REPORT ON
PRELIMINARY RECONNAISSANCE
OF
POTENTIAL RESERVOIRS
GREEN RIVER BASIN, WYOMING

SUBMITTED
TO THE
DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT
AND THE
WYOMING WATER PLANNING PROGRAM, STATE ENGINEER’S OFFICE
CHEYENNE, WYOMING

Submitted by
J. T. Banner & Associates, Inc.
Consulting Engineers
Laramie, Wyoming
July 1, 1969
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GREEN RIVER BASIN, WYOMING

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LETTER OF TRANSMITTAL</td>
<td>1 - 11</td>
</tr>
<tr>
<td>I. SCOPE OF INVESTIGATION</td>
<td>1-1 - 1-2</td>
</tr>
<tr>
<td>II. UPPER KENDALL RESERVOIR</td>
<td>2-1 - 2-7</td>
</tr>
<tr>
<td>III. LOWER KENDALL RESERVOIR</td>
<td>3-1 - 3-7</td>
</tr>
<tr>
<td>IV. NEW FORK NARROWS RESERVOIR</td>
<td>4-1 - 4-8</td>
</tr>
<tr>
<td>V. LOWER GREEN RESERVOIR</td>
<td>5-1 - 5-6</td>
</tr>
<tr>
<td>VI. SUMMARY</td>
<td>6-1 - 6-3</td>
</tr>
</tbody>
</table>
July 1, 1969

Department of Economic Planning and Development
Wyoming Water Planning Program
State Engineer's Office
Cheyenne, Wyoming 82001

Gentlemen:

In accordance with our letter of May 21, 1969, and Mr. Goodson's letter of May 29, 1969, we are submitting herewith our "Report on Preliminary Reconnaissance of Potential Reservoirs - Green River Basin, Wyoming."

We wish to express our appreciation for the assistance and cooperation extended by Mr. Frank Trelease, Director for the Water Planning Program of the Wyoming State Engineer's office, and by Mr. Myron Goodson, Chief of Water Resources of the Department of Economic Planning and Development of the State of Wyoming.

Our findings are briefly summarized below:

1. Upper Kendall Reservoir. A reservoir could be constructed at this site to a capacity of over one million acre-feet. The cost of live storage capacity at this reservoir would vary from $25.25 per acre-foot for a capacity of 200,000 acre-feet to $18.00 per acre-foot for a capacity of 600,000 acre-feet.

2. Lower Kendall Reservoir. A reservoir could be constructed at this site to a capacity of over one million acre-feet. The cost of live storage capacity at this reservoir would vary from $61.00 per acre-foot for a capacity of 200,000 acre-feet to $45.00 per acre-foot for a capacity of 600,000 acre-feet. It is noted that the cost per acre-foot of live storage capacity at this site is approximately 21/2 times that of the cost per acre-foot at the Upper Kendall Reservoir site. The esthetic and recreational values lost at the Lower Kendall Reservoir site are about the same as those lost at the Upper Kendall Reservoir site.

3. New Fork Narrows Reservoir. A reservoir could be constructed at this site to a capacity of over 1.2 million acre-feet. The cost of live storage capacity at this reservoir would vary from $39.50 per acre-foot for a capacity of 200,000 acre-feet to $16.45 per acre-foot for a capacity of 1,100,000 acre-feet. The cost per acre-foot of live storage capacity at this site is from about 30% to 55% more than the cost of live storage capacity at the Upper Kendall Reservoir site for storage capacity varying from 600,000 to 200,000 acre-feet.
4. Lower Green Reservoir. The storage capacity that could be constructed at this site without encroaching on the Stauffer Chemical Plant would be about 260,000 acre-feet. The cost of live storage capacity at this reservoir would vary from $34.75 per acre-foot for a capacity of 200,000 acre-feet to $32.75 for a capacity of 260,000 acre feet. This is approximately 30% more than the cost per acre-foot for the same capacity at the Upper Kendall Reservoir site.

Respectfully submitted,

J. T. BANNER & ASSOCIATES, INC.

[Signature]

JTB: bh
I - SCOPE OF INVESTIGATION

This report submits the results of the preliminary reconnaissance investigation of four reservoir sites in the Green River Basin in Wyoming. The reservoir sites investigated include the Upper Kendall, the Lower Kendall, the New Fork Narrows and the Lower Green. The location of the sites are shown on Plate I-1 at the end of this section of the report.

The Upper Kendall Reservoir is on the Green River main stem about 14 miles north of Daniel. The Lower Kendall Reservoir is on Green River main stem and the dam site for this Reservoir is about two miles below the dam site for the Upper Kendall Reservoir. The Reservoir basin for the Upper Kendall and Lower Kendall Reservoirs cover approximately the same area.

The New Fork Narrows Reservoir is on the New Fork River. The dam site for this Reservoir is about $3\frac{1}{2}$ miles upstream from the confluence of the New Fork River and the Green River. The Lower Green Reservoir is on the main stem of the Green River. The dam site for this Reservoir is about 7 miles above the Town of Green River.

Preliminary general plans for the dam, spillway and outlet works for each of the four reservoirs are included as part of this report. The storage capacities at each Reservoir that were used to prepare the plans for the dam, spillway and outlet works were determined through discussions with the Director of the Water Planning Program. Also, the spillway and outlet works capacities for each Reservoir were determined through discussions with the Director of the Water Planning Program.
Cost estimates for each Reservoir for various storage capacities have been made. From these data, storage capacity - versus total cost curves, and storage capacity versus cost per acre-foot curves have been prepared for each of the four Reservoirs.
II - UPPER KENDALL RESERVOIR

A. GENERAL

The Upper Kendall Reservoir site is on the main stem of the Green River, north of Daniel, Wyoming. The dam site for this Reservoir is about 14 miles north of Daniel and about 4 miles upstream from the point where U.S. Highway 187 and 189 cross the Green River. The dam site for this Reservoir can be reached by a gravel road on the west side of the Green River. On the east side of the Green River the dam site can be reached by automobile over dim trails through the sagebrush.

