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December 10, 2004

Mr. Phil Ogle, Project Manager
Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, Wyoming 82002

RE: Lake Engineering Consultants, Inc. (LEC) Executive Summary for Wyoming Water Development Commission (WWDC) Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan, Phase 2 Project (Johnson County, Wyoming) - WWDC Contract No. 05SC0292444 and LEC Contract No. 021

Phil:

Lake Engineering Consultants, Inc. (LEC) of Littleton, Colorado herein submits 50 paper copies plus one (1) unbound reproducible original paper copy and one (1) electronic digital-format CD copy of the Executive Summary for the Wyoming Water Development Commission (WWDC) Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan, Phase 2 Project located in Johnson County, Wyoming. (Reference is made to WWDC Contract Number 05SC0292444, the WWDC-LEC Contract dated 6/10/04, and the WWDC Scope of Services outlined in Attachment “D” of the WWDC Request for Proposal No.04-19 dated the 8th day of March 2004 (RFP).) WWDC Tasks 1 through 7 for this project have been completed by LEC for the period starting in June 2004 and ending in late November 2004.

If you should have any questions concerning this Lake DeSmet Project Executive Summary, please contact LEC. Thank you for the opportunity for having LEC work on this most interesting WWDC project. If LEC can be of further assistance on this project, please contact me.

Respectfully submitted,

Gary R. Lake, P.E.
Principal

grl:rmn
EXECUTIVE SUMMARY
Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan – Phase 2

INTRODUCTION

General
The Wyoming Water Development Commission (WWDC) in Cheyenne, Wyoming contracted Lake Engineering Consultants, Inc. (LEC) of Littleton, Colorado to conduct a Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan – Phase 2 Project investigation. The results of this investigation are presented in the Lake DeSmet Project Final Report submitted to the WWDC and Lake DeSmet Counties Coalition Joint Powers Board (LDCC JPB) under separate cover. LEC services were provided in accordance with the WWDC Request for Proposal No. 04-19 for this project, dated the 8th day of March 2004 (RFP). Phase 1 of the Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan was completed in 2003 by HKM Engineering, Inc. (HKM) of Sheridan, Wyoming, and provided LEC with a firm basis for conducting the Level II, Phase 2 studies.

At the time of LEC project startup in June 2004, the LDCC JPB was the local sponsor and consisted of Johnson, Sheridan and Campbell Counties. The LDCC JPB had previously requested the WWDC for providing assistance with planning future water uses and performing an overall evaluation of the operation, maintenance and rehabilitation needs for the existing Lake DeSmet Dam and Reservoir. In October 2004, Campbell County was no longer a part of the LDCC JPB.

Project Location and Description
Lake DeSmet is located approximately ten (10) miles north of Buffalo, Wyoming and 15 miles south of Sheridan, Wyoming and to the east of and close to Interstate Highway 90 (I-90) and the Big Horn Mountains in Johnson County, Wyoming. The reservoir is located on the Shell Creek drainage, a tributary to Piney Creek that in turn flows to Clear Creek, a major tributary of the Powder River.

The original Lake DeSmet consisted of two natural lakes and was located in a natural depression in the Shell Creek drainage. Early irrigation projects in the region resulted in several earthen dams being constructed at different times at Lake DeSmet in order to provide additional water storage capacity for flow diversions from Piney Creek and Clear Creek. Reynolds Mining Company, Inc. and later Texaco Inc., owned the Lake DeSmet Dam and Reservoir for many years. Reynolds Mining Company raised the Lake DeSmet Reservoir by 32 feet in 1958 and again by another seven (7 feet) between August 1969 and May 1971. The Piney Creek diversion structure, intake tunnel and shafts, and appurtenances for the present water supply system were also constructed during this time period. (The 1969-1971 period is referred to as the “first stage construction.”) Between October 1974 and September 1976, Texaco Inc. raised the North Dam by 40 feet and constructed the South Dam and three saddle dikes along the east rim of the reservoir (saddle dikes are identified as East Dikes A, B and C) to their current sizes and increased the overall capacity of the reservoir to its present volume. This latest reservoir enlargement is referred to as the “second stage construction.” The LDCC JPB acquired the Lake DeSmet facility from Texaco Inc. in February 2001.

The final constructed heights of the separate Lake DeSmet embankment dams are at elevation 4630 feet (1929 NGVD datum) and the design normal reservoir pool elevation is at elevation 4620 feet. The reported total capacity of the existing Lake DeSmet Reservoir is 234,987 acre-feet (for a water surface area at 3,397 acres) with an active storage capacity of 196,027 acre-feet. The North Dam is 90 feet high and the South Dam is 50 feet high. Both these structures are combined earthfill/rockfill embankments. East Dikes A, B and C were constructed as earthfill/random fill embankments along the east rim of the reservoir to maximum structural heights of 35, 20 and 15 feet, respectively. The present-day normal
reservoir pool in Lake DeSmet at the 4620-foot elevation averages about one (1) mile wide and is approximately 5.5 miles long.

**PROJECT PURPOSE AND SCOPE OF WORK**

There were three initial major physical components for conducting the Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan – Phase 2 Project, as requested by the WWDC and LDCC JPB. These components consisted of the following task items, per the RFP:

- Task 2 -- Performance of a seepage investigation for Lake DeSmet and installation of monitoring weirs at previously-proposed locations below the North Dam, South Dam, and East Dikes;
- Task 3 -- Inspection of the existing Piney Creek water supply intake tunnel and appurtenances to Lake DeSmet; and,
- Task 4 -- Evaluation of the existing Rock Creek diversion dam/headgate structure and associated irrigation system/conveyance facilities.

