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BIG HORN CANAL
FEASIBILITY ANALYSIS
LEVEL II
Agreement No. 05SC0290332

EXECUTIVE SUMMARY

PREPARED FOR
WYOMING WATER DEVELOPMENT COMMISSION
CHEYENNE, WYOMING

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JUNE 1994
EXECUTIVE SUMMARY

PURPOSE

This study is a Level II Feasibility Analysis of rehabilitative needs on the Big Horn Canal. The Canal lies in Washakie and Big Horn Counties located in the Big Horn Basin of west central Wyoming. Many structures are 40 to 50 years old and need replacement. Sections of the Canal are 90 years old and need rehabilitation.

STUDY AREA

The Big Horn Basin is a north to south river basin bordered on the east by the Big Horn Mountains and on the west by the Owl Creeks and Absaroka Mountains. The Big Horn Canal diverts water from the Big Horn River about nine miles southwest of Worland and parallels the river on the west side. The Canal extends north some 50 miles and discharges into a small tributary of the Greybull River, just south of Greybull, Wyoming.

The climate in the project area is arid with an average precipitation of about 6.8 inches. Approximately 60 percent of the precipitation occurs during the April to August period in the form of rainfall. Irrigation is necessary for acceptable production of crops. The normal period of +40°F mean daily temperature occurs from March 31-October 28 each year. The typical frost-free period is 135 days.

SURFACE WATER

The Big Horn Canal enjoys direct appropriation of water rights from the Big Horn River. In the average year, these rights provide sufficient water for crop production. However, in drier years, stored water is purchased on contract from Boysen Reservoir some 48 miles upstream. Initial capacity of the Canal is about 520 cfs. The Canal serves 218 irrigators and 23,800 acres.

ORGANIZATION

The study has been structured into two phases. Phase I is an Alternative Analysis and Phase II is Conceptual Design. This study includes the following tasks:

Phase I - Alternative Analysis

1. Scoping Meeting/Project Meetings
2. Condition of the Existing Canal
3. Economic Analysis/Ability to Pay
4. Rehabilitation Plan
5. Phase I Results Presentation
Phase II - Conceptual Design and Cost Estimates

1. Conceptual Design
2. Subsurface/Geotechnical Evaluation
3. Surveying
4. Cost Estimates
5. Permitting
6. Report/Executive Summary
7. Meeting/Hearing

Phase I

In Phase I, structures on the Canal were inventoried and evaluated for remaining physical life and hydraulic efficiency. Importance of the mainline structures was prioritized based on the economic consequences to the service area, should the structure fail either structurally or hydraulically. Combining the foregoing analyses resulted in a prioritized list of improvements.

With input from the Big Horn Canal Company Board, the proposed Rehabilitation Plan included making the following improvements:

1) Deletion or modification to Wasteway No. 1 at Sta. 69+00.
2) Replacing the check structure at Sta. 220+00.
3) Replacing and lengthening the concrete lining beginning at Sta. 335+38.
4) Reshape 2900 LF of Canal at Sta. 363+00 - 392+00.
5) Rehabilitating the 15-Mile Wasteway at Sta. 444+85.
6) Rehabilitate 5-Mile Wasteway and Dropchute - Sta. 1325+45.
7) Rehabilitate Alamo Creek Wasteway - Sta. 1713+65.

Canal Inventory - The Canal was inspected and structures were reviewed in June and September 1993. After water was taken out of the Canal in October, selected structures were again inspected, particularly below the waterline, to ascertain 1) Physical Condition; 2) Remaining Life; 3) Certain Dimensions; and 4) Operational Evaluation.

The structures on the Canal were rated based upon the field data from the review and evaluation inspections. Structures were rated for importance based upon the following criteria:

1. Physical Condition/Life Remaining
2. Location Along Canal
3. Importance of Structure to Canal Operations
Items that the Canal Board thought in poor condition were inspected closer, but did not receive a higher rating based solely on their concerns.