The topography of the Upper Kendall Reservoir site is such that a reservoir could be constructed to a capacity of close to 1,000,000 acre-feet at the site. This investigation contemplates a reservoir capacity of not to exceed 600,000 acre-feet of total storage. A minimum storage pool of 15,000 acre-feet for fish and recreation purposes has been assumed for this investigation.

The Bureau of Reclamation has completed relatively extensive preliminary investigations of the Upper Kendall Reservoir site. The Bureau investigations include topography of the reservoir and dam site, borings and test pits on the dam site area and preliminary geologic reports for the area. The Bureau's data including its spillway design flood study were available and used in connection with this investigation.

B. SITE CONDITIONS

1. Geologic

The geologic data for the Upper Kendall Reservoir site were obtained from the Bureau of Reclamation data, regional geologic maps and literature, and from a preliminary field investigation in the area.
The sedimentary rocks in the area include interbedded shale and sandstone of the Wasatch formation which is of the Tertiary period and overlying glacial debris consisting of interspersed clay, silt and sand and scattered boulders. The Green River has eroded a narrow channel through the relatively impervious morainal deposits to within several feet of the Wasatch in the area of the dam site. Because of the uneven nature of the pre-glacial topography, the depth to bedrock varies considerably within relatively short distances.

In the dam site area the glacial beds are stable and, it appears, adequate to support the earth embankment. The abutments at the dam site appear to be sufficiently tight so that no special treatment will be required to prevent seepage through and beneath them. Numerous small lakes formed in glacial depressions indicate a high water table which infers water-tight basinal conditions.

Very little topsoil or organic materials are present in the dam site area. Stripping on the abutments will be limited to removing sagebrush, vegetation and some large boulders.

2. Physical

The Green River is about 300 feet wide at the dam axis and meanders through the glacial morain which is typical "knob and basin" topography. The ground surface at the east abutment of the dam slopes up steeply for about 80 feet, then continues upward on a flatter slope for about 70 more feet, and then continues across the "knob and basin" topography to an elevation of about 7,700 feet. The west abutment at the dam site slopes up steeply to an elevation of 7,700 feet.
The Canyon Ditch, which diverts water from the Green River, in the Reservoir basin upstream from the dam site, is located on the east abutment of the dam site. This Ditch provides irrigation water for the Forty Rod Project. The Wyoming State Game and Fish Department has provided fishing and camping sites on the west side of the Green River in the reservoir and dam site areas.

C. PROPOSED FACILITIES

Preliminary design for the facilities to provide a Reservoir with a total storage capacity of 600,000 acre-feet have been made for this investigation. Plates II-1, II-2 and II-3 at the end of this section of this report show the facilities proposed for the 600,000 acre-foot capacity Reservoir. Plate II-1 shows the Reservoir Basin topography at 20 foot contour intervals. Plate II-2 shows the maximum Dam Section, the Dam Plan and the Profile on the Dam axis. Plate II-3 shows the Proposed Spillway and outlet works for the dam.

1. Embankment Section

The proposed maximum embankment section is shown on Plate II-2. For the 600,000 acre-feet live storage capacity the embankment will have a maximum height of 160 feet above the stream bed and a length along the axis of the dam of approximately 9,000 feet. The height of the embankment section above the spillway crest will be 20 feet. A free board above the maximum high water of 10 feet is proposed. A crest width of 35 feet for the dam is proposed.

The proposed embankment section is a zoned earth fill dam. The impermeable core material would be clay, silt and fine sand. The shell material would be a gravelly fill. A pervious embankment drain beneath the downstream one-third of the dam section would be provided. This drain would
be constructed of free draining gravel and would have a minimum thickness of 3 feet.

An upstream slope of 3 1/2 to 1 to a point just below the dead storage water surface elevation is proposed. At this elevation a 20 foot berm and a slope of 4 to 1 from this elevation to the base of the dam is proposed. A downstream slope of 3 to 1 is proposed. It is contemplated that the upstream face of the dam will be protected by rock riprap with a minimum thickness of 3 feet. The bedding material for the riprap would be 1 1/2 feet thick.

2. Spillway

The spillway facilities included an ungated overflow weir section, a rectangular free-flow discharge channel and a hydraulic jump type basin as a terminal structure. The discharge channel will be concrete lined and the terminal structure will be constructed of reinforced concrete.

A maximum spillway capacity of 10,000 cubic feet per second is contemplated. This maximum capacity was arrived at through a review of the Bureau of Reclamation's "Spillway Design Flood Study" for the Upper Kendall Reservoir site.

3. Outlet Works

The proposed outlet works are shown on Plate 11-3. A 12-foot horseshoe shaped outlet tunnel through the east abutment is contemplated. This tunnel will be through glacial till and would be lined with reinforced concrete. This tunnel will serve to handle the water during construction of the dam embankment.

The completed outlet works will include a trash rack at the upstream end of the 12 foot tunnel, a reinforced concrete gate structure with two
36 inch valves and two 72 inch valves, and a 72 inch diameter and 36 inch diameter concrete outlet pipes installed in the 12 foot tunnel from the gate structure to the outlet works terminal structure. The terminal structure would be an hydraulic jump type basin constructed of reinforced concrete.

The capacity of the proposed outlet works varies from 900 cubic feet per second at low water pool to 1,370 cubic feet per second at high water pool. A discharge versus water elevation curve for the outlet works is included on Plate II-3.

