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EXECUTIVE SUMMARY FOR BIG HORN CANAL REHABILITATION LEVEL II STUDY

Prepared For:

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Civil • Water Resources • Environmental

April 20, 2007

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I. INTRODUCTION

On June 2, 2005, Anderson Consulting Engineers, Inc. (ACE) entered into a contract with the Wyoming Water Development Commission (WWDC) to provide professional services for the Big Horn Canal Irrigation District (District). The primary purpose of the study was to evaluate existing conditions of the Big Horn Canal and associated infrastructure, and to make recommendations regarding future implementation of measurement devices. The work effort included an inventory and assessment of existing structures and facilities, development of conceptual designs for structure replacement and rehabilitation, and estimation of the costs associated with implementation of system improvements.

II. DATA COLLECTION EFFORTS

ACE was conducting a concurrent project for the WWDC which resulted in an overlap of data collection efforts. The Worland Area Irrigated Lands Geographic Information System (GIS) Level II Investigation was being completed by Anderson Consulting Engineers, Inc. at the same time as the Big Horn Canal Rehabilitation Study. Because the Big Horn Canal Irrigation District was a participant in the GIS project, there was a subsequent sharing of data between the two projects.

In addition, specifically pertinent to this study is a project previously completed by WWDC, entitled "Big Horn Canal Feasibility Analysis, Level II Phase II Final Report", completed in 1994 by Nelson Engineering. This report was referenced throughout the current study.

III. SYSTEM INVENTORY AND EVALUATION

The Big Horn Canal was field inventoried by ACE staff during the fall of 2005 and spring of 2006. In order to complete a comprehensive mapping and system evaluation effort, crews drove the entire length of the Big Horn Canal from Robertson Diversion to its terminus near the Greybull River. Features inventoried and evaluated during the field investigation were limited to irrigation infrastructure directly associated with the canal and its routine operations: check structures; drop structures, siphons, etc. In addition, associated features which could affect canal conveyance, operations, and maintenance were located and incorporated into the project GIS (i.e., bridges, pipeline crossings, etc).

Structures often consisted of multiple components, particularly the larger structures. For instance, the Fifteenmile Wasteway structure located at Mile 8.50 of the canal consists of three separate components: (1) a check structure across the canal, (2) a wasteway located on the right bank of the canal, and (3), a drop structure conveying waste from the canal downslope to the Fifteenmile Creek floodplain. Each component was evaluated in the field individually and data pertinent to each was collected. The purpose of this strategy was to collect data consistent with other District infrastructure and to refine rehabilitation needs.

In order to facilitate the management of data associated with numerous individual structures and related features, every individual structure was assigned a unique identifier. The identifier is referred to as the IDENT in all data tables. The IDENT denotes the canal system (BHC), the type of structure (CU=culvert, SI=siphon, CH=check, etc), and the serially assigned number for each.

A total of 402 individual structures were inventoried on the Big Horn Canal (Table 1). Of this total, 75 are considered to be flow conveyance and control structures. This number excludes farm turnouts (283), bridges (39) and measurement devices (5). The general character of these conveyance structures is displayed in Figure 1. The Big Horn Canal system suffers from age; many of its structures were built in the early 1900's. Consequently, there are several major structures which are currently in poor or failing condition.

Table 1. Tabulation of Results of the Big Horn Canal System Inventory.

Feature	Good	Fair	Poor	Failing	Total
Bridge	24	12	3	0	39
Check Structure	2	18	8	1	29
Culvert	10	8	0	0	18
Drop Structure	0	2	6	0	8
Farm Turnout	202	72	8	1	283
Headgate	0	0	1	0	1
Lined Reach	2	0	0	1	3
Measurement Device	4	1	0	0	5
Pipe	0	1	0	0	1
Siphon	4	0	0	0	4
Wasteway	3	4	4	0	11
Total	**251**	**118**	**30**	**3**	**402**
Total Conveyance/Control (1)	**21**	**33**	**19**	**2**	**75**

(1) Total structures excluding bridges, farm turnouts, and measurement devices.