Two scope alterations to the Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan – Phase 2 Project, not included in the RFP, are noted below:

- An inspection of the existing North Dam outlet works was to be included in Task 3; and
- An additional task (unnumbered) was requested by the LDCC JPB and WWDC for performing an erosion evaluation of the existing Lake DeSmet southwest shoreline area.

Brief summaries of the LEC project work completed during the 2004 study period are presented in the following sections. Several project coordination meetings were held among the WWDC, LDCC JPB, and LEC project staff during this Level II investigation, including WWDC and LEC project results meetings to the LDCC JPB.

**SEEPAGE INVESTIGATIONS**

**General**

Historically, seepage of reservoir water reportedly has occurred at several locations around Lake DeSmet, particularly when the Lake DeSmet Reservoir water levels are high, i.e., at elevation 4610 feet and higher (up to the full design normal pool elevation of 4620 feet). Subsurface seepage has occurred through natural ground at the right abutment side of the North Dam, at the South Dam, and near the three reservoir dike sections at the east side of Lake DeSmet. Four suspect seepage and monitoring sites were identified by HKM in 2003.

LEC investigated and evaluated Lake DeSmet Reservoir seepage conditions during the period June-November 2004 and estimated reservoir seepage under an assumed full reservoir pool level, utilizing information initially developed by HKM during their previous Lake DeSmet Level II study and all available reports and data, including as-constructed dam embankment drawings.

LEC also collected and reviewed all available related information on the regional and local site geology and hydrology developed previously by the Reynolds Mining Company and later by ChevronTexaco. The historical seepage conditions are summarized in the LEC Lake DeSmet Final Report as well as by HKM in its report and are well documented in other reports by Bechtel Corporation (Houston, Texas), ChevronTexaco, and Tipton and Kalmbach (Denver, Colorado).

**Lake DeSmet Suspect Seepage Areas and Monitoring Weir/Flume Sites**

Three TRACOM 60-degree monitoring flumes were installed by LEC at known and observed seepage sites below the North Dam (Site S-1), South Dam (Site S-2), and East Saddle Dikes B and C (Site S-3) in
order that LDCC JPB personnel can accurately measure/monitor future seepage flows at the sites. The existing large Parshall flume previously used at the S-1 monitoring site was left in place and is to be used in combination with the TRACOM flume installation. LEC also installed a TRACOM 60-degree monitoring flume in combination with a steel weir plate roughly 50 feet downstream of a former Texaco V-notch weir site at Site S-2. The new TRACOM flume is mounted directly below the weir-shaped opening in the steel sheet.

Lastly, LEC installed a TRACOM flume with a steel plate flange section, 1/8 inch thick, mounted at the outlet end of an existing culvert at Site S-3. The discharge water at this site flows clear. Rating tables were developed for all weir/flume installations. These rating tables are to be utilized by LDCC JPB personnel for continued monitoring of seepage flows, as appropriate.

**Summary of Seepage Investigations**

Seepage flow measurements were obtained by LEC at Monitoring Sites S-2 and S-3 during the LEC June to October 2004 field investigation. Estimated and measured flows were on the order of 5 gpm at the S-2 site and about 60 gpm at the S-3 site. The Lake DeSmet Reservoir water surface elevations during this period ranged from about 4607 feet in July 2004 to 4605 feet in October 2004. No seepage flow was observed at Site S-1 and the former-proposed S-4 monitoring site was eliminated altogether. Lake DeSmet water levels were between six (6) and eight (8) feet below the lake elevation of 4613 feet where seepage reportedly can be observed at Site S-1. There was no monitoring weir/flume installed at Site S-4. The HKM-proposed seepage site S-4 was investigated by LEC but later eliminated as a potential Lake DeSmet seepage site.

**Conclusions and Recommendations**

Because flows can now be accurately measured at monitoring Sites S-1, S-2 and S-3, flow monitoring at these sites should be done, at a minimum, on a monthly basis over the next year, including bi-weekly, weekly, or even daily monitoring during periods when measurable surface water runoff would also occur, and should be readily accomplished by LDCC JPB personnel in combination with the routine on-going visits to Lake DeSmet. LEC understands, however, that true seepage flows may not be observed (or measured) at Site S-1 under lake levels below elevation 4613 feet. For Lake DeSmet water levels at elevation 4613 feet or higher and once measurable flows can be observed and made at Site S-1, LEC recommends that all seepage monitoring sites would then be visited by LDCC JPB personnel and measured weekly or bi-weekly, until a seepage flow pattern at each monitoring site can readily be established, at which time the frequency of measurements can possibly be reduced to monthly intervals again, or perhaps quarterly, at the discretion of LDCC JPB.

LEC’s review of the available 2004 and historical piezometer information is consistent with the reported findings of HKM in their December 2003 report. Because Lake DeSmet has been operated at relatively low reservoir levels in 2004 (lower than elevation 4613 feet), there is no indication that the additional 2004 piezometer information results in conclusions or recommendations that could be made that would differ any from those presented by HKM in their 2003 report. LEC is in good agreement with the HKM findings regarding historical Lake DeSmet water levels and their correlation with the available piezometer data.

Others have previously addressed the stability characteristics of the existing North Dam, South Dam, East Saddle Dikes, and embankment sections for both the Service Spillway and Auxiliary Spillway through site inspections and embankment stability modeling under assumed varied embankment loading conditions and have reported that all embankment sections are stable and safe under existing site conditions. LEC concurs with these earlier findings by others. LEC also considers it still a prudent move to install the three piezometers in the downstream embankment section of the North Dam, as originally proposed by HKM in 2003 (i.e., one near the existing piezometer P-1424, and likewise, one near P-1426 and one to be located between P-1426 and P-1424). (The installation of three additional piezometers at
the North Dam had previously been identified in Task 2 of the RFP as well, however, was later abandoned by the WWDC prior to the Phase 2 Project startup.) At a minimum, this proposed piezometer work should include the rehabilitation of the two existing piezometers in question by using piezometer re-development procedures. HKM previously reported that P-1424 and P-1426 should be checked to help determine that they were working properly. Even though LEC has observed no apparent seepage problem associated with the downstream face of the North Dam embankment, this high embankment should be properly monitored at its main section, and given a dam owner’s liability issue as well.

