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LITTLE SNAKE RIVER DAMS
LEVEL II STUDIES

Executive Summary

Prepared for: Wyoming Water Development Commission
Contract No. 05SC0291996
July 2003

Gannett Fleming
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Submitted by:
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July, 2003
1. INTRODUCTION

1.1. Project Purpose, Authorization, and Scope
The Little Snake River Basin experiences chronic shortages of late season irrigation water. The High Savery project that is currently (2003) under construction in the basin is expected to yield 12,000 acre-feet of late-season, supplemental irrigation water in eight out of ten years. This water would only be used on lands that are currently being irrigated with water under Wyoming water rights. In 2002, the Little Snake River Water Conservancy District (LSRWCD) in Baggs applied to the Wyoming Water Development Commission (WWDC) for financial and technical assistance to conduct a Level II study to investigate opportunities for providing additional water storage, and for rehabilitating inadequate or damaged infrastructure to provide more reliable water supplies in the basin. The LSRWCD indicated that the primary need for supplemental water supplies in the basin would be to provide additional acreages of local hay production to reduce current high costs for importing livestock forage during winter months. The 2002 Wyoming Legislature authorized this Level II Feasibility Study by the WWDC to evaluate specifically identified water storage opportunities and rehabilitation projects in the basin.

This Level II study was conducted under the direction and funding of WWDC by Gannett Fleming, Inc. (Gannett Fleming), in association with States West Water Resources Corporation (States West), and Watts and Associates (Watts). This study involved two distinct components of work: (1) the Little Snake River Dams study and (2) rehabilitation plans for the Jons Drop and Four-Mile Flume hydraulic structures near Baggs. States West completed the hydraulic structures rehabilitation designs in October 2002, under a subcontract with Gannett Fleming. The rehabilitation projects are now eligible to proceed to Level III.

This executive summary pertains to the final report for the Little Snake River Dams component of the study, which involved evaluation of four distinct projects: 1) a new dam and reservoir at Upper Willow Creek, Colorado, 2) a new dam and reservoir at Upper Cottonwood Creek, 3) reconstruction or enlargement of Grieve Reservoir, and 4) alternatives for delivering irrigation water to Dolan Mesa by pumping from First Mesa Ditch or by pumping or direct diversion from Savery Creek. A general area map showing the locations of these projects is provided as Figure 1. Table 1 summarizes the study effort and findings for the dam projects. Table 2 summarizes the study findings for the delivery options to Dolan Mesa.

As part of this project, Gannett Fleming and WWDC participated in two meetings with Colorado interests including the Colorado River Water Conservancy District (CRWCD), Colorado Water Conservation Board (CWCB), and Colorado Division of Water Resources (CDWR). These agencies expressed their interest and potential support for a project at the Upper Willow Creek site, or for other projects in the basin that would provide mutual benefit to both states. Discussions between Colorado interests and WWDC are ongoing and in preliminary stages, and there are no definitive project proposals or other agreements at this time.
Table 1. Summary of Dam Projects Evaluated

