This is a digital document from the collections of the Wyoming Water Resources Data System (WRDS) Library.

For additional information about this document and the document conversion process, please contact WRDS at wrds@uwyo.edu and include the phrase “Digital Documents” in your subject heading.

To view other documents please visit the WRDS Library online at: http://library.wrds.uwyo.edu

**Mailing Address:**
Water Resources Data System
University of Wyoming, Dept 3943
1000 E University Avenue
Laramie, WY 82071

**Physical Address:**
Wyoming Hall, Room 249
University of Wyoming
Laramie, WY 82071

**Phone:** (307) 766-6651
**Fax:** (307) 766-3785

_Funding for WRDS and the creation of this electronic document was provided by the Wyoming Water Development Commission_ (http://wwdc.state.wy.us)
WYOMING WATER DEVELOPMENT COMMISSION

GLOBE CANAL INVESTIGATIONS
LEVEL II
FINAL REPORT

AUGUST 1990

JAMES GORES AND ASSOCIATES
450A SOUTH FEDERAL BOULEVARD
RIVERTON, WYOMING 82501
(307) 856-2444

IN ASSOCIATION WITH
C.E. SPURLOCK JR. AND ASSOCIATES INC.
W. ROGER MILLER
# GLOBE CANAL REHABILITATION PLAN

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Summary and Recommendations</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECTION 1 - INTRODUCTION AND BACKGROUND</strong></td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>1-1</td>
</tr>
<tr>
<td>Project Background</td>
<td>1-1</td>
</tr>
<tr>
<td>Purpose of This Investigation</td>
<td>1-2</td>
</tr>
<tr>
<td><strong>SECTION 2 - SEEPAGE SOURCE IDENTIFICATION</strong></td>
<td></td>
</tr>
<tr>
<td>Statement of Problem</td>
<td>2-1</td>
</tr>
<tr>
<td>Geohydrologic System and Its Operation</td>
<td>2-2</td>
</tr>
<tr>
<td>Geologic Framework</td>
<td>2-3</td>
</tr>
<tr>
<td>Operation of the System</td>
<td>2-6</td>
</tr>
<tr>
<td>Movement of Water in the Terrace Deposits</td>
<td>2-11</td>
</tr>
<tr>
<td>Water Budget</td>
<td>2-18</td>
</tr>
<tr>
<td>Geohydrologic Mapping</td>
<td>2-19</td>
</tr>
<tr>
<td>Location and Extent of Seeps, Springs and Slumping</td>
<td>2-19</td>
</tr>
<tr>
<td>Summary of Geohydrologic Mapping</td>
<td>2-20</td>
</tr>
<tr>
<td>Rehabilitation or Remediation of Seepage</td>
<td>2-26</td>
</tr>
<tr>
<td>Selected References</td>
<td>2-28</td>
</tr>
<tr>
<td><strong>SECTION 3 - SOLUTION ALTERNATIVES</strong></td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>3-1</td>
</tr>
<tr>
<td>Philosophy of Alternatives Development</td>
<td>3-1</td>
</tr>
<tr>
<td>Limitations of Existing Subdrain System</td>
<td>3-2</td>
</tr>
<tr>
<td>Area of Greatest Seepage Problems</td>
<td>3-3</td>
</tr>
<tr>
<td>Impacts of Future Seep Water Drainage Systems</td>
<td>3-4</td>
</tr>
<tr>
<td>Expectations For Project Results</td>
<td>3-4</td>
</tr>
<tr>
<td>Alternative No. 1 *</td>
<td>3-6</td>
</tr>
<tr>
<td>Alternative No. 2</td>
<td>3-11</td>
</tr>
<tr>
<td>Alternative No. 3</td>
<td>3-16</td>
</tr>
<tr>
<td>Alternative No. 4</td>
<td>3-20</td>
</tr>
<tr>
<td>Alternative No. 5</td>
<td>3-24</td>
</tr>
<tr>
<td><strong>SECTION 4 - CONCLUSION AND RECOMMENDATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>General Considerations</td>
<td>4-1</td>
</tr>
<tr>
<td>Conclusions</td>
<td>4-3</td>
</tr>
<tr>
<td>Recommendations</td>
<td>4-4</td>
</tr>
<tr>
<td>Sponsorship Recommendations</td>
<td>4-4</td>
</tr>
<tr>
<td><strong>SECTION 5 - RESULTS OF PUBLIC HEARING ON REHABILITATION PLAN</strong></td>
<td>5-1</td>
</tr>
<tr>
<td><strong>SECTION 6 - ANALYSIS OF DRAIN ROUTE ON WEST SIDE OF LOVELL</strong></td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>6-1</td>
</tr>
<tr>
<td>Analysis</td>
<td>6-1</td>
</tr>
</tbody>
</table>
### SECTION 7 - CONCEPTUAL DESIGN OF PROPOSED DRAIN

Introduction 7-1
Globe Canal Spill Structure 7-1
Spill and Drain Line Across School Property 7-2
Conveyance of Existing Open Drain to the New Underground Line 7-3
Conveyance and Drain Line Along Great Western Avenue 7-3
Highway Bore on Great Western Avenue 7-4
Utilities Crossings and Conflicts 7-4
Railroad Bore on Hampshire Avenue 7-5
Hunt Godfrey Canal Crossing 7-6
Outlet Structure 7-6
Drain/Conveyance Pipe 7-6

### SECTION 8 - COST ESTIMATES

8-1

### SECTION 9 - ECONOMIC ANALYSIS

Introduction 9-1
Project Financing 9-1

### SECTION 10 - PERMITTING

Introduction 10-1
Easements 10-1
Wyoming Highway Department Utility License 10-2
Burlington Northern Railroad Application for Pipeline Permit 10-2
The Town of Lovell 10-2

### APPENDIX

* The presentation of each Alternative contains the following sub-sections:

- Estimated Cost
- Description
- Advantages
- Disadvantages
- Utility Conflicts
- Easement Requirements
- Other Considerations
<table>
<thead>
<tr>
<th>EXHIBITS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUNDWATER ELEVATIONS</td>
<td>1-2A</td>
</tr>
<tr>
<td>MAP OF EXISTING DRAIN SYSTEM</td>
<td>3-2A</td>
</tr>
<tr>
<td>PLAN AND PROFILE</td>
<td>3-5A</td>
</tr>
<tr>
<td>CROSS SECTIONS,</td>
<td>3-5B - 3-5E</td>
</tr>
<tr>
<td>ALTERNATIVE NO. 1</td>
<td>3-6A</td>
</tr>
<tr>
<td>ALTERNATIVE NO. 2</td>
<td>3-11A</td>
</tr>
<tr>
<td>FIGURE 3-1</td>
<td></td>
</tr>
<tr>
<td>ALTERNATIVE NO. 3</td>
<td>3-16A</td>
</tr>
<tr>
<td>ALTERNATIVE NO. 4</td>
<td>3-20A</td>
</tr>
<tr>
<td>ALTERNATIVE NO. 5</td>
<td>3-24A</td>
</tr>
<tr>
<td>AERIAL PHOTO</td>
<td>3-27A</td>
</tr>
<tr>
<td>RANKING OF ALTERNATIVES</td>
<td>4-4A</td>
</tr>
<tr>
<td>WEST SIDE DRAIN ROUTE ALTERNATES</td>
<td>6-5A</td>
</tr>
<tr>
<td>JERSEY STREET SPILL STRUCTURE CONCEPTUAL DESIGN</td>
<td>7-2A</td>
</tr>
<tr>
<td>CONVEYANCE/DRAIN LINE CONCEPTUAL DESIGN</td>
<td>7-6A - 7-6C</td>
</tr>
<tr>
<td>(3 Sheets)</td>
<td></td>
</tr>
<tr>
<td>OUTLET STRUCTURE</td>
<td>7-6D</td>
</tr>
<tr>
<td>PROPERTY OWNERSHIPS ADJACENT TO GLOBE CANAL</td>
<td></td>
</tr>
<tr>
<td>(in Appendix)</td>
<td></td>
</tr>
</tbody>
</table>
SUMMARY

This report investigates the ice clogging and flooding problems of the Globe Canal along its reach through the Town of Lovell, Wyoming. The canal traverses the base of the terrace hill on the south edge of town. Seep water issues from this hill up slope of the canal year-round. In sub-freezing weather this seep water freezes into ice masses. With the constantly flowing seep water as their water source, these ice masses grow ever larger, propagating downhill filling the canal and flowing onto properties below the canal.

The seep water responsible for this problem almost entirely originates as agricultural irrigation water applied on the Lovell Bench. Thus, the nature of this problem is one of agricultural drainage.

REHABILITATION PLAN

The Rehabilitation Plan explored five different approaches to mitigating the problem. Those alternative approaches were discussed in detail in that report. The cost of the different alternatives ranged between $185,000 and $678,000.

The Rehabilitation Plan recommended that the project sponsor develop a conceptual design for:

1. A groundwater drain, extending between Nevada and McKinley Avenues near the north rim of the Lovell Bench, and
2. A seep water drain in Doerr Draw, and a winter flow spill structure near Jersey Avenue which will remove free flowing water from the canal near the west edge of town.

In the public presentation of the report those in attendance felt a different alternative would best meet their needs. They advanced the idea of installing a piped drain along the west edge of Lovell which would (1) accept flow from the proposed Jersey Avenue spill structure, (2) divert flow from the existing drain which extends under the town, and (3) would function as a groundwater drain itself. It was this approach which the Farmers Protective Association adopted and the WWDC asked James Gores and Associates develop into a conceptual design.

Cost of the proposed piped drain is estimated to be $533,000.
RECOMMENDATION

The selected project approach has been developed into a conceptual design which is fully detailed in Chapter 7 of this Final Report. This conceptual design plans for the construction of:

1. A spill structure on the Globe Canal near the south end of Jersey Avenue.

2. A combination spill conveyance and drain line extending from the Globe Canal to the Shoshone River via Great Western Avenue.

3. A line to intercept the existing open drain near the southwest corner of the school property.

4. An outlet structure at the northern end of the proposed drain line.

It is recommended that the above improvements be constructed through a local sponsor who is yet to be identified.

OTHER CONSIDERATION

In order for the project to incorporate the locally desired interceptor line, item 3 above, it will be necessary for the drainage district to become one of the project sponsors. The open drain being picked up is a drainage district facility not a portion of the Globe Canal’s (Farmers Protective Association) facilities. As such, the drainage district must be a project participant.

The planned improvements do nothing to alleviate the accumulation of seep water and its accompanying ice masses in the canal reach through the Town of Lovell. The facilities planned in the conceptual design address only the problem of removing from the canal seep water flowing in the canal upstream of town during winter months. It must not be expected that the planned improvements will solve the ice flooding problem because they will not.

Before the project can proceed to construction a local sponsor or group of sponsors must be formed to lead this project forward. That sponsor must be a public entity to receive state funding. Without a sponsor this project will proceed no further.
SECTION 1

INTRODUCTION AND PROJECT BACKGROUND

INTRODUCTION

The Globe Canal is located in Big Horn County, Wyoming. The canal diverts irrigation water from the Shoshone River near Byron. The canal flows Northeast a distance of approximately 10 miles delivering irrigation water to farms situated in the Shoshone River Valley.

According to a 1987 U.S. Soil Conversation report the canal delivers water to approximately 55 users. Of those 36 are farm units. The balance are city lots in the Town of Lovell. The canal serves a total 2892 acres. Depending on the season of the year, the canal diverts between 40 and 80 CFS.

The canal is governed by the Farmers Protective Association. The group is not assembled as a district under Wyoming law and thereby does not have taxing and other legal authorities granted districts.

PROJECT BACKGROUND

For approximately 3/4 of a mile of its route the Globe Canal flows through the Town of Lovell. In this segment of the canals reach it traverses the hillside on the southern edge of Town. This hillside also forms the southern flank of the Shoshone River bottom terrace.

Characteristic of rivers in this region the Shoshone River Valley has two benched terraces. The present river channel occupies the lower bench in which Lovell is situated and which the Globe Canal serves. A second bench from the ancestral river lies south and some 40 feet above the present river plain. The Globe Canal traverses the north facing hillside formed by the junction of these two benches.

Again, characteristic of the area, the upper bench is a clay shale bed rock overlaid by approximately 15 to 18 feet of gravel and 2 foot soil profile. Applied irrigation water and natural precipitation percolates through the soil profile and gravel until it encounters the underlying shale. This impervious barrier then forces the water to migrate to natural and manmade drains. Part of the area of discharge for this water is the interface between the shale and gravel that occurs along the face of the hillside occupied by the Globe Canal. This area of discharge seeps water year round.

Along its reach through the town the gravel/shale interface is some 10 to 15 feet above the elevation of the Globe Canal. The seep water discharged at the gravel/shale interface flows down the hillside both overland and underground until it encounters the Globe Canal. At that point much of the flow is intercepted and is carried down the canal.
During summer months this phenomenon presents few problems. But during the freezing weather of the winter months this seep water becomes a severe nuisance. Water that reaches the canal flows down the canal until it freezes. Ice masses form on the slope above the canal where the seep water issues from the hillside. In areas where significant amounts of water flow from this bank, the ice continues to accumulate and forms glacier type ice masses. These progress downhill, fill the canal with ice and eventually overtopping the canal and flow onto adjacent properties and streets.

The entire northeast facing hillside is shaded in winter months because of the sun's low altitude. Because of this the ice accumulation does not recede until spring weather has brought an extended period of warm weather. During this period snow melt run-off intercepted above town flows down the ditch until it encounters the ice clogged canal in town. This water then commonly overtops the canal, flooding adjacent properties and streets.

PURPOSE OF THIS INVESTIGATION

The purpose of this investigation is to identify and explore several different concepts which may offer relief to the icing and flooding problems. This evaluation will present information on the sources of this problem water. It will present different options of solving the problem. And it will discuss the costs, disadvantages and advantages of each option.
LEGEND

- Water Well
- Spring or Seep
- Open Drain

Water Surface Elevation
"e" indicates estimated elevation

- Primary Drain
- Secondary Drain

Active Seep Area
STATEMENT OF PROBLEM

Ground water discharges from the Lovell Bench into the Globe Canal from seeps and springs throughout the year. The seeps and springs result from discharge of ground-water where the contact of the terrace gravels with the underlying Cretaceous shales, siltstones and sandstones intersect the water table. This seepage effects the canal and its operation and nearby areas along most of the reach of the canal. Where these seeps occur in unpopulated areas, the effects of seepage are insignificant. However, when seepage occurs in populated areas, such as in the Town of Lovell or along major roads, some of the effects can be detrimental and create hazards. Some of the effects are considered positive. Some of the effects are:

I. Seepage into the canal creates continuous flow throughout the year. During the growing season it is masked by irrigation flow in the canal. In the spring and fall it creates a small, free-flowing stream. But, during severe winters it freezes and overtops the canal.

II. The seeps and springs create a "greenbelt" of dense vegetation along the face of the terrace above the canal. The vegetation is diverse, ranging from "dry-land" type plants such as sagebrush and thistle, to phreatophytic or water-loving plants such as cottonwood, willow and wild rose, to hydrophytic or water-dwelling plants such as cattail and water cress. Locally, this vegetation forms nearly impenetrable thickets and at the end of each growing season can be a fire threat.
III. Ground water seepage from the hillside saturates the soil mantle and the underlying shale and siltstone of the bedrock causing slumping. Active and inactive slumps occur along the entire reach of the canal through Lovell. Some of the slumps have caused constrictions and misalignment of the canal and active slumps pose a potential hazard for failure. The tops of many of the slumps are flat to concave upward and are completely saturated forming swamps and marshy areas. Many of the areas between the top of the saturated slumps and the canal are dry, but in a short distance downstream, 10 to 50 feet, the water overtops the slump forming an unstable, slump-prone area from the top of the slump to the canal.

IV. During the winter, ground water discharges from seeps and springs and freezes on the hillside above the canal and in the canal. During extended sub-freezing periods, the canal fills with ice and the ice overtops the canal and glaciates down streets and into nearby yards, basements and crawlspaces. This large mass of ice in the canal can also cause instability in the canal banks with some potential for failure.

V. High ground-water levels below the canal from early spring through the irrigation season are caused by leakage through the bottom and sides of the canal. This occurs in early spring when the ice in the canal melts and when the ice formed below the canal melts. Leakage also occurs when water is first put into the canal each spring, during the irrigation season when higher-than-normal water levels occur in the canal, and after periodic canal maintenance. All of these factors can cause high water levels just below the canal.

GEOHYDROLOGIC SYSTEM AND ITS OPERATION

Before the causes and sources of seepage into the Globe Canal can be defined and before remedial steps to alleviate some of the obvious problems can be developed, the geohydrological system in the area and how it operates must
be defined. The geohydrologic system discussed in this study is the Lovell Bench or Terrace which consists of the area between Foster Gulch and Sand Draw. The Lovell Bench is part of the larger Powell Terrace system which extends from Cody to the confluence of the Shoshone and Big Horn rivers (Mackin, 1937). It is the uppermost terrace along the Shoshoni River. The Lovell Bench is separated both physically and hydrologically from the Powell Terrace by dissection from Foster Gulch and Sand Draw. The bench is about two miles wide and four miles long. The section of the bench which impacts the Town of Lovell extends from Wyoming Highway 32 east northeast to U.S. Highway 310 just east of Lovell, a distance of about two miles. The problem reach of the canal is less than 3/4-mile long.

The geohydrological system consists of two parts, the physical system and the operation of the system. The physical system is the geologic framework. The operation of the system consists of the interrelation of recharge to the system and the water-bearing properties of the system, including water movement, storage, and discharge from the system.

GEOLeGIC FRAMEWORK

The geohydrologic framework of the Lovell Bench consists of many parts. Those which must be defined before the operation of the system can be understood are:

1. The stratigraphy of the rocks which comprise the Lovell Bench;
2. The total and saturated thicknesses of the gravel;
3. The hydrologic characteristics of the gravel;
4. The topography on the top of the terrace;
5. The thickness and hydrologic characteristics of the soil profile; and
6. The configuration of the contact of the gravel with the underlying Cretaceous rocks.
The stratigraphy of the Lovell Bench consists of terrace deposits of sand and gravel overlain by a relatively thin soil profile. The terrace deposits are underlain by shale, siltstone and occasionally sandstone of the Cretaceous Mesa Verde and Frontier formations. Small alluvial fans occur at the mouth of each gully that dissects the terrace edge. The fans intertongue with complex slump deposits which occur between the gullies. The slumps are derived from the terrace sand and gravel and the underlying Cretaceous rocks. The slumps form flat to concave upward benches at the terrace edge and some show multiple slumping. The entire reach of the canal from Lane 12 to U.S. Highway 310 shows evidence of slumping.

The terrace deposits consist of poorly sorted sand and gravel with locally abundant clay and silt. They are part of an old alluvial stream system consisting of multiple meander belts with point- and channel-bar deposits, meander cutoffs and other depositional features common to alluvial systems. The geology is complex and individual channels would be difficult to locate without intensive test drilling and borehole geophysical logging.