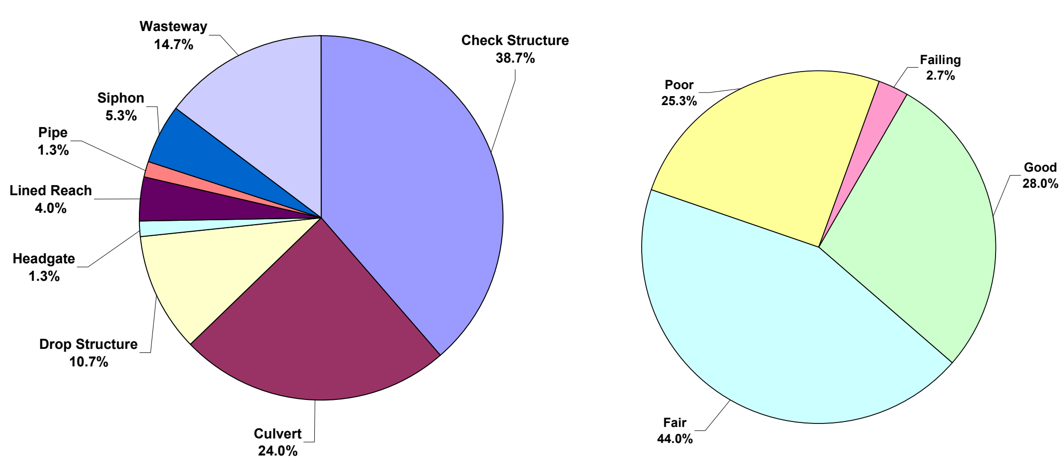

Figure 1. General Characterization of Big Horn Canal Conveyance Structures.

IV. CANAL EVALUATION

The purpose of the canal evaluation work effort was to examine and identify any areas within the canal which may be threatened structurally. To complete this task, ACE inspected the Big Horn Canal from its point of diversion on the Big Horn River to its terminus near Greybull, Wyoming. The initial inspection was conducted during normal operating conditions when approximately 300 cfs of irrigation water was being diverted. During subsequent system inventory efforts, field crews also made canal observations during dry conditions. Particular attention was given to the location of a previous failure which occurred in the early 1980's.

In the early 1980's, the canal experienced a catastrophic failure. At the location indicated in Figure 2, the canal is confined to a very narrow strip of land between Highway 20 and the Big Horn River. A culvert conveying percolated irrigation water captured by subdrains and stormwater and surface irrigation returns runoff under the canal failed. Canal flows were lost to the Big Horn River and water deliveries interrupted. An emergency repair effort was reported to have been completed in less than one week.

Figure 2. Location of Canal Failure.

The District requested funding during the 2005 legislative session to evaluate the structural integrity of the culvert. Based upon a presumed design life of approximately 20 years, the District was aware that the culvert's utility might be limited. During the August 2006 field investigations, the existing culvert failed.

Following the irrigation season, the District hired a local contractor to replace the culvert. The damaged culvert was excavated and replaced with two hundred feet (200 ft) of 24-inch diameter fusible polypipe (SDR-11). The culvert section underlying Highway 20 was not replaced. A vertical section of four-foot diameter corrugated metal pipe was used as a manhole at the location of the joint which failed in 2006. The manhole facilitates the vertical drop required to enable the culvert to run under the canal and provides access for inspection and maintenance. Joints between the culvert and the manhole were encased in concrete.

District personnel report that the slope between the canal and the Big Horn River experiences seepage over a large area beneath the canal. During the field inspection, significant seepage was not visible, however, this could be an attribute of the reduced flows in the canal. The seepage may have a destabilizing effect on the slope, and potential for future slope failure of this section cannot be ruled out pending further analyses. A deep slope failure could potentially be more difficult to repair than the previous failure. Extensive seepage could also result in piping (internal soil erosion) of the slope, similar to the mechanism that caused failure previously. The concrete liner upstream of this location has failed and no longer provides protection against canal seepage in this vicinity. Consequently, given the precarious nature of the canal's location and the importance of protecting the slope from saturation, replacement and extension of the liner was included in the rehabilitation plan.

In addition to evaluation of the canal location discussed above, the entire length of the Big Horn Canal was inspected. There were no major problem areas noted which could threaten the structural integrity of the canal, however, numerous locations where seepage may be significant were identified.

Bank erosion within the canal is not extensive; only isolated instances of limited extent were noted. Also, several areas where the canal banks are very limited in height were noted. These locations do not appear to be threatening to the canal's structural integrity; however, they do appear to be maintenance nuisances to the District.