Since all crossing bridges are the responsibility of other entities, they were rated as least priority. These bridges were inspected and rated because they do affect the Canal with low freeboard or restrictive abutments and have the potential for damaging the Canal through failure. The Association should adopt standard bridge designs and maintain a right to review any new bridge designs for crossing the Canal. Included in these standards should be a list of acceptable materials, clearances and design widths as well as repair standards. The design should also be certified to withstand the loading conditions expected of the bridge.

Safety Features - During the Canal inventory and evaluation conducted in June 1993, a lack of safety features was noted. These features should be addressed and can be taken care of through the maintenance budget of the Canal. Generally, the condition of walkways, handrails and safety chains is poor and in need of improvement.

The Bureau of Reclamation has classified canals based on hazard exposures. They are as follow:

Class A  Those canals adjacent to schools and recreational areas, such as playgrounds, subject to frequent visits by children.

Class B  Those canals nearby or adjacent to urban areas or highways and subject to frequent visits by the public.

Class C  Those canals nearby or adjacent to farms or highways which could be subject to visits by children seeking recreation, such as swimming.

Class D  Those canals far removed from any dwelling subject to infrequent visits by operating personnel and an occasional sportsman.

Class E  Those canals that would be a hazard to domestic animals.

Class F  Those canals that would be an extreme hazard to big game animals.

The Big Horn Canal fits into a variety of these classifications due to its length and location. Structures that are in or near Worland or Basin (Class A or B) should be fenced to prevent accidental injury of children playing in the Canal. These structures should also be fitted with safety chains and ladders to allow access out of the Canal. Structures (Class C or D) should have safety chains and possibly escape ladders to prevent injury to operators and sportsman.
As noted in the Canal inventory evaluation, walkways and handrails are in poor condition. The walkway planks for most structures are old, warped and cracked. Some walkways are only one plank wide. Handrails, for the most part, are non-existent or in poor repair. For the safety of the farmers, operators and any one who may need to cross the channel on these structures, new 3-foot wide walkways with standard 42-inch handrails need to be placed on all necessary structures.

**Economic Evaluation** - Intermediate evaluation of a structure's importance entailed making an economic impact evaluation of consequential damages should a structure fail.

Data from the Northern Washakie Flood Study was utilized to calculate potential consequential loss if a washout occurs. From the Washakie study, updated crop prices, known yields and rotations, a dollar value for the consequential loss is calculated for a unit farm. Applying this dollar value to the acreage downstream gives the total consequential loss if the Canal is breached. The Washakie study used six different scenarios to demonstrate potential yield reductions: 5, 10 and 15-day occurrences in June or July. These scenarios are applied in this study as well.

A "Willingness to Pay" survey was sent to each Canal Association member in October. Response represents about 25% of the irrigable acreage, or 5,986 acres. Producers farming 2,584 acres responded by indicating that some increase in assessment was acceptable for making Canal improvements. Most of those willing to accept an increase indicated that up to $1.00/acre was reasonable. Others indicated they would be willing to go along with a Board decision, or depends on improvements, or would go along with a reasonable amount. In summary and at best, it appears that $1.00/acre increase may be acceptable to most Association members to pay for improvements.

The Phase I - Draft Rehabilitation Plan was presented for review and scrutiny by both the Big Horn Canal Association and Water Development staff in early November, 1993. The intention being to develop a Final Rehabilitation Plan for submittal to the Water Development Commission by December 1, 1993. The WWDC accepted the Draft Report and deemed it unnecessary to prepare the Final Rehabilitation Plan.

**PHASE II**

Phase II work included completing surveying, geotechnical investigations and permitting identification to support conceptual design cost estimates for elements of work identified during Phase I.

Of the seven locations/structures noted on the Rehabilitation Plan completed in Phase I, two were deleted during Phase II work. Wasteway No. 1 at Sta. 69+00 has been eliminated from further consideration since the Canal Company began removal of the structure during the winter of 1993/94 and completed the work in time for the 1994 irrigation season. Reshaping of the
Canal from Sta. 363+00 to Sta. 392+00 has also been eliminated. It was formerly thought that the Canal flowline through this section was high by about one (1) foot causing water to be backed up beyond the concrete lined section. Measurements and surveying completed during Phase II revealed that the high spot is located in a much longer reach that is from one foot to three and a half feet low. One small high spot is noted from Sta. 358+60 to Sta. 362+60; however, it can easily be graded out with normal maintenance cleaning.