<table>
<thead>
<tr>
<th>Site</th>
<th>Geotechnical</th>
<th>Hydrologic</th>
<th>Dam</th>
<th>Hydraulic Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Willow Creek, CO</td>
<td>Geologic mapping identified landslides in both abutments; subsurface - 2 boreholes, 8 test trenches, lab tests for engineering index properties; significant foundation stripping requirements; good local sources for impervious borrow; filter, drain, and riprap must be imported from sources within 10 mile radius</td>
<td>Safe yield = 5000 ac-ft for 10,000 ac-ft reservoir based on customized daily computer model developed from gage records; site-specific PMF analysis by CDWR, peak flow = 17,000 cfs</td>
<td>Earthfill; crest elev. = 6913 ft; reservoir size = 10,000 ac-ft at NHWL= 6900 ft; structural height =133 ft; crest length =1200 ft; 3H:1V upstream, 2.5H:1V downstream slopes; inclined chimney and blanket filter/drain system</td>
<td>Principal spillway/outlet works = tower structure and 6-ft dia. RC conduit through lower right abutment for flows up to 100-yr flood; Emergency spillway = RCC overlay on dam, 275-ft crest length for flows up to PMF</td>
</tr>
<tr>
<td>Upper Cottonwood Creek</td>
<td>Geologic reconnaissance; one shallow auger hole by NRCS; no lab testing</td>
<td>No gage data; annual basin yield estimate = 900 ac-ft derived from regionalized curve for mean basin elevation = 7400 ft, drainage area = 7.9 mi²; PMF estimate based on previous regional studies prorated for drainage area PMF peak flow = 6200 cfs</td>
<td>Earthfill; crest elev. = 6860; reservoir size = 1000 ac-ft at NHWL = 6855; structural height = 60 ft; crest length = 715 ft; 3H:1V upstream, 2.5H:1V downstream slopes; inclined chimney and blanket filter/drain system</td>
<td>Principal spillway/outlet works = tower structure and conduit for flows up to 100-yr flood; Emergency spillway = RCC overlay on dam for flows up to PMF</td>
</tr>
<tr>
<td>Grieve Reservoir Replacement</td>
<td>Geotechnical investigation by Soil Conservation Service, 1986, on alignment 600 ft upstream from old dam; 2 auger borings; 7 test pits; lab tests for engineering index properties; Browns Park sandstone overlain by up to 17 ft of fine-grained alluvium in valley bottom on dam centerline; gravel terrace deposits in reservoir area potential source for riprap bedding</td>
<td>No gage data; annual basin yield estimate = 380 ac-ft derived from regionalized curve for mean basin elevation = 7500 ft, drainage area = 2.9 mi²; additional supply from Belvedere ditch</td>
<td>Earthfill; crest elev. = 7103; reservoir size = 317 ac-ft at NHWL = 7097; structural height = 31.5 ft; crest length = 420 ft; 3H:1V upstream, 2H:1V downstream slopes; toe drain system</td>
<td>Principal spillway/outlet = 30-in dia. riser and 24-in RC conduit protected by filter diaphragm; Emergency spillway = unlined cut in sandstone right abutment, 20 ft wide, 2H:1V side slopes</td>
</tr>
<tr>
<td>Grieve Reservoir Enlargement</td>
<td></td>
<td></td>
<td>7127; reservoir size = 2000 ac-ft at NHWL = 7117; structural height = 55 ft; crest length = 700 ft; 3H:1V upstream, 2.5H:1V downstream slopes; inclined chimney and blanket filter/drain system</td>
<td>Principal spillway/outlet = tower structure and conduit for up to 100-yr flood; Emergency spillway = unlined cut in sandstone right abutment, size TBD</td>
</tr>
</tbody>
</table>
Table 2. Summary of Dolan Mesa Delivery Options

<table>
<thead>
<tr>
<th>Delivery Method</th>
<th>Level 1 - 900 ac-ft</th>
<th>Level 2 - 1800 ac-ft</th>
<th>Level 3 - 2700 ac-ft</th>
</tr>
</thead>
</table>
| Supply from First Mesa Ditch by Pumping | • Replace debris trap at ditch inlet on Little Snake River  
• Remove/replace wet well and pump station  
• Clean channel in reach up to check dam  
• Test existing pipeline and use if free of leaks  
• Install pump booster station at top of mesa, size to meet irrigation system needs | In addition to Level 1:  
• Replace culverts north of sluice gates  
• Replace culverts under county road  
• Rehabilitate stilling basin between sluice gates and culverts  
• Replace sluice gates  
• Enlarge ditch up to first check dam | In addition to Levels 1 and 2:  
• Raise and rehabilitate check dam on Little Snake River, and first check dam in First Mesa Ditch  
• Install additional pipeline adjacent to existing pipeline |
| Supply from Savery Creek by Pumping | • Construct a reinforced concrete (RC) wet well on north bank of Savery Creek  
• Install 12-inch diameter, 3,750-feet long steel pipeline  
• Install RC outfall on Dolan ditch | In addition to Level 1:  
• Rehabilitate Dolan ditch to handle higher flows  
• Install additional pumps and appurtenances | In addition to Levels 1 and 2:  
• Install additional pumps and appurtenances |
| Supply from Savery Creek by Gravity Diversion | • Construct new diversion dam on Savery Creek  
• Construct new supply ditch, 8.5 miles long from diversion to Dolan Mesa  
• Construct 24 siphon structures where supply ditch crosses major drainages | |