V. MEASUREMENT DEVICES

The District has a very limited ability to measure water used within its distribution system. Aside from a rated section of the Big Horn Canal equipped with a stage recorder near its point of diversion, ACE was able to identify only four other measurement devices within the District. The current contract between the District and the Bureau of reclamation for water stored in Boysen Reservoir is due to expire in 2008. In an era of increased demands upon water resources and present drought conditions, it is likely that the implementation of measurement devices will be imposed as part of a new contract. Currently, the District lacks the ability to measure deliveries to all but a handful of users. The implementation of measurement devices throughout the district in conjunction with improved record keeping practices will provide the District with data on how water is being consumed within the system. The District can use this data to target future improvements to the system and to improve the efficiency of water management.

Each of the flow measurement devices typically utilized in irrigation flow measurement programs were evaluated. The relative advantages and disadvantages in terms of accuracy, maintenance requirement, and cost were presented. Recommendations were then made for each of the farm turnout structures inventoried and cost estimates provided.

ACE completed estimates of the cost of construction for each of the measurement devices evaluated based on the assumption that each turnout would need a measurement device capable of measuring a discharge range of approximately 0.5 to 5.0 cfs. Table 2 lists the estimated costs.

ACE examined two possible measurement implementation scenarios and the costs associated with each. The first scenario consists of installing the measurement devices recommended in Table 2. The second scenario involved installing open-flow meter structures (fabricated to accommodate a portable flow meter) at all locations except where fixed flow meters are called for in Table 2. The second scenario has been included because the district has expressed interest in the use of portable open-flow meters, and this type of installation suits itself to district-wide implementation. The implementation costs are summarized in Tables 3 and 4.

Table 2. Measurement Devices Versus Construction Costs.

Measurement Device	Material Cost	Labor Cost	Total
3'-0" Cipolletti Weir	$ 445.77	$ 1,381.60	*$ 1,827.37*
3'-0" Rectangular Box Weir	$ 1,131.89	$ 2,339.80	*$ 3,471.69*
9" Parshall Flume	$ 1,009.50	$ 1,370.00	*$ 2,379.50*
24"x18" Constant Head Orifice	$ 1,711.15	$ 1,736.60	*$ 3,447.75*
Fixed Flow Meter (15" pipe)	$ 3,986.40	$ 1,464.00	*$ 5,450.40*
(12" – 18") Open-Flow Meter*	$ 299.55	$ 1,143.80	*$ 1,443.35*

*Structure only, meter not included in construction estimate.

Table 3. Costs of Implementation Scenario 1.

Measurement Device	No. of Devices	Material Unit Cost	Labor Unit Cost	Combined Unit Cost	Total Device Material Cost	Total Device Labor Cost	Device Total Cost
Cipolletti Weir	126	$ 445.77	$ 1,381.60	$1,827.37	$ 56,167.02	$ 174,081.60	$ 230,248.62
Rectangular Box Weir	64	$ 1,131.89	$ 2,339.80	$3,471.69	$ 72,440.96	$ 149,747.20	$ 222,188.16
Constant Head Orifice	52	$ 1,711.15	$ 1,736.60	$3,447.75	$ 88,979.80	$ 90,303.20	$ 179,283.00
Fixed Meter	28	$ 3,986.40	$ 1,464.00	$5,450.40	$ 111,619.20	$ 40,992.00	$ 152,611.20
Project Totals	***270***				***$ 329,206.98***	***$ 455,124.00***	***$ 784,330.98***

Table 4. Costs of Implementation Scenario 2.

Measurement Device	No. of Devices	Material Unit Cost	Labor Unit Cost	Combined Unit Cost	Total Device Material Cost	Total Device Labor Cost	Device Total Cost
Fixed Meter	28	$ 3,986.40	$ 1,464.00	$ 5,450.40	$ 111,619.20	$ 40,992.00	$ 152,611.20
Open Flow Meter Facilities	242	$ 299.55	$ 1,143.80	$ 1,443.35	$ 72,491.10	$ 276,799.60	$ 349,290.70
Open Flow Meters	5	$ 1,300.00	$ -	$ 1,300.00	$ 6,500.00	$ -	$ 6,500.00
Project Totals	***270***				***$ 190,610.30***	***$ 317,791.60***	***$ 508,401.90***

VI. REHABILITATION PLAN

In an effort to prioritize replacement of individual structures in the District, a database was generated. The database incorporated data for every structure evaluated during the inventory phase of the project which was classified as either "poor" or "failing". Data within the database include overall condition, number of irrigated acres dependent upon the structure, and type of structure.