The thickness of the gravel on the Lovell Bench is poorly documented. A large number of domestic water wells have been completed in the area but few have adequate geologic data. Many of the wells are driven wells and most of the wells which were completed by cable-tool or other methods have poor logs. Based on limited outcrop and the available well data, the elevations on the top of the Lovell Bench, and assuming that the contact of the terrace deposits and the underlying shale is subparallel, the terrace gravels may be as much as 30 feet thick. It is probably in the 20 to 25-foot range near the terrace edge.

The soils in the area have been mapped by the SCS (Soil Conservation Service, 1969). The soil profile on top of the terrace was derived from the terrace and from slope wash from the surrounding Cretaceous rocks. The soils on the terrace are described by the SCS as shallow and well drained with moderate
to rapid permeability. The slopes range from 0 to 3 percent. The soils consist of clay loam to sandy clay loam surface and subsoil layers with loamy substrata. The soils range from a few inches to 2 feet thick. Locally gravel is exposed at the surface.

The soils mapped on the steep edge of the terrace are variable and derived from the terrace deposits and from the underlying shale, silt and sandstone. The soils were formed by two mechanisms. The soils on the hillside were formed by the normal processes of slope wash and weathering. Whereas, the soils on the small slump-formed benches were formed by solifluction and slumping of saturated material. The soils consist of shallow, well drained, but slowly permeable materials. The soil has a high shrink-swell potential and consists of bentonitic silty clay loam to silty clay surface, subsoil and substrate horizons and are underlain by bentonitic shale and silt. Locally, the soils contain abundant clay-bound pebble to cobble gravel. The slopes on top of the slumps range from 0 to 10 percent and are nearly flat to concave upward. The slopes on the steep sides of the terrace are as much as 60 percent. Where the surface is flat and poorly drained the soils are saturated. In some areas, a hummocky caliche (calcium carbonate) rind has been deposited on the surface in the discharge areas; in other areas where the ground is not saturated, a similar caliche zone occurs indicating historic seepage.

The terrace deposits are underlain by shale, siltstone and sandstone of the Cretaceous Mesa Verde and Frontier formations. These rocks dip 6 to 10 degrees west-southwest on the west flank of a broad anticline. The pre-terrace structure consisted of a series of northwest trending highs and lows created by differential erosion of the shale, silt and sandstone, but was was subdued by the meandering of the ancestral Shoshone River when the terraces were formed. This old surface probably effects the hydrology and the location of seeps. The overall effect is probably minimal.
OPERATION OF THE SYSTEM

Many factors effect the operation of the geohydrologic system. They include recharge to the system, discharge from the system, and what happens as the water travels through the system. Although some of these factors are insignificant, they must be addressed before the operation of the system can be understood.

Recharge

Recharge consists of precipitation on the aquifer, underflow from upgradient areas, overland runoff from outside of the area, discharge from bedrock aquifers, leakage from canals which traverse the area, infiltration from irrigation, and infiltration from septic-tank drain fields. A brief discussion of each parameter and their relative importance and effect on seepage in the area is given below.

Precipitation - The average annual precipitation in the Lovell area is 6.60 inches; in 1988 total precipitation was 5.57 inches. Nearly half occurs during the months of April, May and June. The average annual precipitation at Basin, south of the area, is 6.43 inches; long-term variations (1899-1988) are a low of 2.63 inches in 1902 and a high of 11.09 inches in 1924. In 1988 total precipitation was 6.86 inches. Potential recharge from precipitation during the irrigation season is small, about 3 inches, and is about 10 percent of the total applied for irrigation. Based on the size of the study area, about 3000 acres, nearly 750 acre-feet are available for recharge.

Underflow - Underflow into the terrace gravels is insignificant. Foster Gulch has dissected the terrace less than 1 mile upgradient from the project area and has created a discharge area. Bedrock to the south on Highway 32 forms a ground-water divide, further restricting underflow.
Overland Runoff - Runoff from the low hills south of the project area results from storm events and snowmelt. However, the water is intercepted by the canals and drains and conducted out of the area before it effects the groundwater levels in the terrace.

Discharge from Bedrock Aquifers - Discharge from bedrock aquifers into the terrace is probably small and can not be evaluated without expensive test drilling and mapping.

Leakage from Canals - Leakage from the irrigation canals is the secondary source of recharge to the terrace gravels. The water levels in the canal and the length of time the canal contains water are the main factors effecting leakage. The main distribution system for the Elk-Lovell Canal includes lined and unlined canals and laterals. The secondary distribution system includes lined and unlined ditches and gated pipe, and ditches used for both irrigation and return flow. The amount of water in the canals is not measured in the project area. However, the Wyoming State Engineer maintains discharge records for the Elk-Lovell Canal diversion point on the Shoshone River.

Measurement of leakage from the canals would require detailed monitoring of canal flow as it enters and leaves the area and at each diversion point on the canal. It would be labor intensive and expensive and the amount of leakage might be less than the accuracy of measurement. Leakage could also be estimated by monitoring a series of observation wells installed in the canal and installed parallel and perpendicular to the canals for at least one water year. For this study, canal leakage is estimated to range from 1 to 2 cfs or 720 to 1440 acre-feet per year.

Irrigation - Irrigation is the main source of recharge to the terrace deposits. The amount of recharge from irrigation depends on several factors including: irrigation methods used; irrigation frequency, duration and amount;
irrigated area, crop types, and cropping patterns; return flows; available irrigation water; consumptive use; and soil thickness and permeability.

Irrigation methods: The only irrigation method used in the area is flood irrigation. Water is diverted from the main canal to unlined and concrete-lined laterals, then diverted to individual irrigation systems using unlined and concrete-lined ditches. Final distribution is through lined and unlined ditches and gated irrigation pipe. Although the entire area is leveled for flood irrigation, sprinkler irrigation systems would be more water efficient.

Irrigation frequency, duration and amount: Irrigation frequency depends on water availability, the crop types, and the weather conditions. The duration and amount of irrigation not only depends on water availability and weather conditions, but also depend on soil permeability and the land slope.

Irrigated area, crop types and cropping patterns: The amount of irrigated area was estimated from data compiled by the SCS, from data maintained at the ASCS office in Basin and at the Wyoming State Engineer's office in Cheyenne. The total irrigated area in the Elk-Lovell Irrigation District is 15,500 acres. The irrigated acreage for the Lovell part of the Irrigation District, called the Lovell Terrace, is 10,800 acres. The irrigated acreage on the Lovell Bench, which is part of the Lovell Terrace, is about 2440 acres. Crop types and cropping patterns data for the Elk-Lovell Irrigation District for 1982 were compiled by the SCS. Data for 1988 were adjusted to account for increased production of sugar beets in the area. The crop types and cropping patterns on the Lovell Bench are based on the ratio of the irrigated area on the Lovell Bench with the total irrigated area in the Elk-Lovell Irrigation District. These estimates have large variations owing to the yearly changes in cropping patterns.

Return flows: Return flow of irrigation water is to the drains on the Lovell Bench and to waste water channels to the Globe Canal at the edge on the
bench. The amount of return flow has not been measured but probably is significant. Some of the area is waterlogged owing to poor drainage.

Available irrigation water: The amount of irrigation water used by the Elk-Lovell Canal water users was estimated from diversion records maintained by the Wyoming State Engineer's District office in Byron. The total amount of water used by the irrigation district is actually less than the amount of water diverted to the canal from the Shoshone River, but the amount of return flow at the end of the canal is not measured. Therefore the estimate is the maximum possible water applied. The total 96,500 acre-feet was diverted in 1987 and 104,900 acre-feet in 1988. The amount of water available for irrigation during the two-year period ranged from 6.2 to 6.8 feet per year.

Consumptive use: Consumptive water use was estimated from SCS data (SCS, 1970 and 1974). The consumptive use ranges from 17 inches for small grains to more than 26 inches for alfalfa and sugar beets. Consumptive use for water-logged areas was estimated to be nearly the same as lake evaporation for the area, 35 inches per year. Consumptive use for idle areas was estimated to be the same as for small grains and assumes shallow water-table conditions.

Soil thickness and permeability: These data are available from the SCS but have not been used for this study.

An accurate determination of recharge to the terrace deposits by irrigation would require a detailed, labor intensive, and expensive study. It would require measuring canal flow, metering selected irrigated areas, measuring evapotranspiration, installing observation wells, and monitoring water-level changes in the wells for at least one water year. However rough estimates of potential recharge from irrigation can be made using available data which define the total irrigated land on the Elk-Lovell Irrigation District, on the Lovell Terrace, and on the Lovell Bench; the crop types, cropping patterns on
the Lovell Terrace; the total amount of water available for use by the canal
subscribers; and consumptive water use. The following table summarizes the
land use, crop type and cropping patterns for the Elk-Lovell Irrigation
District which includes the Lovell Bench. The table also includes estimates of
the amount of water available for irrigation, the effective precipitation, and
consumptive use data for the different crop types. The data generated in this
table are used later for the water budget.

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Total Irrigated Acreage for Selected Crops on Lovell Terrace (Acres)</th>
<th>Estimated Water Available on Lovell Terrace (Acre-feet)</th>
<th>Estimated Consumptive Water Use (Acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Pasture</td>
<td>2320</td>
<td>2010</td>
<td>454</td>
</tr>
<tr>
<td>Developed</td>
<td>750</td>
<td>750</td>
<td>169</td>
</tr>
<tr>
<td>Waterlogged</td>
<td>2040</td>
<td>2040</td>
<td>461</td>
</tr>
<tr>
<td>Corn</td>
<td>1580</td>
<td>1500</td>
<td>339</td>
</tr>
<tr>
<td>Sugar Beets</td>
<td>830</td>
<td>1300</td>
<td>294</td>
</tr>
<tr>
<td>Pinto Beans</td>
<td>1100</td>
<td>1000</td>
<td>226</td>
</tr>
<tr>
<td>Barley</td>
<td>1400</td>
<td>1400</td>
<td>316</td>
</tr>
<tr>
<td>Wheat</td>
<td>100</td>
<td>100</td>
<td>23</td>
</tr>
<tr>
<td>Oats</td>
<td>280</td>
<td>300</td>
<td>68</td>
</tr>
<tr>
<td>Idle</td>
<td>400</td>
<td>400</td>
<td>90</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>10800</strong></td>
<td><strong>10800</strong></td>
<td><strong>2440</strong></td>
</tr>
</tbody>
</table>

@ Consumptive use data from SCS (1970 and 1974).
+ Irrigated acreage on Lovell Terrace from SCS (1982).
* Acreage on Lovell Terrace adjusted to reflect increased sugar beet production.
% Acreage on Lovell Bench is 23 percent of total acreage on Lovell Terrace.
# Amount of water used on Lovell Bench prorated by the ratio of the water diverted by the Elk-Lovell Canal and the amount of land irrigated.
Septic Tanks - The effects of infiltration from septic systems on recharge to the aquifer are insignificant when compared to the amount of irrigation in the area. The residential areas on the Lovell Bench in the Town of Lovell are served by the Lovell sewer system. The rural areas outside of the Town are on septic systems. Only eight septic systems occur within 500 feet of the edge of the terrace. Although they are upgradient and west of Lovell, their contribution to recharge to the terrace deposits is insignificant. The eight homes probably contribute less than 1700 gallons per day to the ground-water system.

Movement of water in the terrace deposits

Movement of water in the terrace deposits is effected by the geologic framework or plumbing system of the aquifer. The best way to measure movement in the system is to define the potentiometric surface, the hydraulic gradient, water-level changes, and locations of recharge and discharge areas.

Water-level measurements in wells and drains in the Lovell Bench were made at the end of the irrigation season (September 11-29, 1989), when water levels should have been the highest. The measurements were made in conjunction with field mapping of the seeps and springs along the edge of the terrace. The distribution of drains and canals was also mapped to determine recharge and discharge boundaries. Water-well records filed with the Wyoming State Engineer were used as a base to identify water wells in the area. Selected wells were inventoried and water-level measurements made to define the water surface in the area. Other wells identified during the well inventory were also measured. Many of the wells were constructed or sealed in a manner to prevent water-level measurements; some well owners would not allow measurements. Drains and canals were field checked and plotted on air photos of the area. In addition, selected well and home owners near the edge of the Lovell Bench were interviewed to determine historic water-level fluctuations.
Potentiometric Surface - The potentiometric surface map (Figure 2-1) of the terrace deposits is sub-parallel to the topographic surface. It shows that movement of water in the terrace is generally to the east-northeast toward Sand Draw but deflects northward toward the edge of the terrace north of Lane 12. The effect of recharge from the canals is not obvious and probably is small. However, the effect of discharge to the drains on the potentiometric surface is noticeable but does not significantly alter the overall shape of the water surface. The water-level contours begin to change direction within 1000 feet of the edge of the terrace and become sub-parallel to the terrace edge. More detailed definition of the potentiometric surface near the edge of the terrace would require several test holes along and north of Lane 12, water-level measurements in more of the existing wells, and a detailed water-surface profile in the drains.

Hydraulic Characteristics - The hydraulic characteristics of the aquifer needed to estimate ground-water velocity and flow are the hydraulic gradient and conductivity, the aquifer thickness, and the aquifer porosity. Test drilling and aquifer tests were beyond the scope of this project, therefore these aquifer characteristics were estimated from tables relating rock type with hydraulic characteristics (Driscoll, 1986); hydraulic conductivity ranges from 2000 to 20,000 gpd/ft$^2$ and porosity is about 0.25. None of the water wells on the Lovell Bench penetrated the full aquifer thickness, but based on average well depth the thickness is estimated to be between 20 and 25 feet. The saturated thickness is probably between 15 and 20 feet during the peak of the irrigation season and less than 10 feet in winter. The saturated thickness along Sand Draw is probably less than 10 feet all year. The potentiometric map shows that the hydraulic gradient varies from 20 to 30 ft/mi.
Based on these assumptions, estimates of flow velocity range from about 4 to 40 feet per day. The amount of flow to Sand Draw may range from about 400,000 gpd (0.6 cfs or 435 acre-feet) to 6,000,000 gpd (9 cfs or 6,500 acre-feet) per mile of aquifer width. The aquifer width along Sand Draw is less than 3 miles, therefore discharge from the aquifer may range from 1,300 to 19,600 acre-feet. The lower limit for hydraulic conductivity is probably low and a better estimate for the lower limit of discharge is probably 3 cfs or 2,100 acre-feet.

Water-level fluctuations - The frequency, magnitude and causes of water-level fluctuations are parameters needed to understand the operation of the aquifer system. The frequency and magnitude of fluctuations are the easiest to measure, but the causes of the fluctuations are also important parameters.

Short-term or daily water-level fluctuations were not measured for this study. They probably are of small magnitude and their overall effect on seepage is insignificant. They are caused by pumping, irrigation patterns and frequency in adjacent fields, evapotranspiration from phreatophytic plants and shallow ground-water areas, and weather phenomena such as precipitation and barometric changes.

The main source of seasonal and annual water-level fluctuations on the Lovell Bench is irrigation. The magnitude of the fluctuations was estimated from interviews with well owners and from data collected in the area by the Water-Resources Division of the U.S. Geological Survey. Well owners indicated that shallow wells (10 to 20 feet deep) are dry or produce insufficient water for lawn irrigation, livestock, or domestic uses until irrigation starts each spring. They also indicate that water levels decline to their lowest point by mid-winter. In some years, water levels are at or near surface during parts of the irrigation season. A major factor effecting water levels is the duration
of irrigation and the amount of area irrigated. The U.S. Geological Survey data indicate at least 7 feet of fluctuation, local residents indicate more.

Long-term water level fluctuations are caused by major climatic changes such as drought, high rainfall, changes in cropping patterns, or deepening old drains or construction of new drains. None of these have been monitored and probably are insignificant. Long-term records are not available for wells on the Lovell Bench. However, the U.S. Geological Survey (Cassidy and others, 1989) have measured water levels in one well on the Lovell Bench, one well on the Powell Terrace west of Foster Gulch and one well on the alluvium of the Shoshone River east of Sand Draw from June, 1988 to April, 1989. The data are given in the following table:

<table>
<thead>
<tr>
<th>Location</th>
<th>Well Owner</th>
<th>Date</th>
<th>Water Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWSENE Sec. 24 T56N R96W</td>
<td>Haskins</td>
<td>7-13-88</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9-30-88</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12-14-88</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-13-89</td>
<td>12.8</td>
</tr>
<tr>
<td>NESWSW Sec. 29 T56N R96W</td>
<td>Moncur</td>
<td>6-18-88</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9-30-88</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12-14-88</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-13-89</td>
<td>6.8</td>
</tr>
<tr>
<td>SW Sec. 01 T56N R95W</td>
<td>Jellison</td>
<td>7-14-88</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9-30-88</td>
<td>8.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12-14-88</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-13-89</td>
<td>12.2</td>
</tr>
</tbody>
</table>

Long-term water-level measurements have also been made in wells on the Emblem Bench, some 20 miles south of the area by the U.S. Geological Survey (Ringin, 1973). The geohydrology of the terraces is similar and the data indicate a similar range of water level fluctuations.
Discharge

Ground-water discharges from the Lovell Terrace by underflow to Sand Draw and from seeps and springs along the edge of the terrace. Ground water is also discharged to drains completed in the terrace, to wells, to bedrock aquifers, and by evapotranspiration.

Underflow from terrace - Ground-water underflow from the Lovell Bench is mainly to the Lovell Lakes and to Sand Draw and probably is large. Specific data defining the hydraulic parameters are not available. Ground-water underflow from the bench is also the major cause of seepage into the Globe Canal. If underflow to Sand Draw could be increased, seepage into the canal would decrease. Conversely, if the underflow is decreased, seepage to the canal would increase. The amount of underflow to Sand Draw was not measured directly but is estimated to range from about 3 cfs (2,170 acre-feet) to more than 20 cfs (14,500 acre-feet).

Discharge from wells - Discharge from wells is small. All of the water wells completed in the terrace deposits are used for domestic, livestock and lawn-irrigation uses. None of the wells are used for major agricultural irrigation. The amount of discharge is estimated at less than 100,000 gpd (0.2 cfs about 145 acre-feet). This is based on an estimate of the number of wells presently being used on the Bench and assuming that water use is about 2,000 gpd per well.

Discharge from seeps and springs - Discharge from seeps and springs along the terrace edge is the main cause of seepage into the Globe Canal. Seepage occurs in each gully that cuts the terrace and although it seldom occurs as free flow in the gullies, it creates lush phreatophytic and hydrophytic vegetation in the gullies. Field mapping did not find the contact of the saturated gravel deposits with the underlying bedrock in any of the gullies. However,
the mapping indicated that the material in the gullies consists of a melange of reworked terrace and bedrock materials. The contact of the terrace deposits and the shale was usually 15 to 20 feet higher than the saturated zones on the benches and at the mouth of the gullies. This implies that ground water enters the gully at some point near the head of the gully where the contact of the gravel and underlying shale is covered. The water then moves through the alluvium in the gully as underflow. When the water reaches the slump areas at the mouth of the gully, it enters the slumped areas and surfaces on top of some of the slumps and saturates them. The water then flows along the top of the slump and at a low point overtops the slump. Most of the slumps have been saturated at some point in time. Seepage is nearly ubiquitous along much of the terrace. The exceptions are at the base of some of the gullies where "arid" type vegetation predominates, and locally for short distances upstream from the gully.

