, but open, smooth, and grassy, with a fine lake upon its summit, mainly an excellent route, with magnificent scenery along the yawning, sulphur scented and stained canon, for some 6 or 8 miles, and past the ruins of an ancient once loopholed, earth-roofed block-house some 16 by 20 feet in diameter and of unknown origin, to a dense forest at the foot of a bald rocky spur of Mount Washburn. . . . a careful exploration of the first one from its towering front in nearly a foot of newly fallen snow, through a belt of dense pine, fir, and cedars to near the main mountain, resulted in there finding a pass excellent for a bridle-path, and practicable for a wagon-road, at a much lower altitude than the old route. . . . I there, in the gathering twilight, thankfully enjoyed the greeting shout and blazing camp-fire of my men, just safely arrived with the welcome intelligence that they had found a route in all respects preferable to that over the mountain to Cascade Creek. . . . As before stated, portions of any possible route upon either side of the Grand Canon between the forks and the falls of the Yellowstone will be elevated and expensive especially for a wagon road. That upon the eastern side of the canon is utterly impracticable that within it, unknown but doubtless mainly so, while the two remaining that I explored is the shortest, least elevated, and the easiest of construction, in fact, in all respects so preferable that I have no question of its adoption for all purposes other than a lofty, bridle-path lookout, for which purpose a portion of the old route, a branch from the new one over Mount Washburn or both will be ever desirable. Not only was the route thus found less rugged and difficult than feared, but also the Grand Canon was shorter and especially its lower portion less deep and yawning than has been considered. Still it is especially from its yellow and crimson geysers to the falls, beautiful and grand beyond conception, a leading wonder of the park, and of the world, every way worthy of a route along or as near as possible to its misty and sulphur-tinted walls.[139]

The next year, 1879, Norris and his crew improved an existing trail from the outlet at Yellowstone Lake to the east canyon of the Gardner River, via the Mud Volcano, Sulphur Mountain, Great Falls and Canyon of the

Yellowstone, Mount Washburn, Tower Falls, and the Forks of the Yellowstone. The abundance of snow prevented Norris from completing a trail along the rim of the Grand Canyon of the Yellowstone, which he continued to feel was the "true one" for a wagon-road or bridle-trail to the eastern spurs of Mount Washburn, instead of over it.[140]

In 1880, several bridges were completed including ones over Tower Creek, Cascade Creek, and other creeks near the Great Falls of the Yellowstone.[141] The following year, two bridges were built on Alum Creek, two bridges over Sage Creek, and two bridges over Hot Spring Creek.[142] Norris knew that the road between Tower Falls and the mouth of Alum Creek would be costly to build. Together with the abysmal Tower Creek Canyon, the ascent of Mount Washburn via Rowland's Pass, the extensive need of rock-work, culverts, timber cutting, grading, and bridging along the route, Norris calculated that an appropriation of at least an additional $10,000 to supplement the regular appropriation might cover the cost of the road. The use of this amount would not allow for any other construction projects elsewhere in the park.[143]

Finding the construction of the section along the bank of the Yellowstone River as costly as Norris predicted, his successor, P. H. Conger, completed a 3-mile section of road along the bank of the Yellowstone River near the falls and canyon. This provided the tourists with safer and more comfortable access to the wonders.[144]

Compared to the roadwork between Mammoth Hot Springs and Madison Junction, very little work was done on this section after the U. S. Army Corps of Engineers assumed the responsibility for road construction and improvement in 1883. By 1885, $25,000 had been spent on the construction of a road from the Yellowstone Falls via the east trail over Mount Washburn to Yancey's on the Mammoth Hot Springs road. In 1887, the road from the Yellowstone Falls to Yellowstone Lake was described as "not ordinarily in condition for travel before about the middle of July, the altitude being such as to prevent the early melting of the snow.[145]

During 1888, the engineers recommended that the 14 miles of rough road from Yellowstone Lake along the Yellowstone River to the Grand Canyon of the Yellowstone be improved and completed and a new 20-mile road from the Grand Canyon to Yancey's Hole should be built. In the 1889 report to the Secretary of War, Major Allen noted the bridges in the park. Among those listed were a 115-foot trestle, with a 14-foot wide roadway and 30 feet above the low water at the middle point near Yellowstone Falls, and a 40-foot, one-span, King and Queen post-truss bridge with a trestle approach of 30 feet over Cascade Creek. The height above the low water was 20 feet.[146]

The road from the Grand Canyon of the Yellowstone to West Thumb via Yellowstone Lake was one of Lieutenant Hiram Chittenden's first projects after he assumed the responsibility of the road improvement and construction in the park in 1891. By 1892, the 52-mile road from the Grand Canyon to the Upper Geyser Basin via Yellowstone Lake, which opened during the fall of 1891, was in good condition.[147] In 1893, work continued on the road that passed near the Upper Falls and a road near the Grand Canyon at Inspiration Point was opened.[148] In 1894, the crews completed an arch bridge near the Upper Falls. In the following year, 1895, a new road was built from the brink of the Grand Canyon to Inspiration Point, via a point over the Lower Falls, and another new road was built from just south of Alum Creek around Sulphur Mountain, joining the old road near Antelope Creek.[149]

In 1896, Captain George Anderson, the park superintendent, engaged the chief engineer of the Northern Pacific Railway to develop plans for an iron bridge across the Yellowstone River above the Upper Falls. Determined that the visitors should be able to view the Grand Canyon from the eastern bank, Anderson decided that if the cost were not excessive, he would have an attractive iron bridge built.[150]

In 1899, Hiram Chittenden returned to Yellowstone to resume the responsibility for the road construction projects. In his 1899 report, Chittenden described the road along Yellowstone River:

> This length of 15 miles is one of the best-graded roads in the park, carefully laid out by instrumental survey and equal in this respect to any road in the world; but the material of which it is made is for the most part utterly worthless. The road becomes practically impassable in wet weather and well nigh intolerable from dust in dry weather. It must be surfaced with rock or gravel. The work is urgently needed and should be done during the next season. . . . This road [new road on right of Grand Canyon] is to connect with the bridge and give access to the right bank of Grand Canyon for about 3 miles below bridge. The present road is one of the hardest to maintain in the park. It has steep grades, is very narrow and is held up by loose retaining walls which are constantly caving in. The material is also very bad and cuts all to pieces in wet weather. It is proposed to bridge Cascade Creek farther upstream and carry the road to the hotel at a higher level. This work will greatly relieve the task of maintenance in this vicinity.[151]

During the summer of 1903, two crews constructed approximately 5 miles of well-graded road. A portion of this road was near the Canyon Hotel, and the other was near Tower Falls. The work near Tower Falls, which extended into the winter, was of "a very heavy character" as part of the road lies under an overhanging cliff. Chittenden described this segment as a "road of great scenic beauty."[152]

The construction season began late due to remaining snow and soaked ground, leaving few places for desirable camps. However, by the end of the 1904 season, a passable wagon-road on the canyon side was opened to within a mile beyond Dunraven Pass and 2 ½ miles from the summit of Mount Washburn, but Chittenden urgently requested that more money be obtained for the final completion of the road. He stated in his report for 1904 that "This will be by far the finest road for scenery in the park," but "as it rests on the precipitous sides of the mountain it is important to expend considerably more money to increase its width and erect guard walls at dangerous places." Captain Chittenden feared that the stage companies would not use the single width road until it was completed. Chittenden found this particular project to be very difficult mainly due to the lack of desirable camping places, the high altitude, and the great proportion of work through rock.[153]

One of Chittenden's major achievements, the Yellowstone River Bridge, later known as the Melan arch Chittenden Bridge, was a steel and concrete bridge completed in 1903 with great difficulty. He felt that its prominent location in the park merited the bridge to be of an artistic design. For many years the idea of a bridge in this location had been contemplated, but lack of funds prevented its construction. He spent considerable time on the site selection.

Not wanting to introduce an artificial structure at the most desirable and obvious site, the brink of the Upper Falls where the gap narrows to 50 feet, Chittenden chose a 120-foot span between two jutting rocks, about ½ mile above the Upper Falls at the rapids. Despite the volcanic rhyolite rock being of inferior quality for construction, he reported ". . . the fact that it has resisted for an indefinite geological period the action of the river, it must have considerable stability."[154]

Including dangerous rapids below, Chittenden had many obstacles to overcome. One of the most serious was the construction of the framework and related framing. All of the rough material was cut locally, but the finer lumber came from the Pacific Northwest. Using a small dynamo, borrowed from the hotel company, that was connected to the rock-crusher engine along with a temporary plant to provide artificial light, the crews were able to complete the concrete work by working around the clock. Due to the position the bridge had in the public's eye and its unique construction difficulties, the owners of the Melan arch patent relinquished all royalty payments. Some of the material for this bridge as well as material for the others built that year came from the American Bridge Company.[155] After considerable controversy, the bridge was removed in 1962.

Before transferring to Mount Rainier National Park at the end of 1905, Chittenden summarized the state of the road system in the park, and made recommendations for future work. For this section of the Grand Loop, Chittenden recommended:

> Lake Junction to Canyon Junction--Concrete culverts should replace the bridge over Sulphur Creek and the one over a stream to the south of Otter Creek. Eighteen-inch pipe culverts should replace two short bridges on the sidehill grade above the second milepost from the Grand Canyon. The Alum and Otter creek bridges should be rebuilt with shorter spans.
>
> Canyon Junction to Tower Junction--earthen embankments and pipe culverts should replace most of the temporary bridges on this route. In some cases, wooden cribs should support the lower side of the embankments.[156]

Chittenden believed that these timber cribs when filled with rocks would last for twenty or thirty years. He suggested a possible change to the road location from about 1 ¼ miles south of Dunraven Pass to the top of the ridge, where the climb from the hotel at Canyon ends. The original intent was to build on a near level line, however, the surveyor who was told to run a constant grade between the two points, became leery after seeing that a swampy area lay in his path. Without permission he ran the line above the swamp resulting in a rise and fall of 70 feet on the line. Chittenden did not feel that the difference was that great but wrote, ". . . nevertheless, the location is not what was intended and not what it ought to be."[157]

Other recommendations for this section:

> The little hill about 5 ½ miles below the Lake Hotel and another hill a little farther down, where a branch of the Yellowstone flows around an island very close to the

> road and forms a fine trout pool should each be cut down about 10 feet. The considerable hill in road below the sixth milepost should be cut down to the level for the bench on which the road lies on either side of the hill. A strong timber crib should be built in the water's edge to support the road. . . . The side road from the steel-concrete bridge to Artist Point should be given extra width at the lower end, in order that coaches after unloading at the Point may return far enough to be out of each other's way while waiting for the passengers. All of the down timber in the narrow and picturesque valley near the Point gathered up and burned.[158]

In 1907, a survey for a new lower level road to connect Canyon and Tower Falls was undertaken since the existing was not passable until the middle of July. The crews replaced railings on the bridge at Canyon Junction; replaced the bridge over Sulphur Creek with a iron culvert 3 feet in diameter and covered with fill 100 feet long and 14 feet deep; replaced another bridge, 20 feet long, 2 ½ miles south of Canyon with a culvert and necessary fill; and installed three culverts on the Canyon to Inspiration Point road.[159]

In 1912, the 60-foot Alum Creek Bridge, with a sunken center pier, was in very bad condition. A pile trestle bridge was suggested as its replacement. A pile trestle bridge consisting of pile bents and wooden stringers was recommended as a replacement for the 32 feet Otter Creek Bridge that was also in very poor condition. In 1913, a rock-filled log crib was constructed at the canyon near the Upper Falls to replace a retaining wall that had collapsed during the spring of 1912.[160]

Prior to the road improvements and construction program being turned over the newly created National Park Service, Captain John Schultz summarized the condition of the park's road in 1917. The Tower Falls to Lake Junction segment was described:

> Lake to Canyon road should be routed via Sulphur Mountain from Trout Creek. Sulphur Mountain is very interesting and should be shown to the passengers. This road is not more than a mile or so longer than the present road. There is an old road going this way which is in very good condition and could be traveled if one or two culverts are replaced. This takes one farther into Hayden Valley, where elk are very often seen.
>
> Bridge across Alum Creek a foot below the road bed and about four inches above the water level.
>
> Road along the Yellowstone at the rapids and upper falls very narrow and dangerous. Heavy guard rail should be placed along there.
>
> Approach to the concrete bridge from the opposite side of Yellowstone River in very bad condition.

> Going from Canyon toward Dunraven Pass along the hillside half a mile before reaching the entrance of Dunraven Pass, the road should be graded to slope toward the bank and logs should be imbedded along the outer edge of the entire road from this point for about a mile.
>
> Road over top of Mt. Washburn should be cleared of rocks small and large. It is very difficult for a large car to go up there at the present time and extremely hard on tires, as the road is practically covered for miles at a time with sharp stones which have blown onto it.
>
> The last three miles before reaching Tower Falls the road is very rough and narrow and worn. Two or three severe chuck holes.[161]

The next major project for this road was a widening project over Dunraven Pass and at the Grand Canyon of the Yellowstone, and the construction of stone parapets between the Upper Falls and the Canyon Bridge in 1921.[162]

TOWER JUNCTION TO CANYON JUNCTION

In the fall of 1926, E. E. Snyder of the Bureau of Public Roads made a reconnaissance survey for road improvements and construction of the Tower Junction to Canyon Junction section of the road, followed by a location survey by A. O. Stinson, Bureau of Public Roads, in the fall of 1929. The location survey revealed that the plans to use as much of the existing road between station 230 and 413 were not feasible. The National Park Service wanted to use the alignment of the old road for scenic reasons and to also maintain the Mount Washburn connection. However, the park officials agreed with the Bureau that few scenic views would be sacrificed by using a more direct and economical route at a lower elevation. Thus in May 1930, another survey was completed. In August 1930, Morrison-Knudsen Company of Boise, Idaho received the contract and began work by August 9.

The contractor selected three camp sites, Camp "A", which accommodated 100 men, on the left of station 105; Camp "B", which accommodated 40 men, on the right of station 450; and Camp "C", which accommodated 60 men, on the left of station 740. The road camp buildings were constructed of rough pine with heavy tar paper roofs and thin paper walls.

This construction project extended from a point ½ mile south of Tower Falls to a point 1 ½ miles north of the Grand Canyon rim. The grades from station 0.00 to station 230 ranged from 2 to 7 percent where it goes over Dunraven Pass, then follows a near level grade along the flank of Mount Washburn, then goes from 4 to 6 percent grades, crossing over the ridge to Antelope Creek basin, terminating at Antelope Creek at the end of the project, station 839+75. Prior to this improvement, most of the traffic that entered the park from the south and east entrances turned off at Canyon Junction to avoid the excessive grades and sharp curves on the narrow road. In 1930, the cutoff from Canyon Junction to Norris Junction was the major freight route from Mammoth Hot Springs.

The contract called for the construction of an earth-graded 18-foot Standard Type 100 road, and the installation of 4 X 4, 5 X 5, 6 X 6, and 8 X 8-foot concrete box culverts; and 24-inch, 30-inch, and 36-inch corrugated galvanized metal pipe culverts, all of which were to have rustic cement rubble masonry headwalls. The contract also specified the construction of cement rubble masonry and wood guard railing.

A 1-Yard Northwest gas shovel, two 7-Yard LaTourneau Hydraulic scrapers, a scarifier and three 60 Caterpillar tractors began work on September 3. A 60 Caterpillar and cables lowered materials for the 6 x 6-foot box culvert down the mountainside at station 194+50. Five wood-burning stoves were fired up upon the arrival of cold nights. Before closing down for the winter on November 14, the Caterpillars and scrapers had to clear a road through the snow for the men to leave in their trucks and cars. During the winter, a watchman was left at Camp "A" and one at Camp "C."

Work resumed on May 19, 1931. The snow was still 3 to 5 feet deep between stations 230 and 538, but the contractor was able to open ditches and get his equipment prepared. Between stations 833 and 836, the crews built a hand-laid rock embankment on a 1 1/4 slope which merged into the newly built cement rubble masonry retaining walls of a 1/4 to 1 slope in such a manner that "it made an exceptionally neat appearing job for which there were many compliments."[163]

Six box culverts were installed on the segment, but no major structures were part of the project. The sand and gravel material for the box culverts came from a pit along the Yellowstone River about 12 miles from the project. The surfacing material for the section between stations 704 and 839 was obtained from a pit on the left of station 725. Other surfacing material came from the cut area between stations 109 and 112.