A Structure Assessment Index was computed and provided a means of ranking various types of structures within an irrigation district. The method of computing the Structure Assessment Index is described below:

- The Asset Priority Index (API) represents the service area (irrigated acres) served by each structure. Structures with higher API are more vital to the District than those with low API. The total service area for the District is 22,971 acres.
- The Facilities Condition Index (FCI) represents the approximate ratio of structure rehabilitation cost to replacement. For example, a failing structure would require replacement, or 100 percent of its cost to replace.
- The Structure Weight Index represents the relative importance to the District of the structure based on its type. For example, a measurement device is not critical to the District's deliveries; a siphon is. Consequently, the siphon would be assigned a higher weight than a measurement device.
- The Structure Assessment Index is computed as the product of the three indices presented above divided by 1,000. By ranking the inventoried structures based on their Rehabilitation Indices, the District can get a realistic "roadmap" of rehabilitation projects and the order which they should be completed.

For the purposes of this project, all conveyance structures which were classified as either 'poor' or 'failing' condition were assigned a Structure Assessment Index within the database. The database was then sorted based upon the Index and presented as a prioritized list of rehabilitation projects which the District can use as a 'road map' for future rehabilitation scheduling and project funding planning. This list is intended to serve as a general plan of improvements based upon the relative value of a structure to District operations. The District may follow a different order based upon factors such as availability of funds.

Eighteen improvements to existing District infrastructure were recommended. The recommended improvements do not include bridges which are not integral to the District's delivery system, nor does it include individual farm turnouts which are addressed by the District's annual maintenance efforts.

The majority of the recommended improvements involve complete replacement of existing structures in lieu of partial replacement or rehabilitation. For the most part, the structures included in the proposed rehabilitation plan are experiencing significant deterioration of concrete. Partial rehabilitation of these structures would likely be a short-term solution, resulting in corrective measures being required again in the not too distant future.

In addition to the replacement of existing structures, a new check structure has been recommended. This new structure would be located at Mile 36.5 where the District currently relies on concrete rubble in the canal to provide the backwater conditions necessary to service several farm turnouts.

VII. CONCEPTUAL DESIGNS AND COST ESTIMATES

The information developed during the design process was utilized to generate cost estimates for implementation of the individual improvements. The conceptual design of the structures identified for rehabilitation or replacement relied on information obtained during the field inventory and assessment or references illustrating typical design drawings for irrigation structures

A final cost estimate and repayment plan, presented in Table 5, was generated for the project improvements. As indicated in Table 5, the final cost estimate and repayment plan includes 10% for engineering services during construction and 15% for construction contingencies. The WWDC funding for the project was assumed to be in the form of a 67% grant and 33% loan. The terms of the loan were assumed to be 4.0% for a period of 20 years.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Based on the information presented in the previous chapters, the following conclusions and recommendations are provided.

1. In the early 1980's, the canal experienced a catastrophic failure. A 24-inch culvert conveying irrigation returns and surface runoff under the canal corroded and eventually led to failure of the canal. Canal flows were lost to the Big Horn River and water deliveries interrupted. An emergency repair effort was reported to have been completed in less than one week.

2. In 1994, Nelson Engineering, Inc conducted the Big Horn Canal Feasibility Analysis, Level II Study. The report presented a prioritized list of improvements for consideration. Conceptual designs and cost estimates were included in the report. None of the improvements recommended at that time have been completed. At the time the study was completed, the District had not yet been formed; consequently, there was no mechanism to obtain funding through the WWDC. Since that time, the Big Horn Canal Irrigation District has been formed and is eligible for funding in the form of the grant/loan program through the WWDC.

3. ACE was conducting a concurrent project for the WWDC which resulted in an overlap of data collection efforts. The Worland Area Irrigated Lands Geographic Information System (GIS) Level II Investigation was being completed by ACE at the same time as the Big Horn Canal Rehabilitation Study. Because the District was a participant in the GIS project, there was a subsequent sharing of data between the two projects. Consequently, a large amount of GIS information was readily available for utilization in the current project.

Table 5. Big Horn Canal Cost Estimates.