2. UPPER WILLOW CREEK DAM AND RESERVOIR, COLORADO

2.1. General Site Background Information
The Upper Willow Creek site is located on Willow Creek about 10 miles upstream from the confluence of Willow Creek and the Little Snake River, in Moffat County, Colorado (Figure 1). This site has been considered in at least three previous studies. Previous work included preliminary reservoir yield evaluations, and site geologic reconnaissance. No subsurface geotechnical investigations were done during previous studies.

2.2. Geotechnical Investigation
The primary purpose of the geotechnical investigations at Upper Willow Creek was to identify any geologic fatal flaws or constraints to dam construction. A subsurface investigation was conducted between September 30 and October 10, 2002 and included drilling 2 borings, and excavating eight test pits to expose bedrock in the vicinity of the proposed dam foundation. Laboratory tests were conducted on select, representative
samples to determine engineering index properties of the foundation materials and potential construction borrow materials. A preliminary geologic map and interpretive geologic cross-sections were prepared on the basis of the site investigations, which display the general distribution of geologic materials across the site and at depth.

Landslide deposits are mapped in the dam foundation area. Landslides are not interpreted to be a fatal flaw for dam construction. The landslide debris could be excavated and used as a resource in the dam fill. The foundation appears suitable for construction of an earth fill dam.

Local sources for filter and drain materials were not identified during this investigation. These materials would need to be imported from alluvial deposits along the Little Snake River, approximately 7 to 10 miles from the site. A possible source of rip rap is basalt and basaltic intrusive rocks that occur in local areas within the region, also within a 10-mile radius of the dam site.

2.3. Hydrologic Studies
The reservoir safe yield for Upper Willow Creek Reservoir was estimated using a custom-programmed computer model that simulates the daily operation of the reservoir. For this study, safe yield is defined as the maximum quantity of water (demand) that can be withdrawn from the reservoir without exhausting the supply based on the operating rules during the most severe drought of record. The operating rules used in the computer model accounted for active water rights for irrigation between May through September each year.

The safe yield of the basin is estimated as 5,000 acre-feet per year under the specified operating rules, and with a normal pool volume of 10,000 acre-feet, at elevation 6900.

A review of probable maximum flood (PMF) values from previous studies was performed to support spillway sizing and design. A previous study indicated the 21.5 square mile drainage area would generate a PMF peak flow of 14,600 cfs, and a 100-year peak flow of 1,520 cfs. In March 2003, the Colorado Division of Water Resources conducted an independent PMF analysis for the Upper Willow Creek and Pot Hook dam sites. That study predicted larger PMF peak flow estimates for the Upper Willow Creek site, ranging from about 15,900 to 18,700 cfs, depending on assumptions used regarding input parameters. The emergency spillway was resized for the median result from the DWR study of 17,000 cfs peak flow.

2.4. Preliminary Dam and Hydraulic Structures Design
Table 1 summarizes the dam and hydraulics structures conceptual design. Construction of the dam at this location will require substantial stripping to competent rock in the channel bottom and to some height on the abutments. Preliminary estimates based on the geotechnical investigation at the site indicate approximately 15 feet of stripping will be required on average, although local stripping depths may be deeper to remove landslide debris and weak materials on the lower abutments.