The grading project was completed ahead of schedule on September 15, 1931, despite 65 of the men being "drafted" by the National Park Service to fight the Heart Lake fire for a month during July and August of 1931.[164]

By the fall of 1933, the project was surfaced and the Tower Creek Bridge had been completed. Between the time of the grading and the final surfacing, this segment had experienced many slides and many of the fill areas had settled from 1 to 2 feet. Thus at the beginning of the 1934 season, these problems had to be resolved. It became apparent that much of the segment needed additional drainage. The engineers realized that in Yellowstone there is "the necessity for stage construction and the use of an oil processed crushed rock surface for a considerable period of time before the placing of a permanent surface."[165]

In early October 1933, a few days after the surfacing had been completed on the Tower Falls to Canyon Junction segment, a massive slide occurred on the vertical face of Overhanging Cliff near Tower Junction. Due to the instability of the formation and the risk to property and life, the slide removal and restoration was delayed until the next season. Plans had to be drawn to take off part of the cliff during the slide removal. S. J. Groves and Sons Company of Minneapolis, Minnesota received the contract for the low bid of $11,435. Following the removal of the debris, the masonry guardrails and the hand laid rock embankment with masonry toe wall had to be reconstructed.[166] In 1935, more columnar basalt dropped into the ditch under Overhanging Cliff. The Bureau of Public Roads planned for one of their contractors to use the stone, however, the National Park Service wanted it left to protect the underlying gravel in hopes it would prevent further erosion and hence prevent more of the columnar basalt from falling. The National Park Service did allow the contractor to use the loose, talus slides just south of the Overhanging Cliff for use as surfacing aggregate.[167]

Also during 1935, time was spent trying to obliterate and improve old roads, including one between the Melan arch Chittenden Bridge and Canyon Lodge and one north of Tower Falls and the southside of the first gulch east of Camp Roosevelt.[168]

The next major project on this stretch, planned prior to the beginning of World War II, but was not actually completed until 1949, was a grading and surfacing project in the vicinity of the connecting road leading to the rim of the Grand Canyon of the Yellowstone and the connecting road into Canyon Hotel and parking areas. Shortly thereafter, minor slides and one major slide involving about 4,000 cubic yards covered the new road between stations 13 and 18. The investigation into the cause of the major slide revealed that:

> numerous indications of previous land movements in the area immediately above and to the left of centerline of the new highway between stations 12 and 60. The main cause of these land movements appeared to be the extremely `greasy' character of the soil, aggravated by water seeping from a series of ancient pits or `Buffalo Wallows' above the new highway. It was at one these pits, approximately 175 feet left of the centerline of the new highway, that the major slide apparently originated. Test holes were drilled on a parallel line, approximately 200 ft. left of centerline, and entrapped water was encountered at a depth varying from 5 ½ to 6 feet below the surface of the natural ground. This trapped water apparently seeped through a stratum of soft material overlying a stratum of hard clay.
>
> Corrected measures consisted of excavating a 400-foot-long trench to the depth of the hard material, installing 6-inch vitrified clay pipe and backfilling with previous sand backfill to a depth approximately 6 inches below natural ground surface. This was in turn covered with heavy rock to prevent surface erosion. The excavated material was shaped into a neatly rounded berm below the trench. This construction served the double purpose of removing the trapped water and also of conducting surface water away from cut slopes and roadway and depositing it in a natural drainage channel left of station 19. Excavated material from the slide was spread uniformly over the fill slopes between stations 6+50 and 12+50 of the Cascade Creek fill.[169]

At the completion, a standard 28-foot shoulder-to-shoulder grading was followed with 6 inches of crushed stone base course treated with MC-1 asphaltic prime. Many minor culverts were installed and the timber guardrail was replaced.[170]

In 1957, new guardrail was installed on the Tower Junction to Canyon Junction section and in 1960, the section was resurfaced and repairs were made to the earthquake (1959) damaged sections. More improvements were carried out in 1962 and in 1966, the Calcite Springs overlook and parking area was reconstructed. In 1985, 4,787 linear feet of wooden guardrail was installed between Dunraven Pass and Tower Junction and more repairs to the rock wall along the roadside at Calcite Springs were done.[171]

CANYON JUNCTION TO LAKE JUNCTION

During 1931 to 1932, a location survey report was prepared for the Lake Junction to Canyon Junction Road. The report found the Lake Junction to be "favorably situated with regard to traffic in either direction on the Grand Loop, but unfavorably located with respect to the development at Lake Lodge and Lake Hotel, . . . Tourists entering the Park via the East Entrance, may pass north of Lake Junction without being aware of the accommodations at these places".[172] The report described the road from Lake Junction northwards to Canyon Junction

> average twenty feet in width and is partially surfaced and all treated with an oil dust palliative. The alignment and grade is fair throughout a large part of the distance, except for occasional dangerously sharp curves and steep grades which appear without warning other than road signs. The most dangerous part of the road is the so-called Trout Creek Hill descending Elk Antler Creek, a small creek seemingly in the Trout Creek valley. This hill combines a sudden excessive drop in grade, when driving northward on the road, with two sharp reverse curves on a steep slope just above the Yellowstone River.[173]

The report described the recently constructed low type load road up Otter Creek to the newly built bear feeding grounds, however the report supported the reconstruction of the road to a higher standard. It also stated that the branch road over the Melan arch Chittenden Bridge to Canyon Lodge on the east bank of the Yellowstone River was being improved at the time. The engineers found the beautiful, narrow Melan arch Chittenden Bridge to be adequate for the present, however signs of disintegration were noted.[174]

The Inspiration Point Road from the Canyon Hotel junction had been improved to a higher standard and was deemed adequate for a number of years. Some of the improvements had included widening.[175]

Another location survey report for possible relocation of portions of this section was completed in 1937. The report recognized that the construction of an 800-foot bridge over Cascade Creek would boost the expense of the project. In order to conform with the improved portions of the Grand Loop Road adjacent to this section, the report called for the section to be graded to a 28-foot shoulder-to-shoulder width with an ultimate surfaced width of 20 feet. Due to the poor subgrade materials along the entire route, subgrade reinforcement for a depth of 6 inches compacted would be necessary. The engineers suggested that this material could come from a quarry on Dunraven Pass.[176]

By 1939, no progress had been made on this section. The Bureau of Mines was consulted in regard to possible gas hazards on proposed bridge foundation sites in the park. The Cascade Creek Bridge was one of the questionable proposed new bridge sites. The Bureau, who investigated the effect of sulphur compounds on various materials, concluded that ". . . it would not be sound engineering to set concrete piers or steel structures in or on the rhyolite formation investigated by them in the acid or sulphate areas of Yellowstone Park. Evidence points to the ultimate failure of concrete foundations in such locations due to one or all of several causes--subsidence, slides, and chemical action."[177]

All major work in the park was suspended during the United States' involvement in World War II, and with the increased construction costs and several other unanticipated factors, the accepted designs did not consider some essentials. Drainage structures in necessary areas were eliminated, the rolled earth gutter section across the embankment at Cascade Creek was not adequate to prevent erosion, and many of the surfaced areas were not satisfactory. During the early 1950s, 2,000 linear feet of guardrail was replaced with guide posts and 5,000 linear feet of guardrail was treated with linseed oil.[178] More of the surfacing for the Grand Loop and the Canyon parking areas was done in 1952, with additional surfacing work being done in 1962. Also in 1962, 3,058 linear feet of guardrail was installed and work was done at Otter Creek. In 1985, 110 linear feet of new roadside concrete gravity wall with stone face veneer and masonry parapets, 35 feet of 6-inch asphalt curb, and 260 feet of 2-inch asphalt walk was put in at the Sulphur Caldron.[179]

TOWER JUNCTION TO MAMMOTH HOT SPRINGS

In Superintendent Philetus Norris' first report to the Secretary of the Interior in 1877, he deemed the construction of a wagon road from Mammoth Hot Springs to Henry's Lake via the Tower Falls, Mount Washburn, Cascades, Yellowstone Falls, the Lake, Firehole Basin, and the Nez Perce route through to the west side a "pressing necessity". The following year, Norris' top priority was the construction of a road from Mammoth Hot Springs to the Lower Geyser Basin. However, a small crew did begin work on a new road on the Gardner River toward the Yellowstone Falls and Yellowstone Lake.[180] In 1879, the road crews improved the route from Mammoth Hot Springs to Yellowstone Lake via the Mud Volcano, Sulphur Mountain, the Falls, Mount Washburn, Tower Falls, the Forks of the Yellowstone, and the east canyon of the Gardner River.[181] Evidently not satisfied with the route from Mammoth Hot Springs via the Falls to Yellowstone Lake, Norris spent the last few days of the 1880 season exploring for a new and shorter route from the Cascades of the East Gardiner, through a pass in the Stephens Range east of Thompson's Peak, and through another pass of the Washburn Range at the head of a fork of Cascade Creek, west of Dunraven Pass. Bridges were constructed on several streams including branches of the Gardner River.[182] In 1881, Norris' assistant, C. M. Stephens, supervised the construction of a bridge over the east fork of the Gardner River, a bridge at the head of the middle falls, one bridge at the head of the upper falls of the east fork of the Gardner River, one bridge over the main Blacktail Deer Creek, one bridge over Elk Creek near Dry Canyon.[183]

In 1887, the Army, who assumed the responsibility for road construction in 1883, described this section of the road and on to Cooke City over which all supplies for the mining camp are freighted as "rough and hilly country and throughout the greater portion of its extent is unimproved. Some slight grades have been made where it was absolutely necessary and a few crude bridges constructed. The road has been chiefly built and kept in repair by private enterprise and is by far the worst road in the Park, being well nigh impassable a large portion of the year. . . . In my last annual report I recommended the construction of a good road . . . to be continued down the Yellowstone to a junction with the present road to Cooke City, the latter road to be improved from the point of junction to Mammoth Hot Springs."[184]

In 1896, a survey was completed for a new improved route eastward from Mammoth Hot Springs.[185] The following year, the Army planned to build a new road section from Undine Falls on the East Gardiner at the south side of the canyon to Mammoth Hot Springs. The older mail route to Cooke City followed along the north side of the canyon which is "both difficult and dangerous for vehicles." The Army found that this section required "About one mile of the heaviest, most difficult and most expensive work, . . . requiring in one place a stone retaining wall and substantial danger guard . . . the remainder with the exception of the approaches to the proposed bridge across the Middle Gardiner embraces no difficulties of importance."[186]

Another survey was made on a section of the Mammoth Hot Springs to Tower Falls road during April and May of 1902. The crew covered a 6-mile segment from Crescent Hill to a crossing of the Yellowstone and beyond. Captain Chittenden of the Army Corps of Engineers described the work in his report of 1902:

> The old road down into the valley while comparatively direct takes a drop of 1300 feet in about 3 miles and with grades corresponding and it was to eliminate these gradients that the new road was located and constructed. From Crescent Hill the location for the new road was carried well up on the side of the mountain to avoid drifting snow in the winter time. A 6% grade was used for 1,600 feet in gaining the summit. In getting down to the river from the summit at Crescent Hill and the Yellowstone River at the crossing was found to be 1,571 feet, while the distance was 5 miles. Immediately upon crossing the river a 10% grade for about 1300 feet was established in order to reach the high land above the river quickly and to avoid heavy rock work. The construction party consisting of 40 men and 10 teams with camp equipment left the Springs on the 10th of March and Crescent Hill was reached and camp established on the 13th. The instructions to the road crew were to construct a correct but narrow road down the mountain surveyed, the idea being that the road once established on proper lines could be brought up to the standard of the park roads at a later season. Considerable rock was encountered during the construction and to avoid work of this character as much as possible considerable cribbing was put in, 260 linear feet all told. The amount of solid rock handled was 2,176 yards costing $1395. The amount of loose rock handled was 3,643 cubic yards costing $1,092.90. The amount of earth handled was 17,709 cubic yards at a cost of $3,187.62. The right of way cleared of timber to an average width of 33 feet. All stumps were grubbed and the refuse either burned or hauled to one side. There was 14,800 linear feet of bridging built, including 80 linear feet of culverts,

> part of the lumber used was sawed on the ground. The balance was hewed logs and poles. The bridges are 16 feet wide. The cost of the 431 linear feet of bridging was $599.86 at the rate of $1.39 per linear foot. The cost amount given above does not include the subsistence of the men nor the prorated office expenses of the party.[187]

By 1903, grading had almost been completed on the road from Mammoth Hot Springs and three piers of the new high bridge for the Gardner River crossing had been placed. The steel for this bridge and eight others had been delivered from the American Bridge Company.[188] The next year a ½-mile section of the old road was rebuilt and rerouted to eliminate a dangerous segment near Ox Bow Creek and the Crescent Hill Canyon road was "widened to full width".[189]

The new five-span steel arch bridge over the middle Gardner River, also described as the "new high bridge," was the largest bridge in the park. Each span was 76 feet and each of the two approaches were 15 feet totaling a length of 410 feet. The floor was 70 feet above the river surface. The construction of this bridge at this location eliminated nearly 2,000 feet of road and a 60-foot rise and fall at this crossing of the river as compared with the old road.[190] During 1905, Chittenden studied the possibility of rerouting at least 1,000 feet of the road near the head of the falls of the East Gardner River and at its crossing. Chittenden questioned the location of the dangerous section that had been built eight years before. He felt that it probably should have been built on the lower location. Several very large slides during the winter of 1905-1906 destroyed large sections of retaining walls and the resulting condition of the road just reiterated Chittenden's position. The transportation companies also expressed their concern over the safety and condition of the road. The concessionaires felt that even if the retaining walls were rebuilt, the width of the road made it too dangerous for four-line teams to pass safely. Chittenden knew that in order to make the road safe, the road would have to be widened. This would be a costly procedure as a considerable distance of widening would be through solid rock with a depth of 20 feet or more. Thus, Chittenden recommended a new lower route that would be more satisfactory. His successor, Lieutenant Peek, agreed with this recommendation; however, lack of funds prevented any action in 1906.[191] Numerous bad slides occurred on the road about 3 ½ miles east of Mammoth Hot Springs during 1907. The bad conditions in this section of the road reinforced Peek and Chittenden's decision to reroute the road to better ground and also to avert a long grade.[192]

A period of inactivity followed for the next few years. Chittenden and Peek's recommendation was tabled, but the "high" bridge was repainted in 1913 as part of a parkwide bridge improvement program.[193] The next major road program affecting this section came after the Bureau of Public Roads assumed road construction responsibility in 1926.[194]

Among the first reconnaissance surveys planned by the National Park Service for the Bureau of Public Roads was the Mammoth Hot Springs to Tower Junction segment.[195] Location surveys for the road were made in 1930 and in 1932. In 1933, Emergency Conservation Work funds employed local men to work on the Mammoth Hot Springs to Tower Junction project. The men worked well into the winter on this segment nearly completing the grading between Tower Junction and Lava Creek.[196] The grading and surfacing were handled under several contracts with the bituminous surfacing completed in 1936. Attention and study had been given to the "high bridge site" as early as 1929. A well-known landscape architect, Gilmore Clark, of the New York Westchester County Park Development included his assessment of the bridge site in his "Mammoth Plan." Clark agreed with the proponents of a "high bridge" plan as it was suitable from a landscape viewpoint. The Bureau of Public Roads ran various alternate lines and figured several cost estimates for the bridge location. Finally in 1935, all interested parties mutually agreed that the "high bridge" should be constructed.[197]

During the construction of the "high bridge," the Gardner River Bridge, the road crews obliterated many of the old road scars from the various routes, some dating to the 1880s.[198]

NORRIS JUNCTION TO CANYON JUNCTION

During 1885 and 1886, James Blanding, Oscar Swanson and the road overseer, Ed Lamartine began construction of the first road from Norris Geyser Basin to Canyon.[199] In 1887, $12,000 was spent on finishing the 12-mile road, which had only been graded for the first 8 miles east of Norris.[200]

By the end of the nineteenth century, Army Corps officer Hiram Chittenden considered the reconstruction of this section of road "of pressing importance." He described the road as having:

> three of the worst and most dangerous hills on the entire system. The Virginia Cascade hill is a positive menace to the lives of travelers. Several accidents have occurred here, . . . Stage drivers are often compelled to make passengers alight and walk down the hill. The Devil's Elbow --a very short turn of nearly 80 degrees is another dangerous place. Blanding Hill is a long, difficult, and dangerous ascent which is impossible to maintain in good condition. The long hill descending into the valley of the Yellowstone is composed of wretched material, which so cuts up in wet weather as to be impossible of ascent by loaded wagons. The dense forests on top of the plateau retain the snow so late that it has to be shoveled out every spring at great expense. It is proposed to cut out some of the hills, reduce the grades on others, surface the bad stretches and clear the timber away on the north side of the road so as to let the sun in. . . . It is estimated to cost as much as an entire relocation or about $2,000 per mile for 10 miles.[201]

In 1903, Chittenden relocated the most dangerous section, eliminating the bad hills and the dangerous curve, the Devil's Elbow, by carving a road into the face of the cliff. In addition to achieving a safer route, "this road had materially added to the scenic effect of this canyon."[202]

In Chittenden's assessment of the roads in the park just prior to his transfer to Mount Rainier National Park in 1905, he called the Norris Junction to Canyon "the least satisfactory road in the park." Despite correcting the most dangerous curves, eliminating the bad hills, clearing timber for 30 feet on the south side of the road, he recommended:

> To further improve this road and produce the best practicable solution of a very difficult problem, the remaining hills and hollows should be graded out, the roadbed should be built up more deeply with the native material, so that there will be a heavier cushion over the underlying rock, and the entire road should be sprinkled if possible so as to hold the surface from disintegration in extremely dry weather. With these measures taken it is believed that the road can be kept in fair condition. The cost of transporting crushed rock or gravel from any available quarries is too great to be considered for the greater portion of the road.[203]

The 1909 spring snow, which lay very deep on the road, caused significant damage to the road despite the struggle by the road crews to drain it. Two crews ditched and graded the hills and made necessary gravel fills so that at the end of the 1909 fiscal year, the Army engineering officer considered the road to be in "very good condition."[204]

The entire road was graded in 1911 and numerous culverts and one bridge were repaired. Two years later, the retaining wall at Virginia Cascades had been destroyed as a result of severe weather conditions. The crews repaired two bad washout sections and they constructed a dry-rubble guard wall. Part of the road section was resurfaced with local materials.[205]

In 1914, a new route was suggested for the stretch of road from Canyon west to the Virginia Cascades. The road would leave the Canyon area, proceed to Cascade Creek to Grebe Lake, following the Gibbon River into Virginia Canyon. All of the transportation companies operating in the park endorsed the new route, despite the fact that it would be 6 ½ miles longer than the old route. Other factors such as its nearness to water for sprinkling and its more scenic river travel made the route more favorable.[206] However, permitting automobiles to enter the park the following summer prompted the park to reverse their plans for the new route.