Name	Priority/Item Number	Design Sheet (Appendix D)	Structure Type	GIS Identifier	Canal/Lateral Station (mile)	Cost of Project Components	Engineering (10%)	Subtotal	Contingency (15%)	Total Construction Costs	Final Plans/Specifications	Permitting and Mitigation	Legal Fees	Access and Right-of-Way	Total Project Cost	33% Loan	Annual Payment[1]	Assessment[2] (Cost/Acre)
Concrete Liner	BHC-1	1	Lined	BHC-LI-003	6.410	$321,750	$32,175	$353,925	$53,089	$407,014	$30,000	$2,000	$500	$1,000	$440,514	$145,370	$10,697	$0.47
Roberts Dam Diversion Check Structure and Gates	BHC-2	2	Check/Headgate	BHC-HG-001 / BHC-CH-002	0	$271,170	$27,117	$298,287	$44,743	$343,030	$28,000	$2,000	$500	$1,000	$374,530	$123,595	$9,094	$0.40
Wasteway and Drop at Mile 1.32	BHC-3	3	Wasteway / Drop	BHC-WW-002 / BHC-DR-006	1.318	$133,026	$13,303	$146,329	$21,949	$168,278	$18,000	$2,000	$500	$1,000	$189,778	$62,627	$4,608	$0.20
Check at Mile 1.32	BHC-4	4	Check	BHC-CH-003	1.321	$234,911	$23,491	$258,402	$38,760	$297,162	$27,000	$2,000	$500	$1,000	$327,662	$108,128	$7,956	$0.35
Check at Mile 4.2	BHC-5	5	Check	BHC-CH-005	4.203	$46,633	$4,663	$51,296	$7,694	$58,990	$10,000	$2,000	$500	$1,000	$72,490	$23,922	$1,760	$0.08
Fifteenmile Wasteway/Drop	BHC-6	6	Wasteway / Drop	BHC-WW-003 / BHC-DR-007	8.498	$142,186	$14,219	$156,405	$23,461	$179,865	$18,000	$2,000	$500	$1,000	$201,365	$66,451	$4,890	$0.21
Check at Fifteenmile Wasteway	BHC-7	4	Check	BHC-CH-007	8.502	$234,911	$23,491	$258,402	$38,760	$297,162	$27,000	$2,000	$500	$1,000	$327,662	$108,128	$7,956	$0.35
Check at Mile 13.6	BHC-8	7	Check	BHC-CH-008	13.640	$10,868	$1,087	$11,954	$1,793	$13,747	$2,500	$1,000	$500	$500	$18,247	$6,022	$443	$0.02
Check at Fivemile Creek Wasteway	BHC-9	8	Check	BHC-CH-012	24.835	$198,967	$19,897	$218,864	$32,830	$251,694	$17,000	$5,000	$500	$1,000	$275,194	$90,814	$6,682	$0.29
Fivemile Creek Wasteway and Drop	BHC-10	9 & 10	Wasteway / Drop	BHC-WW-006 / BHC-DR-008	24.831	$254,984	$25,498	$280,482	$42,072	$322,554	$28,000	$5,000	$3,000	$3,000	$361,554	$119,313	$8,779	$0.38
Alamo Creek Wasteway	BHC-11	11	Wasteway	BHC-WW-007	31.735	$64,423	$6,442	$70,865	$10,630	$81,495	$11,000	$2,000	$500	$1,000	$95,995	$31,678	$2,331	$0.10
Drop at Alamo Creek Wasteway	BHC-12	11	Drop	BHC-DR-003	31.737	$119,198	$11,920	$131,117	$19,668	$150,785	$19,000	$2,000	$500	$1,000	$173,285	$57,184	$4,208	$0.18
Drop at Mile 34.1	BHC-13	5	Drop	BHC-DR-004	34.113	$36,582	$3,658	$40,240	$6,036	$46,276	$10,000	$2,000	$500	$1,000	$59,776	$19,726	$1,451	$0.06
Drop at Elk Creek Wasteway	BHC-14	12	Drop	BHC-DR-005	39.205	$66,901	$6,690	$73,591	$11,039	$84,630	$13,000	$2,000	$500	$1,000	$101,130	$33,373	$2,456	$0.11
Check at Elk Creek Wasteway	BHC-15	13	Check	BHC-CH-017	39.208	$157,930	$15,793	$173,722	$26,058	$199,781	$20,000	$2,000	$500	$1,000	$223,281	$73,683	$5,422	$0.24
Check at Mile 50.7	BHC-16	14	Check	BHC-CH-025	50.736	$23,874	$2,387	$26,261	$3,939	$30,201	$4,500	$2,000	$500	$1,000	$38,201	$12,606	$928	$0.04
Check at Mile 50.9	BHC-17	14	Check	BHC-CH-026	50.973	$22,149	$2,215	$24,364	$3,655	$28,018	$4,500	$2,000	$500	$1,000	$36,018	$11,886	$875	$0.04
Check at Mile 36.5	BHC-18	15	Check	Proposed	36.44	$26,174	$2,617	$28,791	$4,319	$33,110	$4,500	$2,000	$500	$1,000	$41,110	$13,566	$998	$0.04
														Project Total	**$3,357,792**	**$1,108,071**	**$81,534**	**$3.55**

