Executive Summary

ALLIANCE LATERAL DITCH LEVEL II

REHABILITATION FEASIBILITY STUDY

November, 1986

Prepared for

Wyoming Water Development Commission
Cheyenne, Wyoming

by

CENTENNIAL ENGINEERING & RESEARCH, INC.
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EXECUTIVE SUMMARY

LEVEL II STUDY REPORT
FOR THE
ALLIANCE LATERAL DITCH

Purpose of Study

The earth along the Alliance Lateral Ditch has been sliding down steep side slopes and eroding away for seventy years. To help 23 Sheridan County ranchers devise ways to control alarming repair costs, the Wyoming Legislature authorized a Level II feasibility study in 1986. The Level II report describes the research procedures and determines the most economical rehabilitation measures. Further, the authors considered expanding the number of ditch users to spread the financial burdens of ditch maintenance.

Specifically, the primary objectives were to discover the causes of ditch bank failures and to recommend remedial measures which could substantially reduce future maintenance costs for the agricultural users. Constructed improvements must reduce the occurrence and impact of slope instability at an acceptable return on investment.

The study progressed in two stages: First, engineers and soil scientists evaluated ditch bank heights and steepness, soil strengths, operating conditions of the ditch, and outlet structures. This information helped develop hazard classifications and slope stability tables which in turn provided the basis for creating the recommended ditch rehabilitation program. Second, specific ditch sections were identified as either causing, or having a potential to cause high future costs for the owners. These sections were studied and remedial measures selected to eliminate or reduce maintenance expenditures.
Unfortunately, calculations of economic feasibility, (based on the assumption that a grant would be available from the Water Development Commission for 50% of the projects' costs and that the remaining 50% could be borrowed from the WWDC at 4% interest for 20 years), suggested that most remedial measures yield low rates of return on investment.

**Project Background**

The Alliance Lateral Ditch (Figure 1), was constructed with hand labor and horse-drawn equipment in 1915 in order to convey direct flow rights from Big Goose Creek. Later, storage capacity was developed in Park, Dome Lake Number 1 and Sawmill Reservoirs. Currently 23 farms and ranches west of Sheridan are served by the Alliance Lateral.

The ditch is located along approximately 12 miles of south-facing hillsides. Two draws were used as part of the conveyance system and are now deeply eroded because of their steep grade and the absence of rock in the underlying formations. Throughout much of its length, the ditch was constructed through shallow colluvial soils and the Fort Union Formation which have a tendency to allow moisture to percolate into sandy material and become trapped above the impermeable clay-rich bedrock. As a result, the saturated soils become increasingly unstable and soil slides, or block failures slough into the ditch. Bank failures create excessive maintenance costs and are becoming increasingly difficult to repair. Historically, the ditch owners have expended an average of $3,700 per year for ditch repairs, mainly removing slide materials that have slumped into the ditch. In 1984, maintenance costs were more than $10,000.

**Study Initiative**

In 1985, the Alliance Lateral Ditch Company requested assistance from the Water Development Commission to study the causes of earth movements and to recommend remedial measures which could maintain the service and integrity of the canal.
FIGURE I

ALLIANCE LATERAL
GENERAL PROJECT LOCATION
Escalating maintenance costs and the potential for future significant failures, led to the approval of a Level II Rehabilitation Feasibility Study of the Alliance Lateral.

In June of 1986, the WWDC selected Centennial Engineering and Research, Inc., in association with Warzyn Engineering and Alpha Engineering to complete the study and report their findings to the commission. The contract specified that the consultants' primary tasks were to

1) analyze the present condition and maintenance plan of the ditch,
2) consider the feasibility and cost of various alternative rehabilitation plans, and
3) recommend a "menu" of various rehabilitation projects.

This report is the result of legislative authorization and the contracted study.

Study Proceedings and Findings

Principal steps completed during the Alliance Lateral Ditch Rehabilitation Feasibility Study were:

1) Review of existing geology, geotechnical data, water rights, and historical maintenance cost information.
2) On site soils and technical investigations.
3) Determination of cost effective rehabilitation alternatives.
4) Estimations of reduced annual maintenance expense as a result of preventive rehabilitation.
5) Determination of individual rates of return for specific remedial measures.
6) Conclusions and recommendations.
Cartographers in field reconnaissance mapped the Alliance Lateral, and a geologist obtained soil samples from hazardous and non-hazardous locations. Analysts then tested these samples and developed strength criteria for anticipated soil and water conditions. Using the failure analyses in conjunction with bank heights, slope steepness, and expected water table depths, the lateral was divided into hazard zones. A total of 51 zones were identified and arranged into a four-part hazard classification system. The Hazard Classification Map (Figure 2), shows the locations of drill holes and sand samples, it characterizes each ditch section, and identifies specific hazards located in the field.