The amount of seepage was estimated by making a series of flow measurements along the course of the canal just after diversion to the canal was stopped. These measurements indicated at least 300 gpm (gal/min) seepage from the intersection of Lane 12 and the Globe Canal to Nevada St. Canal flow below Nevada Street was greater than the measuring equipment would handle. Seepage into the Globe Canal was measured in mid-October, 1989 and exceeded 1 cfs. However, seepage was still affected by active irrigation on the Bench. Seepage measured in late November was about 0.1 cfs.

The reach of the Globe Canal in Lovell which is effected by seepage from the Lovell Bench is about 1/2-mile long. Seepage from the Lovell Bench can be estimated from the following assumptions. Irrigation-season seepage through Lovell is about 1 cfs and lasts for about 5 months. Seepage for the rest of the year is about 0.1 cfs. The total reach along the Lovell Bench is about 3 miles. Therefore, as much as 2040 acre-feet may seep into the canal each year.
The canal was examined at low flow from Garfield Street to the west end of town. The base of the canal consists of a gravel substrate, cemented with a clay and caliche matrix. The cemented gravel was excavated at several locations and indicated that the cemented gravel extended to a depth of more than one foot. The banks are heavily overgrown with vegetation and locally are covered with thick layers of silt and/or a clay-bound pebble gravel. Active seepage occurred along at least 50 percent of the canal and active slumps occurred along much of the area.

**Discharge to bedrock aquifers** - Discharge to bedrock aquifers is negligible and would be difficult to estimate without detailed mapping, test drilling, and geophysical logging.

**Discharge to drains in terrace** - Ground-water discharge to the drains from the terrace occurs throughout the year but is masked by irrigation return flow during the summer. There are three major drains and numerous lateral drains (Figure 2-1). Flow in the drains was not measured. The amount of discharge varies with the season and is wholly dependent on irrigation. The maximum discharge occurs in late summer at the peak of the irrigation season. Discharge during the irrigation season is probably quite variable owing to return flow but slowly declines to a winter low flow. Although flow measurement in the drains would be labor intensive and expensive, it is estimated to range from 1 to 3 cfs or 720 to 2170 acre-feet.

**Evapotranspiration** - Evapotranspiration (consumptive use) occurs during the growing season and is related to temperature, wind conditions, humidity, solar radiation, depth to water, and plant types. It can be estimated using several methods, the most accurate is by using lysimeters and other similar equipment. For this study, the evapotranspiration was estimated from data published by the U.S. Soil Conservation Service.
These data estimate the approximate water use for crops in an average year and were used to develop a water budget. The main crops grown in the Lovell Bench are alfalfa, corn, sugar beets, beans, pasture grass and small grain. The amount of evapotranspiration for the different crops are listed in the table on Page 2-10. Evapotranspiration from the waterlogged areas is nearly equal to lake evaporation in the area and is about 35 inches per year. Evaporation from nonirrigated fields in the area is estimated to be the same as that for small grains, 17 inches per year. Especially where the water table is high.

Total consumptive use is estimated to be about 4890 acre-feet.

WATER BUDGET

The water budget is defined as the sum of the water in the system. It can be expressed mathematically as:

\[ \text{Recharge} = \text{Discharge} \pm \text{What happens in the system (change in storage)} \]

The components of recharge are:

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Underflow</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2. Precipitation</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>3. From bedrock aquifers</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4. Overland runoff</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5. Canals</td>
<td>720</td>
<td>1440</td>
</tr>
<tr>
<td>6. Irrigation</td>
<td>8300</td>
<td>9800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>9720</td>
<td>11990</td>
</tr>
</tbody>
</table>

The components of discharge are:

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Underflow</td>
<td>2170</td>
<td>14480</td>
</tr>
<tr>
<td>2. To bedrock aquifers</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. Wells</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td>4. Drains</td>
<td>720</td>
<td>2170</td>
</tr>
<tr>
<td>5. Evapotranspiration</td>
<td>4890</td>
<td>4890</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7925</td>
<td>21685</td>
</tr>
</tbody>
</table>

6. Seepage (difference between recharge and discharge) | 1845 | (9695) |

The change in storage is negligible for this study.
If all assumptions made in determining recharge and discharge, seepage would be the difference between recharge and discharge. The amount of seepage estimated for the canal was 2440 acre-feet.

**GEOHYDROLOGIC MAPPING**

Location and extent of seeps, springs and slumping

Seeps and springs along the Globe Canal were mapped in September, 1989. The mapping indicated that the seeps and springs were inherently related to slumping occurring in the area. Several methods were used to enhance the mapping process. They were false-color infrared and black and white air photos, topographic maps, and information from other studies.

Infrared photography was examined at the Soil Conservation Service office in Lovell. The photos aided in field mapping of phreatophytes and other water-dependent vegetation but the scale was too small for detailed mapping. In addition, the photos were flown in late June before the non-phreatophytic plants were affected by drought conditions.

Black and white photos were examined at the Agricultural Stabilization and Conservation Service office in Basin. Enlargements of the photos were used to define the gullies where heavy vegetation occurred, to help identify the extent of the slumps and the phreatophytic vegetation, the location of the canals and drains, the locations of wells, and locally, the contact of the gravel with the bedrock.

Topographic maps were enlarged for plotting field data, for use as a base map for the potentiometric surface, and for use as a base for the surveying.

The hydrophytic and phreatophytic vegetation mapping was completed in three weeks in September, 1989. The mapping was not done to identify all of the phreatophytic vegetation in the area, but to be used as a guide to locate
Several types of seeps and springs were identified. They were, active point-source springs, active seeps, marshy and saturated ground on top of the slumps, incipient seeps, and historic seeps.

Mapping along the canal indicate that slumping has occurred on the entire reach since the canal has been in use. Evidence for this is canal misalignment, hummocky topography, concave upward terrace surfaces, caliche encrusted surfaces on the uphill sides of the terraces.

Summary of geohydrologic mapping

Seeps were mapped along the reach of the Globe Canal from its intersection with Lane 12 to Old Highway 310. The mapping consisted of making a general examination of the condition of the upper bank of the canal, measuring geologic sections where outcrops are available, location of active and inactive slumps, saturated slumps, and elevations of water levels. The reach was subdivided into 5 sections. The first from Lane 12 to the west edge of the Town of Lovell. The second from the west edge of town to Shoshoni Street. The third from Shoshoni to Nevada streets. The fourth from Nevada to Garfield streets. And finally from Garfield Street to Old Highway 310.

The first stretch contains numerous slump areas and two groves or thickets of willow, cottonwood, and Russian olive trees. The upper face of the terrace is for the most part, covered by a thin veneer of soil and heavily overgrown with vegetation. Each gully that digests the terrace contains abundant vegetation to some point upslope indicating groundwater discharge. Very few of the gullies contain free flowing water and some of the gullies contain "arid" type vegetation in their lower reach. Slumps occurring between the gullies and the tops of the slumps are usually saturated downstream from each gully. The saturated slumps are usually overtopped at some point and the water flows down the bank and into the canal.

Station 1-2: Gully south of intersection of Lane 12 and Globe Canal flows about 20 gpm and contains several springs and seeps (Bischoff Spring). Several areas of cattails occur on terrace slope above the springs and gully. A water-table pond (the land owner reports that the pond goes dry at the end of the irrigation season) has been developed in a gravel pit at the head of the gully. A steep escarpment on the south side (uphill) of the canal, just east of Station 1 is covered with artificial fill for erosion control, the contact of the gravel and underlying shale is covered. Abundant phreatophytic vegetation (wild rose, asparagus, Russian olive, mountain ash, sloe plum, willow and gooseberry) covers the hillside about 300 feet east of Station 1. A small spring, about 5 gpm and two small seeps occur about 350 feet east of Station 1.

Station 2-3: From station 2 to 3 low benches (slump blocks) occur between the canal and the top of the terrace. These benches are partly saturated and have abundant cattail, horsetail (joint-grass), barnyard grass, and water hemlock. Small areas on top of the benches are saturated. Large grove of cottonwood, willow and Russian olive trees at end of Station 3.
Station 3-4: Outcrop near Station 3. Bench below outcrop saturated and water overtops the slump about 60 feet downstream.

<table>
<thead>
<tr>
<th>Description</th>
<th>Interval</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel, medium to coarse, clayey to silty, some sand, clay content decreases upward.</td>
<td>31-35</td>
<td>125-128</td>
</tr>
<tr>
<td>Shale, light gray to tan, silty, some sandy silt.</td>
<td>26-31</td>
<td>122-125</td>
</tr>
<tr>
<td>Covered</td>
<td>21-26</td>
<td>112-122</td>
</tr>
<tr>
<td>Base of steep slope</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Covered, top of slump</td>
<td>11-21</td>
<td>77-112</td>
</tr>
<tr>
<td>Edge of canal to edge of slump.</td>
<td>0-11</td>
<td>34-49</td>
</tr>
</tbody>
</table>

Station 4-5: Seepage is nearly ubiquitous along canal between stations. Large patches of cattails, wild rose and other hydrophytes on top of bench with some willows. Much of area on top of benches is waterlogged. Some areas have a hard caliche (calcium carbonate) crust developed on the surface. Scarps on the face of the terrace indicate as much as 7 feet of slumping. Outcrops suitable for measured sections were not found in this section.

Station 5-7 Upper part of small gully near station 5 contains dense vegetation, but is dry at base. Slump surface west of gully covered with phreatophytes. Steep slope at terrace edge to east of gully terminated by fresh slump face; slump consists of a heterogeneous mixture of clay, silt and gravel. Top of old bench slump saturated and partly covered with vegetation, part of slump has moss-covered caliche crust with water standing on top.

<table>
<thead>
<tr>
<th>Description</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of bench.</td>
<td>40</td>
</tr>
<tr>
<td>Gravel, medium to coarse (mostly 1/16 to 1/2-inch diameter), clayey to silty, some sand, clay content decreases upward.</td>
<td>28-40</td>
</tr>
<tr>
<td>Shale, thin-bedded, light to brownish gray to tan, some rusty brown, silty, dips 10° WSW.</td>
<td>17-28</td>
</tr>
<tr>
<td>Covered</td>
<td>15-17</td>
</tr>
<tr>
<td>Base of steep slope</td>
<td>15</td>
</tr>
<tr>
<td>Break in slope (top of slump), ground saturated.</td>
<td>10</td>
</tr>
<tr>
<td>Edge of canal</td>
<td>0</td>
</tr>
</tbody>
</table>

Seepage or heavy vegetation occurs near the head of many of the gullies but they are dry at the mouth. However, the slumps which occur at either side of the gullies are covered with vegetation and usually are saturated and have overbank flow to the canal. The large gully west of the new Lovell water tank is dry with abundant sagebrush and other dry land plants; two perched water zones occur on the top of the slump but the area between the wet zones and the canal are dry.

Station 7-8: The bench from the gully west of the water tank to water tank is saturated and overbank flow occurs over most of the reach. An active seep occurs below the water tower at the base of an old roadway from the canal to the water tank. The gully west of the water tower is wet in the upper part with heavy vegetation from the mouth of gully to the canal. Slumps on both sides of gully have active seeps. A good exposure of the gravel/shale contact occurs between the gully and water tower.
Station 7-8 (Cont.)

Description

<table>
<thead>
<tr>
<th>Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-40</td>
<td>Gravel, medium to coarse, locally base of gravel is tilted, probably the result of slumping.</td>
</tr>
<tr>
<td>25-35</td>
<td>Shale, grey to brownish gray, dips about 5° W.</td>
</tr>
<tr>
<td>20-25</td>
<td>Covered, slope wash from top of slump to bottom of shale.</td>
</tr>
<tr>
<td>15-20</td>
<td>Slump or top of bench,</td>
</tr>
<tr>
<td>0-15</td>
<td>Steep slope from canal to lower edge of bench</td>
</tr>
</tbody>
</table>

The gully next to the water tower and the area from this gully to the gully at end of Kansas Street are dry. The area has some phreatophytic vegetation and some slumping has occurred near the mouth of the gully. The gully at the end of Kansas Street has a perennial spring-fed stream. The gully is large and extends about 1000 feet to the south. The spring at the head of the gully has been developed with a 10-inch pipe; a small pond occurs just above the spring. Springflow was greater than 150 gpm. A secondary seep occurs in a tributary gully to the west and several areas of dense grass occur along the reach of the gully. Probably the result of underflow in the gully. A small saturated area occurs at the mouth of the gully at the base of the terrace. The area below the seep is dry.

Station 8-9

Only three active seeps occur between the gully at the end of Kansas and Shoshoni streets. One has been developed as a dug well 8 feet in diameter and about 4 feet deep. Much slumping has occurred and most of the slumps which do not have active seeps are covered with a relatively hard caliche crust. The soil under this crust is slightly damp to moist. This implies that the area had active seepage prior to residential development on the terrace and that farm irrigation is the main source of seepage water. When development occurred, irrigation and subsequent seepage decreased. The contact of the gravel and the shale is well exposed in the Shoshoni Street roadcut just below the water tower. The shale dips slightly to the north and the contact is discordant.

Station 9-10

A small seep occurs near Shoshoni Street but additional seeps were not identified between Shoshoni and Montana streets. A broad bench begins near a small footbridge halfway between Shoshoni and Montana streets and extends to Montana Street. Two benches occur between Montana and Nevada streets. Large cottonwood trees occur on the bench at the mouth of a gully near the footbridge and at the mouth of a larger gully at the end of Montana Street. Neither gully contains vegetation indicative of seepage. A small seep occurs on the upper bench near the mouth of the gully at the end of Montana Street. Only four small seeps were identified between Montana and Nevada streets but heavy phreatophytic vegetation occurs on both benches along much of the reach. Neither bench is saturated.

Station 10-11

The slump block east of Nevada Street is saturated from Nevada Street to a small gully at the end of Washington Street. The saturated zone is 50 to 75 feet wide and at least 200 feet long. The saturated areas range from from cattail swamps with free-standing water to areas containing dense hydrophytic vegetation and occasionally free water to hummocky, caliche covered areas with flowing water. The amount of saturation decreases to barely moist at the end of Washington Street. Active seeps were not identified between Washington and Lincoln streets.
Station 10-11 (Cont.) but the top and sides of the benches are nearly covered with a hard caliche crust indicating previous seepage. The large gully at Lincoln Street is an irrigation return flow channel which has considerable erosion in the gully. A 5 gpm seep occurs about halfway between the top of the terrace and the canal. From this channel to Garfield Street multiple benches occur. Most of them are saturated and locally vegetation is heavy. Seepage into the canal occurs along most of this reach and several areas have active slumping into the canal. One of the land owners on top of the terrace has developed a 10-gpm spring on top of the terrace near Garfield Street.

Station 11-12 A small spring has been developed on the east side of Garfield Street. About 50 feet from Garfield an irrigation return flow channel was flowing an estimated 200 gpm. From Garfield to Old Highway 310 several active seeps and slumps were identified. The canal appears to be on a more gravelly substrate and it appears that considerable leakage occurs from the canal.

Survey notes and station descriptions

Station 1. Center line of Globe Canal and Lane 12.
Station 2. Top of vegetation.
Station 3. Top of vegetation. Irrigation return drain 40 feet west. South of west bank of drain canal.
Station 4. Center line of return flow irrigation channel.
Station 5. Top of slump-saturated.
Station 6. Small gully, bottom of slump.
Station 7. Fence line at top of vegetation, alfalfa, heavy vegetation.
Station 9. No description.
Station 10. White tail trees, west end, top of slump. Trees are cottonwood and Russian olive with tall grasses.
Station 11. Gully at east end to trees, top of vegetation, outcrop 200 feet to south (east?).
Station 12. Contact of gravel and shale, west side of gully. Old station 4 and 200 feet from gas pipeline, station 13.
Station 13. Interface between vegetation and dry bank in head of gully. Base of water level in terrace deposits (discharge point), next to gas line.
Station 14. Top of vegetation at fence line.
Station 15. West end of large slump, top of vegetation.
Station 16. Top of vegetation in center of small draw, very wet.
Station 17. Interface with water table in small gully.
Station 18. Small draw (Station 17) top of slump. West end of another slump.
Station 19. Top of vegetation in gully (terrace/water table interface. Large spring in gully 20 feet west, large slumps on both side of gully.

Station 20. West of center of gully, near top of vegetation. Near east end of series of slumps.

Station 21. Contact of gravel and shale.
Station 22. -do-
Station 23. -do-
Station 24. Fence line, top edge of slump, top of vegetation.
Station 25. 200 feet east of fence line. Interface with water table (small stand of willows). East of small gully. Turnout on canal, old station 6. Top of slump saturated, active seepage and slumping.

Station 26. Base of small draw, wet on bottom, some dry area to west. West end of large bench, 40 ft wide x 100 foot + long, created by slumping. Large cottonwood, willow, and Russian olive trees below bench.

Station 26A. Reshot.
Station 27. Top of vegetation, top of slump. Heavy brush and trees between stations 26 and 27. Sagebrush below saturated areas. Some evidence of slumping in this area. Area 100 foot + wide and forms 2 benches.

Station 28. West of old gravel road to water tower. Active spring, may in part be discharge point for extensive slump area between stations 26 and 28. Old road may also alter flow paths of seepage in gully to east.

Station 29. No data.
Station 30. Top of slump (saturated) at fence line on east side of coralls.
Station 31. Contact of gravel with shale, 100 feet east of station 30. Top part of slump (level part) ends 100 feet to east.

Station 32. West end of large seep and west of small gully. Area from station to Russian olive trees, 30 x 90 feet, is saturated and water is running into canal in at least 5 places (5 gpm?).

Station 33. East of small gully and at west end of slump area. Moist surface moist, becoming saturated 10 feet to east. 40 feet above canal.

Station 34. East end of small seep area associated with small spring fed stream, 100 feet to canal. 30 feet downhill soil dry with sagebrush.

Station 35. At break (mouth of) in gully. Top of vegetation, saturated below but dry 30 feet below station to canal. 50 feet to small stream. East of small stream and from base of terrace to 50 feet above canal, very dense vegetation including willow, Russian olive, sloe plum and tall grasses, some cattail and spearmint. Area from dense vegetation to canal covered with sagebrush and rabbit brush, occasionally tall grass but ground not wet.

Triangulation Station F. Top of terrace. Station used as TP for wells and other locations on top of terrace. Gravel on surface. Prism turned upside down.