> It is recommended that this work be not done for the reason that automobiles have been authorized to use the park, beginning August 1, 1915, and that undoubtedly automobiles will increase to the point where animal transportation will be the exception and not the rule. Since considerable increases in distance and grades is of little consequence to automobiles and as the road from Mammoth Hot Springs to Canyon by way of Dunraven Pass or Mt. Washburn and Tower Falls is one of the scenic routes in the park, all automobiles will take it, so that within five years the Norris to Grand Canyon will be used only for freighting, which will probably be mostly automobile trucks and occasionally by persons in autos and carriages who desire for one reason or another to make a short cut. Therefore while the construction of this new road would be a vast improvement in grades, ease of maintenance and scenic value, over the present road it would be still only a connecting road between the east and west roads of the main belt line, and used only incidently the moment autos became general.[207]

In 1926, another survey of the road conditions stated that extensive reconstruction was needed on this section. Many places needed widening, many grades needed improvements, and "numerous sags and humps" needed elimination. The report called for the installation of metal culverts, construction of "substantial retaining wall and parapet at Virginia Cascade" and surfacing the road with crushed rock and oil treatment.[208]

This section received more attention in 1934, in the planning of a new junction at Norris. The Park and Bureau officials felt that the road should be moved approximately 15 feet to "develop the views of the Cascades and the Canyon to the best possible advantage." No precise location was decided and no substantial work was initiated.[209]

Five years later, no major work had been done and the condition of the road became a discussion point at the congressional appropriation hearings. Arthur Demaray, Associate Director of the National Park Service, stated:

> this road section has been purposely kept in a low-class secondary condition and tourist traffic over it discouraged as much as possible. About five years ago we laid down a substantial oil mat in place of the dust oiling treatment which we had been carrying on annually. This improved surface proved a temptation to speeds higher than the grade and alignment could safely carry, hence our justification for allowing a measure of surface deterioration, but it is not felt that this had contributed to the traffic hazard if the restricted speed regulations are observed.[210]

Demaray explained to the congressional committee that it would be a number of years before any major reconstruction or rerouting would be done, but with some additional funding, he proposed a betterment program for an interim solution. The temporary measure would include:

> cutting down of several blind vertical curves that have been the contributing cause of the majority of accidents on this road, widening the cross section in cuts too narrow for safe passage, stabilization of the wet grade in the last mile into Canyon Junction, and complete oil treatment of most of the section. The surplus material from excavation of the vertical curves would be used to raise the grade on poorly drained sections and some additional material would have to be hauled in for grade raising and select surfacing material.[211]

America's entry into World War II prevented only the most minimal road construction or maintenance in the park, thus the reconstruction of this section was delayed again. Only a hot spot was repaired by covering it with a concrete slab during the 1940s.

At the end of the decade, the South Entrance Road and this section were deemed to be in the worst condition of the whole system.[212]

In 1952, a location survey report was completed by the Bureau of Public Roads, but it would be September 1966 before this road section was completed. The 38-foot-wide road had a 1 ½-inch thick bituminous base covering 30 feet. This project also included the Norris by-pass and road obliteration.[213]

CONCLUSION

In summary, the Grand Loop Road is significant as the first, large-scale designed planned system giving people access into the "scenic splendors" of Yellowstone National Park. One of the significant considerations is the fact that the early configuration provided accessibility to the major geologic and scenic wonders. The road has been constructed over many decades with many different standards, techniques, many different materials, and under many administrators. While the Grand Loop Road has basically the same configuration as it was first built, many of the present day road segments may be on the original alignment or in many cases, the alignment could be off several hundred yards or more. But still, the Grand Loop Road has basically the same configuration as it was first built.

ENDNOTES

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2. "A Great Figure of the Yellowstone--General Hiram M. Chittenden," *Livingston Enterprise*, n.d. Hiram Chittenden Papers, Washington State Historical Society, Tacoma, Washington.

3. Culpin, 489.

4. Bruce LeRoy, ed., *H. M. Chittenden: A Western Epic* (Tacoma, Washington: Washington, 1961) 21.

5. Culpin, 490.

6. "A Great Figure of the Yellowstone . . . ."

7. Culpin, 491.

8. "A Great Figure of the Yellowstone . . . ."

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10. Hiram Chittenden, "Reinforced Concrete Arch Bridge Over the Yellowstone River, Yellowstone National Park," *Engineering News* January 14, 1904: 25-27.

[11] A. W. Burney, Assistant Chief of Development, National Park Service, letter to Elizabeth Mock, 9 May 1947, File 650-04, Bridges General 1944-1947, Yellowstone National Park Archives, Yellowstone National Park.

[12] Eleanor Cress, letter to Lemuel Garrison, Superintendent, Yellowstone National Park, 2 October 1959, Hiram Chittenden Papers, Washington State Historical Society, Tacoma, Washington.

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[15] R. M. Marshall, Chief Geographical, U.S.G.S., letter to General Hiram Chittenden,16 August 1913, Hiram Chittenden Papers, Washington State Historical Society, Tacoma, Washington.

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[19] "Chittenden Locks Named for Father of P.A. Woman," *Palo Alto Times* 10 August 1956, Hiram Chittenden Papers, Washington State Historical Society, Tacoma, Washington.

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[21] L. I. Hewes, "America's Park Highways," *Civil Engineering* September 1932: 538.

[22] Hiram Chittenden, *The Yellowstone National Park: Historical and Descriptive* (Cincinnati: Stewart and Kidd, Co., 1915) 237.

[23] Philetus W. Norris, *Report Upon the Yellowstone National Park, to the Secretary of the Interior, for the Year 1877* (Washington D.C.: GPO, 1877) 841. Philetus W. Norris, *Report Upon the Yellowstone National Park to the Secretary of the Interior, for the Year 1878* (Washington D.C.: GPO, 1878) 979.

[24] Norris, *Report . . . 1878* 979-980.

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27. Philetus W. Norris, *Report Upon the Yellowstone National Park, to the Secretary of the Interior, for the Year 1879* (Washington D.C.: GPO, 1879) 7.

28. P. W. Norris, *Annual Report of the Superintendent of the Yellowstone National Park, to the Secretary of the Interior, for the Year 1880* (Washington D.C.: GPO, 1881) 13.

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32. Ibid.

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34. Moses Harris, *Report of the Superintendent of the Yellowstone National Park to the Secretary of the Interior, 1888* (Washington, D.C.: GPO, 1888) 7 and 12.

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56. Unnamed document, but probably a Location Survey report for the Obsidian Cliff to Mammoth Hot Springs road section. File No. 332.1 Firehole-Cascade-Old Faithful Section 1-C-2, Yellowstone National Park Archives, Yellowstone National Park.

57. C. F. Capes, "Final Construction Report Project 1-A1, A3, Grading Mammoth Terraces - Obsidian Cliff Section, Grand Loop National Park Highway Yellowstone National Park Wyoming, June 19. 1933."

58. Kenneth C. McCarter and Frank Mattson, "Report of Kenneth C. McCarter, Asst. Landscape Architect, and Frank E. Mattson, Jr., Landscape Architect, July 18-23, 1932." File Box: L-56, Yellowstone National Park Archives, Yellowstone National Park. The following quoted material is from the above document.

> July 6 - Permission was given to Mr. Anderson of the B.P.R. to use the material which had been stocked piled near Sta. 70 for top dressing on the elimination of old borrow pits. Mr. McCarter located a borrow pit at sta. 300. Many borrow sites have been prospected on this job which have proved worthless, in one instance the material which had been borrowed had the tendency to air-slake after being put into the road. Much boulders or "nigger-heads" generally develop after the pits are opened which cannot be used in the base of the shallow fill across Swan Lake Flats. The relocation between sta. 300 and 315 to avoid the double crossing of the Mammoth water supply concrete pipe line was recommended by McCarter. The

proposed location turns slightly to the left, following closer to the natural fringe of trees and then reverses with easy curvature to the right and ties in with the main line again. This change obliterates much of the old road by following the present road more closely which is very desirable from the landscaping viewpoint.

July 10 - Mr. Toll phoned Mr. Wiggins regarding the water line at the borrow pit at sta. 370. Mr. Wiggins believed the pipe to be about 16 ft. underground. If 2 ft. of covering were left over the pipe it would be satisfactory to Mr. Wiggins to excavate the dike.

July 12 - Mr. Anderson, B.P.R., resident engineer, asked for a relocation of borrow. The pit which had been prospected behind the old barns at the south end of Swan Lake Flats proved inadequate and of undesirable material.

July 13 - Mr. Wiggins does not favor the suggestion of cutting the water pipe line at the borrow pit at sta. 370 and use the marsh as a channel from there to Rustic Falls. His reasons were that the water would spread over the marsh and form a wallow for elk. Channeling would probably cause ice problems and flooding.

July 14 - The removal of the dike which supports the water pipe is still the controlling factor in the obliteration of this most unsightly borrow pit. It was decided that further borrow outside of the dike could be obtained with the prospect of future replacement of the pipe line. When the pipe line is replaced it can be located in the toe of slope of the road and the dike can be smoothed out. This will permit the blending of the slopes of the borrow pit into the side slopes of the marsh. The dike will then be the only unnatural feature remaining. . . . McCarter recommends that when the entire line is replaced that the line through the dike also be replaced for emergency purposes and that the dike be eliminated. The pipe line proved to be about two feet below the surface so the dike could not be partially excavated. It will be rounded off and sloped to fit the new conditions as well as possible.

59. Capes, "Final Construction Report (1931-32) Project 1-A 1, A-3, Grading. Mammoth Terraces-Obsidian Cliff, Grand Loop Project Yellowstone National Park Wyoming."

60. McCarter and Mattson.

61. McCarter and Mattson.

62. C. A. Lord, "Final Report Mammoth Terraces-Obsidian Cliff, Post Construction Project #558, 1933."

63. E. O. Anderson, "Final Construction Report, 1933-1934 on Project NE 1-A1, A3, A4, A5 Surfacing, Grand Loop Highway, Yellowstone National Park, Wyoming, January 11, 1935." Equipment used on this contract included the following:

1 - ½ yard Speeder gas shovel
1 - 1 ¼ yard Bucyrus-Erie gas shovel
1 - 60 Caterpillar tractor with bulldozer
1 - 30 Caterpillar tractor with fresno
9 - 3 ½ ton dump trucks
1 - ¾ ton truck
1 - ½ ton truck
2 - 310 compressors
2 - 15 x 36 Universal crushers
1 - 95 HP Allis-Chalmers engine
1 - 120 HP Waukesha engine
1 - Pioneer-Duplex crushing, screening, and loading plant
1 - 10 ton roller
1 - Auto patrols (10 foot blade)
1 - Tool car.

64. E. O. Anderson, "Final Construction Report, 1933-34 . . . ."

65. E. O. Anderson, "Final Construction Report, 1935 on Project NR 1-A1, A3, A4, A5, Oiling , 1-A2, B, and C-1, Seal Coat, Grand Loop Highway, Yellowstone National Park, Wyoming, January 11, 1936." This project required the following major equipment:

1 Pioneer Duplex crushing and screening plant
1 Madson oil mixing plant
1 Diesel Caterpillar tractor
1 Diesel Auto Patrol (12' blade)
6 3-ton dump trucks
1 3-ton hoist truck
3 1 ½ -ton dump trucks
1 1 ½ -ton flat bed truck
1 welder truck
1 roller
1 distributor
1 sweeper
1 stone chip spreader

66. E. O. Anderson, "Final Construction Report, 1935 . . . ." The bituminous surfacing had a thickness of 3 inches loose and a width of 22 feet. It was constructed on 5 inches loose thickness of crushed rock base course which had been placed the previous year. A prime coat of Liquid Asphaltic Road Material, type MC-1 was used on the base course where needed, however most of it was in excellent condition, thus little priming was needed. Crushed gravel consisting of fairly hard rhyolite boulders and pebbles with sand filter and a small amount of dirt was the aggregate. The bituminous material, which consisted of liquid Asphaltic Road Material, type NC-4 was added into the mixture at a temperature of 175 degrees, then transported to the road at a temperature of 210 degrees or more. The material set up very quickly. A seal coat, which consisted of Liquid Asphaltic Road Material, type RC-1, was then covered with a cover of stone chips which had been crushed to a maximum size of 5/8 inch from basalt slide rock. The color to the chips was a blue gray which lightened the road surface for night driving.

67. E. O. Anderson, "Final Construction Report (1948-49) on Grand Loop National Highway-Wyoming, Project 1-A. B. C-1 Reseal, Yellowstone National Park, State of Wyoming, February 8, 1950."

68. "Final Construction Report (1965-1966) on Yellowstone National Park Project 1-A(1), B(1) and 12(1), Grading and Bituminous Stabilized Base, Grand Loop and Norris-Canyon Cutoff, Yellowstone National Park, State of Wyoming." This report gives very good details of the types materials and equipment used on this project.

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70. Norris, *Report . . . 1878* 979.

71. Norris, *Report . . . 1880* 13.

72. John Hartman, letter to Secretary of the Interior Teller, 20 August 1883.

73. Kingman.

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75. Ibid.

76. Allen, 2863.

77. George S. Anderson, *Report of the Superintendent of the Yellowstone National Park to the Secretary of the Interior, 1892* (Washington D.C.: GPO, 1892) 3 and 5.

78. George S. Anderson, *Report . . . 1895* 8.

79. S. B. M. Young, *Report of the Acting Superintendent of the Yellowstone National Park to the Secretary of the Interior, 1897* (Washington D.C.: GPO, 1897) 4.

80. Chittenden, *Annual Report Upon the Construction, Repairs, and Maintenance of Roads and Bridges in the Yellowstone National Park and Construction of Military Roads from Fort Washakie to Mouth of Buffalo Fork of Snake River, Wyoming, and Erection of Monument to Sergeant Charles Floyd in the Charge of Hiram Chittenden, Captain, Corps of Engineers Being Appendices FFF and KKK, and JJJ of the Annual Report of the Chief of Engineers for 1903* (Washington, D.C: GPO, 1903) 2893.

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82. Peek, *Annual Report . . . 1907* 2463.

83. Peek, *Annual Report . . . 1908* 2544-2545.

84. Willing, "Report of Inspection of Bridges . . . 1909, ..."

85. Knight, Cavanaugh, and Morrow, *Report Upon the Construction . . .* (1912) 3031-3032. Horace Albright, letter to Henry Jacoby, 30 October 1923. File Box-Bridges, 1923, Yellowstone National Park Archives, Yellowstone National Park.

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195. Arno B. Cammerer, letter to Thomas McDonald, 11 September 1926. File Box: Roads, General Correspondence 1919-1926, File, Roads Correspondence May-December 1926, Yellowstone National Park Archives, Yellowstone National Park.

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197. Report by Clark Gilmore, Landscape Architect, Westchester County Park Development, New York, to Horace Albright, Director of the National Park Service, June 1930. C. F. Capes, "Final Survey Report (1937) 1-H3 Bridge Investigation and Design Grand Loop Highway Yellowstone National Park, Wyoming". File Box: Roads. Grand Loop. 1931-1942. 1971. Yellowstone National Park Archives, Yellowstone National Park. The quote below is from the above report by Clark Gilmore:

> The existing road to Tower Falls from Mammoth Hot Springs is unsatisfactory as to both gradient and alignment. Its point of departure from the Mammoth area, however, is from a satisfactory and logical point which is retained in the proposed plan. I carefully inspected the routes proposed by the Bureau of Public Roads engineers as well as the existing road. I do not approve of the location recommended by them on the north side of Gardiner River and Lava Creek for the following reasons:
>
> 1. a new wide scar would be created on the slopes of Mt. Evarts which would take many years to heal
> 2. because there is no timber growth on the south slope of Mt. Evarts the entire road would always be in full view from many points

3. a switchback is necessary and would require exceedingly heavy construction on the steep slopes
4. the fine views of Mt. Evarts and those down the Gardiner River Valley now obtained on the existing road, would be lost on the proposed location.

After studying the problem and discussing it with Chief Landscape Architect Vint, I recommend that the new road to Tower Junction be constructed along the south side of Lava Creek utilizing as much of the existing alignment as may be practicable. At a point about 1/4 mile down stream on the Gardiner River from the present steel bridge, a new high level bridge could be erected, if necessary constructed on a grade. This structure would be entirely satisfactory if built of steel, preferably with open, fully centered arches, and then painted gray to harmonize with the color of the existing rock outcrops. If a switchback was found to be necessary between the bridge over the Gardiner River and Undine Falls, there is a wide stretch of land between Lava Creek and the existing road, which would lend itself well for such a purpose. The south bank of Lava Creek is well wooded and the road from the bridge to Undine Falls would be hidden from view and at the same time views from it are obtained of Mt. Evarts, the distant mountains down the Gardiner River Valley, and the Hot Springs formations at Mammoth Hot Springs. Mr. Vint advised me, upon his arrival at Mammoth Hot Springs that he had previously worked out such a scheme as I have recommended and he concurred in my views.