A four foot diameter concrete pipe with a gate chamber would be installed as shown on Plate II-2 to take care of the Canyon Ditch water rights. The capacity of this pipe would be 200 cubic feet per second with a water elevation of 7,623.


Materials for the impervious core of the dam embankment are available in the glacial deposits on both sides of the River immediately above the proposed dam site. The preliminary field investigations did not locate any gravel materials for the pervious dam embankment. Undoubtedly satisfactory materials could be obtained by screening the river sands and gravels.

Hard, durable rock deposits are available along the Green River upstream from the dam site. These deposits should provide satisfactory rock for the riprap. Aggregates for concrete could be processed from the stream gravels on the Green River and its tributaries.
D. ESTIMATED COSTS

1. Reservoir Capacity - Total = 600,000 A.F., Live = 585,000 A.F.

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<th>Cost</th>
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<td>b. Spillway</td>
<td>1,110,000.00</td>
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<td>c. Outlet Works</td>
<td>1,110,000.00</td>
</tr>
<tr>
<td>d. Clearing and Grubbing</td>
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<tr>
<td>e. Land Acquisition *</td>
<td>885,000.00</td>
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Subtotal $9,286,200.00
+ 15% Engineering and Contingency 1,392,930.00

Total $10,679,130.00

Cost/Acre Foot of Live Storage = $18.25

* Based on land values for irrigated and range areas.
Recreational and esthetic values of this area may be more.

2. Reservoir Capacity - Total = 340,000 A.F., Live = 325,000 A.F.

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<td>c. Outlet Works</td>
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<td>d. Clearing and Grubbing</td>
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<td>e. Land Acquisition *</td>
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Subtotal $6,474,000.00
+ 15% Engineering and Contingency 971,100.00

Total $7,445,100.00

Cost/Acre Foot of Live Storage = $22.91

* Based on land values for irrigated and range areas.
Recreational and esthetic values of this area may be more.

3. Reservoir Capacity - Total = 190,000 A.F., Live = 175,000 A.F.

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<tr>
<td>e. Land Acquisition *</td>
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</table>

Subtotal $3,915,000.00
+ 15% Engineering and Contingency 587,250.00

Total $4,502,250.00

Cost/Acre Foot of Live Storage = $25.73

* Based on land values for irrigated and range areas.
Recreational and esthetic values of this area may be more.
E. SUMMARY

Total storage capacity and water surface area versus reservoir water surface elevation curves for the Upper Kendall Reservoir to a maximum storage capacity of a little over a million acre-feet are shown on Figure II-1, page 2-8.

Total cost versus live storage capacity and cost per acre foot versus live storage capacity curves are shown on Figure II-2, page 2-9. The total cost for a Reservoir at this site with a live storage capacity of about 600,000 acre-feet is about $10,800,000. The cost per acre foot with this storage capacity is about $18.00 per acre-foot. The total cost of a Reservoir with a capacity of 400,000 acre-feet is about $8,600,000, which is a unit cost of about $21.50 per acre foot. The total cost of a Reservoir with a capacity of 200,000 acre feet is about $5,050,000, which is a unit cost of about $25.25 per acre-foot.
III - LOWER KENDALL RESERVOIR

A. GENERAL

The Lower Kendall Reservoir is on the main stem of the Green River, north of Daniel, Wyoming. The dam site for this Reservoir is about 2 miles downstream from the Upper Kendall dam site and is in Section 4, Township 35 North, Range 111 West. The dam site for the Reservoir can be reached by a Wyoming State Game and Fish access road on the west side of the Green River.

The topography of the basin upstream from the dam site is such that a reservoir with a capacity of approximately 1,000,000 acre-feet could be built. This report will consider only reservoirs with a capacity of 600,000 acre-feet or less. A dead storage pool of 15,000 acre-feet, the same as was used for the Upper Kendall Reservoir has been assumed.

The U. S. Geological Survey has advance topographic maps available, in the 7-5 minute series, for the dam site and some of the reservoir area. These topographic data were used to locate the dam site and obtain the embankment quantities. The Bureau of Reclamation, in their study for Upper Kendall, have a reservoir map that includes the lower Kendall dam site. The Bureau's flood study for the Upper Kendall Reservoir was used to size the spillway for the Lower Kendall Reservoir.

B. SITE CONDITIONS

1. Geologic

The geologic data for the Lower Kendall Reservoir site were obtained from the Bureau's Geologic Report on Upper Kendall, regional geologic maps, review of the geologic literature available, and from a preliminary site investigation.
The stratigraphic section at Lower Kendall is similar to that at Upper Kendall. The sedimentary rock, the Wasatch formation, are of the Tertiary Period and are overlain by glacial till of the Pleistocene Epoch. The sediments are impervious shales and sandstone and appear to be tight and well adapted to retain the storage water without much loss. The glacial drift consists of reddish-brown clay, silt and sand, with a small amount of gravel and angular boulders up to several feet in diameter scattered throughout the fine material. This material is impervious and believed to be sufficiently stable to support an earth embankment of the height contemplated. Stripping for the embankment in the dam prism will be limited to removing vegetation and topsoil.

2. Physical

The Green River is about 300 feet wide at the dam axis and meanders through the glacial till which is typical "knob and basin" topography. The ground surface on the east abutment slopes up steeply for about 140 feet then continues for a distance of approximately 2 miles across the highly uneven "knob and basin" topography then slopes up steeply to an elevation of 7,700 feet. The ground surface on the west abutment slopes up steeply to an elevation of 7,700 feet.