After one year of collecting the monitoring weir/flume site flow information and reviewing it concurrently with the recorded Lake DeSmet water levels and regular readings of all the surrounding piezometer sites, a better determination of the existing Lake DeSmet seepage characteristics can be made, as well as for use in predicting future and total seepage amounts in the reservoir over both short-term and long-term conditions. In this manner, a firm pattern of seepage flow discharges, separate from other contributing flow factors, can be determined. If Lake DeSmet water levels are allowed to be raised upwards towards the normal pool elevation of 4620 feet during active reservoir operations and when reliable seepage measurements can be made routinely at the monitoring sites over a minimum period of one year, it is expected that better estimates of total annual (and seasonal) Lake DeSmet seepage can be determined in addition to evaluate any potential adverse impacts to the several dams due to seepage effects. It appears that no rigorous computer-simulated (or other) seepage modeling has been performed for any of the dams at Lake DeSmet to date, even for a worst-case scenario, but perhaps should be considered for the near future if one year of reliable seepage monitoring data is collected that can be properly tied to the measured piezometer readings.

WATER SUPPLY (INTAKE) TUNNEL INSPECTION

General

The Lake DeSmet water supply intake tunnel from Piney Creek and the associated structures provide the main water supply source for the reservoir. The existing intake tunnel and appurtenances are over 30 years old and internal inspections reportedly have never been conducted. Based on early LEC meetings and conversations with Mr. Bruce Yates (Associate County Engineer of Sheridan County) and Mr. Phil Ogle of the WWDC staff in May 2004, there had been no indications of tunnel distress up to that time. Supply water exiting the tunnel reportedly has not indicated signs of any material being eroded from the coal or sandstone formations through which the tunnel is routed, and the tunnel water flow rates have remained undiminished as far as was known. Thus, it did appear then that there had not been any tunnel lining failures of a size sufficient to restrict the tunnel flow capacity or that would allow the materials (coal and/or sandstone) to enter the tunnel. However, the LDCC JPB felt that if the intake tunnel were ever to fail, the reservoir would be greatly and adversely impacted. Thus, the Lake DeSmet water supply intake tunnel inspection was requested by the LDCC JPB to be a part of the Level II study.

Intake Tunnel Inspection Team (TIT) and Remotely-operated Vehicle Inspection

LEC subcontracted the services of Hibbard Inshore, LLC of Lake Angelus, Michigan and Lyman Henn, Inc. of Denver, Colorado to conduct underwater inspections of the tunnel and associated structures using video and sonic technologies in order to determine the overall condition of the water supply facilities and to determine any need for system repairs. Hibbard Inshore furnished the inspection equipment and operators and Mr. Ray Henn of Lyman Henn provided overall direction to the inspection, being primarily concerned with the engineering aspects of the tunnel inspection, and led the Lake DeSmet Tunnel Inspection Team (TIT).

Between July 26 and 30, 2004, the TIT set up and completed the Lake DeSmet water supply intake tunnel inspection. All TIT operations were conducted under the applicable OSHA regulations. Television surveys were completed for the entire water supply intake tunnel (along length), intake shaft (for depth), outlet shaft (for depth) and outlet conduit (along length), including all structure transitions. “Voice over”
video tape recordings of the underwater inspections were also made. Field records and daily reports were issued to the TIT via the site representatives and by telephone. Video media, sonar profiles, and field sketches were prepared as required.

**Results of Intake Tunnel Inspection**

The TIT reviewed the results of the underwater tunnel concrete liner survey, both during and after the actual inspection survey, and issued separate reports to LEC on the findings. Summaries of the inspection findings are presented in the separate reports prepared by Hibbard Inshore and Lyman Henn to LEC. Based on the Hibbard Inshore findings and report, Ray Henn prepared a final condition survey report. These two reports are included in the Lake DeSmet Project Final Report.

Both Hibbard Inshore and Ray Henn of Lyman Henn, Inc. reported that the tunnel inspection went well and better than expected. Based on the TIT tunnel inspection results, a total of 26 concrete condition features were detected and overall included 17 radial (circumferential) cracks, 2 longitudinal cracks, 2 small cracks, 1 displaced concrete joint, 1 spall area, and 3 construction joints. The observed cracks are not of concern, nor are the joint offset or spall area. The construction joints are also of no concern. The overall condition of the concrete linings in the Intake Shaft, Running Tunnel, Outlet Shaft, and Outlet Conduit reportedly is good and there are no proposed special monitoring requirements needed for the water supply intake tunnel and appurtenances at the present time.

**Recommendations**

Ray Henn indicates that a second ROV-type inspection might be warranted within the next 20 to 30 years, excluding a large earthquake or flood event, in which case he suggests a followup inspection to be made as soon as possible after the event. The final tunnel inspection records reported on herein are to be used as a baseline condition for future similar facility inspections by the LDCC JPB.

Also, since no protection grate exists for the top of the existing shaft to the water supply intake tunnel and a potentially dangerous site safety condition exists to unauthorized persons visiting Lake DeSmet, a grate should be manufactured/fabricated by a local-area machine shop operator for its installation, with necessary hold-down appurtenances, at the top of the outlet shaft.

**NORTH DAM OUTLET WORKS INSPECTION**

**General**

LEC completed a detailed inspection of the existing North Dam outlet works conduit and appurtenances on August 25, 2004. An audiotape was made during the entire time of the actual inspection and is included in the Lake DeSmet Project Notebook.