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A-4	12	520720	4959210
A-4-a	12	522610	4955000
B-1	12	524050	4953370
B-2	12	520240	4949710
B-2-a	12	519820	4945230
B-3	12	518170	4944340
C-1	12	511570	4943490
C-1-a	12	511220	4941090
C-2	12	511550	4940270
C-3	12	515510	4932820
C-3-a	12	512880	4927200
C-4	12	512040	4925970
D-1	12	512070	4922990
D-2	12	512650	4922720
D-3	12	515040	4921920
D-3-a	12	519890	4919510
D-4	12	523770	4921350
D-4-a	12	529840	4919390
E-1	12	533200	4918170
E-2	12	533840	4920630
E-3	12	537100	4924770
E-3-a	12	539780	4922090
E-3-b	12	546100	4927360
E-4	12	546110	4932110
F-1	12	548720	4935110
F-1-a	12	545060	4941240
F-2	12	544400	4941840
F-3	12	540130	4947760
F-3-a	12	539620	4949070
F-3-b	12	539610	4951820

UTM References:	Zone	Easting	Northing
G-1	12	540190	4953600
G-1-a	12	540310	4955090
G-2	12	543250	4958970
G-3	12	544450	4965210
G-3-a	12	548890	4969040
G-4	12	548410	4970940
H-1	12	546160	4973570
H-1-a	12	539450	4977890
H-2	12	536200	4978190
H-2-a	12	529600	4976350
I-1	12	540180	4953540
I-1-a	12	539600	4953520
I-1-b	12	529700	4950790
I-2	12	524080	4952510

INDEX TO PHOTOGRAPHS

The original negatives for the photographs taken by Roger Whitacre and Elaine Hale are in the YNP Archives. The original negatives for the photographs taken by Jet Lowe are in the Library of Congress and the YNP Archives.

Photograph Number and Caption with direction of camera		Photographer and Year
Segment "A" Mammoth to Norris Junction		
1	Golden Gate Area, Looking North	Whitacre, 1999
2	Golden Gate Area, Looking Northwest	Whitacre, 1999
3	Modern Gibbon River Bridge South of Norris Campground, Looking southeast	Whitacre, 1999
4	Roaring Mountain Turnout in Early Morning, Looking East	Lowe, 2000
5	Rustic Wayside, Pullout, Stone Steps and Interpretive Kiosk, Looking South	Lowe, 2000
6	Obsidian Cliff Culvert, Looking East	Lowe, 2000
7	Obsidian Cliff Wayside, Kiosk in Distance, Looking South	Lowe, 2000
8	Obsidian Cliff Kiosk, Looking West	Lowe, 2000
9	View West of Bunsen Hill, Culvert in Middle Ground, Looking West	Lowe, 2000
10	Roadway Showing Change in Road Surface, Looking North	Lowe, 2000

Photograph Number and Caption with direction of camera		Photographer and Year
Segment "A" Mammoth to Norris Junction continued		
11	Mammoth Drylaid Stone Retaining Wall and General Store, Looking West	Lowe, 2000
12	Through Hoodoos, South of Mammoth Hot Springs, View to North	Lowe, 1989
13	Seven Mile Bridge, Wy-28, Looking East	Lowe, 1989
Segment "B" Norris Junction to Madison Junction		
14	South of Norris Geyser Basin, Looking Southwest	Whitacre, 1999
15	Vicinity of Fountain Paint Pot, Looking South	Whitacre, 1999
16	Gibbon River Bridge II, Wy-30, Looking Southwest	Hale, 1997
17	Gibbon River Bridge I, Wy-29, Looking Southwest	Lowe, 1989
18	Gibbon Falls Retaining Wall, View to Northeast	Lowe, 1989
19	Gibbon Falls Retaining Wall, View to North	Lowe, 1989
20	Beryl Springs Viaduct, Looking Southwest	Lowe, 1989
21	View Showing Proximity of Roadway to Gibbon River, Looking East	Lowe, 2000
22	Ninety Degree Turn North of Gibbon Falls (Tanker Curve), Looking Northeast	Lowe, 2000
Segment "C" Madison Junction to Old Faithful		
23	Between Madison and Nez Perce Bridge, Looking South	Whitacre, 1999
24	Nez Perce Bridge, Wy-48, Looking West	Lowe, 1989

Photograph Number and Caption with direction of camera		Photographer and Year
Segment "C" Madison Junction to Old Faithful continued		
25	Roadway View North of Upper Geyser Basin, Looking East	Lowe, 2000
Segment "D" Old Faithful to West Thumb		
26	Vicinity of Craig Pass West of the Continental Divide, Looking East	Whitacre, 1999
27	Old Faithful Intersection, Looking Northwest	Whitacre, 1999
28	East Side of Craig Pass, Looking West	Whitacre, 1999
29	Isa Lake Bridge, Wy-31, Looking Southwest	Lowe, 1989
30	Old Faithful Overpass and Cloverleaf, Looking Southeast	Lowe, 2000
31	Craig Pass, Isa Lake Turnout at the Continental Divide, Looking Northeast	Lowe, 2000
Segment "E" West Thumb to Lake		
32	North of Bridge Bay, Looking Northeast	Whitacre, 1999
33	Pumice Point Area Near Yellowstone Lake, Looking Northeast	Whitacre, 1999
34	Bridge Bay Area, Looking Southeast	Whitacre, 1999
35	Road Widening and Forest Environment Near West Thumb, Looking South	Lowe, 2000
36	Mission 66 Era Interpretive Kiosk, North of Pumice Point, Looking East	Lowe, 2000

Photograph Number and Caption with direction of camera		Photographer and Year
Segment "F" Lake Junction to Canyon Junction		
37	Three Miles South of Canyon Intersection, Looking North	Whitacre, 1999
38	Hayden Valley, Alum Creek in Middle of Photograph, View South	Lowe, 2000
39	Otter Creek Bridge, Wy-32, Looking West	Lowe, 1989
40	Sulphur Cauldron Area, Looking North at Turnout	Lowe, 2000
Segment "G" Canyon Junction to Tower Junction		
41	Mount Washburn Switchback, Looking Southwest	Whitacre, 1999
42	Mount Washburn Area, Looking North	Whitacre, 1999
43	Tower Creek Bridge, Wy-33, Looking West	Lowe, 1989
44	Tower Fall and Roadway (blurred) from Hiking Path, Looking Northwest	Lowe, 2000
45	Overhanging Cliff Basalt Formation and Retaining Wall, Looking Northwest	Lowe, 1989
46	Overhanging Cliff and Roadway, Looking North	Lowe, 1989
Segment "H" Tower Junction to Mammoth Hot Springs		
47	Road to Tower-Roosevelt, Looking East	Whitacre, 1999
48	Culvert on Road Next to Roosevelt Ranger Station, Looking North	Lowe, 2000
49	Entrance to Roosevelt Corrals on Old Road Alignment, Looking South	Lowe, 2000

Photograph Number and Caption with direction of camera		Photographer and Year
Segment "H" Tower Junction to Mammoth Hot Springs continued		
50	Lava Creek Bridge, Wy-34, Looking North	Lowe, 1989
51	Gardner River Bridge, Wy-7, Looking Northeast	Lowe, 1989
Segment "I" Norris Junction to Canyon Junction		
52	One Mile West of Canyon, Looking East	Whitacre, 1999
53	Vicinity of Virginia Cascades, Looking West	Whitacre, 1999
54	Vicinity of Virginia Cascades, Looking West	Whitacre, 1999

United States Department of the Interior
National Park Service

National Register of Historic Places Continuation Sheet

Section number ______ Page ______

SUPPLEMENTARY LISTING RECORD

NRIS Reference Number: 03001345

Property Name: Grand Loop Road Historic District
County: Park State: Wyoming

Multiple Name: Historic Resources of Yellowstone National Park : Construction of the Road System MPS

This property is listed in the National Register of Historic Places in accordance with the attached nomination documentation subject to the following exceptions, exclusions, or amendments, notwithstanding the National Park Service certification included in the nomination documentation.

Linda McClelland — December 23, 2003
Signature of the Keeper — Date of Action

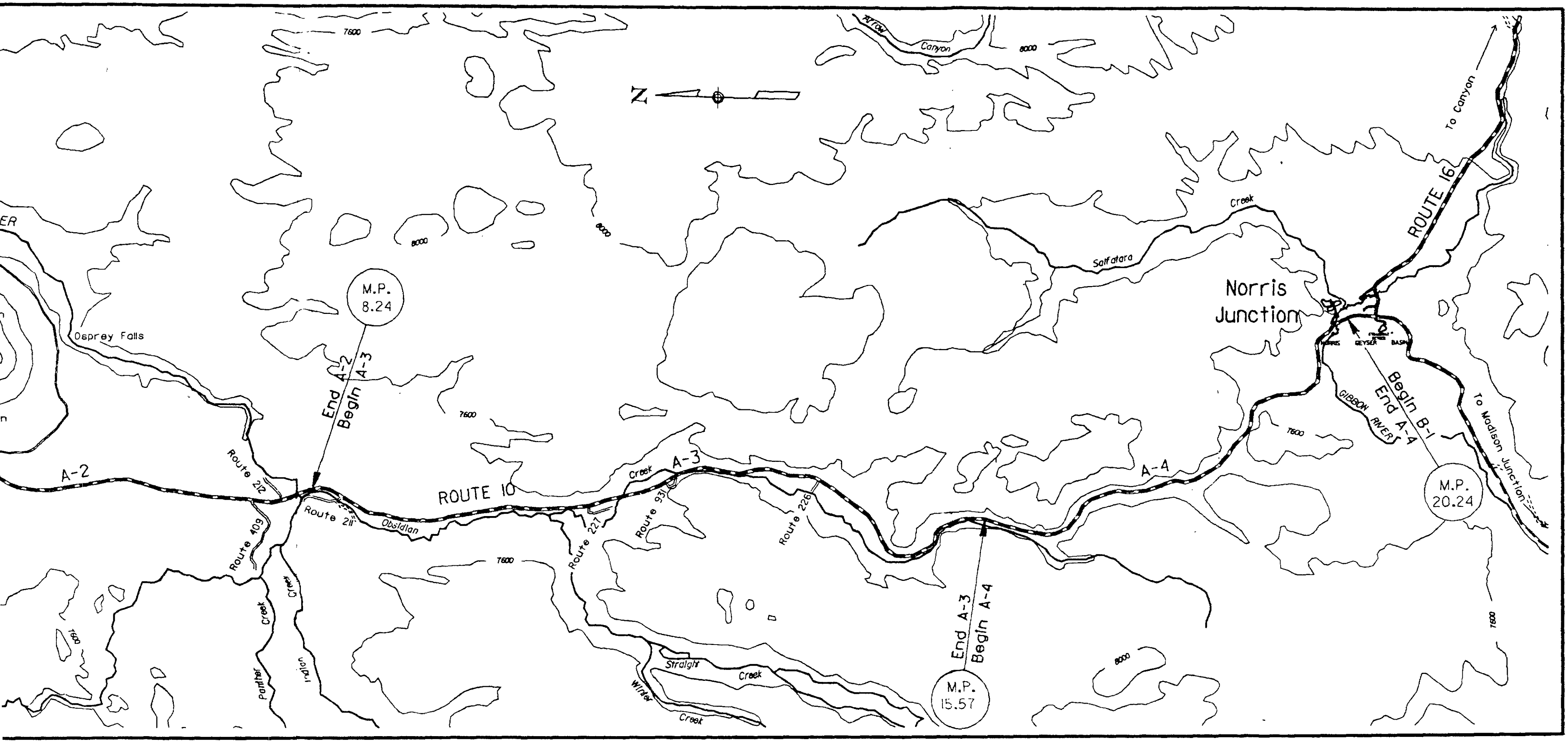
Amended Items in Nomination:

Section 5: Classification
The count of Contributing Resources is hereby amended to add "one" contributing site to recognize the importance of the grading, vegetation, viewpoints, and other elements of the road's immediate historic setting, bringing the total number of contributing resources to "11."

Section 8: Significance
The Period of Significance is hereby amended to "1883-1944" so that the beginning date corresponds to the year planning and construction began on the road that exists today.

The National Park Service Historic Preservation Office was notified of this amendment.

DISTRIBUTION:
National Register property file
Nominating Authority (without nomination attachment)

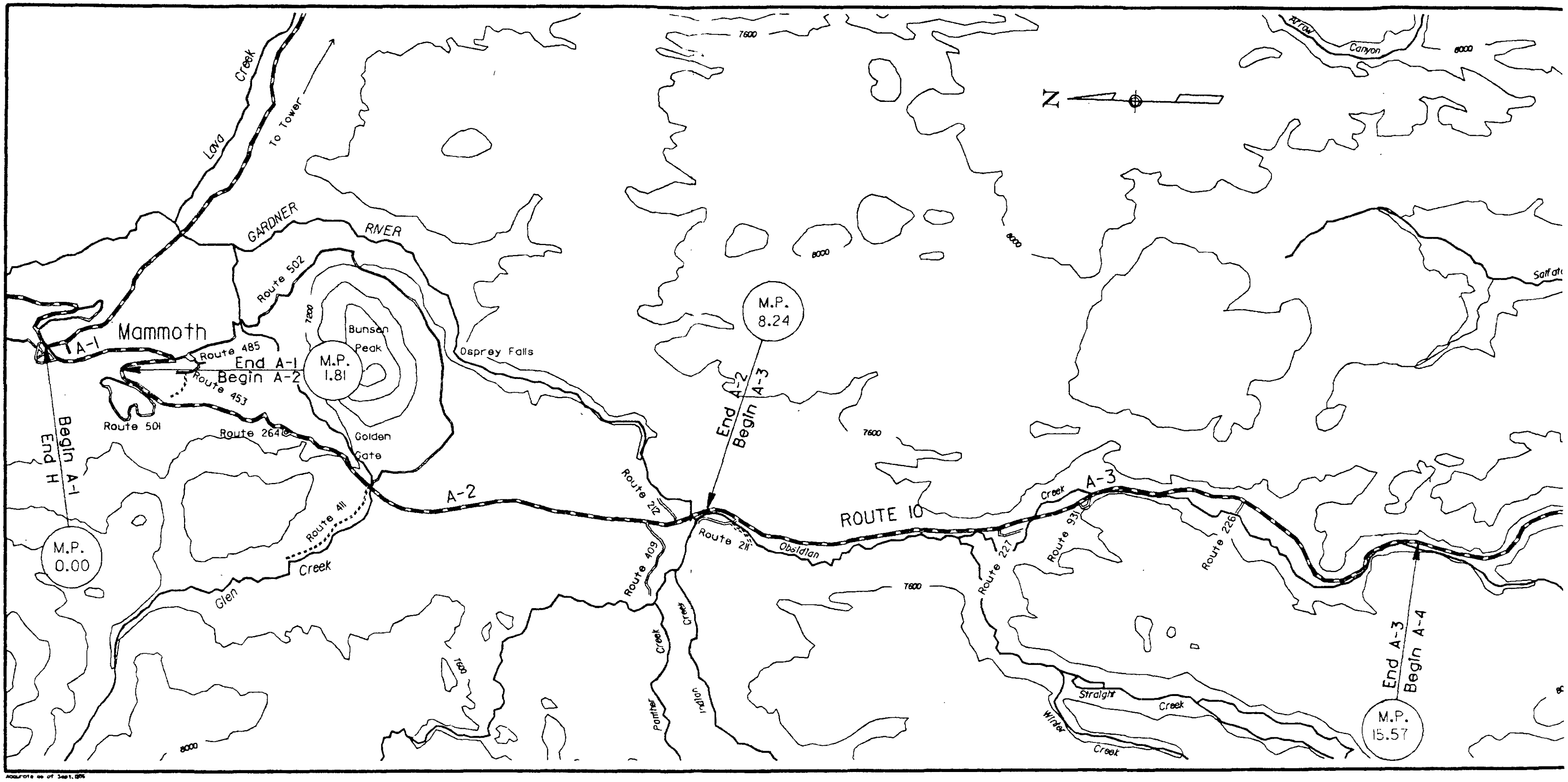


JTES

ROUTE NO.	ROUTE NAME	REPORT PAGE
411	Snow Pass Trailhead Service Rd.	IV-443
453	Mammoth Water Treatment Plant Service Rd.	IV-305
485	Glenn Creek Water Intake Service Rd.	IV-305
501	Mammoth Terrace Loop Drive	IV-449
502	Bunsen Peak Loop Rd.	IV-339
931	Obsidian Cliff Parking Area	IV-339