Station 36. East of small stream, saturated slump area, 25 x 30 feet, dry below saturated area. Very dense vegetation between this slump and fence near station 37. At east end of vegetation is large slump which extends east to Shoshoni St.
Station 43. From station 42 to 43, mostly dry with some slumping over entire reach. At least 2 benches occur and start about 15 feet east of a large dry gully (cottonwood trees at base of gully). The upper bench is saturated for most of the distance from station 43 to Nevada Street, the lower bench is only locally saturated. Frequently the better exposed side hills in this area have irregularly shaped vegetation and moist areas indicative of capillarity. The upper terrace is saturated for 100 feet to the next gully.

Station 44. A small gully drains the upper terrace, about 1 gpm flow. A very small amount of seepage into the canal occurs from station 44 to Nevada Street.

Station 45. Contact of grave with shale in roadcut on east side to Nevada Street.

Station 46. A broad, rabbitbrush covered surface, gently slopes for about 75 feet from the top of the terrace to an abrupt escarpment between Nevada Street and station 46. A large 50 x 30 foot saturated slump occurs at the base of the escarpment. The elevation at this station is at the top of the vegetation.

Station 47. Between two stands of willows on top of a broad slump surface extending from station 46 to 47. The area is saturated from the canal to the station.

Station 48. At break in slope at top of large slumped area. Area covered with horsetail to 5 to 8 feet above slump. Gravel talus pile occurs on parts of slope above slump.

Station 49. At east end of open area and at top of vegetation and slump. Top of slump saturated and marshy, Cottonwood, Russian olive, and Chinese elm abundant. Area from 25 to 100 feet east of station 49 not saturated and has a steeper slope; abundant vegetation and tall grass. Small gully crosses this area.

Station 50. Spring flowing at about 5 gpm, not at gravel/shale contact, total seepage area is 10 feet wide. Water cress in depression below spring indicates year round flow. Small gully 30 feet east has lush vegetation but is not boggy, tops of slumps on both sides of gully are saturated. Large dry flat area at base of gully next to canal, may be secondary slump at base of main slump.

Station 51. Irrigation return channel 25 feet east of station. Large swampy area extends for some distance to east, open area for 50 feet the dense impenetrable.

Station 52. East end of swampy area and at edge of dense vegetation. Area at base of tree is waterlogged and is 6 feet east and 2 feet below station.

Station 53. At top of large slump area, may in part be man made. To west is a 12-foot embankment up to top of hill. Large return flow channel 50 feet west of station. No water at top of slump, covered with gravel. Active slump at edge of canal, seepage occurs along a 30-foot section.

Station 54. Developed spring consists of 2, 4-inch diameter, PVC pipes, one goes south at least 50 feet, the other 50 feet east. Pipes are near base of gravel. Spring flow is 10 gpm. Spring is on a man-made terrace on top of the slump block.
REHABILITATION OR REMEDIATION OF SEEPAGE

This section discusses various types of potential rehabilitation and seepage remediation methods. It only addresses locations and construction methods. Costs and economics of the system, how a solution or solutions would effect or impact the immediate and/or surrounding area, and identification of responsible parties are discussed in Section 3 of this report.

REMEDICATION ON TOP OF TERRACE

Deep, buried drain at or below bedrock between local irrigated areas and the edge of terrace. This would be a continuous, trencher-installed combination perforated pipe, gravel-filled geotextile drain. It would be installed along Lane 12 from Road 10 1/2 to Road 11 1/2, northward on Old highway 310 and then into a drain below the terrace.

Grout curtain to divert groundwater away from the edge of the terrace. This would be at nearly the same place but could hug the terrace more closely. It would consist of a series of closely-spaced bedrock wells that are grouted from bedrock to near surface. This would cause a ground water high and would divert the water from the present problem area to some point to the east.

Alter irrigation and/or cropping practices and patterns. This would range from no irrigation north of Lane 12 to growing crops such as small grain and beans that require less water late in the growing season to changing irrigation methods from flood irrigation to sprinkler methods. If water costs in area were comparable to costs in other parts of the country, water use would obviously decrease.

Relief wells to dewater areas effected by seepage and to recycle return flow. This would require several large-diameter, high-capacity, properly-
spaced wells, adapting the present irrigation system to accept the additional water, and installing a larger conveyance system.

Deepen existing open drains, maintain lateral drains more efficiently, install additional open drains along Lane 12 to Sand draw.

Combinations of the above.

REMEDIATION AT FACE OR BASE OF TERRACE

Install either piped drains or unpiped gravel drains near the top of the slumped areas. They would be trencher-installed drains and consist of either perforated pipe encased in a gravel-packed geotextile or just a gravel-packed geotextile. Installation would require detailed test drilling on the tops of the slumps and would require significant brush removal for installation. These drains would have to be tied into larger master drains that either are under the canal or tie into existing drains.

Install horizontal, driven drains upslope in each of the problem areas. The method would also require detailed test drilling and the drains would have to be tied to other drains.

Selective draining of major problem areas using one of the preceding methods.

Install a cement-pipe, encased canal with a buried drain next to or below the encased canal. Installation would require detailed test drilling and would require significant brush removal for installation. These drains would have to be tied into larger master drains that either are under the canal or tie into existing drains.

Purchase the effected properties.

Combinations of the above.
SELECTED REFERENCES


Driscoll, F.G., 1986, Groundwater and Wells: Johnson Division, St. Paul, MN.


SECTION 3
SOLUTION ALTERNATIVES

INTRODUCTION

This section of the report presents five different project alternatives which offer a solution to the current seepage problem. Each of these has advantages, disadvantages, requirements and associated cost. These aspects of each alternative will be discussed in this Section.

Before discussing each of the five drainage alternatives, however, the philosophy with which the alternatives were developed will be explained. Also, the limitations of the existing drain system within Lovell will be discussed.

PHILOSOPHY OF ALTERNATIVES DEVELOPMENT

The central theme in all solution alternatives is to prevent water and sub-freezing air from coming in contact in the Globe Canal’s reach through town. This applies to both seep water issuing from the hillside above the canal as well as free flowing water in the canal. There are practical, economical and technical limits to the degree to which this air/water separation can be achieved.

Each drainage alternative was assembled with two main objectives.

First: Divert all flowing water from the Globe Canal upstream of the west end of the town.

Second: During winter months collect the seep water issuing from the slope immediately above the canal before it surfaces and freezes.

To meet these objectives, all five alternatives call for diverting the winter time flow from the canal at the west side of town near Jersey Avenue. The most convenient location to dispose of this water is the existing subdrain approximately 1500 feet west of Jersey Avenue. This structure and line will be referred to as the Jersey Avenue spill in the rest of this report.

Diverting this flow will limit the water in the canal to the seep water which enters the ditch downstream of this spill. This will significantly reduce the quantity of water contributing to ice accumulation and the amount of water overtopping the canal should it become ice clogged.

Even more importantly, diverting the flow from the canal will eliminate the problem of snow melt water flooding the canal during ice clogged conditions.
In the alternatives four different approaches address the second objective: collecting the seep water issuing from the slope above the Globe Canal. These approaches will collect the water before it can surface and freeze causing ice blockages.

**LIMITATIONS OF EXISTING SUBDRAIN SYSTEM**

During this investigation, the condition and probable capacity of the existing subdrains which run through Lovell was examined. The pipe size, manhole rim and pipe flow line elevations and the general condition of the upper sections of both Drain No. 1 and Drain No. 2 in the Town of Lovell were determined. A sketch of these drains is shown on the next page.

Discussion's with the members of the drainage district indicated that the drains were built sometime before 1930. They were constructed using three-foot straight barrel (No bell) sections of clay pipe laid open joint. The drains are currently in poor condition.

Some sections of the drains were filled with gravel, roots and silt, while other sections were free flowing. The Town of Lovell personnel report that Drain No. 2 occasionally surcharges during summer months, flowing out of the tops of the manholes. This problem occurs most frequently between MH 8 and MH 5. From our mid-November observations it appears that this section of the drain is severely clogged. In mid-November 1989, this drain was flowing approximately 1/3 full. The drainage district said that the section of this drain which runs diagonally southwest of Camron Avenue across the school district's acreage is in poor condition. Portions of this segment have required repair due to pipe collapse.

The school district is currently planning for a building project on their acreage. The project architect indicates that the school district is exploring relocating a portion of this drain. The grade of the existing drain would provide a capacity of about 1.5 CFS in a new 10" line. However, the capacity of the present line is estimated to be only 30% of that or about 0.5 CFS.

Drain No. 2 discharges at the extreme north end of Montana Street. The landowner on whose property the drain discharges, said that he has not noticed an appreciable difference between summer and winter flow levels in the drain. He has a water gap cut in the tile in which the top 1/2 of the pipe is removed for livestock watering. It provides a clear view of the volume carried by this 24" pipe.

Drain No. 1 in mid-November 1989 was submerged with non-flowing water for most of its length along 7th Street. Heavy root intrusion occurs in the middle manhole of this run of pipe. Some slow moving flow was evident in the manhole on the east end of 7th Street where this drain turns north. The town staff reports no winter time problems with either of the drains.
Although these drains are not in good condition, they could accept the rather small amount of winter time flow that would be diverted to them. Flows would **NOT** be diverted to these drains in summer months.

**AREA OF GREATEST SEEPAGE PROBLEMS**

Throughout the course of this investigation efforts were made to identify the area(s) which contributed the most seep water to the canal. And local officials were asked which reaches of the canal had historically experienced greatest ice flooding problems.

Flow measurements were made in the Globe Canal in late November 1989. This was approximately one month after both the Globe and Elk-Lovell Canals had been shut down. By this time all irrigation run-off had ceased and the residual flow in the canal was from seep water. Measurements were made using a modified Parshall Flume with a 3" throat. Flows found in Globe Canal were as follows:

- South End of Jersey Ave.
- Flow Entering From Doerr Draw
- West Side of Shoshone Ave.
- 75’ West of Nevada Ave.
- South End of Lincoln Ave.
- West Side of Garfield Ave.

<table>
<thead>
<tr>
<th>Location</th>
<th>Flow Rate (gpm)</th>
<th>Location</th>
<th>Flow Rate (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South End of Jersey Ave.</td>
<td>8 gpm</td>
<td>Flow Entering From Doerr Draw</td>
<td>17 gpm</td>
</tr>
<tr>
<td>Flow Entering From Doerr Draw</td>
<td>17 gpm</td>
<td>West Side of Shoshone Ave.</td>
<td>17 gpm</td>
</tr>
<tr>
<td>West Side of Shoshone Ave.</td>
<td>17 gpm</td>
<td>75’ West of Nevada Ave.</td>
<td>21 gpm</td>
</tr>
<tr>
<td>75’ West of Nevada Ave.</td>
<td>21 gpm</td>
<td>South End of Lincoln Ave.</td>
<td>27 gpm</td>
</tr>
<tr>
<td>South End of Lincoln Ave.</td>
<td>27 gpm</td>
<td>West Side of Garfield Ave.</td>
<td>55 gpm</td>
</tr>
</tbody>
</table>

It is obvious that measurable water loss occurs between Jersey and Shoshone Avenues. This area has a history of seep water flooding lawns and daylight basements during the summer irrigation season when the canal flows at maximum capacity. Also, Doerr Draw contributes the major portion of the flow on the west end of town.

From casual observation of active seeps it appears that far more than 4 gpm is entering the canal in the two blocks between Shoshone and Nevada Avenues. While flow measurements don’t show it, it is safe to assume water is seeping from the canal and loss is probably about the same as inflow.

The area contributing the largest amount of seep water lies on the east end of the canal’s reach through Lovell. In the three block section between Nevada and Garfield Avenues the flow almost triples. And the greatest portion of that inflow occurs in the one block section between Lincoln and Garfield Avenues. The flow doubles in this one block section alone.
The most persistent ice flooding problems occur in this three block reach of the canal. This area has repeatedly flooded according to local officials. The only property not reporting a history of flooding is the Joe Cobos property; on the west side of Garfield immediately below the canal and abutting Eight Street. All other properties immediately below the canal in this area report ice flooding problems.

In conclusion, both flow measurements and the history of ice flooding indicate that the worst problems are on the extreme east end of town and to a lesser degree on the extreme west end of town. The central part of the canal is comparatively trouble free. This correlates closely with the level of agricultural irrigation activities on the Lovell Bench immediately above these areas.

IMPACTS OF FUTURE SEEP WATER DRAINAGE SYSTEMS

There are several items of consideration in evaluating the impact of any future ground water drain system. First, removal of the seep water during summer months will almost certainly impact the vigor of the trees and other seep water fed vegetation growing on the hillside above the Globe Canal. This wooded area is viewed as an asset by many local residents.

To diminish this impact it may be possible to configure the drains so they can be valved off during the growing season. If a successful valving system can be configured, seep water would follow traditional routes during summer and be drained away during freezing weather. This would be highly experimental.

The option valving of the drains could only be successfully applied with Alternative No. 5, installing a drain on the Lovell Bench. This option could not be successfully applied to the spur drains laid from the canal up slope. Valving the drain on, under Alternative No. 5, would be an experimental undertaking. It would require careful configuration of the drain to devise a mechanism to assure that the seep water could not simply follow the gravel envelope and surface rather than following its traditional flow patterns.

Any drain system extending from the canal up slope must be designed to withstand the continued movement in the unstable slump blocks above the canal. The Town of Lovell reports that slippage of this unstable ground in Garfield Avenue was severe enough that it uncoupled a joint in the water main over the canal causing a major leak. There are several synthetic drain materials which, with proper design consideration, should withstand the degree of movement expected.

EXPECTATIONS FOR PROJECT RESULTS

DRAINAGE IS NOT A PRECISE SCIENCE. This is especially true when applying drainage treatments to a unique set of problems such as those
confronted in this project. The drainage alternatives developed in this rehabilitation plan represent logical approaches, all of which will work. Each alternative will yield its own individual degree of success. With today's knowledge, however, there is no way to accurately predict the comparative level of success of the different alternatives. Only sound technical judgment based on experience can be used to make those predictions.

None of the alternative solutions can entirely remove the offending seep water, nor were they intended to. Some ice accumulation will continue, perhaps to the extent that ice flooding problems may still occur in the future. The project sponsor must be cognizant of this fact and expectations of the solutions must be realistic. The objective strived for is not to entirely solve the problem (that is probably not achievable) but to reduce it's magnitude to the degree that the currently affected people can live with it.
GLOBE CANAL
RANDOM CROSS SECTIONS
Page 3-5B
GLOBE CANAL
RANDOM CROSS SECTIONS
ALTERNATIVE NO. 1

Construct Drains in Doerr Draw, Shoshone, Nevada and Garfield Avenues. Discharge to existing tile subdrains.
ALTERNATIVE NO. 1

ESTIMATED COST

$278,000

DESCRIPTION

Alternative No. 1 places needed drains within existing canal and city rights-of-way to the maximum extent possible. Only three easements or rights-of-way would be required. These are discussed later.

Under this alternative, the primary drains which would be constructed, from west to east, would be located in:

- The Jersey Avenue Spill
- Doerr Draw, with a spur drain to the west
- Shoshone Avenue, with a west spur drain near 10th Street
- Nevada Avenue
- Garfield Avenue, with a spur drain to the west

The Jersey Avenue spill line would be tied into the existing drain crossing the school district parcel which is west of Jersey Avenue and south of 7th Street. The winter seep water flow collected from Doerr Draw and Shoshone Avenue would be piped to 9th and Montana then north on Montana to be discharged to the existing subdrain at Montana and 6th.

The conveyance line along the canal between Kansas and Montana Avenues would be constructed of watertight pipe installed in the canal bank. Flow from the Nevada Avenue line would be piped to 8th and Nevada then west on 8th Street to Montana Avenue where it would intersect the new drain described above. The Garfield Avenue drain would be piped north to 7th Street then 1/2 block west on 7th Street to discharge to the existing drain.

It must be understood that the collected SEEP WATER WOULD BE DISCHARGED TO THE EXISTING DRAINS ONLY DURING WINTER MONTHS.

ADVANTAGES

Alternative No. 1 would require only three easement acquisitions. All but 3500 feet of its 9700 feet of total drain length would be constructed in existing public rights-of-way. All collected drain water would be discharged to the existing subdrains in the Town of
Lovell. This would eliminate freezing problems with the collected seep water, a feature not offered by any of the other alternatives. This alternative will offer moderate maintenance costs. Construction would require only 1100 feet of construction along the canal right-of-way. It would require disrupting little of the hillside vegetation between Jersey and Garfield Avenues. And it would have little affect on the existing canal or its turnouts.

DISADVANTAGES

This alternative ranks third in construction cost. Because the location of drains are limited to existing rights-of-ways, this system configuration doesn't lend itself to efficient collection of the seep water. As such, the drains will not be intercepting as much of the seep water flow as other alternatives. It is the least effective of all drainage alternatives. Accumulations of damaging ice would be diminished but not eliminated.

With the conveyance pipe located in the canal bank between Kansas and Montana Avenues, any wash-out in this area would damage the pipe as well. Canal cleaning activities in this area would require caution not to damage either the pipe in the canal bank or the drain lines at the four required crossings.

During construction this alternative would require extensive replacement of street surfacing, will conflict with more underground utilities and would disrupt more local traffic than any other alternative.

UTILITY CONFLICTS

Alternative No. 1 would require working around many public and private utilities. From west to east, utilities that are known to conflict with the routing of this alternative are:

- Doerr Draw to Shoshone Avenue; few if any utilities would be encountered
- Shoshone Avenue; City water and sewer
  CATV and Gas - Unknown
  Telephone
  Overhead Power
- Montana Avenue; City water and sewer full length of Montana Ave. and crossings at every intersection
  All Others Unknown
- Shoshone Avenue to Montana along canal bank - No Known Utilities
- Nevada Avenue; City water and sewer
  CATV, Telephone & Gas - Unknown
  Overhead Power
- Garfield Avenue; City water and sewer
  All Other Utilities Unknown

3-8
EASEMENT REQUIREMENTS

Either permanent easements or rights-of-way would be required for the construction and maintenance of the drains in the following locations:

- Jersey Avenue Spill, 1400 ft.
- Doerr Draw, 1000 ft.
- Spur drain west of Shoshone and north of 10th Street, 600 ft.
- Spur drain west of Garfield Avenue, 500 feet

Lengths of the above easements are only scaled distances given to the nearest 100 feet.