**Results of Inspection**

LEC notes that the existing two slide gates at the inlet end of the outlet works tunnel system were badly leaking in a spray fashion. An estimated combined rate of the two-gate system leakage is 20 to 40 gallons per minute (gpm), based on a measured/calculated flow into the basin area of the baffled energy dissipator. Also, a separation distance of 3/8 inch was measured at both sides of the tunnel near the top "connections" of the existing transition structure to the rectangular-shaped tunnel, however, the bottom "connections" were tight. Evidence of a small amount of water leakage from above was noted at the left side of the tunnel, however, is not considered significant.

There are drainage galleries located adjacent to the outside walls of the outlet tunnel conduit. The galleries daylight in 8-inch diameter pipes at the downstream end of the outlet structure. During the August 25 inspection, the right-side gallery was producing approximately one (1) gpm of seepage. The left-side gallery was flowing at about five (5) gpm. These low flow rates indicate that the seepage alongside the outlet tunnel conduit is relatively insignificant.
**Recommendations**

Pictures of the leaking slide gates were first sent to Steward Manufacturing, Inc. in Birmingham, Alabama, the original slide gate manufacturer, for recommendations and a projected cost for repair recommendations to rehabilitate the two slide gates. Steward instead referred the Lake DeSmet matter to its sister company, Hardie-Tynes, Inc. (located in Birmingham as well). Hardie-Tynes reported that the 40- to 60-gpm leakage range is too much, but probably not indicative of a pending catastrophic failure. The leakage could be due to the existing cast iron gate frame and/or the gate body itself that may have undergone severe erosion (due to excess pressure flows and cavitation) starting long ago and just becoming enlarged. This erosional wear, with corrosion and/or debris impacts, would only get worse with time. It is noteworthy that this tunnel system had been inspected about five years ago by Texaco staff and the slide gates showed no leakage at that time. Hardie-Tynes suggests that the only possible method to properly evaluate the cause of the gate leakage is to inspect the gate body, gate frame, and seal areas after the outlet works system would be totally dewatered. Hardie-Tynes reports that any repairs to the Lake DeSmet slide gates could require more than just seal replacement.

**ROCK CREEK DIVERSION AND CONVEYANCE DESIGNS**

**General**

LEC evaluated the existing Rock Creek diversion structure and appurtenances in addition to having evaluated alternate conveyance methods for a total improved Rock Creek diversion/conveyance irrigation system, and includes the Lake DeSmet and Barkey Ditches and the existing ChevronTexaco irrigation structures. The total Rock Creek diversion/conveyance system and separate system components are identified and discussed in the Lake DeSmet Project Final Report.

**Existing System Description Summary and Commentary**

The LDCC JPB has a storage right in Lake DeSmet for 875 acre-feet from Rock Creek under Wyoming Storage Permit 1300R. This 875 acre-feet amount is then available for use by the Belus Family, a local landowner family that has the storage rights on Shell Creek. Flow conveyance from Rock Creek to Lake DeSmet is through the existing Lake DeSmet and Barkey Ditches and the ChevronTexaco irrigation system. However, this water must be taken into Lake DeSmet from Rock Creek during the period from the beginning of runoff in the early spring to the beginning of the irrigation season. After the irrigators call for water, the water in the Lake DeSmet Ditch is committed for irrigation use. After October 1, if water is still available from Rock Creek, it may be directed to Lake DeSmet through the irrigation conveyance system.

The time frame available to take the 875 acre-feet is short; generally on the order of a few weeks. The existing ditch system cannot carry enough water to deliver the 875 acre-feet in a short time period. This system does not allow for the entire 875 acre-feet to be conveyed to the Lake DeSmet Reservoir in most years.

The existing Rock Creek to Lake DeSmet diversion/conveyance system consists of a diversion dam and headgate structure on Rock Creek, the Lake DeSmet and Barkey Ditches, and the ChevronTexaco irrigation system. The Rock Creek diversion system consists of two low dams constructed of large boulders with underlying plastic sheeting across the main channel of Rock Creek and a reinforced concrete headgate structure at the left bank side. The small dams allow the water surface in Rock Creek to be raised so creek flows can be diverted into the Lake DeSmet Ditch through two gates in the headgate structure. A turnout structure from the Lake DeSmet Ditch leads to the Barkey Ditch that in turn crosses Johnson County Road 39 in a pipe culvert. Further downstream, the U. S. Department of Agriculture Natural Resources Conservation Service (NRCS) has constructed combined gated intake and pipeline structures. The structures can capture ditch flows for irrigation use in the ChevronTexaco center pivots in Shell Creek. One structure also can be operated to bypass flows for continuation in Barkey Ditch and/or
capture flows in a spillway and pipeline leading to a structure discharging into the South Fork of Shell Creek. The flows that discharge into the South Fork Shell Creek ultimately flow into Shell Creek and to the Shell Creek Reservoir and then to Lake DeSmet.

**Rock Creek Diversion Dam and Headgate**

The Rock Creek diversion dam allows the Rock Creek water surface to be raised and provide a low hydraulic head for the left gate. Under current conditions, with an intact diversion dam and high flows in Rock Creek, it is estimated that the left gate could take about 36 cubic feet per second (cfs). However, the dam is subject to being washed out during high flows. The combined gate capacity would be on the order of 100 cfs if three (3) feet of head on both gates could be provided. Currently, the combined gate capacity cannot be fully utilized because of the existing diversion dam inadequacy.

**Lake DeSmet Ditch**

The Lake DeSmet Ditch flow depths and velocities were estimated for a flow of 100 cfs. Estimated ditch flow depths for 100 cfs are one (1) to two (2) feet and flow velocities are estimated between about two (2) to four (4) feet per second (fps). The calculated ditch freeboard is on the order of four (4) to five (5) feet, indicating that the existing ditch can easily handle more than 100 cfs.