The design concept for handling the inflow design flood is a combined outlet/principal spillway to accommodate flood inflows up to the 100-year flood, in combination with a
roller-compacted concrete (RCC) emergency spillway constructed over the top of the dam. The RCC spillway would have a formed, concrete panel-faced main chute section with a crest set at an elevation between the principal spillway/outlet crest and the longer auxiliary emergency spillway overflow crest. The intent of this formed and faced main chute section is to limit the overtopping flows over a smaller segment of the dam that would be constructed with highly erosion-resistant armoring protection to handle up to the 500-year event. The remainder of the RCC overflow section would be more economical unfaced RCC on the downstream slope. This section could be covered with rock or soil and seeded to enhance the visual appearance on the downstream slope.

3. **Upper Cottonwood Creek Reservoir**

3.1. **General Site Background Information**

The Upper Cottonwood Creek Reservoir site was evaluated as a potential resource for supplementing First Mesa Ditch water, or to supply new irrigated acreage on Dolan Mesa via a new diversion and ditch directly from Cottonwood Creek. The dam site that was evaluated in this study is located further upstream in the drainage from the original Cottonwood site that was considered in a 1991 Level I study. The new location is approximately 6 miles north of Dixon. The upper site appears more favorable for reservoir construction compared to the lower site in terms of topography and fewer environmental impacts. However, there is limited information available for this site, and the basis for design and costs at this point should be considered Level I.

3.2. **Geotechnical Reconnaissance**

Site reconnaissance was conducted to observe the general site conditions. The proposed site is situated in a valley that has been eroded through Cretaceous Lewis Shale, which is exposed in the valley slopes and locally in the valley floor. The formation consists of medium to dark gray, calcareous shale with interbeds of siltstone. These rock are generally weak and moderately weathered. No evidence of landslides was observed on either abutment area.

3.3. **Hydrologic Analysis**

The stream is ephemeral in this upper part of the basin. A comprehensive review of stream flow gages in the area concluded that none of the regional gage records were suitable for this study. Lacking representative gage data, a regionalized basin yield curve that relates the mean basin elevation to the average annual basin yield was used to estimate the average annual basin yield. From the regionalized curve, the yield was estimated to be approximately 113 acre-feet per mi² of basin area. With a 7.9 mi² watershed, the average annual basin yield would be approximately 900 acre-feet. Additional detailed study is required to further advance the estimate of available water and determine a reservoir safe yield.

3.4. **Dam and Hydraulic Structures Design**

Dam and hydraulic structures design elements are summarized on Table 1.
4. **GRIEVE RESERVOIR**

4.1. General Site Background Information
The Grieve Reservoir site is located on Sweetwater Gulch, immediately west of State Highway 70, approximately 9 miles east of Savory (Figure 1). The small dam was constructed in 1936, and impounded approximately 400 acre-feet. The dam washed out during a flood in 1984, and has not been replaced or repaired, although a small embankment has been constructed to store some water.

In 1985, the Soil Conservation Service (SCS, now NRCS) inspected the site and prepared a preliminary design for repairing the breached dam. The SCS performed detailed subsurface investigation at the site in 1986, and recommended a new replacement dam. The replacement dam was designed by SCS on an alignment about 600 feet upstream from the old dam, in order to take advantage of a sandstone bench on the right abutment that provides a suitable emergency spillway location. The results of the SCS geotechnical study and design for the replacement dam are summarized in the report. Cost estimates for the replacement dam were reviewed and updated.

4.2. Hydrologic Studies
The estimated average annual basin yield for the Grieve Reservoir basin is approximately 130 acre-feet per mi² of basin area, based on the regionalized basin curve. For a 2.9 square mile watershed, it is concluded that the direct yield from this small basin is less than 400 acre-feet annually. In addition to the direct yield from the basin, the reservoir is also supplied from water rights on the Belvedere Ditch (also called the Morgan Ditch No. 1). There is sufficient supply from direct basin yield, supplemented by the ditch supply for the replacement reservoir.