The Canyon Ditch which has its inlet in the reservoir area, crosses the east abutment of the dam site. This ditch supplies irrigation water for the Forty Rod Project. The Wyoming State Game and Fish Commission have built an access road to fishing and camping sites on the west side of the Green River in this area.
C. PROPOSED FACILITIES

Preliminary design for the facilities that would provide a reservoir with a live storage capacity of 600,000 acre-feet have been made for this report. Plates III-1, III-2 and III-3 at the end of this section of the report, show the facilities proposed for the 600,000 acre-feet capacity reservoir. Plate III-1 shows the reservoir basin topography with 20 foot contour intervals. Plate III-2 shows the Maximum Dam Section, the Dam Plan and the Profile along the dam axis. Plate III-3 shows the Proposed Spillway and Outlet Works for the dam.

1. Embankment Section

The proposed maximum embankment section is shown on Plate III-2. For the 600,000 acre-feet live storage capacity the embankment will have a maximum height of 192 feet above the stream bed and a length along the axis of the dam of approximately 14,380 feet. The height of the embankment section above the spillway crest will be 20 feet. A free board above the maximum high water of 10 feet is proposed. A crest width of 35 feet for the dam is proposed.

The proposed embankment section is a zoned earth fill dam. The impermeable core material would be clay, silt and fine sand. The shell material would be a gravelly fill. A pervious embankment drain beneath the downstream one-third of the dam section would be provided. This drain would be constructed of free draining gravel and would have a minimum thickness of 3 feet.

An upstream slope of $3\frac{1}{2}$ to 1 to a point just below the dead storage water surface elevation is proposed. At this elevation a 20 foot berm and a slope of $\frac{4}{3}$ to 1 from this elevation to the base of the dam is proposed.
A downstream slope of 3 to 1 is proposed. It is contemplated that the upstream face of the dam will be protected by rock riprap with a minimum thickness of 3 feet. The bedding material for the riprap would be 1 ½ feet thick.

2. Spillway

The spillway facilities included an ungated overflow weir section, a rectangular free-flow discharge channel and a hydraulic jump type basin as a terminal structure. The discharge channel will be concrete lined and the terminal structure will be constructed of reinforced concrete.

A maximum spillway capacity of 10,000 cubic feet per second is contemplated. This maximum capacity was arrived at through a review of the Bureau of Reclamation's "Spillway Design Flood Study" for the Upper Kendall Reservoir site.

3. Outlet Works

The proposed outlet works are shown on Plate III-3. A 12 foot horseshoe shaped cut and cover conduit through the embankment section is contemplated. This conduit will have cut-off collars to minimize seepage along the contact between the outside surface of the conduit and the embankment. The cut and cover conduit will be constructed of reinforced concrete and will be used to divert the flow of the Green River during construction of the dam embankment.

The completed outlet works will include a trashracked inlet structure, the 12 foot horseshoe shaped cut and cover conduit, a reinforced concrete gate chamber with two 72" valves and two 36" valves, and a reinforced concrete hydraulic jump type terminal basin. Inside the 12-foot diameter conduit, downstream from the gate chamber, a 72 inch diameter and a 36 inch
diameter outlet pipes will be provided to regulate the flow for the by-pass requirements of the reservoir.

The capacity of the proposed outlet works varies from 1,050 cubic feet per second at the dead storage water surface to 1,525 cubic feet per second at the normal water surface. A discharge versus water elevation curve for the outlet works is shown on Plate III-3.

A four foot diameter concrete pipe with a gate chamber and cut-off collars, would be installed as shown on Plate III-2 to take care of the Canyon Ditch water rights. The capacity of this pipe would be 200 cubic feet per second with a water elevation of 7,603.

4. **Available Construction Materials**

The glacial deposits on either side of the Green River will be satisfactory for the impervious core material of the dam embankment. No extensive deposits of gravel for the shell material and pervious section of the dam embankment were located but with a screening of the river gravels, it is felt that satisfactory material could be obtained. No source of riprap or concrete aggregate were located although, there are some deposits of hard, durable rock upstream along the Green River that could be used for riprap. Concrete aggregate probably could be processed from gravels in the Green River or its tributaries.
### D. ESTIMATED COSTS

1. **Reservoir Capacity - Total = 600,000 A.F., Live = 585,000 A.F.**

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<td>Clearing and Grubbing</td>
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<td><strong>Total</strong></td>
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Cost/Acre Foot of Live Storage = $45.59

* Based on land values for irrigated and range areas. Recreational and esthetic values of this area may be more.

2. **Reservoir Capacity - Total = 450,000 A.F., Live = 435,000 A.F.**

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<td>Clearing and Grubbing</td>
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<td><strong>Total</strong></td>
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Cost/Acre Foot of Live Storage = $52.06

* Based on land values for irrigated and range areas. Recreational and esthetic values of this area may be more.

3. **Reservoir Capacity - Total = 215,000 A.F., Live = 200,000 A.F.**

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<td>Spillway</td>
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<td>Outlet Works</td>
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<td>Land Acquisition *</td>
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<td><strong>Subtotal</strong></td>
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<td>+ 15% Engineering and Contingency</td>
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<tr>
<td><strong>Total</strong></td>
<td>$12,186,550.00</td>
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Cost/Acre Foot of Live Storage = $60.93

* Based on land values for irrigated and range areas. Recreational and esthetic values of this area may be more.
E. SUMMARY

Total storage capacity and water surface area versus reservoir water surface elevation curves for the Lower Kendall Reservoir to a maximum storage capacity of about one million acre-feet are shown on Figure III-1, page 3-8.

Total cost versus live storage capacity and cost per acre-foot versus live storage capacity curves are shown on Figure III-2, page 3-9. The total cost of a Reservoir at this site with a live storage capacity of 600,000 acre feet is $27,000,000, which is a unit cost of $45.00 per acre-foot. The total cost of a Reservoir with a capacity of 400,000 acre-feet is $21,400,000, which results in a unit cost of $53.50 per acre-foot. The total cost of a Reservoir with a capacity of 200,000 acre-feet is $12,200,000, which results in a unit cost of $61.00 per acre-foot.
OUTLET WORKS

PROFILE ON § OF OUTLET WORKS

SECTION A-A

NOTE: Section B-B is similar to section A-A but does not include 36" and 72" outlet pipe.