**Fish Pasture Gates and Barkey Ditch**

The Fish Pasture irrigation gates are located on the divide between an unnamed tributary to Rock Creek and an unnamed tributary to the South Fork Shell Creek. Beyond the gates, the Lake DeSmet Ditch continues to the southeast in the Rock Creek drainage and is also known as the M&M Ditch. The M&M gate structure is very old (reportedly about 95 years) and in poor condition. Stoplogs can be installed in a connected sill and gate structure in order to provide headwater for two sets of lateral gates to two ditches, namely the Ruby Ditch and the Barkey Ditch. The Ruby Ditch, however, is presently abandoned, and the gate remains closed. The calculated Barkey Ditch gate capacity is approximately 29 cfs at three (3) feet of head.

**Barkey Ditch and Johnson County Road 39 Culvert Crossing**

The Barkey Ditch crosses Johnson County Road 39 via a 36-inch diameter culvert. The maximum ditch capacity immediately upstream of the culvert reportedly has been reported by ChevronTexaco to be 16 cfs (with no freeboard). In 2003, the ditch banks downstream of the culvert reportedly washed out at about 15 cfs. The existing culvert could pass about 38 cfs if the local ditch carrying capacity was adequate.

**ChevronTexaco Irrigation and Spillway Structures**

The Barkey Ditch continues generally north-northwest to two ChevronTexaco structures. One structure is used to direct water into a pressure pipe system that extends to agricultural fields in the Shell Creek drainage at the east side of Interstate Highway 90 (I-90). The system piping is connected to and runs a sprinkler irrigation system for ChevronTexaco. The second structure (Spillway Structure) captures overflow water that is not taken into the irrigation system and discharges it to the South Fork of Shell Creek. These discharges in turn flow into the Shell Creek Reservoir and ultimately to Lake DeSmet. The ChevronTexaco structures were constructed by the NRCS in 2000.

**Barkey Ditch-ChevronTexaco Irrigation Structure to I-90**

The Barkey Ditch continues north and east for about 2.2 miles to the I-90 crossing. The minimum ditch flow capacity with two (2) feet of freeboard is estimated to be 38 cfs. The ditch terminates in a concrete-lined channel structure and pipe crossing under I-90. The as-built conditions of this pipe crossing at I-90 are unknown. Based on an assumed 15-foot difference in head and a 24-inch pipe, the system could pass 41 cfs.
M&M Ditch and I-90 Siphon Crossing

The Lake DeSmet Ditch is also known as the M&M Ditch downstream of the Fish Pasture gates. The M&M Ditch continues for about six (6) miles to an inverted siphon crossing at I-90. The ditch capacity at this location is in excess of 200 cfs at a 4-foot flow depth. Based on a review of the I-90 as-built construction drawings, the inverted siphon is a 48-inch diameter steel pipe about 380 feet long. The flow through the siphon would be 110 cfs for headwater and tailwater depths of four (4) feet.

Available Rock Creek Flows

A diversion flow of 20 cfs from Rock Creek would provide 875 acre-feet to users if the water were available for 22 days in any given year. This flow rate requires that sufficient water be available in Rock Creek, and the ditch system be free of ice and snow early in the spring, in order that the water can be taken prior to the irrigation season. Based on the historical period of streamflow records for Rock Creek and the assumption that basin runoff begins in April and the irrigation season starts in May, only the month of April would be available to capture the creek water for Lake DeSmet. However, based on U. S. Geological Survey (USGS) records for Rock Creek near Buffalo, Wyoming (for water years 1945 through 2003), springtime flows in Rock Creek have averaged only about 16 cfs for the month of April. Creek flows have been even lower in recent years, and the 20 cfs is not generally available in all years.

Summary

- The majority of the existing Rock Creek diversion/conveyance system has sufficient hydraulic capacity to convey about 20 to 25 cfs to the South Fork of Shell Creek and thence to Lake DeSmet, with the exception of the restricted ditch capacity near the Johnson County Road 39 culvert crossing. The local ditch reach restricts the system capacity to about 15 to 18 cfs. These noted flow ranges require that sufficient water be available in Rock Creek and the ditch system be free of ice and snow in the spring so that water can be taken prior to the irrigation season.
- The existing Rock Creek diversion dam is not adequate to provide sufficient hydraulic head to allow any more than about 36 cfs to flow into the Lake DeSmet Ditch. Reconstruction of this diversion dam to provide more flow could benefit the irrigators, however, would not help with the early spring flows necessary to take the 875 acre-feet unless sufficient creek water supplies were available and certain other parts of the total Rock Creek conveyance system also underwent specific reconstruction improvements.

Conclusions and Recommendations

If more supply water was available in Rock Creek and could readily be taken into the Lake DeSmet Ditch system, there are three potential alternatives to convey water to the Lake DeSmet drainage and thence to Lake DeSmet. Each alternative would involve conveying the diverted water to the Lake DeSmet Ditch and ultimately releasing it to a natural watercourse that is tributary to Lake DeSmet. Each alternative described below would increase the total system conveyance flow rate to 40 cfs, thereby allowing the 875 acre-feet to be conveyed in about 12 days if sufficient creek water was available. Also noteworthy is that there would be greater losses due to seepage and evapotranspiration in a natural watercourse than in a man-made constructed irrigation ditch or pipeline.

- Upgrade existing Rock Creek diversion/conveyance system as required to allow increased flows to the spillway at the ChevronTexaco Irrigation Structure. The most restricted conveyance sections of this alternative appear to be the ChevronTexaco Spillway and the Barkey Ditch near the Johnson County Road 39 culvert crossing. Upgrading the Chevron Texaco Spillway to take more than 25 cfs may require an additional parallel pipeline, depending on surveys and final design. Raising the banks of the existing Barkey Ditch near the county roadway crossing could provide additional conveyance capacity. The system would then have a carrying capacity up to
about 38 cfs. Additional total system conveyance capacity would require rehabilitation of the existing Rock Creek diversion dam and the Barkey Ditch turnout structure.