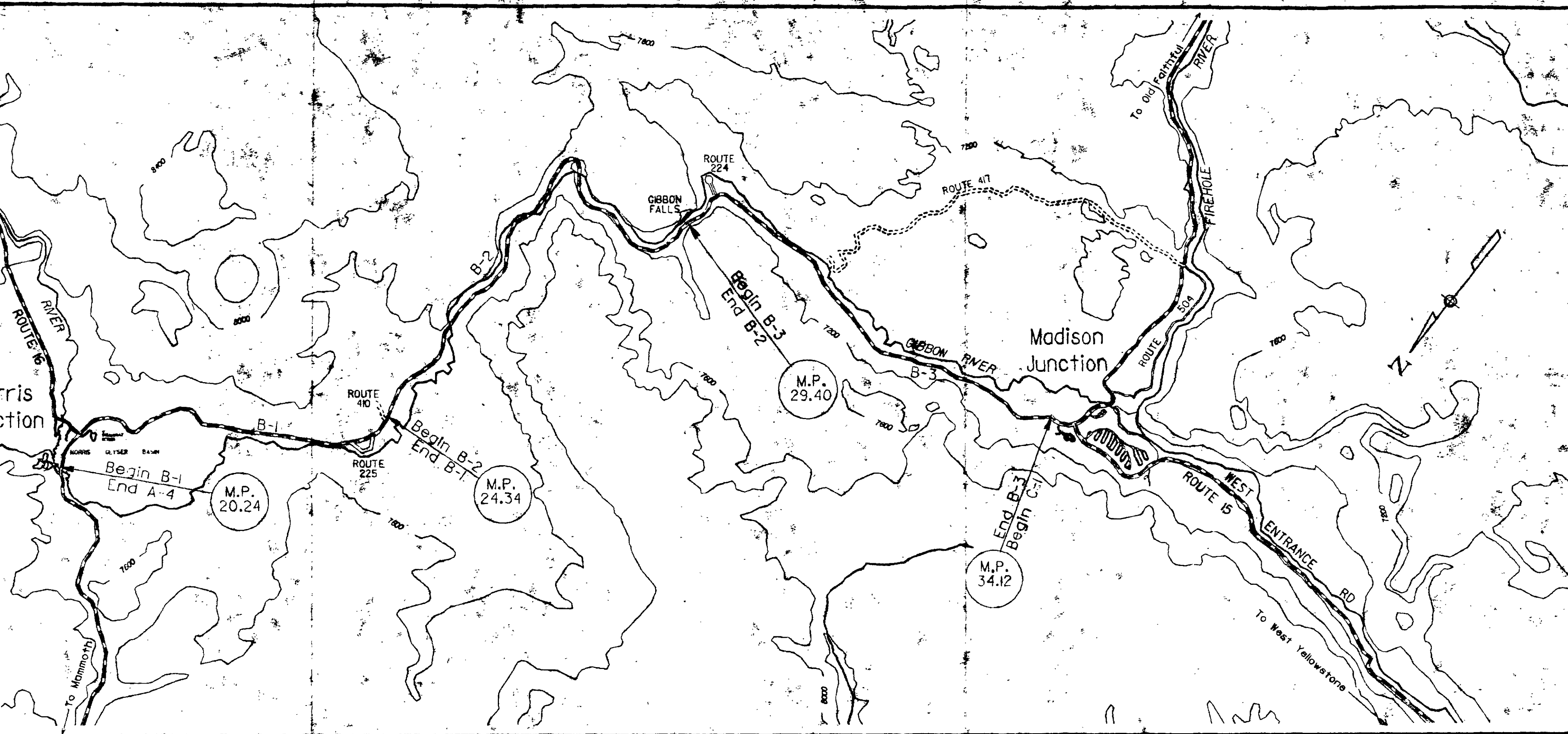
ROUTE 10 - GRAND LOOP ROAD
SEGMENT A

0 ½ 1 2 Miles
5000 0 5000 10000 Feet
SCALE



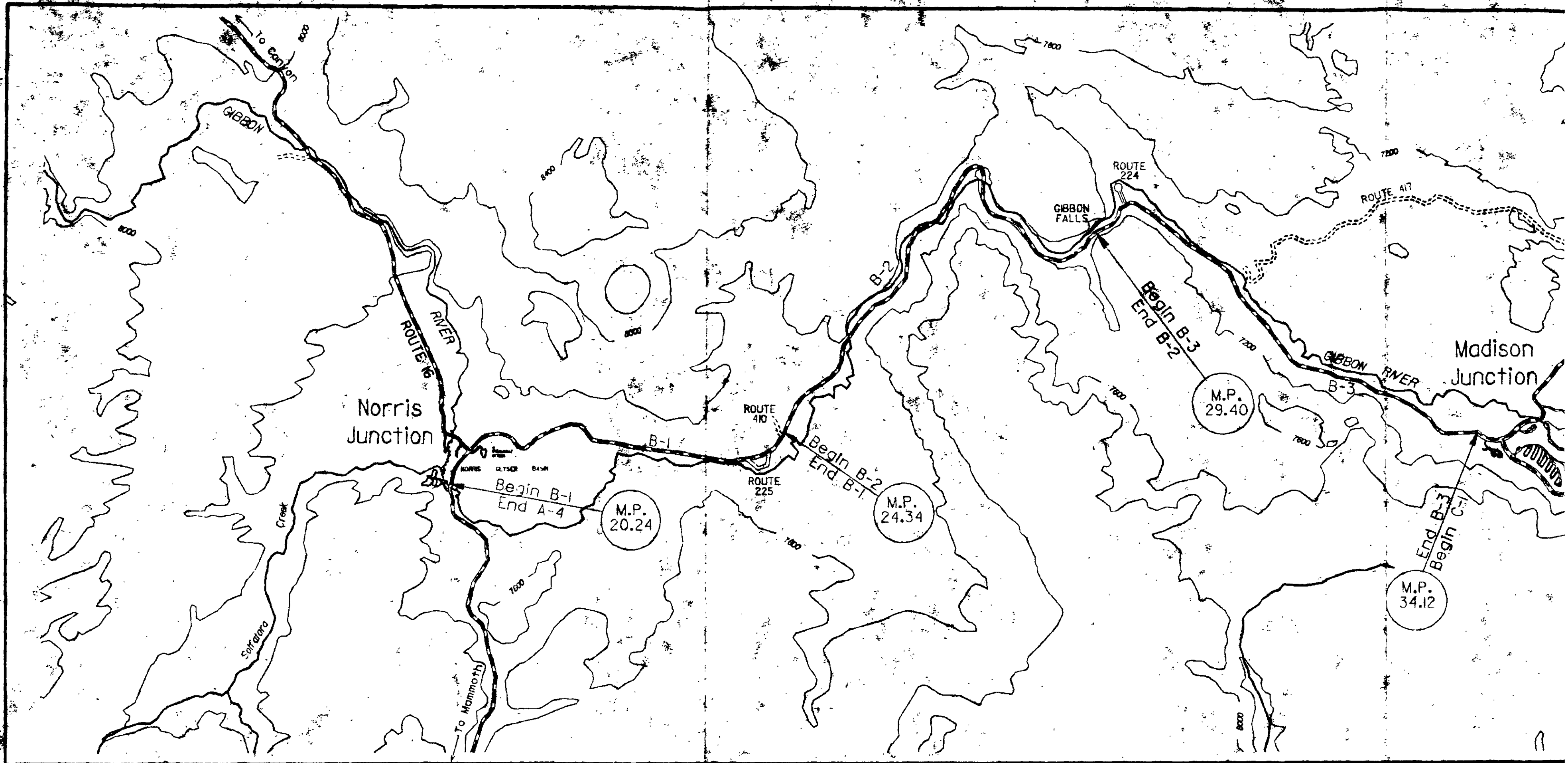
APPURTENANT ROUTES

ROUTE NO.	ROUTE NAME	REPORT PAGE	ROUTE NO.	ROUTE NAME	REPORT PAGE
211	Indian Creek Campground	IV-339	411	Snow Pass Trailhead Service Rd.	IV-443
212	Sheepeater Cliff Rd.	IV-339	453	Mammoth Water Treatment Plant Service Rd.	IV-305
226	Beaver Ponds Picnic Area Rd.	IV-339	485	Glenn Creek Water Intake Service Rd.	IV-305
227	Apollinaris Spring Picnic Area Rd.	IV-339	501	Mammoth Terrace Loop Drive	IV-449
264	Hoodoos Loop Rd.	IV-339	502	Bunsen Peak Loop Rd.	IV-339
409	Mammoth Water Intake Service Rd.	IV-339	931	Obsidian Cliff Parking Area	IV-339



ROUTE 10 - GRAND LOOP ROAD
SEGMENT B
NORRIS JUNCTION TO MADISON JUNCTION

0 1/2 1 2 Miles
5000 0 5000 10000 Feet
SCALE

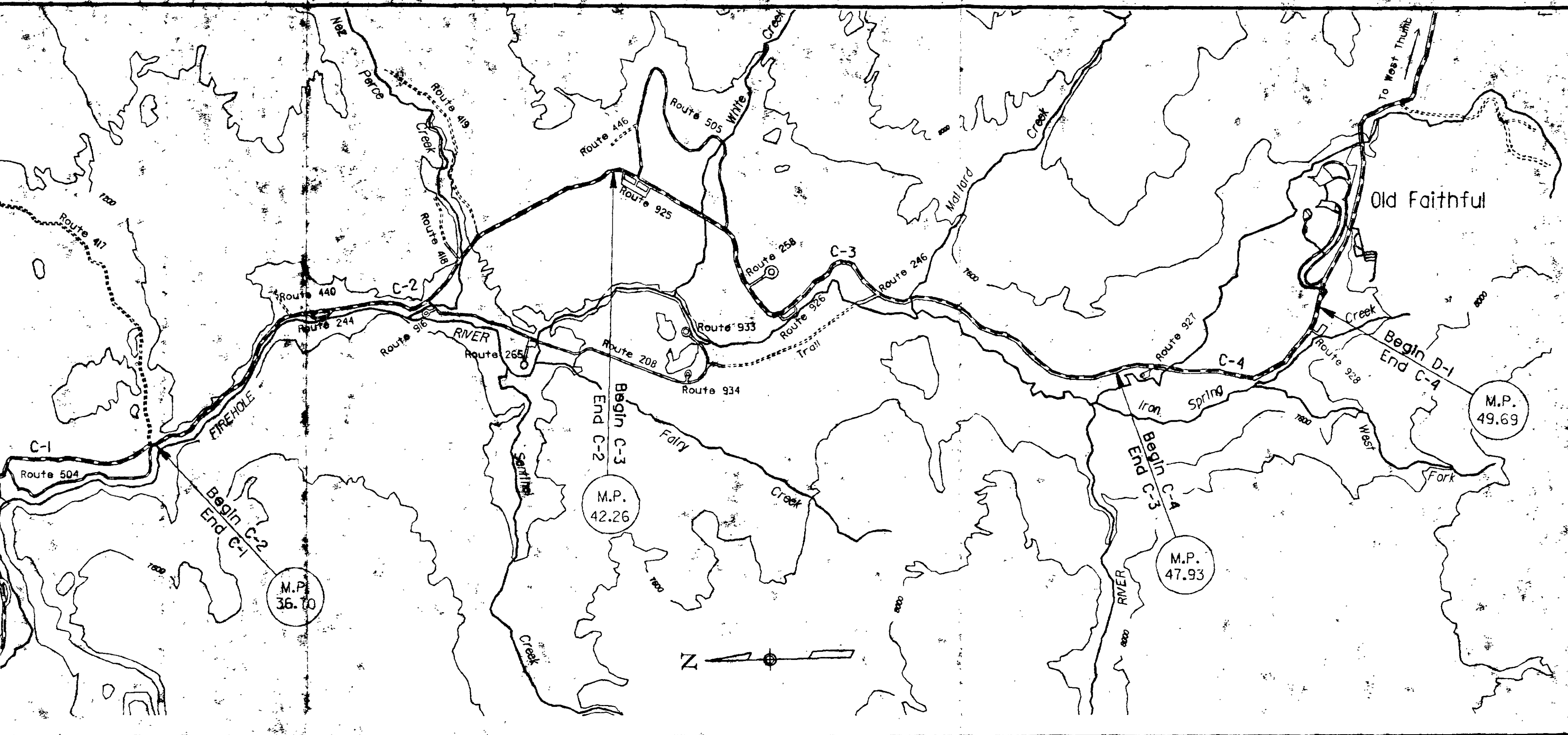


APPURTENANT ROUTES

ROUTE NO.	ROUTE NAME	REPORT PAGE
224	Gibbon Falls Picnic Area Rd.	IV-355
225	Gibbon Meadows Picnic Area Rd.	IV-355
410	Gibbon Meadows Service Rd.	IV-355

RO

NORRIS JU



TES

	ROUTE NAME	REPORT PAGE
04	Firehole Canyon Drive	IV-455
05	Firehole Lake Drive	IV-459
16	Nez Perce Picnic Area	IV-323
25	Fountain Paint Pots Parking Area	IV-405
26	Midway Geyser Basin Parking Area	IV-405
27	Biscuit Basin Parking Area	IV-406
28	Black Sand Basin Parking Area	IV-405
33	Feather Lake Picnic Area	IV-323
34	Goose Lake Picnic Area	IV-323

ROUTE 10 - GRAND LOOP ROAD

SEGMENT C

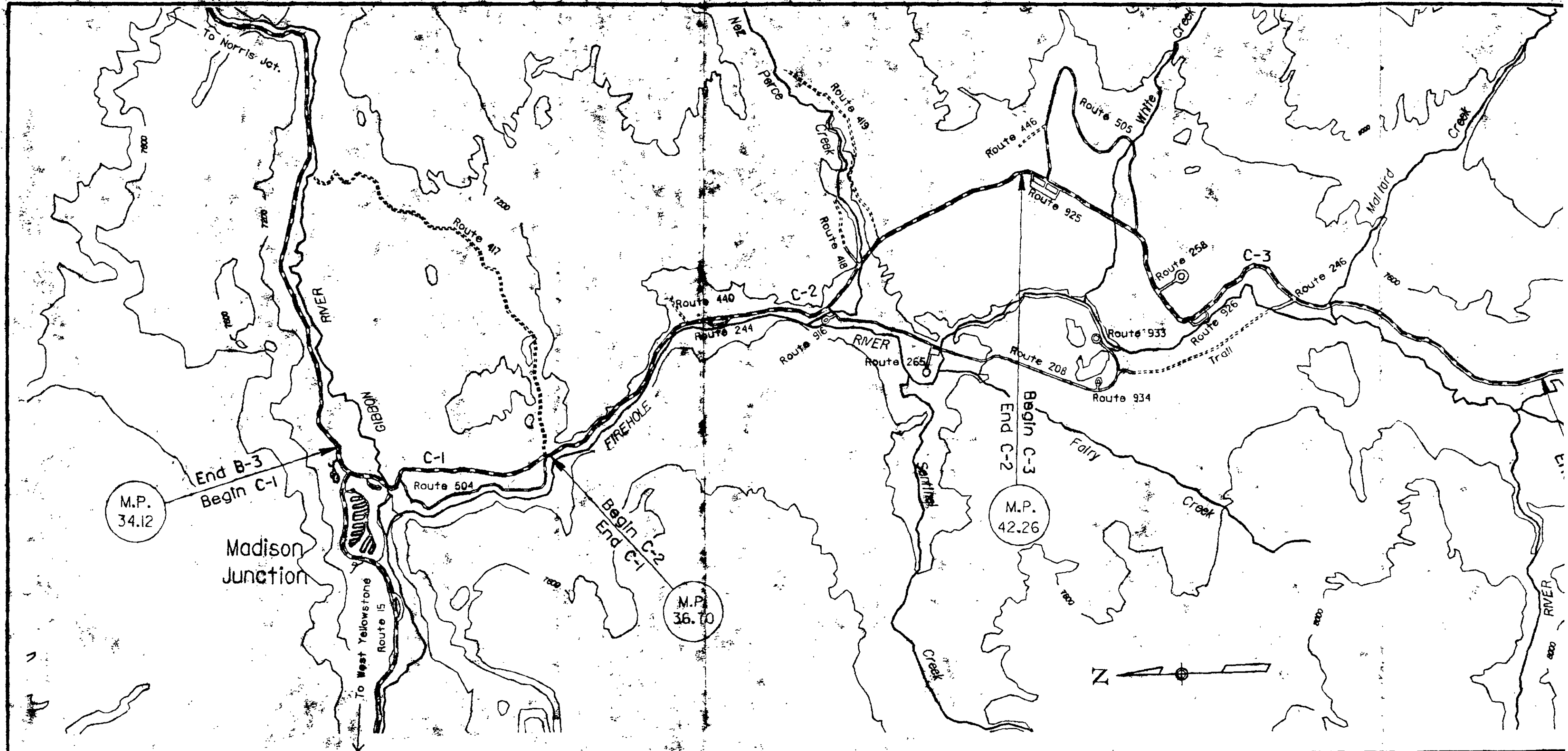
MADISON JUNCTION TO OLD FAITHFUL

0 ½ 1 2 Miles

5000 0 5000 10000 Feet

SCALE

[redacted]