(1) Based on a loan equal to 33% of the total project cost at 4.0% interest with a loan of 20 years.

(2) Based on the following approximate acreage: 22971 acres

4. An inventory and evaluation of irrigation infrastructure associated with the District was conducted following completion of the 2005 irrigation season. The system inventory included assessment of all infrastructure associated with the Big Horn Canal. Specifically, all bridges, check structures, culverts (in-line and crossing), drop structures, farm turnouts, diversions, lined reaches measurement devices, pipelines, siphons and wasteways were evaluated. A total of twenty-one structures (21) were found to be in “poor” or “failing” condition and in need of rehabilitation or replacement. Several of the structures were individual components of larger structures. Consequently, eighteen structure replacement projects were identified.

5. One of the tasks of the current project was to evaluate and provide conceptual designs for replacement of the culvert which previously failed. During the course of this study, the culvert failed once again, however, damage was limited to the culvert itself with no damage to the canal. The District completed the irrigation season with reduced diversions in order to defer culvert replacement until after the irrigation season. The culvert was then excavated and replaced with 24-inch fusible polypipe. At the juncture between the new pipe and the old culvert underlying Hwy 20, a 48-inch manhole was installed allowing access to the culvert for maintenance and inspection.

6. The entire length of the Big Horn Canal was inspected to determine its structural integrity and to note locations where significant seepage losses may be occurring. There were no locations where the canal appears to be threatened structurally. However, several areas where seepage appears significant were noted and inventoried.

7. The District currently contracts with the Bureau of Reclamation for water stored in Boysen Reservoir for a portion of its irrigation needs. Renewal of this contract due to expire in 2008, will likely carry covenants for measurement of water delivered to the users. Currently, there are essentially no measurement devices in the District. A total of 270 active farm turnouts were evaluated. Following evaluation of various alternatives, including use of portable flow meters, recommended measurement device types were tabulated. Estimated total cost of implementing individually prescribed measurement devices was approximately $784,331 (Scenario 1). Implementation of Scenario 2 which employed portable flow meters was approximately $508,402.

8. A Rehabilitation Plan (Plan) was developed for the District by assigning a Structure Assessment Index (SAI) to every structure. The SAI is a composite weighting factor including factors describing the structure’s condition, its type, and the area served. Based upon a ranked listing of all structures based upon their individual SAI’s, a prioritized list of rehabilitation needs was developed. Major structures included in the Plan included the Robertson Diversion at the Big Horn River and the concrete liner immediately upstream of the location of the previous canal failure. Also, an additional check structure was recommended at a location where one is needed but does not currently exist.

9. Conceptual design information was prepared for all components of the Plan. Project cost and assessment information associated with the construction of the individual components is also presented.

10. Based upon the items listed above, the following recommendations are made:

    a. The District should consider initiation of a phased implementation of measurement devices at all farm turnouts.

    b. The District should focus additional effort on the routine inspection and maintenance program of all canal underdrains in an effort to mitigate potential problems associated with blocked culverts before significant storm runoff occurs.

    c. Applications to the Wyoming Water Development Commission Grant/Loan program should be completed. This 33% loan/67% grant program would be accessed for the improvements to the canal infrastructure, including major structures, farmers' turnout structures, and installation of measurement devices.

    d. The Rehabilitation Plan should be used as a 'roadmap' to guide the District with future rehabilitation efforts. The District can select projects which can be implemented within the constraints of the willingness/ability-to-pay of District water users. Priority should be given to those items ranked high on the list.

    e. Replacement of the concrete liner at the location of the previous failure should be given high priority. The majority of District acreage lies downstream of this location. Given the topographic layout of the site and existing seepage, future failures could be likely.