- Upgrade existing Rock Creek diversion/conveyance system to allow for additional flow conveyance in the Barkey Ditch to the pressure pipe crossing under I-90. At this location, flows can be turned into the old Barkey Ditch, terminating in an existing drainage that leads to Lake DeSmet, or otherwise released into a small drainage located near the pipe outfall. The old Barkey Ditch would require periodic cleanout. Also, the capacity of the pipe under I-90 is unknown. If it is too small, this alternative may not be feasible. However, the water could also be released into an existing drainage to the west side of I-90 at the head end of the pressure pipe, or into a new pipe to cross under I-90 at the Shell Creek Road underpass.

- Upgrade the existing Rock Creek diversion/conveyance system in order that the water in the M&M Ditch can be routed through the I-90 siphon under I-90 to a new turnout structure, thence in a new ditch and outfall pipe to a drainage that is tributary to Lake DeSmet. This alternative would involve the construction of a new turnout structure and pipe, and in addition would require significant erosion control measures, or an extension of the outfall pipe, to reach a low-gradient natural channel before non-erodible flow releases could be made. The LDCC JPB would also incur higher maintenance costs because it would have to participate in maintenance of the M&M Ditch from the Fish Pasture to the new turnout structure.

LAKE DESMET SOUTHWEST SHORELINE EROSION INVESTIGATION

Reconnaissance-level Field Investigation, Limited Level Survey, and Local Site Evaluation

LEC performed a general site reconnaissance-level field investigation, limited level survey, and local site evaluation of the Lake DeSmet southwest shoreline area, which reportedly has undergone severe localized erosion due to impinging water wave action across the reservoir surface. There is also a concern that additional future erosion to the shoreline in this area can potentially disrupt and perhaps change a local tributary stream channel that is in close proximity to the lake’s shoreline.

Several localized deep cracks were also observed to exist at the top areas along the eroded and near-vertical bank walls at the shoreline area. Due to the observed and measured heights of the eroded bank wall sections, with measured vertical wall heights on the order of 10 to 15 feet (based on level survey) above the eroded “beach area” below the walls, this site condition alone presents an unsafe condition locally to tourists or other visitors, unauthorized persons, and animals as well if they were to approach too close to the bank edges.

The stream tributary is located immediately south of an existing fence line that has already been damaged due to bank failure. At a Lake DeSmet normal water surface elevation of 4620 feet, severe water wave action over the reservoir surface during severe storms could potentially “channelize” across the fence line and disrupt the tributary stream drainageway to the south. Of more concern, however, is the fact that occasional bank failures along several hundred feet in this southwest shoreline area have and can occur anytime and thus public safety must be considered first.

Conclusions and Recommendations

At a minimum, the top areas along the near-vertical banks at the southwest shoreline area should be provided some level of protection against pedestrian/tourist traffic from walking too close to the bank edges. Suitable low split-rail fencing and posted warning signs should provide a good measure of protection and safeguarding against possible accidents to visitors (and animals), and are often utilized within jurisdictional park areas for public safety purposes.

Major earthworks would be required for any erosion mitigation and/or protection at the southwest shoreline area and to safeguard against the adverse effects of severe water wave action at the shoreline that potentially could “short-circuit” across the existing fence line and disrupt the local drainageway to the south. This work would
include, at a minimum, local excavation and backfilling, shaping and grading of the overburden soils and weathered bedrock away from the shoreline on a recommended slope no steeper than 4H:1V (or 25 percent) and daylighting to higher ground. Topsoil would also have to be stripped locally and stored in temporary stockpiles for later re-use. Several acres would have to be disturbed in the process. Therefore, a less costly effort would be to provide heavy boulder riprap against the existing gully and shoreline for future erosion control purposes. In any case, this work should be performed under the direction of the LDCC JPB and/or a competent construction engineer.

PROPOSED LAKE DESMET PROJECT IMPROVEMENTS AND COST ESTIMATES

Lake DeSmet Project improvements are proposed by LEC, including the estimated costs for the improvements. The proposed improvements include an inspection and alternative rehabilitation repair and/or replacement costs for the two slide gates that are part of the existing North Dam outlet works system, the fabrication and installation of a new grate for the top of the existing outlet shaft to the Piney Creek water supply intake tunnel system, alternative improvements to the existing Rock Creek irrigation diversion and conveyance systems, and local-area Lake DeSmet southwest shoreline stabilization and protection. LDCC JPB options are also presented by LEC for the installation of the former HKM-proposed three (3) new piezometers in the downstream embankment section of the North Dam (or, at a minimum, the rehabilitation of two (2) existing piezometers in the embankment) for future dam safety monitoring and for the installation of a remote water level/flow monitoring system with data transmission capabilities to LDCC JPB.