OTHER CONSIDERATIONS

This alternative would disturb a considerable footage of city streets. This commits nearly $40,000 of the project budget to street repair. And it will cause considerable traffic disruption.
PRELIMINARY ESTIMATE OF COSTS

Project: GLOBE CANAL INVESTIGATIONS

Project No: 405-01-00-89

Date: 12/89

Estimate By: James Gores & Associates

ALTERNATIVE NO. 1: PLACE DRAINS IN SHOSHONE, NEVADA AND GARFIELD AVENUES

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>12,000.00</td>
<td>12,000.00</td>
</tr>
<tr>
<td>2.</td>
<td>8&quot; Spill Line</td>
<td>1400</td>
<td>L.F.</td>
<td>10.00</td>
<td>14,000.00</td>
</tr>
<tr>
<td>3.</td>
<td>Seep Water Drain Line</td>
<td>3700</td>
<td>L.F.</td>
<td>20.00</td>
<td>74,000.00</td>
</tr>
<tr>
<td>4.</td>
<td>Seep Water Conveyance Line</td>
<td>4600</td>
<td>L.F.</td>
<td>12.00</td>
<td>55,200.00</td>
</tr>
<tr>
<td>5.</td>
<td>Pavement Repair</td>
<td>4450</td>
<td>L.F.</td>
<td>8.50</td>
<td>37,825.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION SUBTOTAL 193,025.00

Easement Acquisition & Surveying 3500 L.F. 5.00 17,500.00

210,525.00

Engineering, Contingencies, Legal Inspection & Administration * 35% 67,558.75

278,000.00

3-10
ALTERNATIVE NO. 2

Encase Globe Canal, install drains in up slope seeps and convey collected water in the encasement pipe.
Figure 3-1

Drain and Conveyance Line used in Alternative No. 1

Canal Encasement used in Alternative No. 2

Drain Option used in Alternative No. 2
ESTIMATED COST

$678,000

DESCRIPTION

Alternative No. 2 calls for encasing the entire Globe Canal from just west of Kansas Avenue east to Garfield Avenue in either a 33 or 36 inch reinforced concrete pipe. All seep water would be collected by constructing gravel encased drains running up slope from this pipe. These drains would collect seep water from offending slump areas. They would be tapped into the concrete encasement pipe and that pipe would then serve as a conduit for the collected drain water.

This alternative also requires the construction of the Jersey Avenue Spill. The concrete pipe encasement of the canal will require both inlet and outlet structures to the pipe. The lateral drains uphill from the pipe would be strategically located to collect seep water concentrated in the hillside above the canal as depicted in the sketch of this alternative. As with all the other alternatives, this one will require the construction of a drain in the Doerr Draw, south of Jersey and Kansas Avenues.

Seep water collection drains would essentially be perpendicular to the canal and run up slope to collect seep water from those areas identified as principal contributors to seep water flow and ice accumulation. These lateral drains would be constructed of corrugated plastic pipe encased in gravel and may or may not be wrapped in a geotextile filter fabric. Some styles of totally synthetic drains may prove acceptable and offer cost savings. Regardless of the configuration of the drains they must be constructed to withstand continued downhill creep movement and the slump blocks which they would be draining.

CANAL ENCASEMENT OPTION: As described above, the concrete pipe encasement of the canal is scheduled to stop at the east edge of Garfield Avenue. That pipe encasement could be extended to the box culvert on McKinley Avenue if it is viewed by the sponsor that that section of the canal warrants the expense of encasement. However, in assembling this investigation no incidents of ice caused flooding damage was reported east of Garfield Avenue.

DRAIN WATER CONVEYANCE OPTION: Rather than conveying the collected seep water in the concrete encasement pipe the water could be carried in a gravel encased drain line constructed immediately adjacent to and on the uphill side of the concrete encasement pipe. This drain system is to be constructed simultaneously with the pipe encasement and would be placed in the existing canal along with the encasement pipe itself. This combination, drain and conveyance pipe, would receive collected seep water from the uphill spur drains and would serve the function of collecting seep water now surfacing on the slope of the canal itself. This drain would terminate on the east side of Garfield Avenue along with the concrete encasement.
This approach to the collection and conveyance would add a collection mechanism between the spur drains running uphill and would eliminate the necessity of tapping the uphill spur drains into concrete pipe.

Measures would have to be taken to limit winter time cold air flow in the canal encasement pipe to prevent freezing of the adjacent soil as well as the parallel and drain itself.

**ADVANTAGES**

This alternative, like all others, would divert free flowing water in the canal into the Jersey Avenue Spill and discharge that collected water to the existing subdrain crossing the school property. With careful placement of the drain lines this alternative would be the most effective at removing nuisance seep water. This alternative would encase the canal through town eliminating the present attractive nuisance which the canal creates. Also, it should reduce available mosquito breeding areas within the town. Encasement of the canal could create an open pathway, potentially available to jogging and similar recreational activities. This alternative conflicts only moderately with other existing private and public utilities. It will provide a low maintenance drainage system and it will reduce maintenance of the Globe Canal itself.

**DISADVANTAGES**

Cost of this alternative ranks highest of all systems considered. Constructing the seep water spur lines up slope of the canal would scar the existing hillside vegetation and would require extensive easement acquisition from adjacent property owners. Construction of these spur drains would be difficult and costly. Because installation of the uphill spur drains will very likely remove most of the current seep water from the hillside, it will quite likely result in a reduced vigor of the vegetation on the hillside. A program of removing dead vegetation from the hillside will be required to avert potential fire hazards. All construction activities will be taking place in a congested and confined work area. Those areas bordered by homes would be very difficult to work in. Preconstruction activities will require test drilling on the hillside to define optimum location of the lateral drains.

**UTILITY CONFLICTS**

This alternative would require modest utility conflicts. Sewer and water crossings will be necessitated at Shoshone, Nevada and Garfield Avenues. A sewer crossing will be required at Montana Avenue. Some crossings of gas, power and cable TV may be required at these avenues as well. No other utility conflicts are known to exist.
EASEMENT REQUIREMENTS

Construction of this alternative will require permanent easement or rights-of-way for:

- Jersey Avenue Spill, 1400 ft.
- Doerr Draw Drain, 1000 ft.
- Numerous (10 to 15) individual spur drain extensions uphill of the canal, 75 to 200 ft. each

Construction easements will be required to allow adequate equipment access adjacent to the canal to lay the encasement pipe between Kansas and Garfield Avenues. The canal right-of-way width is undefined but it is considered to be 100 feet width. This width, however, will be inadequate to accommodate required construction activities and temporary construction easements will be required.

OTHER CONSIDERATIONS

This alternative will require a longer lead time than will other alternatives. This is due to the amount of easement and right-of-way acquisition activities and its required surveying. The reduced foliage vigor on the hillside up slope of the canal may be viewed as a disbenefit by many local citizens and may be viewed as an economic loss to adjacent property owners. This alternative will require the direct involvement of the larger number of people because of the associated easement acquisitions. As such, greater involvement will be required by the sponsor, their legal counsel and local political leaders.
PRELIMINARY ESTIMATE OF COSTS

Project: GLOBE CANAL INVESTIGATIONS  
Date: 12/15  
Estimate By: James Gores & Associates

ALTERNATIVE NO. 2:  ENCASE CANAL, SPOT DRAIN SLUMPS

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>12,000.00</td>
<td>12,000.00</td>
</tr>
<tr>
<td>2. 8&quot; Spill Line</td>
<td>1400</td>
<td>L.F.</td>
<td>10.00</td>
<td>14,000.00</td>
</tr>
<tr>
<td>3. 36&quot; Canal Encasement Pipe</td>
<td>3200</td>
<td>L.F.</td>
<td>70.00</td>
<td>224,000.00</td>
</tr>
<tr>
<td>4. Headwall &amp; Outlet Structures</td>
<td>1</td>
<td>L.S.</td>
<td>18,000.00</td>
<td>18,000.00</td>
</tr>
<tr>
<td>5. Street Crossing</td>
<td>3</td>
<td>Ea.</td>
<td>8,000.00</td>
<td>24,000.00</td>
</tr>
<tr>
<td>6. Turnout</td>
<td>12</td>
<td>Ea.</td>
<td>1,200.00</td>
<td>14,400.00</td>
</tr>
<tr>
<td>7. Seep Water Collection &amp; Drain Line</td>
<td>3500</td>
<td>L.F.</td>
<td>30.00</td>
<td>105,000.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION SUBTOTAL                  411,400.00

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easement Acquisition &amp; Surveying</td>
<td>8050</td>
<td>L.F.</td>
<td>5.00</td>
<td>40,250.00</td>
</tr>
</tbody>
</table>

SUBTOTAL                               451,650.00

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering, Contingencies, Legal Inspection &amp; Administration</td>
<td>35%</td>
<td></td>
<td></td>
<td>143,990.00</td>
</tr>
</tbody>
</table>

TOTAL                                   595,640.00

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encasement Option 36&quot; RCP</td>
<td>450</td>
<td>L.F.</td>
<td>70.00</td>
<td>31,500.00</td>
</tr>
<tr>
<td>Drain Conveyance Option</td>
<td>3650</td>
<td>L.F.</td>
<td>8.00</td>
<td>29,200.00</td>
</tr>
</tbody>
</table>

SUBTOTAL                                60,700.00

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering, Contingencies, Legal Inspection &amp; Administration On Options</td>
<td>35%</td>
<td>21,245.00</td>
</tr>
</tbody>
</table>

TOTAL OPTIONS                           81,945.00

TOTAL WITH OPTIONS                       678,000.00
ALTERNATIVE NO. 3

Divert free flowing water from the Globe Canal, encase a portion of the canal and collect seep water only in the most troublesome areas.
ALTERNATIVE NO. 3

ESTIMATED COST

$406,000

DESCRIPTION

Alternative No. 3 is a scaling back of Alternative No. 2. It collects seepage from only the most problem prone areas of the canal.

In this alternative seep water from Doerr Draw would be piped to the Jersey Avenue Spill. As with other alternatives, this spill would discharge to the existing tile drain No. 2 on the school property. However, in this alternative the Jersey Avenue Spill would carry the seep water and the free flowing water diverted from the canal. The canal would be encased in 33 or 36 inch reinforced concrete pipe from the west side of Nevada Avenue east to Garfield Avenue. Seep areas in this reach of the canal would be treated by running lateral drains uphill in the same fashion as Alternative No. 2.

ENCASEMENT OPTION: As with Alternative No. 2 the canal could be encased downstream from Garfield Avenue to McKinley Avenue.

DRAIN OPTION: Again, as with Alternative No. 2 the gravel encased drain and seep water conveyance pipe could be constructed adjacent to and on the uphill side of the reinforced concrete encasement pipe. This drain would yield additional benefits in collecting seep water issuing into the canal bank. In the reach of the canal between Nevada and Garfield Avenues that is a significantly larger problem then it is upstream. This option of seep water collection is warranted and recommended in this reach of the canal.

ADVANTAGES

Alternative No. 3 would offer considerable cost savings over Alternative No. 2 by eliminating both the canal encasement and uphill spur drains between Kansas and Nevada Avenues. This alternative eliminates approximately 1800 feet of encasement and would eliminate the up slope spur drains in the reach between Kansas Avenue and Nevada Avenue as well. While seeps exist in the Kansas to Nevada Avenue area they are less active than the downhill remainder of the canal. Alternative No. 3 would offer moderate maintenance on the drains and some reduced maintenance on the canal.

DISADVANTAGES

As with Alternative No. 2, installation of the up slope seep water drains will scar the hillside and reduce the vigor of the vegetation in the Nevada Avenue to Garfield Avenue reach of the canal. Constructing these drains would require permanent easements or rights-of-way from up slope property owners. Construction of these spur drains would be difficult and they pose the possibility of drying up hillside vegetation. And as with Alternative No. 2, this may result in an accumulation of dry brush and a potential fire hazard.
UTILITY CONFLICTS

Alternative No. 3 would require water and sewer crossings at both Nevada and Garfield Avenues. No other known utility crossings would be required.

EASEMENT REQUIREMENTS

This alternative would require the following permanent easements or rights-of-way:

- Jersey Avenue Spill, 1400 feet
- Doerr Draw, 1200 feet
- Easements for approximately 6 up slope seep water spur drains from three different property owners, 100 to 200 feet per drain

Construction easements would be required adjacent to the canal to allow adequate equipment access to lay the encasement pipe between Nevada and Garfield Avenues.

OTHER CONSIDERATIONS

This alternative will require lead time for the easement acquisition and their associated surveyings. The reduced vigor of the foliage and visible construction scars on the hillside between Nevada and Garfield Avenues may be viewed as a disbenefit by local citizens and may be viewed as a property devaluation to adjacent property owners.
PRELIMINARY ESTIMATE OF COSTS

Project: GLOBE CANAL INVESTIGATIONS
Date: 12/15
Project No: 405-01-00-89
Estimate By: James Gores & Associates

ALTERNATIVE NO. 3: DRAIN DOERR DRAW, SPOT TREAT SEEPS FROM MONTANA TO GARFIELD

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>12,000.00</td>
<td>12,000.00</td>
</tr>
<tr>
<td>2.</td>
<td>8&quot; Spill Drain Line</td>
<td>1400</td>
<td>L.F.</td>
<td>10.00</td>
<td>14,000.00</td>
</tr>
<tr>
<td>3.</td>
<td>Seep Water Drain in Doerr Draw</td>
<td>1200</td>
<td>L.F.</td>
<td>20.00</td>
<td>24,000.00</td>
</tr>
<tr>
<td>4.</td>
<td>Seep Water Drain Line</td>
<td>1400</td>
<td>L.F.</td>
<td>30.00</td>
<td>42,000.00</td>
</tr>
<tr>
<td>5.</td>
<td>Seep Water Conveyance Pipe</td>
<td>500</td>
<td>L.F.</td>
<td>12.00</td>
<td>6,000.00</td>
</tr>
<tr>
<td>6.</td>
<td>36&quot; Canal Pipe</td>
<td>1400</td>
<td>L.F.</td>
<td>70.00</td>
<td>98,000.00</td>
</tr>
<tr>
<td>7.</td>
<td>Street Crossing</td>
<td>2</td>
<td>Ea.</td>
<td>8,000.00</td>
<td>16,000.00</td>
</tr>
<tr>
<td>8.</td>
<td>Turn outs</td>
<td>4</td>
<td>Ea.</td>
<td>1,200.00</td>
<td>4,800.00</td>
</tr>
<tr>
<td>9.</td>
<td>Headwall and Outlet Structures on Canal Piping</td>
<td>1</td>
<td>L.S.</td>
<td>18,000.00</td>
<td>18,000.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION SUBTOTAL

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easement Acquisition &amp; Surveying</td>
<td>5400</td>
<td>L.F.</td>
<td>5.00</td>
<td>27,000.00</td>
</tr>
<tr>
<td></td>
<td>Engineering, Contingencies, Legal Inspection &amp; Administration</td>
<td>35%</td>
<td></td>
<td></td>
<td>82,180.00</td>
</tr>
</tbody>
</table>

TOTAL

343,980.00

Encasement Option 36" RCP
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>L.F.</td>
<td>70.00</td>
<td>31,500.00</td>
</tr>
</tbody>
</table>

Drain Conveyance Option
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>L.F.</td>
<td>8.00</td>
<td>14,800.00</td>
</tr>
</tbody>
</table>

SUBTOTAL

46,300.00

Engineering, Contingencies, Legal Inspection & Administration On Options 35%

16,205.00

TOTAL OPTIONS

62,505.00

TOTAL WITH OPTIONS

406,000.00
Divert free flowing water from the Globe Canal and purchase properties most frequently ice flooded.
ESTIMATED COST

$185,000

DESCRIPTION

Alternative No. 4 requires two actions. First, under this alternative only the Doerr Draw seep water collection and the Jersey Avenue Spill would be constructed. Its configuration would be the same as in Alternative No. 3. The spill structure would divert the flowing water from the canal and carry both this water and the collected seep water to drain No. 2.

The second action to this alternative would involve purchase of the properties most often ice flooded below the canal. This would require purchasing five parcels of property located between Nevada and Garfield Avenues. Based on local information, these properties are most often affected by flooding and ice flows. Although adjacent properties may occasionally be affected, the magnitude of past damages to these properties does not warrant purchasing them.

ADVANTAGES

This alternative is the least costly of all alternatives, but only by 5%. Minimum construction would be required under this alternative. Operation and maintenance of the drain and spill and Jersey Avenue Spill would be minimal. The purchased properties could be transferred to public use for parks or other non-residential purposes. No construction would be needed up slope of the canal with the exception of constructing the Doerr Draw seep water drain. This alternative offers the least construction impacts of any of the alternatives considered in this rehabilitation plan. It also offers the lowest operation and maintenance cost.

DISADVANTAGES

This alternative WOULD NOT SOLVE the icing problem. Rather, it would only purchase those properties most often affected. Reaching mutually agreeable purchase terms with the affected owners could be difficult. Because property purchase costs cannot be closely predicted total project costs can not be estimated with good accuracy.

UTILITY CONFLICTS

Under Alternative No. 4 no known utility crossings would be required.
EASEMENT REQUIREMENTS

Permanent easements or rights-of-way would be required for the Jersey Avenue Spill and Doerr Draw, the same as under Alternative No. 3. This would require 1400 feet of easement for the Jersey Avenue Spill and approximately 1200 feet of easement for the Doerr Draw seep water drain.

OTHER CONSIDERATIONS

The action of purchasing affected properties may cause discord among the project sponsor and remaining owners adjacent to the canal. It will also demand much time commitment by local political leaders.
PRELIMINARY ESTIMATE OF COSTS

Project: GLOBE CANAL INVESTIGATIONS  Date: 12/15
Project No: 405-01-00-89  Estimate By: James Gores & Associates

ALTERNATIVE NO. 4: BUY OUT AFFECTED PROPERTIES BELOW THE CANAL

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>12,000.00</td>
<td>12,000.00</td>
</tr>
<tr>
<td>2.</td>
<td>8&quot; Spill Drain Line</td>
<td>1400</td>
<td>L.F.</td>
<td>10.00</td>
<td>14,000.00</td>
</tr>
<tr>
<td>3.</td>
<td>Seep Water Drain in Doerr Draw</td>
<td>1200</td>
<td>L.F.</td>
<td>20.00</td>
<td>24,000.00</td>
</tr>
<tr>
<td>4.</td>
<td>Seep Water Conveyance Line</td>
<td>500</td>
<td>L.F.</td>
<td>12.00</td>
<td>6,000.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION SUBTOTAL

56,000.00

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Purchase Properties with Home</td>
<td>2</td>
<td>Ea.</td>
<td>32,000.00</td>
<td>64,000.00</td>
</tr>
<tr>
<td>6. Purchase Property with Mobile Home</td>
<td>3</td>
<td>Ea.</td>
<td>8,000.00</td>
<td>24,000.00</td>
</tr>
</tbody>
</table>

SUBTOTAL

88,000.00

- Legal Services Associated with Land Purchases: 10% - 8,800.00
- Easement Acquisition & Surveying: 2600 L.F. - 5.00 - 13,000.00
- Engineering, Contingencies, Legal Inspection & Administration: 35% - 19,600.00

TOTAL PROJECT

185,000.00

OPT4.CAL
ALTERNATIVE NO. 5

Direct free flowing water from the canal and construct a curtain drain of the Lovell bench immediately above the east end of Lovell.
ALTERNATIVE NO. 5

ESTIMATE COST

$195,000

DESCRIPTION

Under this alternative drainage construction would be applied only to the most problematical sections along the canal. As with the other alternatives, the Jersey Avenue Spill and the seep water drain in Doerr Draw would be constructed.