The proposed Rehabilitation Plan developed during Conceptual Design includes making improvements to five significant structures on the Canal. Discussion of each follows:

CHECK STRUCTURE - STATION 220+00 - This structure was identified in Phase I as having a very short remaining life and being crucial to proper Canal operations.

The structure includes four bays of flashboards and incorporates a 2 1/2'-3' drop. The concrete is in very deteriorated condition, the handrails are non-existent and the walkway is minimal. Large scour holes have been formed immediately downstream reflective of a structure that needs improved hydraulic efficiency. The water surface at this point on the Canal is about 44 feet wide with a normal depth of about 4.5 feet. Maximum irrigation flow in the Canal at this location is about 593 cfs. In accordance with USBR criteria, a surcharge of 20% has been added to arrive at a design discharge of 712 cfs. The conceptual design for the replacement structure conforms to USBR criteria.

CONCRETE LINING - STA. 334+88 - STA. 342+58 - The present concrete lining is about 370 feet in length, protecting the Canal where it is in close proximity to a very steep dropoff into the Big Horn River. The lining is reinforced, at least in the bottom section, and appears to be four to five inches thick. The base width is 35 feet and sidewalls are on 1:1 (horizontal to vertical) slopes to a height of six to seven feet. When running full, normal water depth approaches within three to four inches of the top of the lining. The invert concrete is spalling and buckling while the sidewalls are cracked, severely buckled and breaking off, particularly on the southeast or river side. The northwest side of the Canal is very close to the highway and encroaches into the right-of-way. During Phase I, this structure was identified as being the first priority for replacement by the Canal Company.

The Canal Company is desirous of both replacing and increasing the length of lining. The proposed work involves excavating the old lining, reshaping the canal with a narrowed base width and flattening sideslopes to 2:1. The proposed lining is four inches of non-reinforced concrete, incorporating sealed construction, contraction and expansion joints in the base slab and walls. The concrete will be fiber mesh reinforced, low slump, low water/cement ratio type. The lining will be increased in length 50 feet upstream and 350 feet downstream.
FIFTEEN-MILE CREEK WASTEWAY - STA. 444+85 - Fifteen-Mile Wasteway is a significant structure on the Canal that is not only a protective device for Fifteen-Mile Siphon, but is critical for daily operations. The support arms and roller gates are corroded through and difficult for the operators to adjust. The concrete outfall structure has settled and the walls have separated, eroded and broken off. Because of a low profile up-canal, standing water upstream cannot be drained via this wasteway. Reaches upstream retain as much as three and a half feet of water through the winter months.

The Canal Company is desirous of replacing this structure with a new structure. The proposed work involves excavating out the old structure, and replacing it with a new reinforced concrete structure. Three new 12-foot wide roller gates will be installed on the Canal channel. The wasteway will be of the same flashboard design as the existing structure. The open channel spillway will be replaced by a new reinforced concrete spillway of similar design. There will be five bays, five feet long, and a sixth bay with a three-foot lower flowline. This bay can be used to drain the Canal during the offseason. The stilling pool will require placement of riprap for erosion protection.

FIVE-MILE CREEK WASTEWAY - STATION 1325+45 - This wasteway is of similar design as 15-Mile Wasteway. The canal channel portion of the wasteway is in reasonably good condition. The spilled water runs down a channel about 600 LF to a massive concrete drop structure that has settled a considerable amount.

Another problem is the significant amount of sand deposition that occurs above the wasteway and below the Five-mile Creek Flume. The wasteway has six bays incorporating flashboards, but two are silted in from sand deposition. The Canal Company is desirous of revamping the structure to enable drafting and discharging sediments from the Canal. In lieu of rebuilding the outfall structure, it is proposed to build a box culvert drop type of outfall that discharges into the same drainage, but located a few hundred feet upstream of the existing outfall.