These hazards include excessive bank slopes and ditch grades which cause channel erosion and sedimentation, deteriorating pipes which are not in line or on grade with the ditch thereby contributing to bank erosion, and finally, water seepage that saturates underlying soils resulting in increased chances for slope failure.

To explain the specific causes of these bank failures, Engineers developed three hypotheses:

1) Soil and bedrock characteristics permit the infiltration and capture of moisture which reduces the shear strength and increases the driving force in the soils.
2) Ditch alignment and grade promotes toe and channel bottom erosion which weakens the upper bank and causes sloughing.
3) Steep bank inclinations cause side wall sloughing.

Recommended Alternatives

Preliminary screenings of proposed rehabilitation alternatives were made by analyzing the technical properties associated with each improvement, and by considering the initial capital expenditure. Recommended alternatives are discussed separately below.
Pipes were selected as a viable rehabilitation alternative after considering their excellent technical properties and cost. Culverts, easily installed, provide stability to the toe of the slopes, control erosion on the outside meanders of the ditch, and limit water seepage from the ditch. A comparison of hydraulically equivalent types of pipe resulted in the selection of 36" diameter, 16 gauge corrugated metal, the most economical alternative. The pipe has been successfully used in similar rehabilitation projects. Furthermore, it provides the best protection from hazards associated with slope failures.

Problems associated with ditch alignment and ditch grade or bank inclination can be alleviated by earthmoving. Reducing the bank slope increases slope stability by removing the driving forces on the slope. Realigning the ditch centerline can reduce the amount of toe erosion on outside meanders thereby increasing bank stability. Sediment generation can be reduced by controlling the ditch grade or by protecting the ditch bottom and sides against erosion with riprap. Additional slope stability can be achieved by revegetating the ditch bank. Revegetation promotes local bank stability and consequently should be employed in conjunction with earthmoving. By creating a more stable ditch profile, the chances for bank slides are reduced and the owners benefit from lowered maintenance costs.

Limiting water infiltration into bank slopes is critical when trying to maintain a stable ditch profile. Some bank failures and slope slides can be attributed to snow melt which cause soils to become saturated, losing their cohesive strength. Many scarp faces caused by these slides are oriented perpendicular with northwest winter winds and hence capture wind blown snow. Thus the location of collected snow is important and construction of new snow fences is recommended to reduce the amount of snow loading and consequently, the amount of moisture present on these slide zones. Fences are to be installed in conjunction with drainage ditches to convey snow melt away from slide areas. By decreasing the available water source that causes soil slides, slumping can be reduced, saving ditch cleaning costs.
At least two existing pipe structures were leaking and several of the outlets were creating excessive bank erosion due to the vertical drop of the water. Remedial measures on pipes included masking the inside of the culverts, protecting the inlets with wing walls and realigning the pipe grade and centerline. These rehabilitative efforts will reduce maintenance costs attributable to erosion around the structures and will increase their life span.

An existing dam structure in Zone 49 is undersized, the spillway is not capable of handling a 10 to 15 year rainfall event, and sedimentation is threatening the operation of both diversion headgates. The dam presently has no outlet control. Suggested remedial measures include increasing the dam free board, enlarging the spillway capacity and providing for outlet control. Maintenance savings were estimated by prorating the cost of repairing the entire structure should a major runoff event destroy the dam.

The Locations and Feasibility of Selected Projects

Removal efforts were concentrated on the major and moderate hazard areas as defined on the classification map. A TOTAL OF 22 ZONES WERE IDENTIFIED AS NEEDING REHABILITATIVE WORK. These zones, most susceptible to periodic blockage, were areas where slope movements could block the ditch and water flowing in the canal could be lost to adjacent natural drainages. Table 1 summarizes the locations; type; initial cost and calculated rate of return, based on maintenance cost savings; for the recommended rehabilitation projects.

The length of buried pipe needed to maintain a stable ditch profile was measured in the field. Other zones were analyzed for incorporating one or more of the various rehabilitation alternatives selected in the previous review. The ditch owners' cost outlined in Table 1, represents 50% of the construction cost for the rehabilitation project. The matching 50% grant may be applied for through the WWDC provided that the ditch owners establish a court established assessment district.
TABLE 1 - RECOMMENDED REHABILITATION ALTERNATIVES

<table>
<thead>
<tr>
<th>Zone No.</th>
<th>Ditch Owners Share @ 50% in Dollars</th>
<th>Annual Maintenance Savings in Dollars</th>
<th>Annual Rate of Return (%)</th>
<th>Recommended Remedial Measures</th>
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<td>2.3</td>
<td>1,2,6</td>
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</table>

TOTAL 51,350.00 3,000.00 AVERAGE RATE OF RETURN = 5.8%

(*) Includes a 30% factor for engineering and contingencies

(#) Recommended Remedial Measure Codes

1. Realign ditch center or grade
2. Reduce bank slopes.
3. Repair existing pipe
4. Install new pipe.
5. Install snowfence
6. Revegetate.
7. Repair existing structure
8. Install riprap
Estimating the cost of previous ditch repairs is difficult because there is no information describing the location of construction improvements and their individual costs. The annual savings reported on Table 1 is an estimate of the reduction in equipment time and operator salaries attributed to ditch repairs after bank failures occur. By establishing a stable ditch profile before failures, maintenance costs can be reduced for the owners.