SECTION C-C

PROFILE ON § OF SPILLWAY

OUTLET DISCHARGE CURVES

SPILLWAY DISCHARGE CURVE
A. GENERAL

The New Fork Narrows Reservoir site is on the New Fork River in Sublette County, northeast of Big Piney and southwest of Pinedale. The New Fork River is one of the major tributaries of the Green River in Wyoming. The dam site for this Reservoir is in Sections 11 and 14, T. 30 N., R. 110 W., about 12 miles northeast of Big Piney and about 3½ miles upstream from the confluence of the Green River and the New Fork River. Wyoming State Highway 1801 traverses part of the Reservoir area and is immediately adjacent to the New Fork River at the proposed Reservoir dam site.

The U. S. Bureau of Reclamation did make a preliminary reconnaissance area-capacity curve for the proposed New Fork Reservoir. U. S. Geological Survey 7.5 Minute Series topographic maps with 20 foot contour intervals for the Reservoir and dam site areas are available. These Bureau data and the topographic maps were used to prepare the Reservoir area topographic maps and for the preliminary dam design proposed in this report.

The topography of the New Fork Narrows Reservoir site is such that a Reservoir probably could be built to a capacity as much as close to 3,000,000 acre-feet. This investigation contemplates a Reservoir with a capacity of not more than 1,200,000 acre-feet of total storage. Cost data for total storage capacities less the 1,200,000 acre-feet are included as part of this report. A dead storage pool of 50,000 acre-feet to provide some fish and recreation benefits is proposed.
B. SITE CONDITIONS

1. Geologic

The geologic information for this report was obtained from field reconnaissance investigation, review of the geologic literature for the area and from geological maps of the area.

Sedimentary rocks of the Wasatch formation, which are in the lower Eocene Epoch, are found on both the north and south abutments at the proposed dam site. The Wasatch formation consists of sandstones, carbonaceous shales, and some beds of bituminous coals. Overlying the Wasatch formation is the alluvial plain, alluvial deposits of the Quaternary Period composed of clays, silts and gravels.

It appears from surface examination that considerable slippage has occurred on the south abutment at the dam site. Before final conclusions in regard to this site as a satisfactory dam site and the final dam design are made, extensive foundation investigations including test pits and borings would be necessary.

The heavy vegetation on the alluvial flood plain would require a stripping depth of 18 to 24 inches in the Dam site area. There would be considerable clearing and grubbing of trees and brush in the Reservoir area.

2. Physical

The New York River is about 200 feet wide at the dam axis and meanders through the alluvial flood plain of the Reservoir basin. The ground surface at the south abutment of the dam site slopes up steeply to the top of Ross butte at an elevation of 7,460 feet. On the north abutment of the dam site the ground slopes up rather steeply to the top of the south end of a mesa at an elevation of 7,000 feet.
Wyoming State Highway No. 1801 crosses the dam site and traverses the lower part of the Reservoir area and would have to be relocated when the dam and Reservoir are constructed. U. S. Highway No 187 would encroach on the high water area of the Reservoir in the upper end of the site, if the reservoir is constructed to a capacity of 1,200,000 acre-feet. This would mean relocation of this highway if the Reservoir is constructed to this capacity. Also, the construction of the Reservoir to the 1,200,000 acre feet of capacity, would necessitate the relocation of the part of facilities at the Boulder Fish Hatchery and the buildings at New York. The Reservoir could be constructed to a capacity of 360,000 acre-feet without necessitating the relocation of any of U. S. Highway No. 187, the Boulder Fish Hatchery facilities or the buildings at New York.

A considerable portion of the lands in the New York Basin that would be flooded by the Reservoir construction are under irrigation. A number of irrigation canals and ditches diverting water from the New Fork River would be partially or wholly flooded by the Reservoir construction.

C. PROPOSED FACILITIES

Preliminary design for the facilities that would provide a reservoir with a total storage capacity of 1,200,000 acre-feet have been made for this study. Plates IV-1, IV-2 and IV-3 at the end of this section of the report, show the facilities which are proposed for this Reservoir. Plate IV-1 shows the Reservoir basin topography with 20 foot contour intervals. Plate IV-2 shows the Maximum Dam Section, the Dam Plan and the Profile along the dam axis. Plate IV-3 shows the proposed spillway and outlet works for the dam.
1. **Embankment Section**

The proposed maximum embankment section is shown on Plate IV-2. For the 1,200,000 acre-feet live storage capacity, the embankment would have a maximum height of 155 feet above the stream bed and a length along the axis of the dam of approximately 3,940 feet. The height of the embankment section above the spillway crest will be 20 feet. A free board above the maximum high water of 10 feet is proposed. A top width of 35 feet for the dam is proposed.

The proposed embankment section is a zoned earth fill dam. The impervious core material would be clays, silts and fine sands. The shell material would be gravelly fill. A pervious embankment drain beneath the downstream one-third of the dam section is contemplated. This drain would be constructed of free draining gravel and rock and would have a minimum thickness of 3 feet.

An upstream slope of $3\frac{1}{2}$ to 1 to a point just below the dead storage pool level is proposed. At this elevation a 20 foot berm and a slope of 4 to 1 from this elevation to the base of the dam is proposed. A downstream slope of 3 to 1 is proposed. The upstream face of the dam will be protected by rock riprap with a minimum thickness of 3 feet. The bedding material for the riprap will be 1$\frac{1}{2}$ feet thick.