Revamping the existing structure includes excavating the two inoperable discharge bays and retrofitting them with two 4-foot wide by 4-foot high underflow slidegates. Other minor concrete work and structural repairs will also be necessary to accommodate the gates and restore support to the vehicle bridge. Improvements to the outfall ditch include shaping and steepening the slope to maintain sufficient velocity to keep sediments in suspension. The outfall structure will include a reinforced concrete inlet for a box culvert structure. The culvert will be six feet wide by five feet high and 110 feet long. The culvert will discharge into an existing drainage structure that will require some earthwork and riprap placement for erosion control.
ALAMO CREEK WASTEWAY - STA. 1713+65 - This wasteway is of similar design as 15-Mile Creek and 5-Mile Creek Wasteways. The discharge structure is of impressive size and scale. Photographs of the existing structure are enclosed. Physical condition of the structure was estimated at five years remaining life in Phase I, primarily due to deteriorated concrete in the discharge spillway. The second level slab is undermined and supporting soils have either washed away or settled leaving a void about two feet deep by ten feet wide and extending ten feet under the slab. The supporting wall has broken and a large piece has fallen out. Four lower wing walls have separated at the joints and one has broken and toppled over.

A repair procedure is proposed to restore the structure and extend the physical life to fifteen to twenty years. The roller gates, presently in good condition, may need replacing before then, however. Improvements include filling the void previously mentioned with lean portland cement grout, and forming new walls inside the old walls. The old walls can serve as an outside form and remain in place. The existing walls and slab will have to be sandblasted or bush-hammered to obtain a good bond with the new concrete. Additionally, separated joints will need to be grouted and rejoined with high strength epoxy grout. New walls would be eight inches thick.

Soils testing occurred at each of the five locations. Resistivity tests indicate that the soils are not corrosive to metals such as angle iron, rebar, turnouts and other miscellaneous hardware. Testing for sulphate attack indicates Type I or II cement is suitable for concrete construction. Laboratory tests resulted in determining soilbearing and lateral pressure used in structure design.

The Phase II - Draft Report was prepared in March, 1994 and presented to the Big Horn Canal Association and Water Development staff at the monthly canal board meeting in May 1994. Input on this draft report was incorporated into the Final Report of June 1994.

PERMITTING

Land ownership adjacent to the Canal at the locations for improvements are listed below:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>STA.</th>
<th>LEGAL DESCRIPTION</th>
<th>OWNER/OWNER NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Check Structure</td>
<td>220+00</td>
<td>N1/2NW1/4,S-11T46N, R93W,</td>
<td>Vic Weber/009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Washakie County</td>
<td></td>
</tr>
<tr>
<td>2) Lined Section</td>
<td>334+88-342+73</td>
<td>E1/2NE1/4,S-35T47N, R93W,</td>
<td>Wayne T. Voss/013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Washakie County</td>
<td>Wyoming Trans. Dept.</td>
</tr>
<tr>
<td>3) 15-Mile Creek Wasteway</td>
<td>444+85</td>
<td>NE1/4NW1/4,S-27T47N, R93W,</td>
<td>Wayne T. Voss/013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Washakie County</td>
<td></td>
</tr>
</tbody>
</table>
Improvements at Sta. 220+00 check structure will take place within existing Canal easement. However, a large temporary easement would be necessary to accommodate construction activity.

The lined section is very close to Highway 20 and the Wyoming Transportation Department resident engineer should be notified of construction plans. Right-of-way in this area needs to be clarified as to whether the Canal encroaches into the highway right-of-way or if the highway encroaches into Canal easement. Temporary easement may be required from the adjacent private property owner.

Improvements at 15-Mile Creek Wasteway will necessitate obtaining temporary construction easement from the adjacent private property owner.

5-Mile Creek Wasteway and drainage is situated on land administered by BLM-Grass Creek Resource District. Drainageway improvements and earthwork will necessitate obtaining clearance and approval from them. Longterm approval will likely be in the form of a special lease, the terms and conditions of which will have to be negotiated.

Improvements at Alamo Creek Wasteway are to the structures proper. The only easement required should be a temporary easement for construction only.