As part of the scope of this study, Gannett Fleming also considered an enlarged reservoir, on the order of 2,000 acre-feet. This reservoir would provide water for the currently permitted acreage (445 acres) in the Sweetwater Gulch subbasin, and in addition could be used to supplement supplies in the Little Snake River, and/or to provide a recreational benefit. No new irrigable acreages were identified in the Sweetwater Gulch drainage. In order to confirm that adequate water supplies are available for an enlarged reservoir, additional studies are needed.

4.3. Preliminary Dam Sections

4.3.1. SCS Replacement Dam
The key features of the replacement dam and reservoir designed by SCS are summarized on Table 1. The reservoir was sized at approximately 317 acre-feet based on site constraints, with the dam and reservoir situated at an elevation such that the Battle highway would not be impacted.

4.3.2. New Enlarged Reservoir
An enlarged Grieve Reservoir was sized at approximately 2,000 acre-feet based on the assumption that adequate supplies are available from the Belvedere (Morgan Ditch No. 1)
sources. This would need to be confirmed by additional studies that included yield estimates for the supplying drainage and a more detailed evaluation of water rights on the ditch system. The key elements of the dam and hydraulic structures are summarized on Table 1. An adverse factor for the enlarged reservoir is the need to relocate approximately 1 mile of Highway 70 and the adjacent utilities. As indicated in the Level 1 study (Western Water Consultants, 1991), this could make the project cost prohibitive.

5. IRRIGATION SUPPLY TO DOLAN MESA

This study evaluated three alternatives for delivering water to Dolan Mesa: (1) supply from First Mesa Ditch by pumping, (2) supply from Savery Creek by pumping, and (3) supply from Savery Creek by gravity flow.

5.1. General Site Background Information

Dolan Mesa is located north of the Little Snake River and west of Savery Creek as shown on Figure 1. It was partially irrigated prior to 1920 by the Dolan Ditch. The ditch was abandoned in 1920 because of high maintenance costs. The LSRWCD estimates that there are about 1600 acres of irrigable land on Dolan Mesa. A small side channel sump and buried pipeline were constructed at an unknown time period to pump water up to the mesa from First Mesa Ditch. This pumping system is currently burnt out and inoperable. The total capacity and acreages that were served by this former pumping system are unknown.

5.2. Irrigation Supply Requirements

Previous studies determined that the annual consumptive irrigation requirement (CIR) is approximately 1.66 acre-feet per acre on Dolan Mesa. For an estimated 1,600 acres of irrigable land, the annual CIR is therefore estimated to be 2,656 acre-feet if all suitable lands are irrigated.

To facilitate decision making, analyses were conducted assuming total irrigation water requirements as shown on Table 3.

<table>
<thead>
<tr>
<th>Service Level</th>
<th>Irrigation Water Delivery (acre-feet)</th>
</tr>
</thead>
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<tr>
<td>Level 1</td>
<td>900</td>
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<tr>
<td>Level 2</td>
<td>1,800</td>
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<tr>
<td>Level 3</td>
<td>2,700</td>
</tr>
</tbody>
</table>

Supply sources in First Mesa Ditch and Savery Creek were analyzed in this study. It is anticipated that the supply from First Mesa Ditch will use the historic water rights to irrigate the mesa. The supply from Savery Creek will use the existing 43 cubic feet per second (cfs) Dolan Ditch water right, which will be transferred to a new point of diversion on Savery Creek.

5.3. System Elements

The key features and requirements for the Dolan Mesa Delivery options, at the three levels of service, are summarized on Table 2.
6. **Needs and Benefits**

**6.1. Needs**
The High Savery project, which is under construction, is intended to supply 12,000 acre-feet of late-season, supplemental water eight out of ten years. The supply is expected to support approximately 13,900 of the approximately 17,500 acres that are currently irrigated. The 1999 Little Snake Supplemental Irrigation Water Supply Environmental Impact Statement noted that the need for late season water is likely greater than the 15,090 acre-feet calculated because it is economically feasible to pump water to permitted lands that cannot be reached by gravity flow. Although High Savery will address much of irrigation water needs, there exist additional irrigation water needs in the Little Snake River Basin. An assessment of the needs beyond those that will be met by High Savory have not been addressed quantitatively in previous studies, and the hydrologic modeling that would be required to do so is beyond the scope of the present study. As a result, the needs descriptions for additional storage water contained in this report are based largely upon local input of a qualitative nature. If any of the potential projects considered in this report are recommended for possible construction, detailed hydrologic studies will be needed to establish more precise estimates of water needs.