An LEC Opinion of Probable Cost table was developed for the WWDC and LDCC JPB use in considering possible Lake DeSmet Level III project improvements, and is presented on the following page. Unit cost information was obtained from local sources and rural Wyoming costs in the region for estimating total project construction costs for all LEC proposed Lake DeSmet Project improvements. The cost to end users include all identified and recommended improvements proposed during this Level II investigation, and may also include those components that are not eligible for WWDC funding. The total cost estimates are summarized in the following table, are based on January 2006 construction costs, and include 10% for construction engineering and 15% for construction contingencies.
### SUMMARY TABLE OF LAKE DESMET PROPOSED
### PROJECT CONSTRUCTION AND RELATED COST ESTIMATES

#### NORTH DAM OUTLET WORKS SYSTEM

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Preliminary Designs and Specifications</td>
<td>$6,000</td>
</tr>
<tr>
<td>Permitting and Mitigation</td>
<td>$0</td>
</tr>
<tr>
<td>Legal Fees</td>
<td>$0</td>
</tr>
<tr>
<td>Acquisition of Access and Right-of-Way</td>
<td>$0</td>
</tr>
<tr>
<td>Cost of Project Components</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Work Items</strong></td>
<td></td>
</tr>
<tr>
<td>a. Inspect existing slide gates w/ totally dewatered outlet works system (inspection team includes LEC, gate manufacturer representative, and LDCC JPB representative)</td>
<td>$6,500</td>
</tr>
<tr>
<td>b. Remove existing slide gates; replace bronze seals provided by gate manufacturer; reinstall slide gates</td>
<td>$50,000</td>
</tr>
<tr>
<td>Construction Cost Subtotal (CCS) #1</td>
<td>$56,500</td>
</tr>
<tr>
<td>Engineering Costs + CC#1 x 10%</td>
<td>5,650</td>
</tr>
<tr>
<td>Subtotal #2</td>
<td>$62,150</td>
</tr>
<tr>
<td>Contingency = Subtotal #2 x 15%</td>
<td>$9,322</td>
</tr>
<tr>
<td>Construction Cost Total</td>
<td>$71,472</td>
</tr>
<tr>
<td>Project Cost Total</td>
<td>$77,472</td>
</tr>
</tbody>
</table>

#### OR

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Remove existing slide gates and appurtenances and replace with new gates and appurtenances</td>
<td></td>
</tr>
<tr>
<td>Construction Cost Subtotal (CCS) #1</td>
<td>$70,000</td>
</tr>
<tr>
<td>Engineering Costs + CC#1 x 10%</td>
<td>7,000</td>
</tr>
<tr>
<td>Subtotal #2</td>
<td>$77,000</td>
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<tr>
<td>Contingency = Subtotal #2 x 15%</td>
<td>$11,550</td>
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<tr>
<td>Construction Cost Total</td>
<td>$88,550</td>
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<tr>
<td>Project Cost Total</td>
<td>$94,550</td>
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#### NORTH DAM INTAKE TUNNEL SYSTEM

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Preliminary Designs and Specifications</td>
<td>$500</td>
</tr>
<tr>
<td>Permitting and Mitigation</td>
<td>$0</td>
</tr>
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<td>$0</td>
</tr>
<tr>
<td>Acquisition of Access and Right-of-Way</td>
<td>$0</td>
</tr>
<tr>
<td>Cost of Project Components</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Work Items</strong></td>
<td></td>
</tr>
<tr>
<td>a. Fabricate and install new top grate for existing outlet shaft to intake tunnel</td>
<td>$5,000</td>
</tr>
<tr>
<td>Construction Cost Subtotal (CCS) #1</td>
<td>$5,000</td>
</tr>
<tr>
<td>Engineering Costs + CC#1 x 10%</td>
<td>$500</td>
</tr>
<tr>
<td>Subtotal #2</td>
<td>$5,500</td>
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<tr>
<td>Contingency = Subtotal #2 x 15%</td>
<td>$825</td>
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<tr>
<td>Construction Cost Total</td>
<td>$6,325</td>
</tr>
<tr>
<td>Project Cost Total</td>
<td>$6,825</td>
</tr>
</tbody>
</table>
NORTH DAM INSTRUMENTATION

Preparation of Preliminary Designs and Specifications $4,000 (b.) to $6,000 (a.)
Permitting and Mitigation $0 to $500 (a.)
Legal Fees $0 $0
Acquisition of Access and Right-of-Way $0 $0

Cost of Project Components

Work Items

a. Install 3 new piezometers in downstream embankment of North Dam; provide flush-mounts and lockable caps

Construction Cost Subtotal (CCS) #1 $7,500
Engineering Costs + CC#1 x 10% $7,500
Subtotal #2 $7,750
Contingency = Subtotal #2 x 15% $1,232

Construction Cost Total $8,250
Project Cost Total $9,487

OR

b. Re-develop 2 existing piezometers in downstream embankment of North Dam.

Construction Cost Subtotal (CCS) #1 $3,000
Engineering Costs + CC#1 x 10% $3,000
Subtotal #2 $3,300
Contingency = Subtotal #2 x 15% $495

Construction Cost Total $3,795
Project Cost Total $7,795

ROCK CREEK DIVERSION WORKS / CONVEYANCE SYSTEM IMPROVEMENTS – (Rock Creek Diversion upgrades: 1) $15,000 for the rearrangement of the existing boulder drop and placing additional boulders as needed, including grouting the boulders in-place, in order to raise the Rock Creek water surface; cost estimate includes second gate; 2) $65,000 for full diversion dam reconstruction with a new reinforced concrete dam structure and placing and compacting suitable backfill behind the existing headgate structure walls; Note: Item 1) is an LDCC JPB least-cost option.