None of the proposed improvements should require a Corps of Engineers 404 Permit, WDEQ-WQD 401 Permit, or a WDEQ General Stormwater Permit for Construction Activities.

PROJECT COST ESTIMATES

The individual items in this project are estimated as follows:

1) Check at STA 220+00  $45,450
2) Lined Section 173,113
3) Fifteen Mile Wasteway 157,212
4) Five Mile Wasteway 76,615
5) Alamo Creek Wasteway 12,350
Total Cost $464,740

Since 1988, annual inflation rates in central Wyoming have varied from 3 1/2% - 4 1/2% annually. In an attempt to extend raw estimated costs into 1995 values, an annual inflation rate of 5% has been applied. Accordingly, the raw estimate of construction cost of $464,740.00 has been inflated 5% to $487,977.00. Estimated project costs are illustrated as follow:
FINAL COST ESTIMATES

Preparation of Final Designs and Specifications (8.5%) $ 41,500
Permitting and Mitigation (2%) 9,800
Legal Fees (@1.5%) 7,400
Acquisition of Access and Rights-of-Way 2,500

Costs of Project Components
Construction Cost Subtotal #1 $487,977
Engineering Costs = CCS#1x10% 48,798
Subtotal #2 $536,775
Contingency (Subtotal #2x15%) 80,516
Construction Cost Total $617,291

Project Cost Total $679,000 (Rnd)

The WWDC financing package features a 50% grant-50% loan mix. Loan terms are 4% annual interest for not more than 40 years. Typically, interest is deferred until one year after the improvements have been used, at which time the first repayment is due. Expected annual costs for the Big Horn Canal Company have been estimated as follow:

Estimated Project Cost $679,000
Grant Portion 339,500
Loan Portion 339,500
Financed at 4% (APR):
- 20-year term annual repayment 24,981
- 30-year term annual repayment 19,633
- 40-year term annual repayment 17,153

The corresponding increase in Annual Assessment using a basis of 23,800 acres is illustrated below:

<table>
<thead>
<tr>
<th>Term</th>
<th>Per Acre</th>
<th>Total Repayment</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 years</td>
<td>$1.05</td>
<td>$499,620</td>
</tr>
<tr>
<td>30 years</td>
<td>$.83</td>
<td>$588,990</td>
</tr>
<tr>
<td>40 years</td>
<td>$.72</td>
<td>$686,120</td>
</tr>
</tbody>
</table>

CONCLUSIONS

As a result of this study, several conclusions can be noted.

1) Many large structures on the Canal are nearing the end of their physical life. Consequently, the distribution system is becoming more vulnerable to a disruption in service.
2) An extended disruption in water distribution during the June-July period could pose very significant economic losses to users of the system.

3) Active maintenance and repair of the Canal channel and structures appears to have improved within the last couple of years.

4) Many structures are in need of improvements for operator and public safety.

5) The Canal Company should continue improving scheduled maintenance and repair.

6) Elk Creek Siphon has 15-20 years of physical life remaining (see Phase I report).

7) Structure replacement has been prioritized as follows:
   (a) Replace the concrete lining at Sta. 335+38.
   (b) Replace the 15-Mile Creek Wasteway Structure at Sta. 444+85.
   (c) Replace the check structure at Sta. 220+00.
   (d) Rehabilitate the 5-Mile Creek Wasteway Structure at Sta. 1373+50.
   (e) Repair and rehabilitate the Alamo Creek Wasteway Spillway at Sta. 1713+65.

8) From the 'Willingness to Pay' survey conducted during Phase I, it appears $1.00/acre increased assessment would be acceptable to the membership to pay for improvements. Other structures of lesser importance were identified during Phase I.

RECOMMENDATIONS

1) Complete formation of the irrigation district so as to qualify for project funding with State agencies.

2) Accept the findings of this study.

3) Proceed into Level III Phase to complete final design and construction of the prioritized improvements.

4) Implement a formal Board inspection of all Canal features each year to continue prioritizing needed improvements.

5) Annually consider maintenance and replacement priorities presented in this report when scheduling future replacement projects.