Borrowing $51,350 from the WWDC at 4% interest for 20 years, creates twenty annual payments of approximately $3,780. Cost savings estimated from preventive maintenance projects are $3,000 per year.

Some of the recommended remedial measures yield a favorable rate of return, but most improvements are too costly for the ditch owners even with a 50% matching grant from the WWDC. Therefore, a ditch enlargement plan was sought; a plan which could generate enough revenue to pay the amortized costs associated with a permanent reduction in maintenance. Transmission lines from the Alliance Lateral Ditch to the City of Sheridan Golf Course and to Don Ena Subdivision were analyzed. The concept as presented, shared a construction cost of $250,000 equally between the WWDC and the City of Sheridan. The city and subdivision water users would pay a share of the annual maintenance cost associated with water transmission through the lateral. A favorable response to the project was voiced by the golf course commission and by proponents of a new irrigation system for the subdivision. The ditch owners and representatives of the City of Sheridan foresaw operating conflicts relating to diversion rights and project coordination.

Rejection of this proposal left the ditch users with the same burdensome maintenance costs, and 55 residents in the subdivision still in need of an additional source of irrigation water. Further review of the enlargement project added new life to the proposal. Engineers proposed the construction of specific ditch improvements, and approximately 3500 lineal feet of pipe to establish a gravity pressurized water system for the subdivision.
As proposed, subdivision residents would apply for a 50% grant and a 50% loan to build $60,000 of rennovation projects, and a 75% grant and a 25% loan to fund a $40,000 ditch enlargement. Among the benefits derived from this proposal are:

1. Ditch maintenance expense is divided among more participants,
2. Ditch owners lower their maintenance costs with no capital expenditure,
3. Subdivision residents are provided with a gravity pressurized irrigation system, and
4. Loan payments for the system are expected to be $700 per year less than operating a pumping system.

In addition to being much simpler and more reliable, the pressurized irrigation system would save an estimated $3,000 to $5,000 per year after loan repayment. Clearly the public interest is served. Wyoming water is developed for a new beneficial use and a serious water shortage problem is solved. By using Alliance Lateral water for lawn irrigation, subdivision residents would no longer look to the City of Sheridan to satisfy this critical need.

**Conclusions**

Ditch bank slides can be attributed to the amount of moisture present in the soils, the inclination of the banks, the erosional potential created by the ditch centerline and grade, the orientation of the surrounding topography and the type of materials present along the ditch route. Water decreases shearing strength in the soils, steep banks are generally unstable, east-facing slopes store excessive amounts of winter snow that subsequently adds to soil saturation, water transmission causes bank undercutting that promotes sliding and area soils are susceptible to the infiltration and capture of available water.
Rehabilitation techniques that are technically feasible solutions to the problems located along the ditch route include:

1) Ditch centerline and grade realignment to restrict the amount and location of erosion.
2) Bank reductions to establish a stronger ditch profile.
3) Pipe repair to limit seepage and erosion around the pipe.
4) Pipe installation through potential slide areas to strengthen the toe of the bank and to limit seepage and erosion.
5) Snow fence installation to capture and redirect snow melts away from slide areas.
6) Revegetation after earthmoving operations to promote stability.
7) Structure repair to provide safety, conveyance and operating efficiency to the ditch.
8) Riprap installation to protect against ditch bottom and bank erosion to limit sediment generation and bank slumps.

Recommendations

1. DITCH REHABILITATION MEASURES:
   It is recommended that the improvements receiving a favorable rate of return for the ditch owners be constructed. The ditch company is encouraged to either form an assessment district, and seek assistance directly from the WWDC, or reduce maintenance costs by providing service to additional water users. Conveying water for the Don Ena Subdivision appears to substantially improve the financial feasibility of correcting chronic maintenance problems.

2. IMPROVED MAINTENANCE PRACTICES:
   Information in the report, particularly the Hazard Classification Map, will help identify where maintenance work occurs. The authors recommend that the ditch company record the locations and costs of significant repairs.
Second, it is suggested that excavation of the upper bank be avoided when cleaning the ditch. If the channel remains properly aligned, the toe of the hill side can remain in place to help prevent future sloughing.