2. **Spillway**

The proposed spillway facilities for the New Fork Narrows Reservoir are shown on Plate IV-3. The proposed facilities include a drop inlet (morning glory) type spillway and an ungated overflow weir type spillway.
A maximum total spillway capacity of 13,000 cubic feet per second is contemplated.

The morning glory spillway would have a capacity of 7,000 cubic feet per second with the proposed 10 foot head. The overflow crest for this spillway would have an inside diameter of 21 feet. This circular weir would drop through a transition shaft to a 12 foot horseshoe conduit. This 12 foot horseshoe conduit together with a second conduit of the same size would serve to handle the stream flow during construction of the embankment section. The terminal structure for this spillway would be an hydraulic jump type spillway basin. This spillway facility would be constructed of reinforced concrete.

The ungated overflow weir spillway would have a capacity of 6,000 cubic feet per second with a head of 10 feet. The crest control section would have a length of about 55 feet. From the overflow weir, the water would be carried in a rectangular chute to the hydraulic jump type stilling basin. This spillway facility would also be constructed of reinforced concrete.

3. Outlet Works

The proposed outlet works for the New York Narrows Reservoir are shown on Plate IV-3. It is contemplated that the flows during construction of the dam embankment will be diverted through two 12 foot horseshoe shaped reinforced concrete cut and cove conduits. The two conduits would have a combined capacity of 4,000 cubic feet per second with a 20 foot head. As noted above, one of these reinforced concrete conduits will be used for the morning glory spillway. The other conduit will be used for the outlet works.
The completed outlet works will include a trashracked inlet structure for the 12 foot horseshoe shaped conduit, a reinforced concrete gate structure in the conduit with two 72" valves and two 36" valves. From the gate structure to the outlet works terminal structure, 72 inch and 36 inch concrete pipes will be installed in the 12 foot conduit to serve as outlet pipes. The terminal structure would be a hydraulic jump type basin constructed of reinforced concrete.

The capacity of the proposed outlet works varies from 740 cubic feet per second with the water surface in the reservoir at dead storage elevation to 1,350 cubic feet per second with the water surface at spillway crest elevation. A discharge versus water surface elevation curve for the outlet works is included on Plate IV-3.

4. **Available Construction Materials**

Materials for the impervious core of the dam embankment are available in the alluvial flood plan of the New York River. The sand and gravel material for the embankment shell should also be available in the Reservoir area. Aggregates for concrete and for the gravelly material for concrete and for the gravelly material for the pervious drain could be obtained from the stream deposits with a screening operation. Whether or not hard, durable rock for riprap is available has not been determined. If no suitable rock is available, it would be possible to use a soil-cement type of embankment slope protection.

5. **Grouting**

It is anticipated that it may be necessary to grout the foundations at the proposed dam site to reduce excessive seepage. An item has been included in the cost estimate for such grouting.
D. ESTIMATED COST

1. Reservoir Capacity - Total = 1,200,000 A.F., Live = 1,150,000 A.F.

   a. Embankment (9,750,000 c.y.) $10,725,000.00
   b. Spillway 1,280,000.00
   c. Outlet Works 620,000.00
   d. Clearing and Grubbing 390,000.00
   e. Grouting 120,000.00
   f. Land Acquisition 1,400,000.00
   g. Relocation of Existing Facilities 1,750,000.00

   Subtotal $16,285,000.00
   + 15% Engineering and Contingency 2,442,750.00

   Total $18,727,750.00

   Cost/Acre Foot of Live Storage = $16.29

2. Reservoir Capacity - Total = 650,000 A.F., Live = 600,000 A.F.

   a. Embankment (6,700,000 c.y.) $ 7,370,000.00
   b. Spillway 1,211,000.00
   c. Outlet Works 525,000.00
   d. Clearing and Grubbing 280,000.00
   e. Grouting 112,500.00
   f. Land Acquisition 935,000.00
   g. Relocation of Existing Facilities 1,750,000.00

   Subtotal $13,183,500.00
   + 15% Engineering and Contingency 1,827,525.00

   Total $14,011,025.00

   Cost/Acre Foot of Live Storage = $23.35

3. Reservoir Capacity - Total = 350,000 A.F., Live = 300,000 A.F.

   a. Embankment (4,850,000 c.y.) $ 5,335,000.00
   b. Spillway 1,180,000.00
   c. Outlet Works 460,000.00
   d. Clearing and Grubbing 190,000.00
   e. Grouting 108,000.00
   f. Land Acquisition 813,000.00
   g. Relocation of Existing Facilities 722,000.00

   Subtotal $ 8,808,000.00
   + 15% Engineering and Contingency 1,321,200.00

   Total $10,129,200.00

   Cost/Acre Foot of Live Storage = $33.76
E. SUMMARY

Total storage capacity and water surface area versus reservoir water surface elevation curves for the New Fork Narrows Reservoir to a maximum storage capacity of about two million acre-feet are shown on Figure IV-1, page 4-9.

Total cost versus live storage capacity and cost per acre-foot versus live storage capacity curves are shown in Figure IV-2, page 4-10. It is noted that there is a break in these curves between the 370,000 and 350,000 acre-feet of storage capacity. With 370,000 acre-feet of storage capacity U.S. Highway No. 187 would have to be relocated. As near as can be determined from the U.S. Geological Survey 7.5 Minute Series topographic maps the 350,000 acre-feet of storage would involve no relocation of this highway.