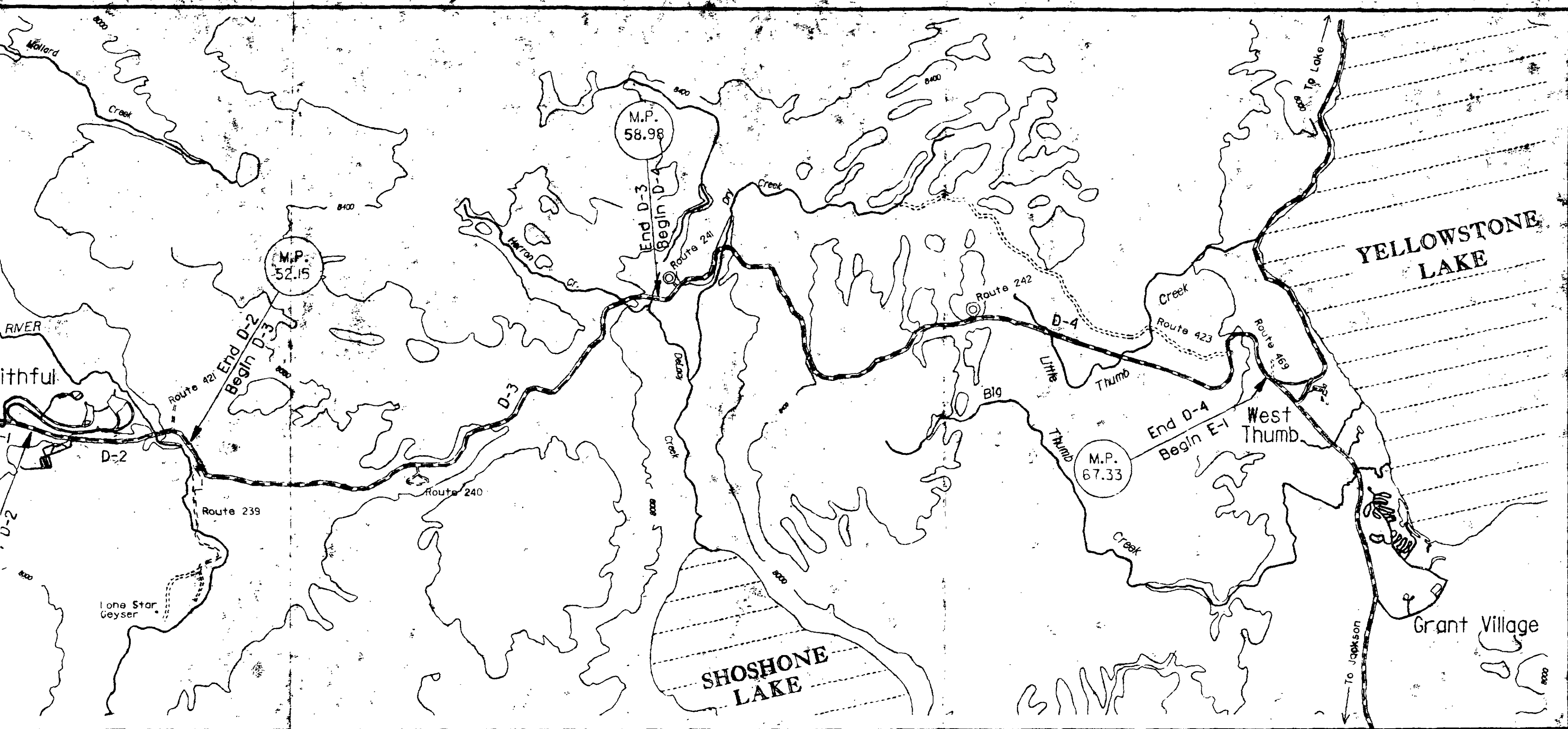
APPURTENANT ROUTES

ROUTE NO.	ROUTE NAME	REPORT PAGE
208	Fountain Freight Rd.	IV-325
244	Firehole River Picnic Area	IV-405
246	Fountain Freight Trailhead Rd.	IV-405
258	Whiskey Flats Picnic Area Rd.	IV-405
265	Ojo Caliente Rd.	IV-325
417	Mesa Service Rd.	IV-405
418	Nez Perce Patrol Cabin Service Rd.	IV-405
419	Nez Perce Creek Trailhead Service Rd.	IV-405
440	Firehole River Maintenance Yard Service Rd.	IV-405
446	Firehole Lake Service Rd.	IV-459

ROUTE NO.	ROUTE NAME	REPORT PAGE
504	Firehole Canyon Drive	IV-455
505	Firehole Lake Drive	IV-459
916	Nez Perce Picnic Area	IV-325
925	Fountain Paint Pots Parking Area	IV-405
926	Midway Geyser Basin Parking Area	IV-405
927	Biscuit Basin Parking Area	IV-406
928	Black Sand Basin Parking Area	IV-405
933	Feather Lake Picnic Area	IV-323
934	Goose Lake Picnic Area	IV-323

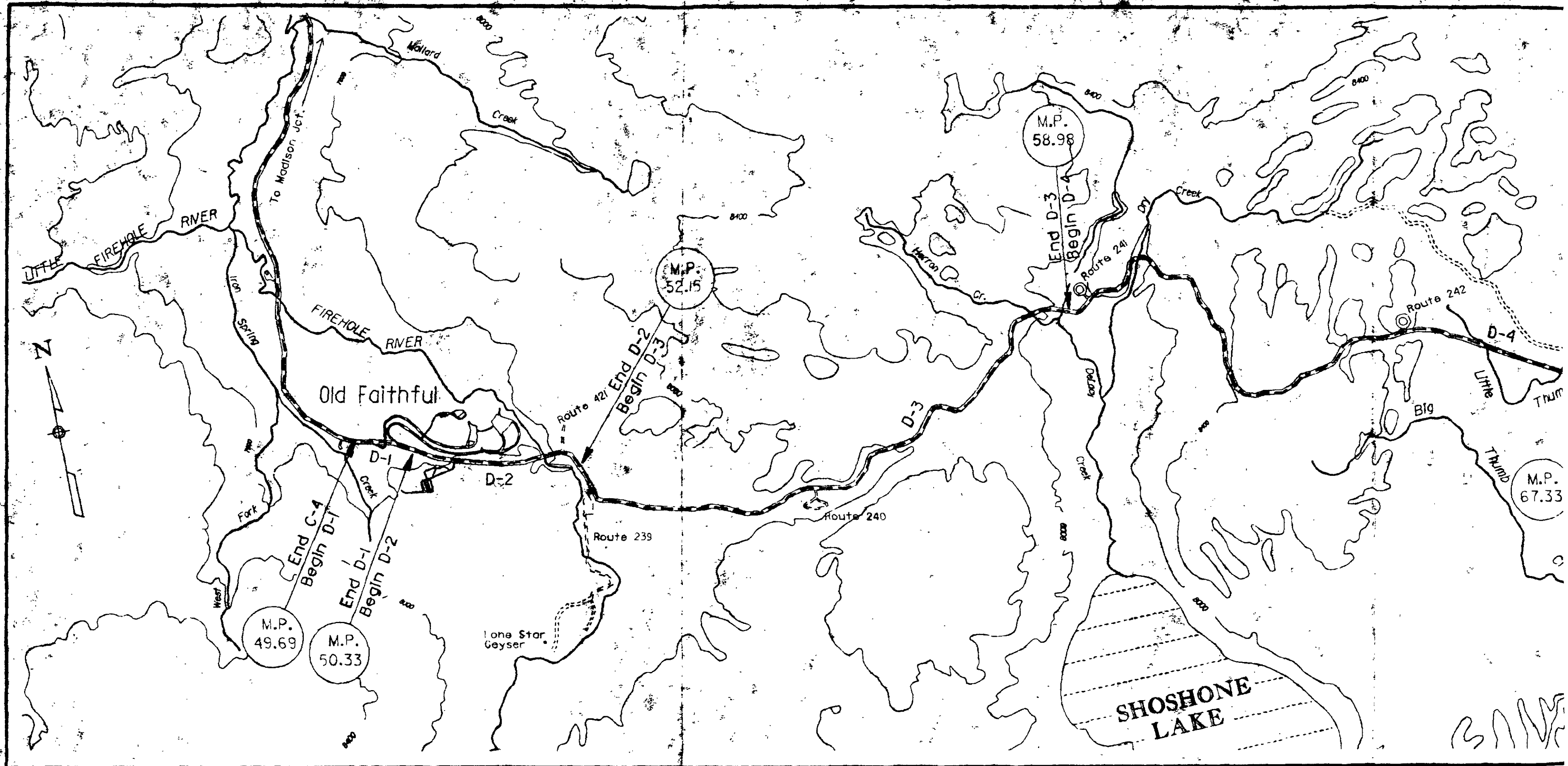
ROU

MADISO



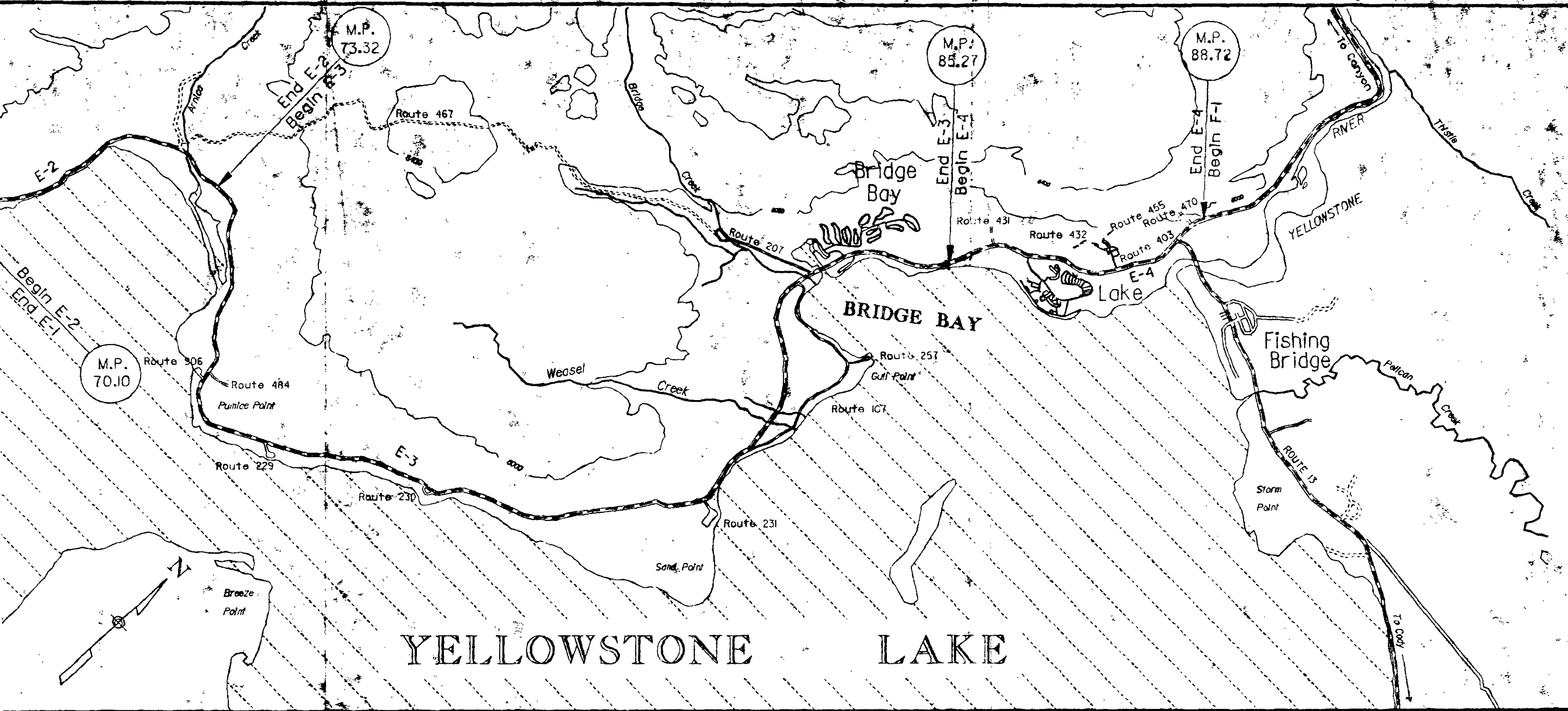
ROUTE 10 - GRAND LOOP ROAD
SEGMENT D
OLD FAITHFUL TO WEST THUMB

YELLOWSTONE NATIONAL PARK - PARKWIDE ROAD ENGINEERING STUDY



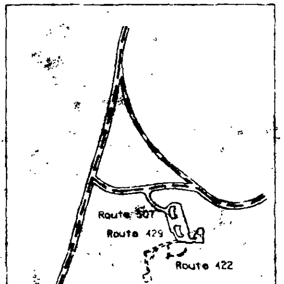
APPRUTENANT ROUTES

Route No.	Route Name	Report Page
239	Lone Star Geyser Trailhead and Service Rd.	IV-393
240	Spring Creek Picnic Area	IV-393
241	DeLacey Creek Picnic Area	IV-393
242	Divide Picnic Area	IV-393
421	Old Faithful Water Supply Service Rd.	IV-393
423	Dry Creek Service Rd.	IV-393



ES

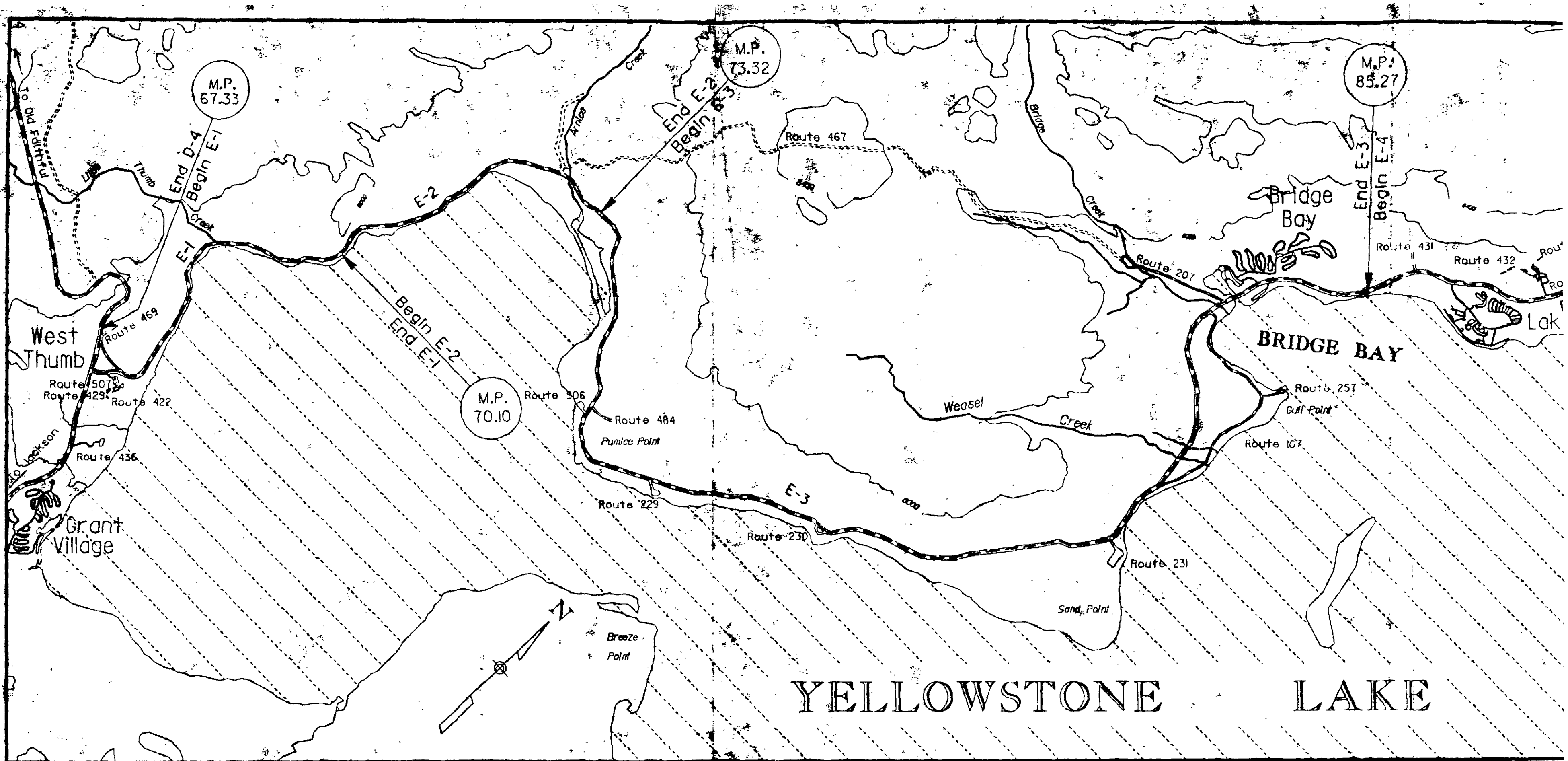
ROUTE NO.	ROUTE NAME	REPORT PAGE
431	Lake Transfer Station Rd.	IV-269
432	Lake Residence Area Service Rd.	IV 277
455	Lake Residence Water Tank Service Rd.	IV-277
467	Arnica Creek Natural Bridge Service Rd.	IV-317
469	Duck Lake Service Rd.	IV-317
470	Fishing Bridge Water Intake Service Rd.	IV-301
484	Pumice Point Service Rd.	IV-361
507	West Thumb Rd.	IV-465
906	Pumice Point Parking Area	IV 361



WEST THUMB DETAIL
Not to Scale

ROUTE 10 - GRAND LOOP ROAD
SEGMENT E
WEST THUMB TO FISHING BRIDGE

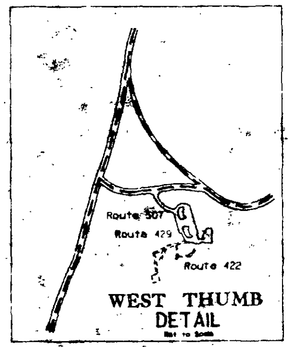
0 ½ 1 2 Miles
5000 0 5000 10000 Feet
SCALE