Preparation of Preliminary Designs and Specifications $27,000 to $34,000
Permitting and Mitigation $3,000 to $5,000
Legal Fees $3,000 $6,000

Acquisition of Access and Right-of-Way

Cost of Project Components
### Alternative I Work Items

1. Rock Creek diversion upgrade (includes diversion and care of Rock Creek)
2. Replace Barkey Gate
3. Grade Barkey Ditch
4. Install parallel spillway structure and pipe
5. Provide field surveying prior to design @ 15%

**Construction Cost Subtotal (CCS)**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$15,000 / $ 65,000</td>
<td></td>
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</table>

**Total Engineering Costs**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$46,000 / $104,000</td>
<td></td>
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</table>

**Subtotal #2**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$50,600 / $114,400</td>
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**Contingency = Subtotal #2 x 15%**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
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</thead>
<tbody>
<tr>
<td>$7,590 / $ 17,160</td>
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**Construction Cost Total**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$59,190 / $131,560</td>
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**Project Cost Total**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$92,190 / $176,560</td>
<td></td>
</tr>
</tbody>
</table>

OR

### Alternative II Work Items

1. Rock Creek diversion upgrade (includes diversion and care of Rock Creek)
2. Replace Barkey Gate
3. Re-grade Barkey Ditch
4. Clean Barkey Ditch
5. Install additional piping
6. Provide field surveying prior to design @ 15%

**Construction Cost Subtotal (CCS)**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$15,000 / $ 65,000</td>
<td></td>
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</tbody>
</table>

**Total Engineering Costs**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$42,550 / $100,050</td>
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**Subtotal #2**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
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<td>$46,805 / $110,055</td>
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</tbody>
</table>

**Contingency = Subtotal #2 x 15%**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
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</thead>
<tbody>
<tr>
<td>$7,021 / $ 16,508</td>
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</table>

**Construction Cost Total**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
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</thead>
<tbody>
<tr>
<td>$53,826 / $126,563</td>
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</table>

**Project Cost Total**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$86,826 / $171,563</td>
<td></td>
</tr>
</tbody>
</table>

OR

### Alternative III Work Items

1. Rock Creek diversion upgrade (includes diversion and care of Rock Creek)
2. Install turnout structure at siphon outlet
3. Install approximately 2,000 LF of 24-inch HDPE pipe
4. Provide erosion protection
5. Provide field surveying prior to design at 15%

**Construction Cost Subtotal (CCS)**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$15,000 / $ 65,000</td>
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</tbody>
</table>

**Total Engineering Costs**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$57,500 / $115,00</td>
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**Subtotal #2**

<table>
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<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
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<tbody>
<tr>
<td>$63,250 / $126,500</td>
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</table>

**Contingency = Subtotal #2 x 15%**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
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</thead>
<tbody>
<tr>
<td>$9,488 / $ 18,975</td>
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</table>

**Construction Cost Total**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
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</thead>
<tbody>
<tr>
<td>$72,738 / $145,475</td>
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</table>

**Project Cost Total**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Total Amounts (Minimum / Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$105,738 / $190,475</td>
<td></td>
</tr>
</tbody>
</table>
LAKE DESMET DITCH DIVERSION WORKS / CONVEYENCE SYSTEM IMPROVEMENTS

Preparation of Preliminary Designs and Specifications $6,000
Permitting and Mitigation $0
Legal Fees $0
Acquisition of Access and Right-of-Way $0
Cost of Project Components

Work Items

a. Demolish existing Fish Pasture gate structure / appurtenances $2,000
b. Construct lean concrete Cipolletti weir with steel plate $2,500
c. Construct reinforced concrete irrigation gate turnout structure (approximately 60 cubic yards), including wood beams (3 x 12s), anchor bolts, and appurtenances for structure walkway

d. Install Waterman slide gates (3 gates with appurtenances, installed)
e. Install new irrigation lateral turnout structure

Construction cost subtotal (CCS) #1 $20,000
Engineering costs = CCS #1 x 10% $3,100
Subtotal #2 $34,100
Contingency = Subtotal #2 x 15% $5,115
Construction Cost Total $39,215
Project Cost Total $45,215

LAKE DESMET SOUTHWEST SHORELINE REMEDIATION EARTHWORKS

Preparation of Preliminary Designs and Specifications $1,000
Permitting and Mitigation $0
Legal Fees $0
Acquisition of Access and Right-of-Way $0
Cost of Project Components

Work Items

a. Install fencing and warning signs along steep bank sections of reservoir shoreline for pedestrian / visiting tourist / animal protection $5,000

Construction cost subtotal (CCS) #1 $5,000
Engineering costs = CCS #1 x 10% $500
Subtotal #2 $5,500
Contingency = Subtotal #2 x 15% $825
Construction Cost Total $6,325
Project Cost Total $7,325
Preparation of Preliminary Designs and Specifications $3,000
Permitting and Mitigation $0
Legal Fees $0
Acquisition of Access and Right-of-Way $0
Cost of Project Components

Work Items

Options for Local Shoreline Stabilization

a. Perform earthworks construction in LDCC JPB area of concern to include topsoil removal and stockpiling for later use in site reclamation; light clearing and grubbing operations; overburden excavation; backfilling operations; and rough shaping, grading and materials compaction (including large riprap), under direction of LDCC JPB and/or LEC
$30,000

Construction cost subtotal (CCS) #1 $30,000
Engineering costs = CCS #1 x 10% $3,000
Subtotal #2 $33,000
Contingency = Subtotal #2 x 15% $4,950
Construction Cost Total $37,950
Project Cost Total $40,950

OR
b. Provide only large riprap protection in LDCC area of concern $17,000

Construction cost subtotal (CCS) #1 $17,000
Engineering costs = CCS #1 x 10% $1,700
Subtotal #2 $18,700
Contingency = Subtotal #2 x 15% $2,805
Construction Cost Total $21,505
Project Cost Total $24,505

MECHANICAL / ELECTRICAL QUANTITY (LDCC OPTION)

Preparation of Preliminary Designs and Specifications $3,000
Permitting and Mitigation $0
Legal Fees $0
Acquisition of Access and Right-of-Way $0
Cost of Project Components

Work Items

a. Install Stevens or AEC water level / flow sensor devices with remote transmission capabilities for seepage monitoring $20,000

Construction cost subtotal (CCS) #1 $20,000
Engineering costs = CCS #1 x 10% $2,000
Subtotal #2 $22,000
Contingency = Subtotal #2 x 15% $3,300
Construction Cost Total $25,300
Project Cost Total $28,300