The total cost of a Reservoir at this site with a live storage capacity of 1,100,000 acre-feet is $18,100,000, which amounts to a unit cost of $16.45 per acre-foot of storage capacity. The total cost of a Reservoir with a capacity of 600,000 acre-feet is $13,900,000, which results in a unit cost of $23.20 per acre-foot. The total cost of a Reservoir with a capacity of 370,000 acre-feet is $12,300,000, which results in a unit cost of $33.30 per acre-foot. The total cost of a Reservoir with a capacity of 350,000 acre feet is $11,100,000, which is a unit cost of $31.75 per acre-foot. The total cost of a Reservoir with a capacity of 200,000 acre-feet is $7,900,000 which is a unit cost of $39.50 per acre-foot.
### AREA CAPACITY TABLE

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**Capacities and areas are rounded.**

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**STATE OF WYOMING**

DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT

WYOMING WATER PLANNING PROGRAM

STATE ENGINEERS OFFICE

NEW FORK NARROWS DAM

RESERVOIR AREA

J. T. BANNER & ASSOCIATES, ENGINEERS & ARCHITECTS, LARAMIE, WYOMING

APPROVED DATE

DRAWN BY J. C.

PLATE III-1
A. GENERAL

The Lower Green Reservoir is located on the main stem of the Green River above the town of Green River and below the existing Bureau of Reclamation Fontanelle Reservoir. The dam site for the Reservoir is located in Sections 25 and 26, T. 19 N. R. 108 W. about 7 miles upstream from the Town of Green River. The east abutment of the dam site is accessible from the Blue Rim Road. The Reservoir Basin on the east side of the Green River is traversed by the Blue Rim Road and several other dirt roads.

The topography of the Lower Green Reservoir site is such that a reservoir of close to 3,000,000 acre-feet of storage capacity could be constructed. For this investigation, a maximum total storage capacity of 270,000 acre-feet in the proposed Lower Green Reservoir has been used. A Reservoir of greater storage capacity than the 270,000 acre-feet would result in the high water line encroaching on the Stauffer Chemical Plant which is located on the Green River in the vicinity of Big Island. For this preliminary investigation, a minimum of 8,000 acre-feet of dead storage capacity has been assumed.

U. S. Geological Survey 7.5 minute series maps with 20 foot contour intervals are available for the area of the proposed Lower Green Reservoir. These topographic data were used to prepare the topographic map of the Reservoir Basin, and for the preliminary dam design.
B. SITE CONDITIONS

1. Geologic

The geologic information for this report was obtained from reconnaissance field investigations and from a review of the geological literature and maps which are available for the area.

Sedimentary rocks of the Laney shale member of the Green River formation which are in the Middle Eocene Epoch, are exposed throughout the Reservoir basin. The Laney shale member consists of brown marlstone, shale, muddy sandstone, and beds of oil shale. Overlying the Laney Shale are alluvial deposits in the river flood plain which consist of river transported silts, sands and gravels. The alluvial deposits form an extensive bench that slopes up gently away from the Green River.

Due to the close proximity of the Rock Springs uplift to the east, it is contemplated that minor faulting may have occurred at the dam site for the Lower Green Reservoir. Final design of a dam for this site would involve extensive investigations, including borings and test pits to determine the foundation conditions.

2. Physical

The Green River is about 300 feet wide at the proposed dam site and meanders through the alluvial flood plain of the Reservoir basin. The ground surface on the east abutment at the dam site slopes up steeply from the River for about 90 feet and then slopes up gently to an elevation of 6,210 feet. At the west abutment of the dam, the ground surface slopes up gently from the River for about 30 feet and then slopes up steeply to an elevation of 6,210 feet.
The Reservoir basin will inundate several ranch buildings and about
250 acres of irrigated land. As noted earlier in this report, the live
storage capacity of the Reservoir was limited to a maximum of 270,000
acre-feet because of the location of Stauffer Chemical Plant. A dirt
road and the railroad track to this plant would either have to be
relocated or raised to accommodate the 270,000 acre-foot capacity Reservoir.
Also, there are power transmission lines that would have to be relocated.

C. PROPOSED FACILITIES

Preliminary design for the facilities that would provide a reservoir
with a total storage capacity of 270,000 acre-feet have been made for this
report. Plates V-1, V-2 and V-3 at the end of this section of the report
show the facilities proposed for this reservoir. Plate V-1 shows the
Reservoir basin topography with 20 foot contour intervals. Plate V-2
shows the Maximum Dam Section, the Dam Plan and the Profile along the Dam
Axis. Plate V-3 shows the proposed spillway and outlet works for the Dam.

1. Embankment Section

The proposed maximum embankment section is shown on Plate V-2.
For the 270,000 acre-feet live storage capacity the embankment will have
a maximum height of 100 feet above the stream bed and a length along the
axis of the dam of approximately 3,300 feet. The height of the embank-
ment section above the spillway crest will be 20 feet. A free board
above the maximum high water of 10 feet is proposed. A crest width of
35 feet for the dam is proposed.

The proposed embankment section is a zoned earth fill dam. The imper-
vious core material would be clay, silt and fine sand. The shell material
would be gravelly fill. A pervious embankment drain beneath the downstream
one-third of the dam section would be provided. This drain would be constructed of free draining gravel and would have a minimum thickness of 3 feet.

An upstream slope of $3\frac{1}{2}$ to 1 to a point just below the dead storage pool level is proposed. At this elevation a 20 foot berm and a slope of 4 to 1 from this elevation to the base of the dam is proposed. A downstream slope of 3 to 1 for the embankment section is proposed. It is contemplated that the upstream face of the dam will be protected by rock riprap with a minimum thickness of 3 feet, and a bedding material thickness of $1\frac{1}{2}$ feet.

2. **Spillway**

The proposed spillway facilities include a radial gated overflow weir section, a rectangular free-flow discharge channel and an hydraulic jump type basin as a terminal structure. The spillway facilities will be constructed of reinforced concrete.

A maximum spillway capacity of 20,000 cubic feet per second is contemplated. This maximum capacity was arrived at through a review of the Bureau of Reclamation's Flood Study for the Fontenelle Reservoir.