However, this alternative adopts the approach of intercepting seep water between Nevada and Garfield Avenues with a drain on top of the bench before it reaches the slope above the canal. This would require constructing a gravel encased curtain drain at bedrock level, a depth of about 20 feet. This should provide a positive block to seep water flow reaching the face of the hill between the bench and the canal. This seep water drain would be located at the north edge of the cultivated field extending between Nevada and McKinley Avenues. Collected seep water would be conveyed to the canal and discharged on the east side of McKinley Avenue.

This alternative will not entirely eliminate ice accumulation in the canal but should diminish accumulation to the point of eliminating damage.

ADVANTAGES

This alternative offers the second lowest construction cost of all systems considered. It is only 5% more costly than Alternative No. 4. Using Alternative No. 5 would require no construction along the canal through town. Also, it provides a positive blockage to the water source causing the greatest nuisance. Construction would impact a minimum number of property owners and the resultant project should offer low maintenance and operation costs. No work would be required in the canal itself.

DISADVANTAGES

Construction of the 20 foot deep drain on top of the bench will be difficult and expensive. The private wells located between this drain and the crest of the bench will be dried up. This may affect approximately four property owners. However, the collected seep water could be made available for irrigation to those affected. Finally, interception of this flow will dry up the hillside down slope of the bench likely causing loss of vegetation on the face of the hill between Nevada and McKinley Avenues. This may result in an increase in associated fire hazards in this area.
UTILITY CONFLICTS

Under this alternative no municipal water or sewer crossings are necessary. Utility conflicts will likely be limited to the power and telephone paralleling the most promising route.

OTHER CONSIDERATIONS

As with Alternatives 3 and 4, local citizens may view the reduced vegetation above the canal between Nevada and McKinley Avenues as a disbenefit. Also, adjacent property owners may view any reduction in the vigor of this wooded areas as a devaluation of their properties.
# PRELIMINARY ESTIMATE OF COSTS

**Project:** GLOBE CANAL INVESTIGATIONS  
**Date:** 12/15  
**Project No:** 405-01-00-89  
**Estimate By:** James Gores & Associates

**ALTERNATIVE NO. 5: CONSTRUCT DRAIN NEAR NORTH EDGE OF LOVELL BENCH**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>12,000.00</td>
<td>12,000.00</td>
</tr>
<tr>
<td>2.</td>
<td>8&quot; Spill Drain Line</td>
<td>1400</td>
<td>L.F.</td>
<td>10.00</td>
<td>14,000.00</td>
</tr>
<tr>
<td>3.</td>
<td>Seep Water Drain in Doerr Draw</td>
<td>1200</td>
<td>L.F.</td>
<td>20.00</td>
<td>24,000.00</td>
</tr>
<tr>
<td>4.</td>
<td>Doerr Draw Seepwater Conveyance Line</td>
<td>500</td>
<td>L.F.</td>
<td>12.00</td>
<td>6,000.00</td>
</tr>
<tr>
<td>5.</td>
<td>Curtain Drain on Lovell Bench</td>
<td>2500</td>
<td>L.F.</td>
<td>25.00</td>
<td>62,500.00</td>
</tr>
<tr>
<td>6.</td>
<td>Drain Outlet</td>
<td>1</td>
<td>L.S.</td>
<td>3,000.00</td>
<td>3,000.00</td>
</tr>
<tr>
<td>7.</td>
<td>Street Crossing</td>
<td>1</td>
<td>Ea.</td>
<td>4,000.00</td>
<td>4,000.00</td>
</tr>
</tbody>
</table>

**CONSTRUCTION SUBTOTAL**  
125,500.00

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easement Acquisition &amp; Surveying</td>
<td>5100</td>
<td>L.F.</td>
<td>5.00</td>
<td>25,500.00</td>
</tr>
<tr>
<td></td>
<td>Engineering, Contingencies, Legal Inspection &amp; Administration</td>
<td>35%</td>
<td></td>
<td>43,925.00</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL PROJECT**  
195,000.00
CONCLUSIONS AND RECOMMENDATIONS

GENERAL CONSIDERATIONS

The ranking of alternatives given in Figure 4-1 simply compares the five alternative in the following six categories:

1. Cost
2. Conflicts with Streets, Roads and Utilities
3. Easement Requirements
4. Probable Operation and Maintenance Costs
5. Impact Properties Adjacent to the Canal
6. Probable Effectiveness in Removing Seep Water and the Degree to which the Alternative would solve the problem

No attempt was made to assign weighting factors of the comparative importance of these criteria. Those are decisions which should be left to the local sponsor. Alternates were simply ranked from best to least desirable for each criteria and given numerical rankings of 1 to 5 respectively.

Ranking the alternatives considered each category as described below.

1. COST

Alternatives were ranked based on total project cost. This includes construction costs, the cost of surveying and acquiring needed easements or real property and related non-construction costs. Non-construction costs include engineering design, construction inspection, contingencies, legal and administration costs. These costs were estimated at 35% of total construction as follows: Engineering Design 10%, Construction Inspection 10%, Contingencies 10%, Legal Services 3% and Administration 2%. Construction costs were estimated using scaled map distances for line lengths and applying recent similar construction costs to those quantities. It must be understood that these costs are only general estimates and are meant to show only comparative cost magnitude between alternatives. Costs given for estimates of real property purchases are general estimates based on conversations with local real estate professionals.
2. UTILITY CONFLICTS

A general assessment was made of the number of utility crossings and street closures necessitated by each alternative. Conflicts with, and interruptions of, existing utilities impact both construction costs and the inconvenience of local residence. As such, they become an important consideration.

3. EASEMENT REQUIREMENTS

Each alternative requires different amounts of easement or rights-of-way to install needed drains and associated improvements. Acquisitions of these easements will require lead time to conduct land surveys, negotiate with the property owner, and if necessary, take legal condemnation action to acquire the necessary rights-of-way. The complexity of the project increases as easement requirements increase.

4. PROBABLE OPERATION AND MAINTENANCE COSTS

Each alternative was evaluated in general terms for its probable future operation and maintenance costs. No detailed estimate of these costs were assembled but rather the project configuration was reviewed from the aspect of the number of drains, manholes and pipelines, and other constructed improvements which will require maintenance expenditures.

5. IMPACTS ON PROPERTIES ADJACENT TO THE CANAL

Each alternative was reviewed for its impact on properties adjacent to the canal. This includes, among other factors, installation of seep water drains on adjacent properties and surface damages that would result with the installation of the drains. Attention was given to this factor because local officials had expressed a wish to minimize, if possible, damage to the growth of trees and other vegetation now occurring on the hillside above the canal.

6. PROBABLE EFFECTIVENESS

A general assessment was made of each alternative's probable effectiveness in removing seep water and eliminating the canal icing problem. The degree to which each alternative will be effective in removing seep water is almost directly proportional to the number of drains that are installed. In general, the removal of seep water will become increasingly effective as more drains are installed and more construction costs are incurred. The degree of elimination of seep water is proportional to the intensity of the program undertaken.
Alternatives other than the five presented in this report were looked into. Those included a program to implement sprinkler irrigation on all agricultural properties on the north edge of the Lovell bench. By converting to sprinkler irrigation the amount of applied irrigation water could be reduced. This action would in turn reduce the quantity of seep water generated. Consideration was also given to the out-right purchase of the cultivated properties between Lane 12 and the north edge of the Lovell Bench. Both of these alternatives were judged not to be readily implementable. Further consideration of these concepts were terminated.

CONCLUSIONS

Each of the five alternatives developed in this rehabilitation plan will offer varying degrees of relief to the icing problem in the Globe Canal. Costs of those alternatives range from a high of $678,000 to a low of approximately $185,000.

Alternative No. 2, if built, could be designed to eliminate nearly all of the offending seep water. It, however, is the most costly of all those considered and would impact the adjacent property owners far more than other alternatives considered. It would offer an elimination of the attracted nuisance which the canal now constitutes. Also, it would significantly reduce maintenance requirements of the Globe Canal through town.

Alternative No. 4 involves the least construction and cost of all alternatives. It, however, would do little to solve the ice clogging problem. Rather, it would only purchase land space to allow the ice flooding problem to continue with less damage. Ice flooding and its associated nuisances would continue but would impact adjacent residence less. Nonetheless, it would provide a means of alleviating some impacts which currently occur.

Alternative No. 5 offers costs nearly as low and provides an acceptable reduction in the magnitude of the ice clogging in the Globe Canal. It requires no construction in the canal right-of-way itself and construction does not impact properties adjacent to the canal. Some continued ice accumulation in the canal should be expected if this alternative is implemented. However, the severity of the problem should be reduced to the extent that minimal future damage would occur. It is expected though, that with the installation of this curtain drain much of the seep will be removed year-round. This will reduce the water now reaching the vegetation on the hillside. It also will impact the private wells which lie between the crest .pa of the hill and the curtain drain. Those homeowners affected may be able to install a pump irrigation system which would use the collected seep water as an irrigation water source.
RECOMMENDATIONS

Construct the Doerr Draw Drain, the Jersey Avenue Spill and a Curtain Drain on Lovell Bench. Based on the evaluation of the alternatives developed in this rehabilitation plan it is recommended that the sponsor develop a preliminary design and detailed cost estimate for Alternative No. 5. This alternative offers the best possibility for success of all the concepts which were developed in this evaluation. It provides a cost nearly as low as the least expensive approach. It also offers the potential of constructing the project in two phases.

The first phase could include the Jersey Avenue Spill and Doerr Draw Drain. The sponsor(s) could, if they wished, operate the system on a trial basis with those improvements in place. This would allow the opportunity to see if the diversion of upstream waters alleviated the icing problem to the extent that it would be acceptable to the local residence and political entities.

The second phase could be constructed if significant problems continue to occur. The curtain drain on the Lovell Bench between Nevada and Garfield Streets could be constructed as the second phase. This would remove seep water in this most problematical reach of the canal.

Additionally, this alternative offers the ability to extend the curtain drain west of Nevada Street, should problems persist. To implement this option the curtain drain could be extended south along the alley on the east side of Nevada Avenue to the alley immediately north of Wyoming Street. The drain could be routed west through this alley and continue west on .pa Tenth Street to the east edge of Doerr Draw. Installing a drain of this magnitude would remove most of the offending seep water from the hill slope above the Globe Canal.

It is further recommended that the preliminary design be developed to provide this phased construction concept.

It is because of this alternative's effectiveness as versus its cost, its ability to be constructed in phases and its ability to be extended to accomplish a more comprehensive removal of seep water that leads to recommending this alternative.

SPONSORSHIP RECOMMENDATIONS

The problem of ice accumulation in Globe Canal more than anything else is a result of an irrigation drainage problem. The problem area abuts both the Lovell and Lovell Bench Drainage Drainage Districts. As such, the sponsorship of the project should include, if not be lead by, these two districts. From a practical standpoint, the project would best be sponsored by a body comprised of the Globe Canal (Farmers Protective Association), the Drainage Districts, the Town of Lovell and perhaps, Big Horn County.

Under WWDC rules the project sponsor must be a legally formed entity. This would include all entities mentioned above with the exception of the Farmers Protective Association.
<table>
<thead>
<tr>
<th>ALTERNATIVE NO.</th>
<th>COST</th>
<th>UTILITY CONFLICTS</th>
<th>EASEMENT REQUIREMENTS</th>
<th>O &amp; M REQUIREMENTS</th>
<th>IMPACTS ON ADJACENT PROPERTIES</th>
<th>EFFECTIVENESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO. 1</td>
<td>278,000</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>NO. 2</td>
<td>678,000</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>NO. 3</td>
<td>406,000</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>NO. 4</td>
<td>185,000</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>NO. 5</td>
<td>195,000</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Ranking: 1 is lowest/least severe/most effective
5 is highest/most severe/least effective
SECTION 5

RESULTS OF PUBLIC HEARING ON REHABILITATION PLAN

The Globe Canal Level II Rehabilitation Plan, which is sections 1 through 4 of this report, was published and distributed in December 1989. Following the report's distribution a public meeting was held January 19, 1990 at Lovell's fire station to present the report to the public. The meeting was arranged by the Globe Canal Board (Farmers Protective Association). A special effort was made to invite all members of the Farmers Protective Association, representatives of the school district, the Town of Lovell, the Drainage Districts, Soil Conservation Service, R.C. & D, and all interested members of the public. A sign up list of those who were in attendance at the meeting is in the appendix of this report.

The report was presented with graphic aids depicting the alternate solutions that had been developed in Section 3 of the rehabilitation plan. All alternates were discussed and their advantages and disadvantages were explained. Topics which were discussed regarding each alternate solution were:

* Cost
* Utility Conflicts
* Easement Requirements
* Operation and Maintenance
* Impact on Adjacent Property Owners
* Expected Effectiveness
* Impact on Existing Tile Drains

James Gores and Associates presented their recommendation that Alternative No. 5 be adopted and constructed. This alternative involved construction of a drain in Doerr Draw, a canal spill and waste structure in the vicinity of Jersey Avenue, and a curtain drain on the east end of the Lovell Bench between Nevada Avenue and McKinley Avenue.

Those in attendance expressed two main concerns with the recommended alternative. First, that the proposed curtain drain would impact some three or four shallow private wells. The audience's second concern was the plan's reliance on the existing tile Drain No. 2. This drain was scheduled to carry and dispose of collected seep water flow during the winter months. Those in attendance felt that because the existing drain was in poor condition its longevity was questionable.
Discussions focused on the need to divert seep water and run-off water which currently collect in the Globe Canal. It was felt by those in attendance that this nuisance water needed to be diverted from the canal upstream of the west edge of town. Run-off and seep water entering the ice clogged portion of the canal commonly causes flooding problems. Those at the meeting further felt that there is a need to reduce the current summer time load on the existing tile Drain No. 2.

At the conclusion of the meeting a consensus of the Globe Canal representatives and others in attendance, was that the feasibility of and cost for a drain line along the west edge of town should be investigated. The sentiment was that this line should serve both as a groundwater drain and a conveyance for nuisance water spilled from the canal. The route suggested for this line was along Great Western Avenue from the Globe Canal to the Shoshone River. Jon Wade and John Jackson, of the Water Development Commission staff, asked the Globe Canal representatives to return to the Water Development Commission with an adopted approach which they wished to have developed into a Conceptual Design.

The local people expressed interest in having a buried line serve as the connection between the existing open drain and the new buried drain line. It was felt by the group in attendance that an open drain would contribute to weed and insect problems and would lead to higher future maintenance costs.

On February 15, 1990 James Gores and Associates received a call from Mr. Reed Williams of the Globe Canal Board (Farmers Protective Association) saying the board had adopted a plan which they want developed into a Conceptual Design. Mr. Williams said that the board wanted to investigate a drain along the west side of town as was discussed in the public meeting. Mr. Williams also said that the school district expressed similar sentiments and wished to have the line located near the district's west property line.

Mr. Williams also relayed that the Globe Canal Board had met to discuss this project with the Drainage District. He reported that it was the consensus of that meeting that the winter ice clogging and flooding problem along the canal in town was a problem of the Town of Lovell and not the Globe Canal nor the Drainage District. He said that as a result, the Globe Canal Board had decided to reduce their level of participation in guiding the future development project. He said that the Globe Canal would not be moving forward as the project sponsor.

The Farmers Protective Association (Globe Canal) forwarded to the Water Development Commission a summary of the comments which Mr. Reed had relayed to us by phone. Following receipt of that letter James Gores & Associates was directed by the Water Development Commission staff to evaluate the feasibility and cost of installing the proposed drain along the west side of town. James Gores and Associates was further requested to develop a Conceptual Design for construction of this proposed drain.
SECTION 6

ANALYSIS OF DRAIN ROUTE ON WEST SIDE OF LOVELL

Introduction

The consensus of the public meeting on the Globe Canal Rehabilitation Plan was that the canal's greatest need was a drain and waste line on the west side of the Town of Lovell. The preferred location of this line was Great Western Avenue. Those in attendance felt that the facility should serve the following functions:

1. At the west edge of town the accumulated seep water and run-off flow should be spilled from the Globe Canal.

2. Pick up the flow from the existing open drain which now feeds into the existing tile Drain No. 2. This would reduce both the summer and winter load on Drain No. 2 which is in poor condition.

3. Serve as a sub-water drain in addition to carrying collected surface water.

It was with these objectives that potential routes for the drain were evaluated.

The open drain coming into the southwest corner of the school property is not a part of the Globe Canal (Farmers Protection Association) facilities. This and all other area drains are part of the Drainage District's facilities. Because of this the Drainage District must be a financial participant in the project of this open drain to be picked up by the proposed spill and drain line.

Analysis

Analysis of potential routes took into consideration several factors. Some of these were:

* Availability of public rights-of-way.
* Route lengths between the Jersey Avenue spill and the Shoshoni River.
* Utility, railroad and highway crossings.
* The number of private properties which the proposed line would cross.
* Impact of crossing these properties with the line.
* The probable ease of obtaining needed private easements.
The impact on street surfacing.

Disruption of traffic and agricultural activities.

Considering all of the above factors, Great Western Avenue proved to be the most favorable south to north route. The line extends between the terminus of the open portion of Drain No. 2 and city park on the north. This route offers the least overall impact to traffic, street surfacing and private properties. The route does present utility congestion problems in the 1-1/2 block section in front of the sugar plant.

The best routing of the line is on either end of Great Western Avenue was less clear. This involves two line segments.

1. Between the Jersey Avenue spill structure and the south end of Great Western Avenue.

2. Between city park (at Great Western Avenue and Third Street) and the Shoshone River.

Evaluating the southern segment gave consideration to two routes. The first paralleled the south edge of the school property between the Jersey Avenue spill and the southerly extension of Great Western Avenue. The second route extended diagonally across the school property between the Jersey Avenue spill structure and Great Western Avenue. Topography of the area dictated that the shorter diagonal route be used.

Both routes flow opposite the natural fall of the terrain. Paralleling the south property of the school district forces the drain pipe to be well below the bottom of the existing open drain at the southwest corner of the school property. Not only would this route be longer it would be more difficult and costly to construct. This routing would add an additional 2 to 3 feet in depth to the line.

Evaluation of the route between city park and the river was less cut and dry. Two routes are available.

The line could be routed straight north from the corner of Third Street and Great Western Avenue. This route would parallel the west side of city park, go under three railroad spurs and the main track. Proceeding north it would follow the east edge of the Tate and Lyle (Great Western) properties, across the Hunt Godfrey Canal and empty into the waste way for that canal.

The alternate route would extend from Third Street and Great Western Avenue diagonally northeast across city park to Hampshire Avenue. (This segment would be located along the north edge of the park.) From there the line would go north under the Burlington Northern Railroad and through the Bischoff Livestock Company feedlots. At its north end it would cross the Hunt Godfrey Canal and discharge to the natural waste way.

6-2
As shown in the cost estimates on the following pages, it is less costly to route the drain across city park and through the Bischoff feedlots.

The route selected for development into a Conceptual Design has three segments as follows:

1. The drain begins at the Jersey Street spill structure and proceeds diagonally across school district property to Great Western Avenue. This segment will be terminated about 150 feet south of the northwest corner of the school property; about 300 feet south of the senior citizen center. At this point the existing open drain will also be picked up.