APPURTENANT ROUTES

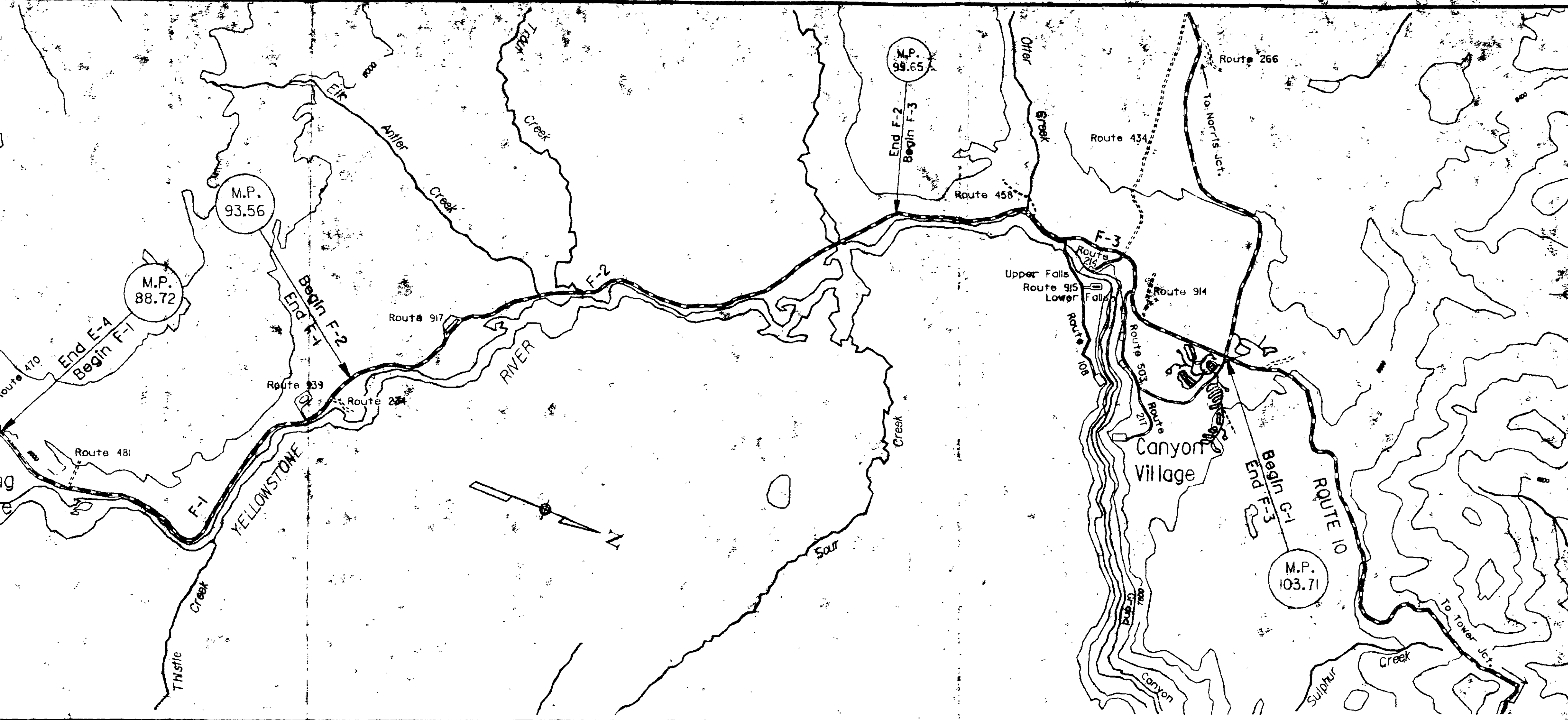
ROUTE NO.	ROUTE NAME	REPORT PAGE
107	Gull Point Drive	IV-263
207	Natural Bridge Rd.	IV-317
229	Spruce Forest Picnic Area	IV-361
230	Dot Island Picnic Area	IV-361
231	Sand Point Picnic Area	IV-361
257	Gull Point Picnic Area Rd.	IV-263
403	Lake Residence Area Rd.	IV-277
422	West Thumb Water Intake Service Rd.	IV-465
429	West Thumb Service Rd.	IV-465
430	Little Thumb Creek Borrow Pit Service Rd.	IV-361

ROUTE NO.	ROUTE NAME	REPORT PAGE
431	Lake Transfer Station Rd.	IV-269
432	Lake Residence Area Service Rd.	IV-277
455	Lake Residence Water Tank Service Rd.	IV-277
467	Arnica Creek Natural Bridge Service Rd.	IV-317
469	Duck Lake Service Rd.	IV-317
470	Fishing Bridge Water Intake Service Rd.	IV-361
484	Pumice Point Service Rd.	IV-361
507	West Thumb Rd.	IV-465
906	Pumice Point Parking Area	IV 361

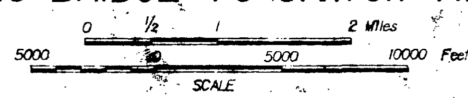


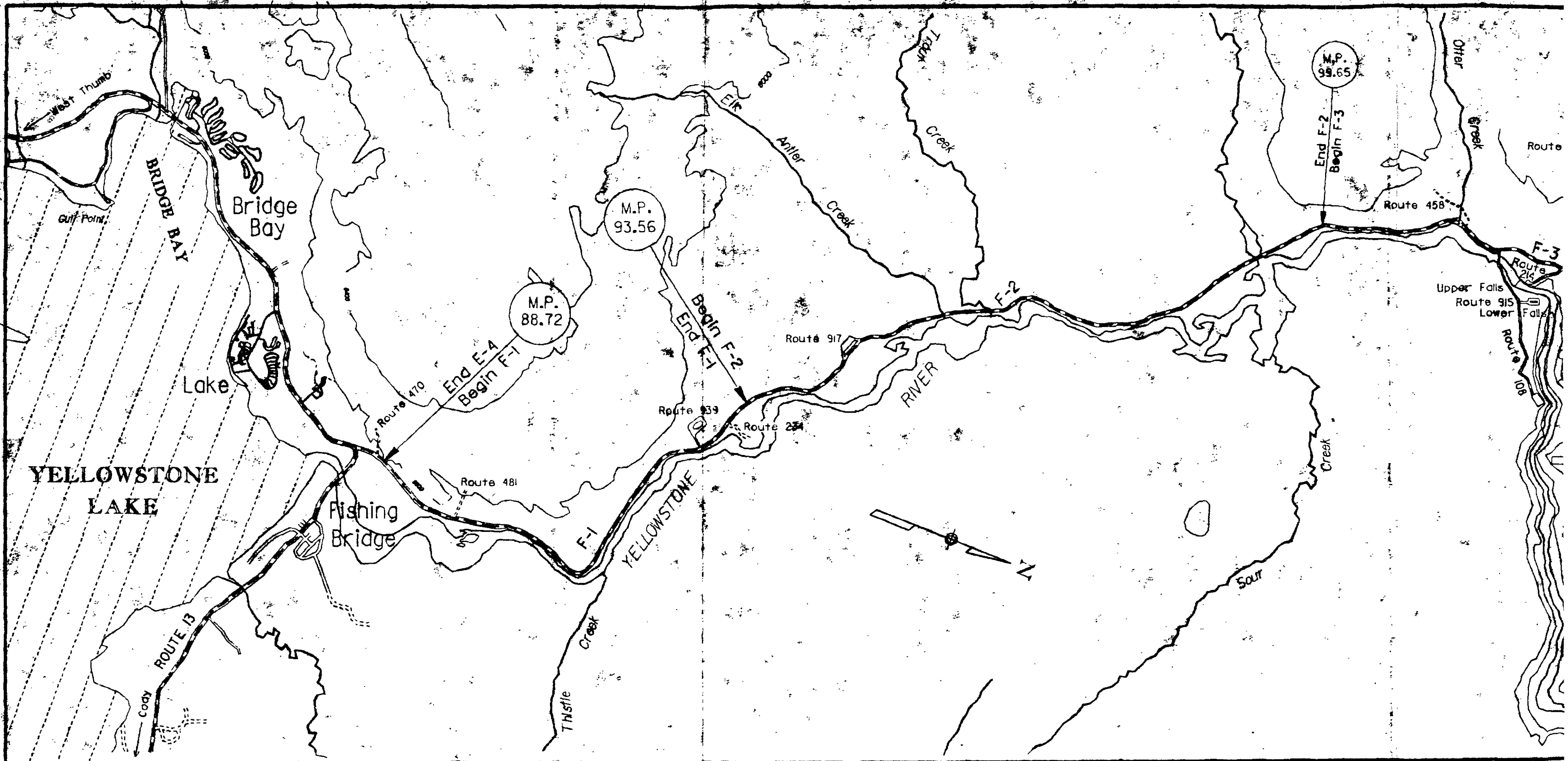
RO

WES



ROUTE 10 - GRAND LOOP ROAD
SEGMENT F
FISHING BRIDGE TO CANYON VILLAGE





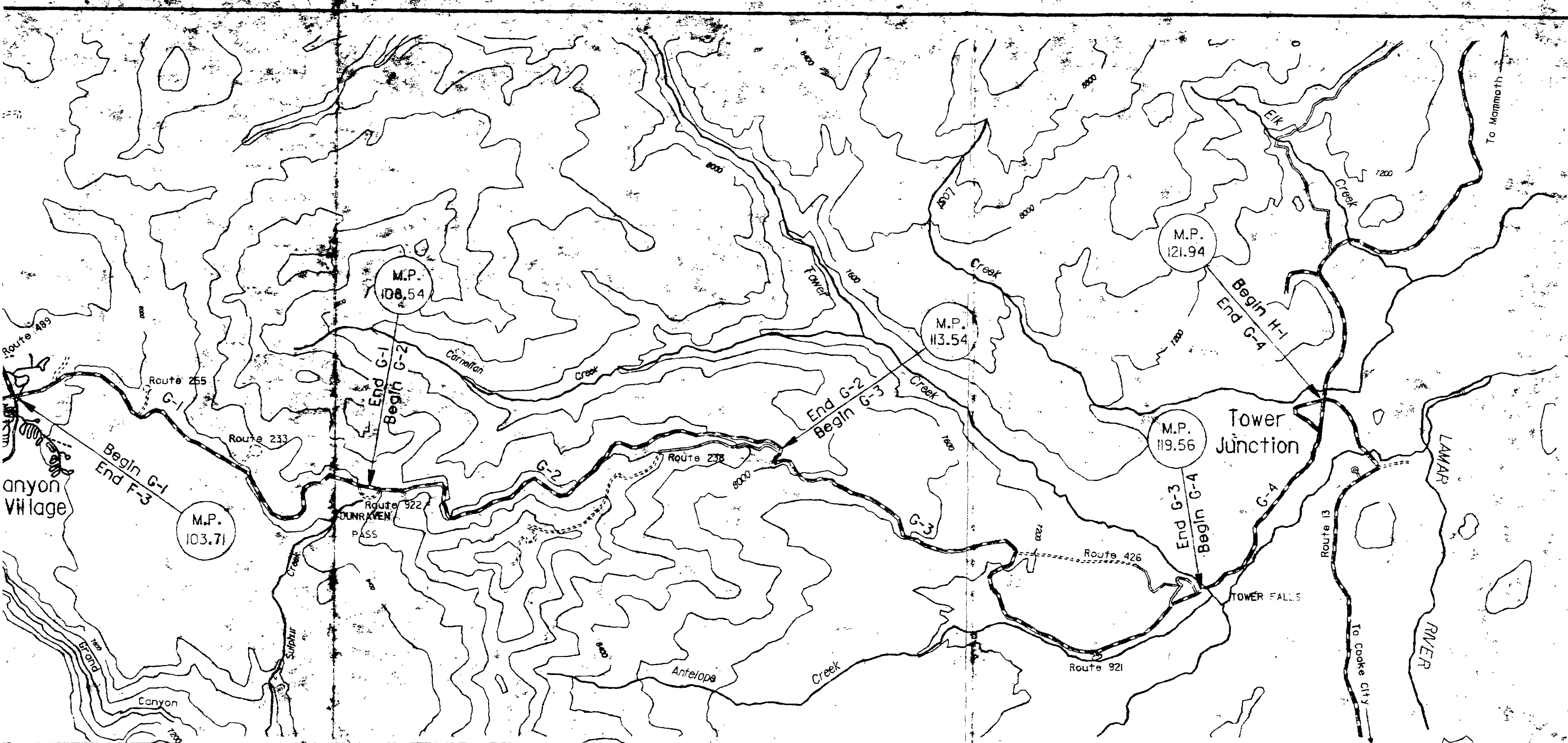
Accurate as of Sept. 1986

APPURTENANT ROUTES

ROUTE NO.	ROUTE NAME	REPORT PAGE
108	South Rim Drive	IV-249
234	Buffalo Ford Picnic Area Rd.	IV-373
434	Grebe Lake Service Rd.	IV-433
458	Otter Creek Service Rd.	IV-373
470	Fishing Bridge Water Intake Service Rd.	IV-373
481	Fishing Bridge Microwave Service Rd.	IV-373
914	Canyon Horse Corral Rd. and Parking Area	IV-249
915	Uncle Tom's Parking Area	IV-249
917	Mud Volcano Parking Area	IV-373
939	Cascade Picnic Area	IV-373