3. **Outlet Works**

The proposed outlet works are shown on Plate V-3. Three 12 foot horseshoe shaped, cast in place, cut and cover conduits are proposed. These conduits would be used to divert the River during construction of the dam embankment. The inlets for the outlet conduits will be a trash-racked reinforced concrete structure. The gate structure will be located in the center of the dam and will house three $8\frac{1}{2}$ foot by 12 foot radial gates. The outlet works terminal structure will be an hydraulic jump type stilling basin.
The capacity of the outlet works varies from 5,000 cubic feet per second with the water elevation at dead storage pool level to 14,750 cubic feet per second with the water elevation at normal and maximum water surface level. A discharge versus water elevation curve for the outlet works is shown on Plate V-3.

4. Available Construction Materials

The alluvial deposits upstream from the dam site will provide the materials for the impervious core of the dam embankment. The gravelly material for the shell could be obtained from the river gravels or from gravel pits downstream from the dam site. Concrete aggregates would be obtained from the gravel pits in the area. A source of hard, durable rock for riprap has not been located. If satisfactory rock for riprap is not located, soil cement could be used for the embankment slope protection.

5. Grouting

It is contemplated that grouting of the foundation for the dam site may be necessary, and this item has been included in the cost estimate for this Reservoir.

D. ESTIMATED COST

1. Reservoir Capacity - Total = 270,000 A.F., Live = 262,000 A.F.

   a. Embankment (3,200,000 c.y.) $ 3,520,000.00  
   b. Spillway 1,820,000.00  
   c. Outlet Works 1,220,000.00  
   d. Clearing and Grubbing 36,000.00  
   e. Grouting 99,000.00  
   f. Land Acquisition 171,000.00  
   g. Relocation of Existing Facilities 500,000.00  

   Subtotal $ 7,366,000.00  

   + 15% Engineering and Contingency 1,104,900.00  

   Total $ 8,470,900.00  

   Cost/Acre Foot of Live Storage = $32.33
2. Reservoir Capacity - Total = 195,000 A.F., Live = 187,000 A.F.

a. Embankment (2,050,000 c.y.) $ 2,255,000.00
b. Spillway 1,800,000.00
c. Outlet Works 1,120,000.00
d. Clearing and Grubbing 30,000.00
e. Grouting 87,000.00
f. Land Acquisition 145,000.00
g. Relocation of Existing Facilities 300,000.00

Subtotal $ 5,737,000.00
+ 15% Engineering and Contingency 860,550.00

Total $ 6,597,550.00

Total Cost/Acre Foot of Live Storage = $35.28

E. SUMMARY

Total storage capacity and water surface area versus reservoir water surface elevation curves for the Lower Green Reservoir to a maximum storage capacity of about 270,000 acre-feet are shown on Figure V-1, page 5-7.

Total cost versus live storage capacity and cost per acre-foot versus live storage capacity curves for the Lower Green Reservoir shown in Figure V-2, page 5-8. The total cost of a Reservoir at this site with a live storage capacity of 260,000 acre-feet is $8,400,000, which is a unit cost of about $32.30 per acre-foot. The total cost of a Reservoir with a capacity of 200,000 acre-feet is $6,950,000, which results in a unit cost of $34.75 per acre-foot.
VI - SUMMARY

The total cost and the cost per acre-foot for various reservoir capacities at each of the four reservoir sites are summarized in Table VI-1, page 6-3. It is noted that these cost figures do not include the intangible esthetic and recreational values that may be lost through the construction of either of the Kendall Reservoirs.

The most economical storage capacity could be obtained at the Upper Kendall Reservoir. The cost per unit of storage capacity at the Lower Kendall Reservoir would be more than double that for the Upper Kendall Reservoir. The esthetic and recreational values that may be lost as a result of constructing the Upper Kendall and Lower Kendall Reservoirs would be about the same for each Reservoir since much of the reservoir basin area for the two reservoirs is the same.

Cost per unit of storage capacity at the New Forks Narrows Reservoir is about 30% more than at the Upper Kendall Reservoir for a reservoir with a live storage capacity of about 600,000 acre-feet. For a reservoir with capacities ranging from 200,000 to 400,000 acre-feet, the cost per unit of storage capacity at the New Forks Narrows Reservoir is on the order of 50% more than at the Upper Kendall Reservoir.

Cost per unit of storage capacity at the Lower Green Reservoir would be on the order of 35 to 40% more than at the Upper Kendall Reservoir. Also, there would be no esthetic or recreational values lost as a result of the construction of the Lower Green Reservoir.

The live storage capacities that would be desirable at the Upper Kendall Reservoir and the New Forks Narrows Reservoir would depend on the storable water supplies that might be available at these Reservoir sites. The higher capacities at these two Reservoir sites that have
been considered in this report do contemplate that there would be carry-over storage capacity.

The maximum storage capacity considered in this report for the Lower Green Reservoir is about 260,000 acre-feet. This maximum was set to avoid encroachment on the Stauffer Chemical Plant on the east side of the Green River at the upper end of the Reservoir. It is possible that when the trona deposits which can be economically brought to this plant are exhausted, that the plant would be relocated. This may justify considering two stages of construction for this Reservoir. The first stage could be construction to a capacity of about 260,000 acre-feet or something less with provisions in the dam construction contemplating that the Reservoir capacity may be increased sometime in the future. The additional reservoir capacity could then be constructed when it is needed and economically justified. There would be no question in regard to the storable water supplies at the Lower Green Reservoir justifying a Reservoir capacity of 260,000 acre-feet, and probably considerable more.

The water surface area and the water surface area per acre-foot of storage capacity for the reservoirs listed in Table VI-1 are shown in the tabulation. These data do not indicate any significant differences in the reservoir evaporation losses at the various Reservoir sites.
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