2. The middle segment occupies the entire length north on Great Western Avenue.

3. The final segment of the line extends from the corner of Third Street and Great Western Avenue diagonally northeast along the north edge of city park to Hampshire Avenue, just south of the railroad. The line will then continue north across the Burlington Northern Railroad, through the Bischoff Livestock Company feedlots, cross the Hunt Godfrey Canal and terminate at the natural waste way.

This is the most cost efficient route which could be identified within the scope and intent for this report.
PRELIMINARY ESTIMATE OF CONSTRUCTION COSTS

Project: GLOBE CANAL - WEST SIDE DRAIN - ALT. 2
(Through Feed Lot)

Project No: 405-01-00-89

Date: JULY 27, 1990

Estimate By: J. GORES

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diversion/Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>13,900.00</td>
<td>13,900.00</td>
</tr>
<tr>
<td>2. 21&quot; RCP</td>
<td>1560</td>
<td>L.F.</td>
<td>33.00</td>
<td>51,480.00</td>
</tr>
<tr>
<td>3. 24&quot; RCP</td>
<td>4780</td>
<td>L.F.</td>
<td>38.00</td>
<td>181,640.00</td>
</tr>
<tr>
<td>4. 8&quot; VCP from Open Drain</td>
<td>520</td>
<td>L.F.</td>
<td>20.00</td>
<td>10,400.00</td>
</tr>
<tr>
<td>5. Open Drain Inlet Structure</td>
<td>14</td>
<td>Ea.</td>
<td>1,240.00</td>
<td>17,360.00</td>
</tr>
<tr>
<td>6. Standard M.H.</td>
<td>120</td>
<td>L.F.</td>
<td>260.00</td>
<td>31,200.00</td>
</tr>
<tr>
<td>7. Pavement Replacement</td>
<td>2560</td>
<td>L.F.</td>
<td>16.50</td>
<td>42,240.00</td>
</tr>
<tr>
<td>9. Gravel Surface Replacement</td>
<td>1300</td>
<td>L.F.</td>
<td>4.50</td>
<td>5,850.00</td>
</tr>
<tr>
<td>10. Topsoil Restoration</td>
<td>1400</td>
<td>L.F.</td>
<td>1.60</td>
<td>2,240.00</td>
</tr>
<tr>
<td>11. Utility Crossings</td>
<td>12</td>
<td>Ea.</td>
<td>415.00</td>
<td>4,980.00</td>
</tr>
<tr>
<td>12. Railroad Bore</td>
<td>60</td>
<td>L.F.</td>
<td>250.00</td>
<td>15,000.00</td>
</tr>
<tr>
<td>13. Feed Lot Pen Crossing/Restoration</td>
<td>200</td>
<td>L.F.</td>
<td>2.00</td>
<td>500.00</td>
</tr>
<tr>
<td>14. Aerial Canal Crossing</td>
<td>60</td>
<td>L.F.</td>
<td>40.00</td>
<td>2,400.00</td>
</tr>
<tr>
<td>15. Spill/Discharge Structure</td>
<td>1</td>
<td>L.S.</td>
<td>4,120.00</td>
<td>4,120.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION SUB-TOTAL                                 | 384,810.00

NON-CONSTRUCTION COSTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Surveying/Easement Acquisition</td>
<td>1</td>
<td>L.S.</td>
<td>6,000.00</td>
<td>6,000.00</td>
</tr>
<tr>
<td>Engineering Design</td>
<td>1</td>
<td>L.S.</td>
<td>34,000.00</td>
<td>34,000.00</td>
</tr>
<tr>
<td>Construction Engineering (10%)</td>
<td></td>
<td></td>
<td></td>
<td>38,481.00</td>
</tr>
<tr>
<td>Legal &amp; Administrative (3%)</td>
<td></td>
<td></td>
<td></td>
<td>11,544.30</td>
</tr>
<tr>
<td>Construction Contingencies (15%)</td>
<td></td>
<td></td>
<td></td>
<td>57,721.50</td>
</tr>
</tbody>
</table>

NON-CONSTRUCTION SUB-TOTAL                               | 147,746.80

PROJECT TOTAL                                           | 532,556.80

GC3\GLOBE
## Preliminary Estimate of Construction Costs

**Project:** GLOBE CANAL - WEST SIDE DRAIN - ALT. 1  
(Under four R.R. Tracks)  

**Project No:** 405-01-00-89  

**Date:** JULY 27, 1990  

**Estimate By:** J. GORES

### Construction Costs

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diversion/Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>13,900.00</td>
<td>13,900.00</td>
</tr>
<tr>
<td>2. 21&quot; RCP</td>
<td>1560</td>
<td>L.F.</td>
<td>33.00</td>
<td>51,480.00</td>
</tr>
<tr>
<td>3. 24&quot; RCP</td>
<td>4270</td>
<td>L.F.</td>
<td>39.00</td>
<td>166,530.00</td>
</tr>
<tr>
<td>4. M.N.</td>
<td>16</td>
<td>Ea.</td>
<td>1,240.00</td>
<td>19,840.00</td>
</tr>
<tr>
<td>5. 8&quot; PVC)</td>
<td>520</td>
<td>L.F.</td>
<td>20.00</td>
<td>10,400.00</td>
</tr>
<tr>
<td>6. Highway Bore</td>
<td>120</td>
<td>L.F.</td>
<td>260.00</td>
<td>31,200.00</td>
</tr>
<tr>
<td>7. Pavement Replacement</td>
<td>2500</td>
<td>L.F.</td>
<td>16.50</td>
<td>41,250.00</td>
</tr>
<tr>
<td>8. Gravel Surface Replacement</td>
<td>1300</td>
<td>L.F.</td>
<td>4.50</td>
<td>5,850.00</td>
</tr>
<tr>
<td>9. Topsoil Restoration</td>
<td>1400</td>
<td>L.F.</td>
<td>1.60</td>
<td>2,240.00</td>
</tr>
<tr>
<td>10. Utility Crossings</td>
<td>13</td>
<td>Ea.</td>
<td>415.00</td>
<td>5,395.00</td>
</tr>
<tr>
<td>11. Railroad Bore (S.Spur)</td>
<td>60</td>
<td>L.F.</td>
<td>250.00</td>
<td>15,000.00</td>
</tr>
<tr>
<td>12. Railroad Bore (Secondary &amp; Main Line)</td>
<td>130</td>
<td>L.F.</td>
<td>260.00</td>
<td>33,800.00</td>
</tr>
<tr>
<td>13. Underground Canal Crossing</td>
<td>60</td>
<td>L.F.</td>
<td>20.00</td>
<td>1,200.00</td>
</tr>
<tr>
<td>14. Spill/Discharge Structure</td>
<td>1</td>
<td>L.S.</td>
<td>4,120.00</td>
<td>4,120.00</td>
</tr>
</tbody>
</table>

**Construction Sub-Total:** 402,205.00

### Non-Construction Costs

- Land Surveying/Easement Acquisition: 1 L.S. $5,000.00 = $5,000.00
- Engineering Design: 1 L.S. $37,000.00 = $37,000.00
- Construction Engineering (10%): $40,220.50
- Legal & Administrative (3%): $12,066.15
- Construction Contingencies (15%): $60,330.75

**Non-Construction Sub-Total:** $154,617.40

**Project Total:** $556,822.40
SECTION 7
CONCEPTUAL DESIGN

Introduction

The Conceptual Design of the drain and waste line is not complex. Many details not included here will have to be fully developed in the engineering design. The major elements of the project, however, have been identified in this report. The fundamental features of project's components have been developed sufficiently to determine how they can be successfully worked into this project.

Major elements of the proposed drain system will include:

* The spill structure on the Globe Canal just west of Jersey Avenue.
* The line between the spill structure and the southerly extension of Great Western Avenue.
* Conveyance of the existing open drain (at the southwest corner of the school property) to this proposed drain line.
* The combination sub-drain and conveyance line along Great Western Avenue to the river.
* The highway crossing bore on Great Western Avenue.
* Utility crossings and conflicts in the area of the sugar plant.
* The railroad bore on Hampshire Avenue.
* The Hunt Godfrey Canal crossing.
* The outlet structure.

The Conceptual Design of these major features will be discussed in the remainder of this section. It should be noted that all underground pipes are proposed to serve as both conveyance and sub-water drains.

Globe Canal Spill Structure

To function as intended this structure must be capable of:

1. Passing summer irrigation flow to the lower portion of the canal.
2. Diverting all winter time flow to the drain/waste line.

3. Remaining sufficiently ice free to function as designed.

4. Permitting flow in excess of the drain line capacity to proceed on down the canal.

5. Provide for summer spilling of excess flow. This could be a desirable feature for instances such as thunderstorm run-off.

To accomplish these objectives we have assembled the conceptual structure as shown on the following page. The design concept depicted here shows only major features of the structure. It does not attempt to provide structural engineering considerations, complete dimensioning for hydraulic capacities, nor complete answers to the deicing questions.

Spill and Drain Line Across School Property

This line must carry the diverted seep water flow during winter months plus any intermittent run-off flows spilled from the canal. The natural slope of the terrain in this area is to the northeast. The spill and drain line must flow northwest; against the natural fall of the terrain. Thus, the line gets progressively deeper as it extends west. The ground elevation at the proposed manhole immediately below the spill structure and the line’s first manhole on Great Western Avenue are both the same. Since the terrain is level all slope in the line has to be provided by progressively increasing depths of bury.

Sizing of this line is based on judgment. There is no available data with which to scientifically select the lines sizing. The proposed 21" line sizing was based on the following logic.

1. The maximum irrigation season capacity of the canal at the west edge of Lovell is 40 cubic feet per second (CFS).

2. It was assumed that the maximum probable snow melt or late winter storm run-off which would be intercepted by the canal between Foster Gulch and the west edge of town will be 1/4 to 1/2 of the canal’s summer maximum capacity. This would be a volume of 10 or 20 CFS.

3. The maximum economical trench depth is about 10 feet, given the combination of local groundwater conditions and slope stability of trench excavations in the local soils.

4. This constraint yields an available maximum slope of about 3 feet per thousand for the pipe extending between the Jersey Avenue spill and Great Western Avenue.

5. A desirable minimum flow velocity in the pipe is about 3 feet per second.
Globe Canal
Jersey Street Spill Structure

Standard USBR Check with Slide Gate

Area to be Heated to Above Freezing

Summer Wasteway Weir (5' Long)

Heat Conduits

Winter Seepwater Discharge

Section A-A

Pg. 7-2 A

Proj. No. 405-01-01-89
At a slope of .003 (3 feet per thousand) a 21 inch concrete pipe will carry about 9 CFS and flow about 4 feet per second. Plastic pipe would carry a slightly greater volume.

In the final analysis an argument can be made for about any other size pipe as well. However, it will be difficult to use a smaller sized line because of the limited available slope.

**Conveyance of Existing Open Drain to the New Underground Line**

One objective of this Conceptual Design is to pick up the flow from the existing open drain which terminates at the southwest corner of the school property. From this point the existing drain converts to an underground tile line, locally referred to as Drain No. 2. This tile line is in poor condition. Several collapsed sections are clearly evident by the presence of sink holes along its route across the school property.

The existing open drain can be diverted to the proposed new line in one of two ways. The open drain can be extended north along the extension of Great Western Avenue. Or it can be conveyed by an underground line also along Great Western Avenue. The underground line must be approximately 8 inches in diameter.

Based on the slope of the existing 10" tile across the school property Drain No. 2 now flows a maximum of 1/2 CFS. There are about 38 irrigated acres above the open portion of this drain. If a 1 CFS per 70 acre irrigation application rate is assumed and it is further assumed that all applied water reaches this drain, the 1/2 CFS volume compares closely. A 8" line would carry this flow volume with the available slope of 6 feet per 1000 feet.

If an open drain were used its construction costs would be less than enclosing the drain in pipe. However, at the public meeting held January 19, 1990 the local participants expressed interest that this drain be a buried line. Locally it was felt that an open drain would contribute to insect and weed problems and would result in more costly maintenance in future years.

**Conveyance and Drain Line Along Great Western Avenue**

As with the proposed upstream 21" line, the pipe size for this segment of the drain cannot be selected with precision. The logic leading to the 24" recommended size is as follows:

1. The natural slope of the ground is about .004 (4 feet per thousand) along Great Western Avenue and the remaining route to the river.

2. The line should be capable of carrying approximately 15 CFS. This includes 9 CFS from the canal spill, 1/2 CFS from the existing open drain, and 5 to 6 CFS of additional sub-water collected along the line's route to the river.
3. A 24" line would carry about 15 CFS at the 4 foot per thousand slope and would carry a velocity of 4.5 feet per second.

4. There have been no reports of the existing 24" Drain No. 2 on Montana Avenue being overloaded.

As with the 21" line, equally sound arguments can be made for other line sizes. This size, however, is probably within one pipe size of a desirable optimum.

**Highway Bore On Great Western Avenue**

U.S. Highway 310 must be crossed with a bore extending north to south on Great Western Avenue. This bore will have to be 36" diameter to accommodate the proposed 24" tongue and groove drain pipe. Because of the rocky soil, high groundwater and congestion of utilities this bore will be a difficult installation. The steel casing pipe for this bore should have a minimum wall thickness of 1/2".

If the Highway Department is to be reconstructing the highway at this intersection in the future it is recommended that an RCP casing should be installed by open cut construction. If such an installation could be made it could be done at approximately one-half the projected cost of the needed bore.

**Utilities Crossings and Conflicts**

The proposed route has few conflicts with the existing utilities except for the 1-1/2 blocks in front of the sugar plant. In spite of that congestion there is sufficient room to install the proposed drain line. We suggest the line be installed on the extreme west side of Great Western Avenue. This will place the line between the west curb and the existing 6 inch high pressure gas line. This location takes advantage of the widest unoccupied corridor in the street and minimizes service line conflicts.

Along the balance of the route the final location should be closely coordinated with the Town of Lovell. This line should be strategically located so it will not conflict with the town's utility location conventions nor future utility planning.

James Gores and Associates contacted all local utility owners asking the location of their respective utilities within Great Western and Hampshire Avenues. It is those locations which are shown on our Conceptual layout. Not all the utility crossings may have been identified in this study. Listed below are the main utility crossings which will be required. They are given in the order in which they will be encountered from north to south.
1. Water service line crossings in the Bischoff feedlot.

2. Six inch water line crossing on the west side of Hampshire Avenue where the proposed drain line will turn west to go along the north edge of city park.

3. Six inch high pressure gas line at the corner of Third Street and Great Western Avenue where the proposed drain line will turn south on Great Western Avenue.

4. The sewer and water main services entering the sugar plant from Great Western Avenue. (The 6" water enters in front of the main office, the 4" sewer exits just south of the retaining wall.)

5. The 6" high pressure gas main on the north side of the highway.

6. The 14" Town of Lovell water transmission main on the south side of the highway on Great Western Avenue.

7. The gravity flow irrigation line on Great Western Avenue at the south edge of the highway.

8. The 6" gas line in the same location.

9. The 2" gas line into the school one block south of the highway.

10. The 8" sanitary sewer at the corner of Seventh Street and Great Western Avenue.

Other major utility crossings may be needed as well, however, in our meeting with the local utility operators no other lines were identified. We did not attempt to locate private water and sewer service lines which will be encountered. However, given the routing of the line, we expect few will be encountered. The senior citizens center, the school and the homes opposite the sugar plant are the only services along the route. The services for the home are all on the opposite side of Great Western Avenue and will not be crossed by the proposed drain. It should be noted that utility crossings 9. and 10. above may not be necessary if the line can be routed along the extreme west edge of Great Western Avenue south of the highway. Their costs, however, are included in the project estimate.

Railroad Bore On Hampshire Avenue

It is expected that the railroad bore on Hampshire Avenue can be made without difficulty. A 2" gas line and 6" water line are the only utilities in the area. These two lines are far enough apart that a bore can be easily installed between them. We expect the soil will
be gravel with cobbles which may add some difficulty to boring. The bore will have to be at least 36" diameter to accommodate the 24" drain pipe. If a bell and spigot 24" RCP or another pipe size of a larger diameter is used, a larger diameter bore will be required. The bore length, depth and casing thickness will have to comply with Burlington Northern Railroad standards. The entire installation design must be reviewed and approved by the Burlington Northern Railroad Denver office. This is discussed in further detail in the permitting section of this report.

Hunt Godfrey Canal Crossing

The water surface elevation in the natural waste way north of the Hunt Godfrey Canal is only 2 feet lower than the water surface in the canal itself. We recommend that the drain line's discharge be at or above the level of the water surface in the waste way. Thus, the crossing of the Hunt Godfrey Canal will have to be either an aerial crossing or an inverted siphon. We recommend the use of an aerial crossing. We feel an aerial crossing will be more maintenance free than would an inverted siphon.

Outlet Structure

The outlet structure at the waste way should be a standard Bureau of Reclamation cast-in-place concrete baffled outlet structure with appropriate bank protection. This structure will permit discharge of the drain without damage of the waste way banks.

Drain/Conveyance Pipe

All pipe planned in this Conceptual Design is intended to function as both a conveyance pipe and underground drain line. The Conceptual Design for the 21" and 24" pipe is based on gravel packed tongue and groove reinforced Class III concrete pipe. The 8" pipe is planned to be a PVC or polyethylene pipe.