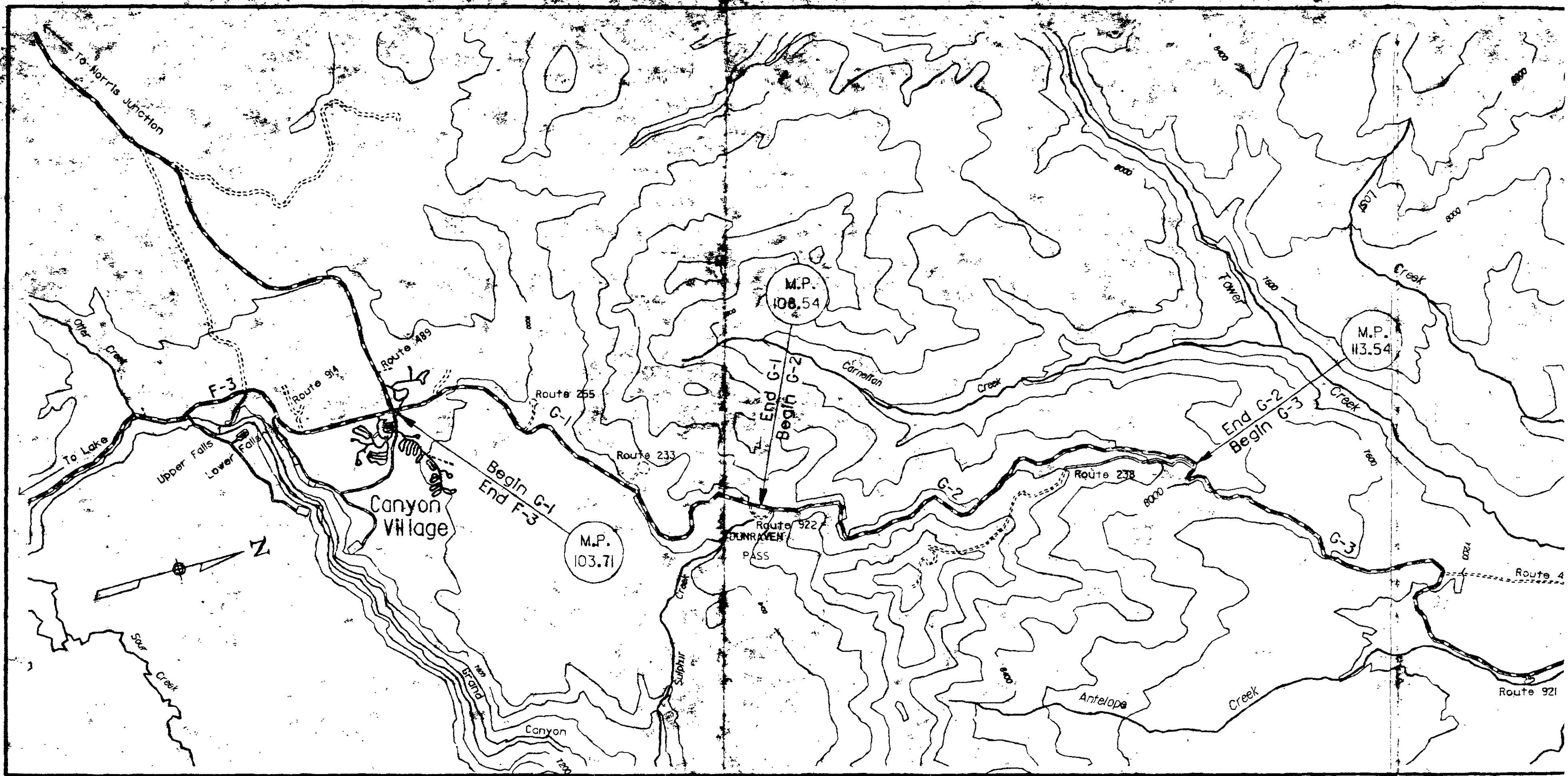
RO

FISH



ROUTE 10 - GRAND LOOP ROAD
SEGMENT G
CANYON VILLAGE TO TOWER JUNCTION

0 ½ 1 2 Miles
5000 0 5000 10000 Feet
SCALE

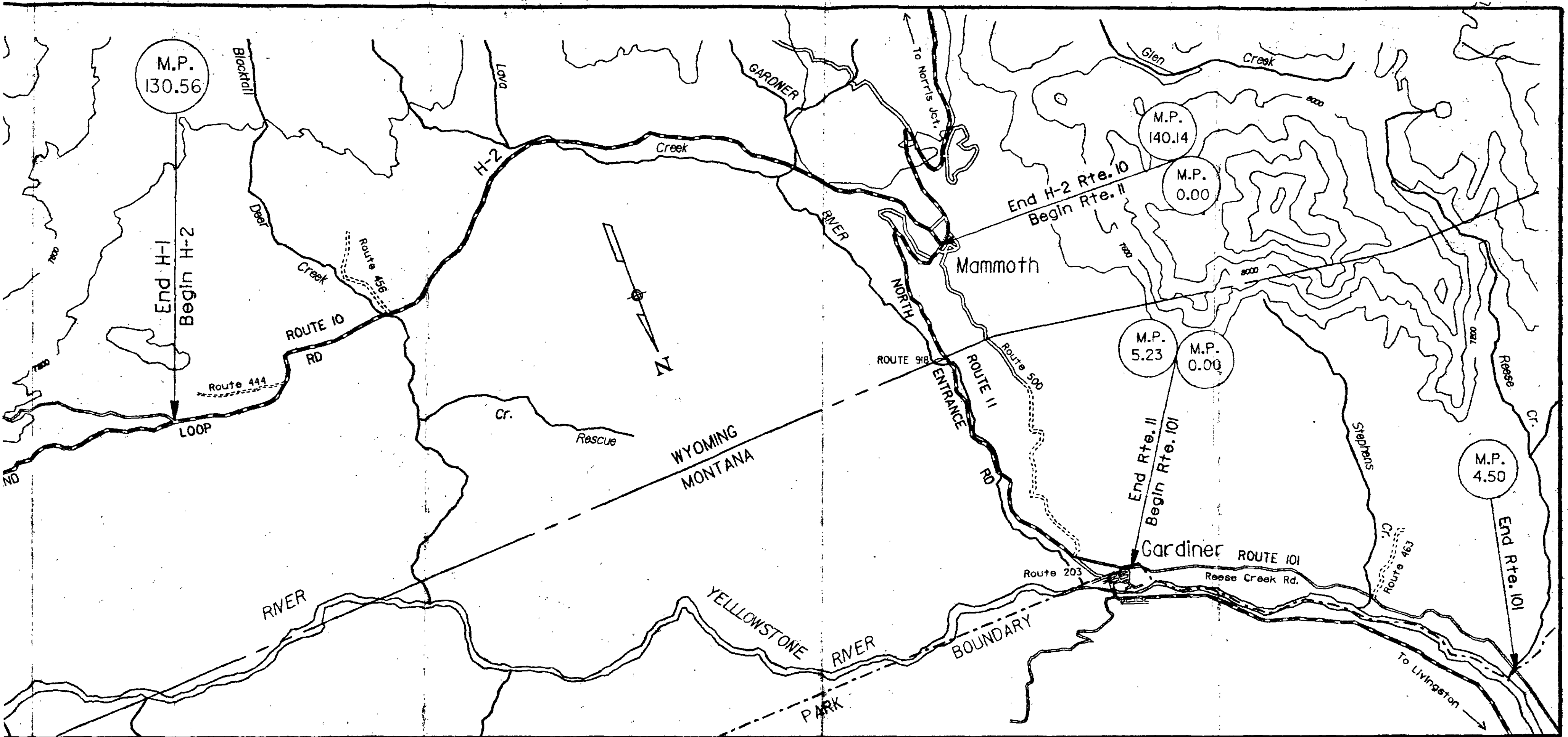


APPURTENANT ROUTES

ROUTE NO.	ROUTE NAME	REPORT PAGE
233	Dunraven Picnic Area	IV-367
238	Chittenden Rd.	IV-367
255	Cascade Lake Trailhead and Picnic Parking Area	IV-367
476	Old Dunraven Service Rd.	IV-367
489	Old Canyon Water Intake Service Rd.	IV-367
921	Antelope Creek Picnic Area	IV-367
922	Dunraven Summit Picnic Area	IV-367

ROU

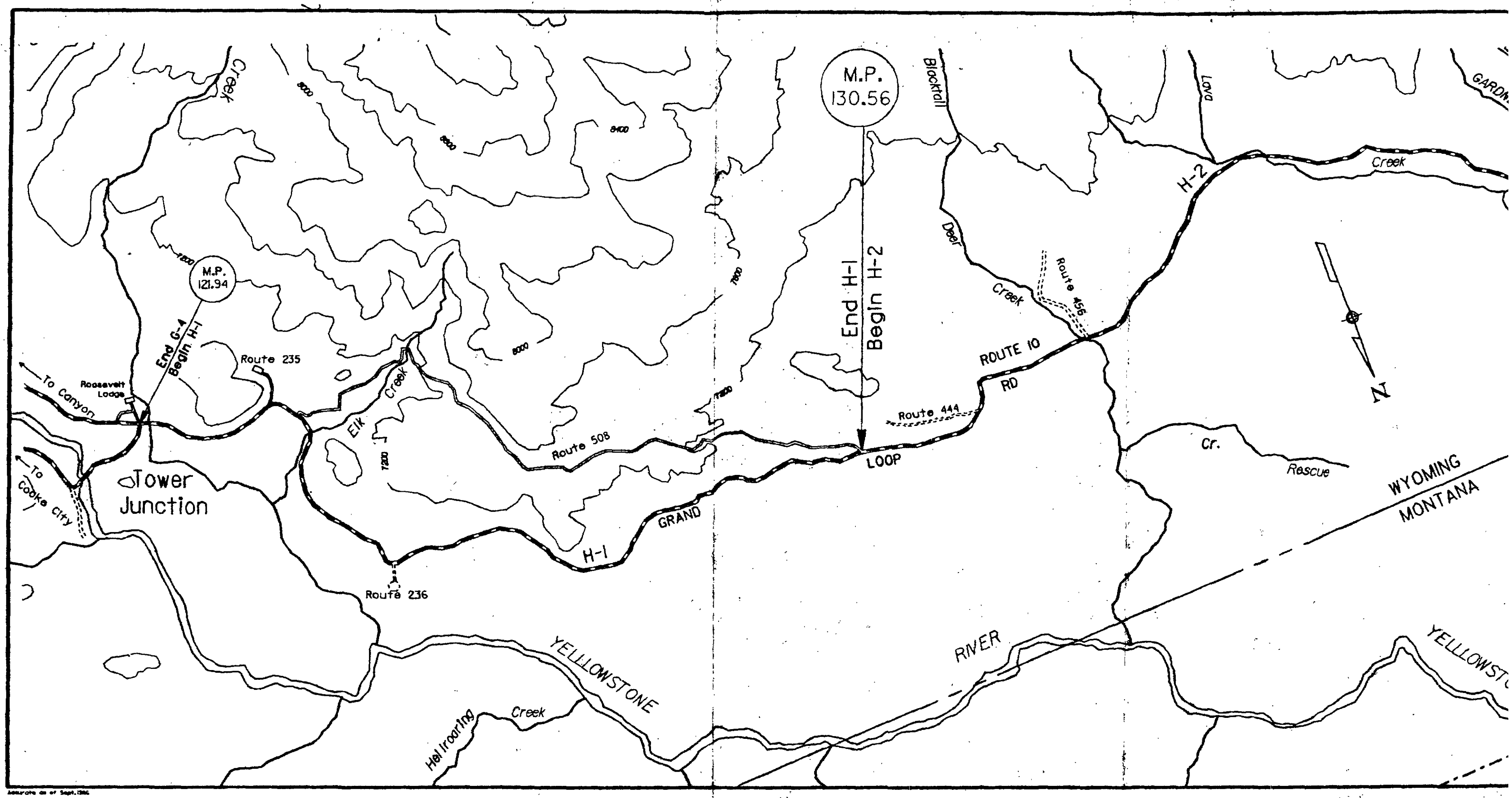
CANYON



ROUTE 10 - GRAND LOOP ROAD
SEGMENT H
TOWER JUNCTION TO MAMMOTH
ROUTE 11 - NORTH ENTRANCE RD.
ROUTE 101 - REESE CREEK RD.
ROUTE 500

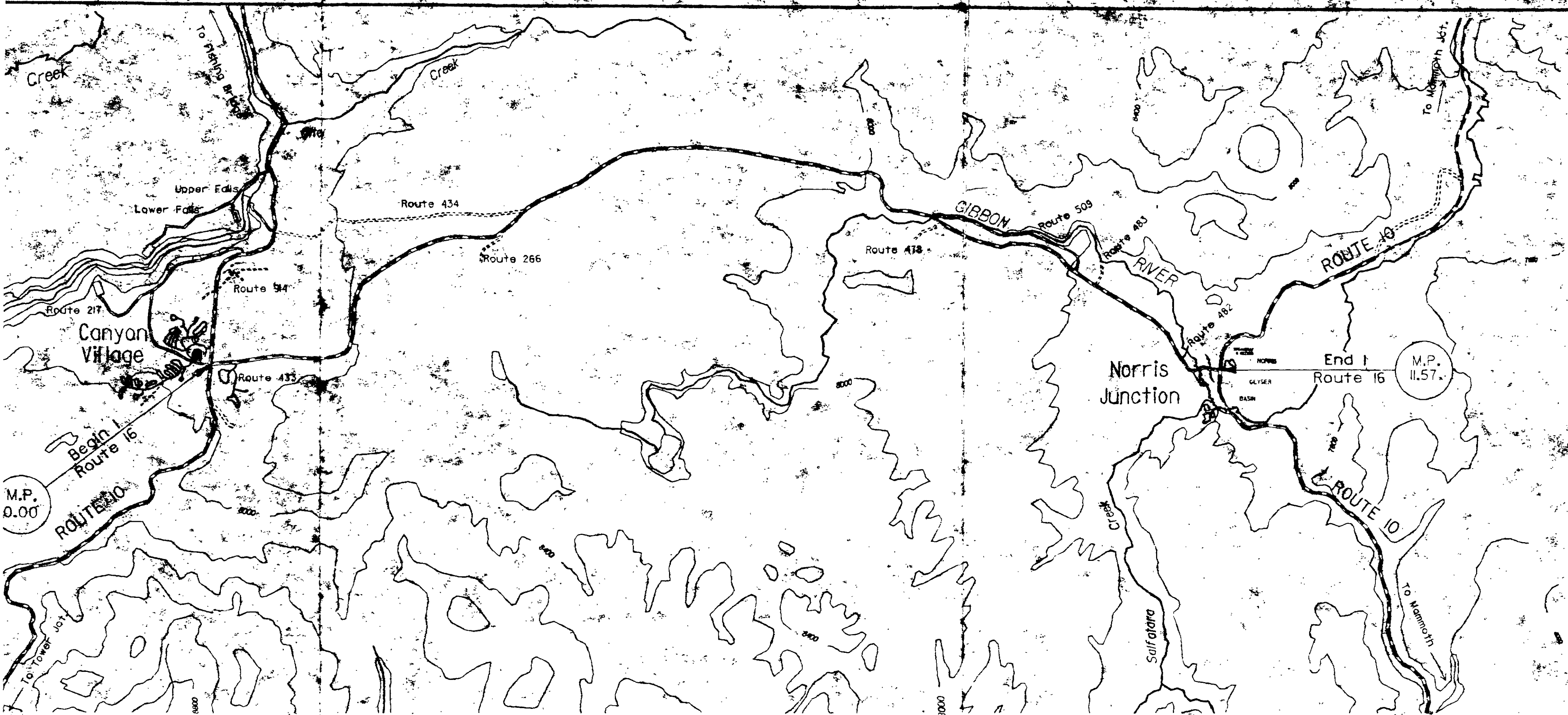
0 ½ 1 2 Miles
5000 0 5000 10000 Feet
SCALE

[redacted]



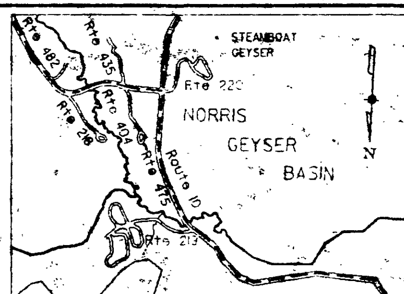
APPURTENANT ROUTES

ROUTE NO.	ROUTE NAME	REPORT PAGE
101	Reese Creek Rd.	IV-235
203	North Entrance Concessionaire Service Rd.	IV-301
235	Petrified Tree Rd.	IV-379
236	Hellroaring Creek Trailhead Rd.	IV-379
444	Frog Rock Service Rd.	IV-379
456	Blacktail Creek Service Rd.	IV-379
463	Stephens Creek Rd.	IV-235
500	Mammoth Gardiner High Rd.	IV-439
508	Blacktail Plateau Drive	IV-379
918	45th Parallel Parking Area	IV-133



ROUTES

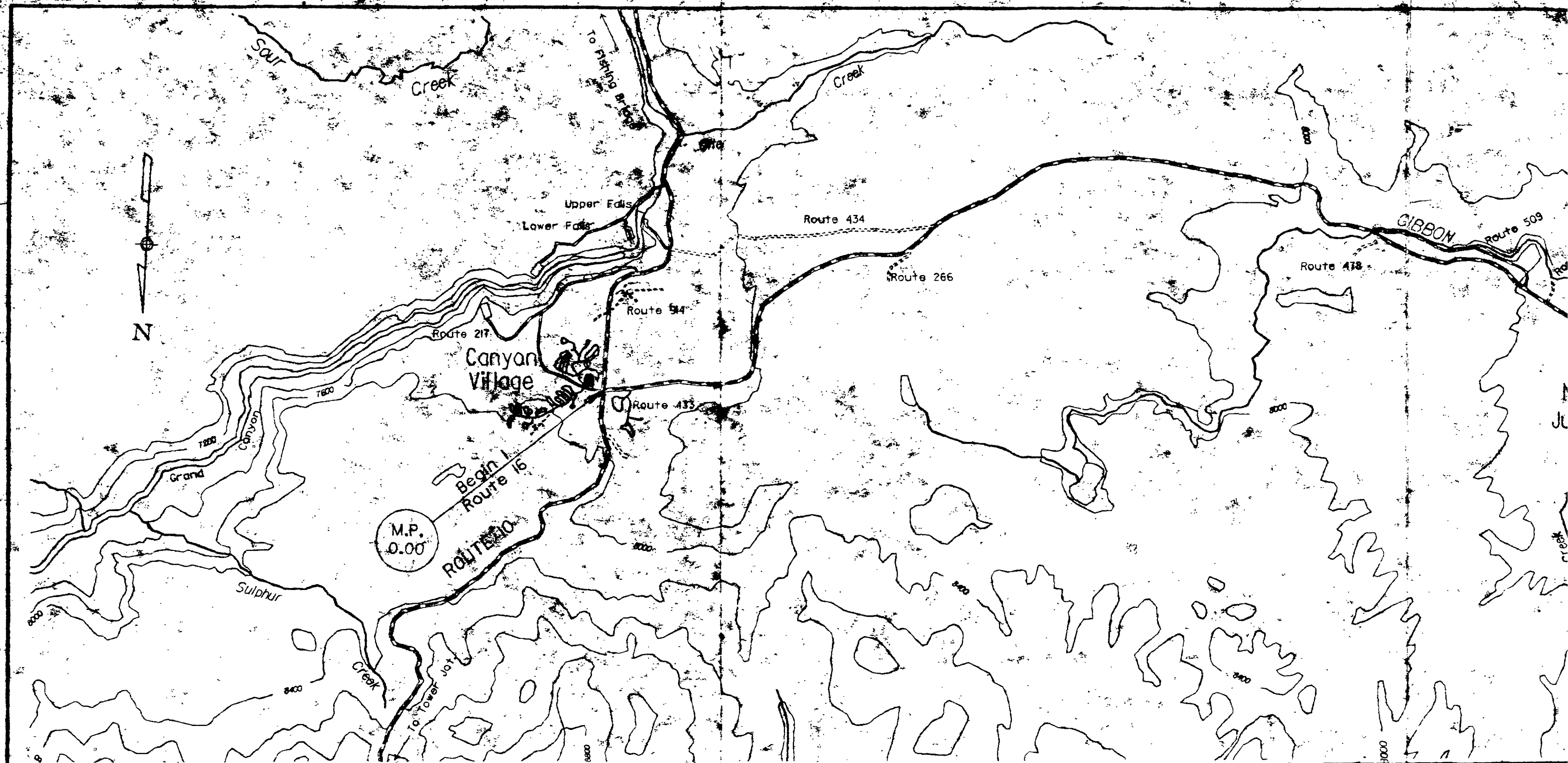
ROUTE NO.	ROUTE NAME	PAGE
435	Norris Water Tank Service Rd.	IV-[illegible]
475	Norris Water Pump Station Service Rd.	IV-47
478	Ice Lake Service Rd.	IV-487
482	Norris Pit Rd.	IV-487
483	Norris Substation Service Rd.	IV-433
509	Virginia Cascade Drive	IV-4[illegible]



NORRIS JUNCTION DETAIL

ROUTE 16 - NORRIS CANYON ROAD
CANYON VILLAGE TO NORRIS JUNCTION

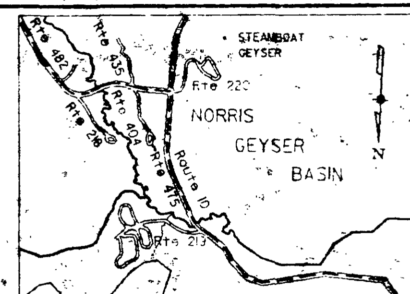
0 1/2 1 2 Miles
5000 0 5000 10000 Feet
SCALE



Accurate as of Sept. 86

APPURTENANT ROUTES

ROUTE NO.	ROUTE NAME	REPORT PAGE
218	Norris Picnic Area Rd.	IV-347
266	Grebe Lake Trailhead Rd.	IV-433
404	Norris Administrative Service Rd.	IV-347
433	Canyon Residence Area Service Rd.	IV-249
434	Grebe Lake Service Rd.	IV-433
435	Norris Water Tank Service Rd.	IV-[illegible]47
475	Norris Water Pump Station Service Rd.	IV-[illegible]47
478	Ice Lake Service Rd.	IV-4[illegible]
482	Norris Pit Rd.	IV-4[illegible]
483	Norris Substation Service Rd.	IV-433
509	Virginia Cascade Drive	IV-4[illegible]



NORRIS JUNCTION DETAIL

RO
CANYO