**6.2. Benefits**
The direct irrigation benefits attributable to a new water project consist of the net value (after deducting on-farm production costs) of the increase in irrigated crop production due to the project. Most of the irrigated crop production in the Little Snake Basin consists of irrigated hay and pasture production in support of livestock. A value of $28.67 per acre-foot was estimated for the direct benefits of supplemental irrigation water for this study. Recreational and indirect benefits were also calculated and accounted for in the computation of total benefits.

While direct, recreational, and indirect benefit categories are the focus of the present study, it should be noted that there might be additional public benefits associated with developing some of Wyoming’s undeveloped allocation of water in the Little Snake Basin as provided for in the Colorado River Compact. An 1989 economic analysis by Western Research Corporation found that Wyoming residents, as a group, would be willing to pay significant amounts of money to see Wyoming’s water resources developed to the benefit of Wyoming rather than lost to out-of-state users. This benefit has not been quantified with respect to the projects considered here, but could be considered qualitatively in project evaluations.

7. **Economic Analysis**
There are two ways of looking at benefits and costs for these projects: 1) from the State’s perspective where all costs and benefits must be considered, and 2) from the project sponsor’s (financial) perspective. From the sponsor’s perspective, only loan payments are considered as costs, and the only benefits that are valid are direct irrigation benefits that accrue to the sponsor. Recreation and indirect benefits do not necessarily accrue to the project sponsor, so cannot be compared directly to the sponsor’s financial costs.

Benefits and costs from the state’s perspective are summarized on Table 4. Sponsor’s benefits and costs are presented in annual payment terms on Table 5.
Table 4. Total Project Benefits and Costs from the State’s Perspective

<table>
<thead>
<tr>
<th>Project</th>
<th>Annual Supply (ac-ft)</th>
<th>Irrigation</th>
<th>Benefits (Present Value)</th>
<th>Total</th>
<th>Total Cost</th>
</tr>
</thead>
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<tr>
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<td>Direct</td>
<td>Indirect</td>
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<td></td>
</tr>
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Dolan Mesa Supply Options

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<thead>
<tr>
<th>Project</th>
<th>Annual Supply (ac-ft)</th>
<th>Irrigation</th>
<th>Benefits (Present Value)</th>
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<th>Total Cost</th>
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<tr>
<td>Pump from First Mesa</td>
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<td>$1,283,000</td>
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Gravity Diversion from Savery Cr.

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Table 5. Annual Project Benefits and Costs from the Sponsor’s Perspective

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<th>Project</th>
<th>Annual Supply (ac-ft)</th>
<th>Annual Benefit Per AF</th>
<th>Annual Direct Irrigation Benefit</th>
<th>Annual Cost (50% Loan)</th>
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<td>Per AF</td>
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Dolan Mesa Supply Options

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<th>Annual Direct Irrigation Benefit</th>
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<td>Per AF</td>
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<td>Per AF</td>
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<td>$28.67</td>
<td>$77,400</td>
<td>$101,500</td>
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<td>Pump from Savery Creek</td>
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<td>1800</td>
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<td>$140,600</td>
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</table>

1 For dam projects, water supply = estimated firm yield - conveyance losses
2 Indirect benefits = Total irrigation benefit - direct irrigation benefits given in the text.
3 Annual costs include financing of construction cost + estimated annual electricity costs.
Figure 1
LITTLE SNAKE RIVER DAMS PROJECT LOCATION MAP

Date: May 2003
Project: 40280
File: sandstone.dwg