Other types of pipe could be used and possible cost savings achieved. These include ribbed polyethylene (ADS style pipe). There could be cost savings in using a synthetic filter fabric as opposed to washed gravel. These approaches may bear merits which should be explored in the project's final design. The piping system shown in the Conceptual Design is without question feasible and will function satisfactorily. It is also likely the most costly. Other less proven pipe and filter materials should be explored in the project design for potential cost savings.
On the following page we present our estimate of the project costs. The costs are given in expected 1991 dollars. This is done to the degree of accuracy we were able to obtain. We assumed a 3% inflation factor in prices between current 1990 prices and the estimated 1991 prices. It is questionable whether the estimate can be confidently forecast to that degree of accuracy. With the routing shown in the Conceptual Design we estimate the project will cost $533,000 if constructed in 1991.
PRELIMINARY ESTIMATE OF CONSTRUCTION COSTS

Project: GLOBE CANAL - WEST SIDE DRAIN - ALT. 2
(Through Feed Lot)

Project No: 405-01-00-89

Date: JULY 27, 1990
Estimate By: J. GORES

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diversion/Spill Structure</td>
<td>1</td>
<td>L.S.</td>
<td>13,900.00</td>
<td>13,900.00</td>
</tr>
<tr>
<td>2. 21&quot; RCP</td>
<td>1560</td>
<td>L.F.</td>
<td>33.00</td>
<td>51,480.00</td>
</tr>
<tr>
<td>3. 24&quot; RCP</td>
<td>4780</td>
<td>L.F.</td>
<td>38.00</td>
<td>181,640.00</td>
</tr>
<tr>
<td>4. 8&quot; VCP from Open Drain</td>
<td>520</td>
<td>L.F.</td>
<td>20.00</td>
<td>10,400.00</td>
</tr>
<tr>
<td>5. Open Drain Inlet Structure</td>
<td>1</td>
<td>L.S.</td>
<td>1,500.00</td>
<td>1,500.00</td>
</tr>
<tr>
<td>6. Standard M.H.</td>
<td>14</td>
<td>Ea.</td>
<td>1,240.00</td>
<td>17,360.00</td>
</tr>
<tr>
<td>7. Highway Bore</td>
<td>120</td>
<td>L.F.</td>
<td>260.00</td>
<td>31,200.00</td>
</tr>
<tr>
<td>8. Pavement Replacement</td>
<td>2560</td>
<td>L.F.</td>
<td>16.50</td>
<td>42,240.00</td>
</tr>
<tr>
<td>9. Gravel Surface Replacement</td>
<td>1300</td>
<td>L.F.</td>
<td>4.50</td>
<td>5,850.00</td>
</tr>
<tr>
<td>10. Topsoil Restoration</td>
<td>1400</td>
<td>L.F.</td>
<td>1.60</td>
<td>2,240.00</td>
</tr>
<tr>
<td>11. Utility Crossings</td>
<td>12</td>
<td>Ea.</td>
<td>415.00</td>
<td>4,980.00</td>
</tr>
<tr>
<td>12. Railroad Bore</td>
<td>60</td>
<td>L.F.</td>
<td>250.00</td>
<td>15,000.00</td>
</tr>
<tr>
<td>13. Feed Lot Pen Crossing/Restoration</td>
<td>250</td>
<td>L.F.</td>
<td>2.00</td>
<td>500.00</td>
</tr>
<tr>
<td>14. Aerial Canal Crossing</td>
<td>60</td>
<td>L.F.</td>
<td>40.00</td>
<td>2,400.00</td>
</tr>
<tr>
<td>15. Spill/Discharge Structure</td>
<td>1</td>
<td>L.S.</td>
<td>4,120.00</td>
<td>4,120.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION SUB-TOTAL: 384,810.00

NON-CONSTRUCTION COSTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Surveying/Easement Acquisition</td>
<td>1</td>
<td>L.S.</td>
<td>6,000.00</td>
<td>6,000.00</td>
</tr>
<tr>
<td>Engineering Design</td>
<td>1</td>
<td>L.S.</td>
<td>34,000.00</td>
<td>34,000.00</td>
</tr>
<tr>
<td>Construction Engineering (10%)</td>
<td></td>
<td></td>
<td></td>
<td>38,481.00</td>
</tr>
<tr>
<td>Legal &amp; Administrative (3%)</td>
<td></td>
<td></td>
<td></td>
<td>11,544.30</td>
</tr>
<tr>
<td>Construction Contingencies (15%)</td>
<td></td>
<td></td>
<td></td>
<td>57,721.50</td>
</tr>
</tbody>
</table>

NON-CONSTRUCTION SUB-TOTAL: 147,746.80

PROJECT TOTAL: 532,556.80

GC3\GLOBE
SECTION 9

ECONOMIC ANALYSIS

Introduction

The Globe Canal (Farmers Protective Association), in 1987, was delivering water to and assessing approximately 2890 users. Since then the canal has submitted to the State Engineers Office a correction of their records to reflect deliveries which the canal has historically made. The approval of that submitted is still pending before the Board of Control. Some acreage under the Hunt Godfrey Canal was actually being served by the Globe Canal and vice versa. After making these adjustments Globe now serves a little over 3000 acres. Assessments to the users are currently $5.00 per acre per year.

Cropping on the lands served by the canal consists mostly of alfalfa hay, corn for both feed and silage, feed barley and sugar beets. In 1987 acreages of these crops were about equal, with sugar beet acreage being the largest. According to a 1987 report by the Soil Conservation Service the acreages of crops and net return per acre of production was as follows:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
<th>Production Cost per Acre</th>
<th>Net Return Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Barley</td>
<td>694</td>
<td>$169.36</td>
<td>($34.96)</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>578</td>
<td>$176.43</td>
<td>$3.57</td>
</tr>
<tr>
<td>Corn-Grain</td>
<td>434</td>
<td>$243.08</td>
<td>($24.68)</td>
</tr>
<tr>
<td>Corn-Silage</td>
<td>434</td>
<td>$317.68</td>
<td>($17.68)</td>
</tr>
<tr>
<td>Sugar Beets</td>
<td>752</td>
<td>$527.17</td>
<td>($274.83)</td>
</tr>
</tbody>
</table>

The reported return to land for 1987 was $171,900 for the entire 2892 acres served by the canal at that time. Without the sugar beet income net total return would have been approximately a negative $30,000. Net income per acre in 1987 averaged about $59.50 assuming reported figures were correct.

Project Financing

The cost of the proposed Jersey Avenue spill structure and Great Western Avenue drain line is $533,000. This equates to $173 per acre based on 3000 acres.
There are a number of financing possibilities for the project. Possibilities range from the Farmers Protective Association funding the entire project themselves to the project being funded by a consortium of local entities. For purposes of this report we looked at three alternative approaches. Those are:

1. Globe Canal paying 100% of the costs.
2. Globe Canal financing 50% of the costs through a 35 year 4% state loan with WWDC granting the other 50%.
3. A consortium of local groups financing the project in conjunction with the State of Wyoming. For purposes of the approach it was assumed that the Globe Canal would be required to pay 25% of the costs using a 35 year 4% loan.

In each case it is assumed that; the total project costs will be $533,000, current assessments are $5.00 per acre per year, the total acreage being assessed is 3000 acres, a 35 year 4% loan is used to finance the Globe Canal’s portion of the project cost and that a sinking fund representing 2% of the project cost ($10,740) is set aside each year for repair and eventual replacement of the drain. The cost to the individual farmers is shown below. All figures are shown on a cost per acre basis and all figures are rounded off.

<table>
<thead>
<tr>
<th>Financing Alternative</th>
<th>Amount Financed</th>
<th>Loan Repayment</th>
<th>Sinking Fund Pmt.</th>
<th>Annual Assessment After Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (100% financed)</td>
<td>178</td>
<td>$9.50</td>
<td>$3.60</td>
<td>$18.10</td>
</tr>
<tr>
<td>2. (50% financed)</td>
<td>89</td>
<td>4.80</td>
<td>3.60</td>
<td>13.40</td>
</tr>
<tr>
<td>3. (25% financed)</td>
<td>44</td>
<td>2.40</td>
<td>3.60</td>
<td>11.00</td>
</tr>
</tbody>
</table>

The above table shows that when loan repayment plus a repair and replacement sinking fund are added to the associations present assessment that the new assessment could range between $11.00 to $18.10 per acre per year. It is obvious that if this project is to be accomplished within an economic range for local agriculture a broad base of local entities must assist in financing the project. If the drainage districts, Globe Canal, Elk-Lovell Canal, Town of Lovell and State of Wyoming could together finance the project it may be achieved within economically affordable assessments.

It must be understood that in order for the Farmers Protective Association to act as the project sponsor it must be converted from an association to a legally formed district. State law precludes granting state funds to a body which is not a public body.
Introduction

The project will require few permits. None are required from any of the regulatory agencies. This includes DEQ, EPA and the Corps of Engineers. Those permits which are necessary are briefly discussed below.

Easements

Easements will be required from several local landowners. From north to south along the route those individuals are:

1. Bischoff Livestock Company (Loretta Bischoff)
   
   For the outlet structure and line from the outlet, south to the railroad.

2. Hunt Godfrey Canal
   
   For the canal crossing on the north side of the Bischoff livestock properties.

3. Tate and Lyle Inc. (sugar factory)
   
   For an easement across city park. Records in the county clerk’s office indicate the city park land is leased by the town from Tate and Lyle.

4. Wanda B. Huston
   
   For an easement for the line south of Seventh Street to the terminus of the open drain near the southwest corner of the school property.

5. School District #2
   
   From an easement between Great Western Avenue and the Jersey Street spill structure.

6. George Doerr
   
   A very short easement will be required across the Doerr property from the southern edge of the school property toward the Jersey Avenue spill structure.
7. Minol Ota

An easement will be required for installation of the Jersey Street spill structure, the drain line and manhole immediately north of the proposed spill structure.

**Wyoming Highway Department Utility License**

A Wyoming Highway Department Utility License will be required for the bore under the highway at Great Western Avenue. The application will need to be made at the time the design is assembled. A copy of the completed bore design will need to accompany the license application as Exhibit "A". No fee is charged and the application process is routine. The application will need to be submitted to the Basin office for review and approval. Formal approval will be granted through the Cheyenne headquarters office. The approval process requires about 4 to 6 weeks. A copy of the application form is in the appendix of this report.

**Burlington Northern Railroad Application for Pipeline Permit**

An application will have to be made to the Burlington Northern Denver Division Office for a "Pipeline Permit," commonly referred to as a Bore Permit. The permit must be accompanied by the completed design and project specifications for the intended bore. The installation must comply with Burlington Northern’s design standards which are stated on the permit application. The application is to be submitted to Mr. Jim Daume, Division Engineer, Burlington Northern Railroad, 304 Inverness Way, Suite 200, Englewood, Colorado 80112 (303)799-2790. The local Road Master is Mr. Dan Ruddy in Greybull. He can be reached at 765-2191. The permit application must be reviewed and approved by the Denver Division Engineering Staff. The approval process will require approximately 2 months.

There is a $450.00 application fee. The permit for construction is valid for one year from date of issuance. If construction is not complete within one year the permit is voided.

**The Town of Lovell**

All other portions of the proposed line are in rights-of-way owned by the Town of Lovell. The design engineer must coordinate with the town regarding its preference for line location and restoration of street surfacing and potential conflicts with town utilities and other improvements.
November 27, 1989

James Gores & Associates
450A South Federal Blvd.
Riverton, Wyoming 82501

Attention: Mr. Jim Gores

Subject: Transmittal of Laboratory Test Results
Job No. 89-4358

Dear Mr. Gores:

Transmitted with this letter are the laboratory test results for the soil sample submitted to our office on November 9, 1989. The sample was identified as having been obtained from the south end of Washington, Goble Canal Project.

The soil sample was tested for moisture content, dry density, gradation and Atterberg limits. An attempt was made to perform an in-liner permeability to determine the permeability of the soil. This test failed due to the disturbed nature of the soil sample received. Piping occurred during the test invalidating the test results. Laboratory test results are summarized in Table I.

Based on the test results, we anticipate permeability of the soil will range between $1 \times 10^{-6}$ to $1 \times 10^{-7}$ cm/sec. The actual permeability will be dependent upon the in-place dry density of the soil and/or the percent of maximum dry density the soil is compacted to. Actual permeabilities can also vary significantly with change in soil properties.

If you have any questions or if we can be of further assistance, please call.

Sincerely,

CHEN-NORTHERN, INC.

BY

Steven M. Herman
Project Engineer

SMH:ked
Enclosure
TABLE I
Laboratory Test Results

1) GRADATION

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4</td>
<td>100</td>
</tr>
<tr>
<td>No. 8</td>
<td>98</td>
</tr>
<tr>
<td>No. 16</td>
<td>96</td>
</tr>
<tr>
<td>No. 30</td>
<td>95</td>
</tr>
<tr>
<td>No. 50</td>
<td>93</td>
</tr>
<tr>
<td>No. 100</td>
<td>89</td>
</tr>
<tr>
<td>No. 200</td>
<td>81</td>
</tr>
</tbody>
</table>

2) HYDROMETER

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.050</td>
<td>75</td>
</tr>
<tr>
<td>0.037</td>
<td>71</td>
</tr>
<tr>
<td>0.019</td>
<td>58</td>
</tr>
<tr>
<td>0.009</td>
<td>46</td>
</tr>
<tr>
<td>0.005</td>
<td>40</td>
</tr>
<tr>
<td>0.002</td>
<td>36</td>
</tr>
<tr>
<td>0.001</td>
<td>26</td>
</tr>
</tbody>
</table>

3) ATTERBERG LIMITS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Limit, %:</td>
<td>37</td>
</tr>
<tr>
<td>Plasticity Index, %:</td>
<td>18</td>
</tr>
</tbody>
</table>

4) MOISTURE-DENSITY

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Moisture, %:</td>
<td>25.9</td>
</tr>
<tr>
<td>Dry Density, pcf:</td>
<td>94.8</td>
</tr>
</tbody>
</table>

Job No. 89-4358
November 27, 1989
OWNERSHIP IN A PORTION OF BLOCKS 5, 7, & 8, LINNABARY FIRST ADDITION (NOT TO SCALE)
OWNERSHIP IN A PORTION OF BLOCKS 7,8,& 9, LINNABARY ADDITION, PLAT B

not to scale
OWNERSHIP IN A PORTION OF BLOCKS 4, 5, 6, 7, & 8
CITY VIEW ADDITION (not to scale)
OWNERSHIP IN A PORTION OF BLOCKS 4, 5, 6, 7, & 8
CITY VIEW ADDITION  (not to scale)
# Globe Canal Meeting

Jan. 19, 1990

## Attendance List

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jim Cora</td>
<td>James Cora and Assoc., Riverton</td>
<td>856-2444</td>
</tr>
<tr>
<td>Roger Miller</td>
<td>Roger Miller, Geologist, Casper</td>
<td>237-6027</td>
</tr>
<tr>
<td>Bill Hack</td>
<td>Town of Lovell</td>
<td>548-6551</td>
</tr>
<tr>
<td>Mr. &amp; Mrs. Groom &amp; Jaffett</td>
<td></td>
<td>548-2346</td>
</tr>
<tr>
<td>Don Waterholder</td>
<td></td>
<td>548-6873</td>
</tr>
<tr>
<td>Paul Clark</td>
<td>Canal rider</td>
<td>548-2388</td>
</tr>
<tr>
<td>Keith Allred</td>
<td>Canal Sec</td>
<td>548-2327</td>
</tr>
<tr>
<td>Lynne Miremble</td>
<td>Canal Board Member</td>
<td>548-2383</td>
</tr>
<tr>
<td>John Jackson</td>
<td>WWDC</td>
<td>777-7626</td>
</tr>
<tr>
<td>Jon Wade</td>
<td>WWDC</td>
<td>777-7626</td>
</tr>
<tr>
<td>Gary H. Boman</td>
<td>RC&amp;D Coord.</td>
<td>587-6739</td>
</tr>
<tr>
<td>Ralph Shepperin</td>
<td>Globe Canal</td>
<td>548-7454</td>
</tr>
<tr>
<td>Chuck Galley</td>
<td>Lovell DNR Dist.</td>
<td>548-2703</td>
</tr>
<tr>
<td>Fred Fishwick</td>
<td>Mayor, Lovell</td>
<td>548-2892</td>
</tr>
<tr>
<td>Grant Yungay</td>
<td>SCS</td>
<td>548-7422</td>
</tr>
<tr>
<td>Don Bartlett</td>
<td>Lovell School</td>
<td>548-2236</td>
</tr>
</tbody>
</table>
APPLICATION FOR PIPE LINE PERMIT

To BURLINGTON NORTHERN RAILROAD COMPANY

Date _____________________

1. At what City or Village is permit desired?

2. Full name and address of Applicant

3. If Applicant is a corporation, in what state incorporated?

   If an individual, under what firm name is business conducted?

   If partnership, give name of all partners

4. Product to be handled in pipe line

5. Pipe Data:

   a. Outside diameter
   b. Inside diameter
   c. Pipe material
   d. Specifications and grade
   e. Wall thickness
   f. Actual working pressure
   g. Type of joint
   h. Coating
   i. Method of installation
   j. Will cathodic protection be provided?

6. a. Depth of pipe under track (top of tie to bottom of casing)
   b. Angle of crossing

7. If pipe is to be placed longitudinally with track, give
   a. location of pipe in relation to centerline of nearest track
   b. depth of coverage (ground line to top of pipe)

8. If installation is to be by jacking or boring method give location of jacking and receiving pits
   a. Depth
   b. Distance facing wall of pit to centerline of nearest track (measured normal)

9. Reference plans (to be forwarded with original application)
   a. Drawing Number
   b. Prepared by

Applicant agrees that if installation requires any or all of the following work; removal and replacement of track, bridging, protection of track or other railway facilities by work or flagging, engineering and/or supervision; such work is to be performed by railway employes and the cost borne by Applicant. If in the opinion of the Railway Company sufficient hazard is involved the Applicant will be required to furnish liability and property damage insurance in form and amounts satisfactory to Burlington Northern Railroad Company.

By ___________________________________________________________________  (Applicant)
____________________________________________________________________ (Title)

RECOMMENDATIONS: (If additional space is required attach supplemental sheet)

Date _____________________  19

APPLICATION APPROVED:

____________________________________________________________________ (Superintendent)
____________________________________________________________________ (Asst. Vice President—Operations)

____________________________________________________________________ (General Manager Leases)
____________________________________________________________________ (Regional Manager Engineering)

FORM 16002 12-80

Printed in U.S.A.
CONSTRUCTION OF PIPE LINES ON RAILWAY RIGHT OF WAY

GENERAL REQUIREMENTS: Pipe lines under railway tracks or across or along railway right of way shall conform to current American Railway Engineering Association Specifications if constructed in the United States and shall conform to current regulations regarding pipe line crossings under railroad as issued and amended by the Board of Transport Commissioners for Canada if constructed in Canada or where laws or orders of public authority prescribe a higher degree of protection than specified herein, then the higher degree of protection so specified shall be adhered to.

Plans and specifications for proposed installation shall be submitted to railway division superintendent and meet the approval of the railway company before construction is begun. Plans shall be drawn to scale showing the relation of the proposed pipe line, angle of crossing, location of valves, railway survey station, right of way line and general layout of tracks and railway facilities. Plan should also show a cross-section (or sections) from field surveys, showing the pipe in relation to actual profile of ground and tracks, complete description of material to be used, and location of jacking and receiving pits. If open cutting or tunneling is necessary, details of sheeting and method of supporting tracks or driving tunnel should be shown.

The execution of the work on the railway right of way, including the supporting of tracks, shall be subject to the inspection and direction of the Regional Manager Engineering of the Railway Company.

Pipe lines shall be installed under tracks by boring or jacking if practicable. Boring excavation must not exceed the outside diameter of the pipe. Jacking or boring of corrugated metal pipe, cast iron pipe or pipe with flanges, bolts or couplings will not be permitted.

Pipe lines shall be located, where practicable, to cross tracks at approximately right angle thereto but preferably at not less than 45 degrees and shall not be placed within a culvert, under railway bridges or closer than 45 feet to any portion of any railway bridge, building or other important structure, except in special cases and then by special design as approved by the Assistant Vice President Engineering of the Railway Company.

Pipe lines laid longitudinally on railway right of way shall be placed within a culvert, under railway bridges or closer than 45 feet to any portion of any railway bridge, building or other important structure. Pipe line carrying flammable products or products under pressure located within 25 feet of the centerline of any track or where there is danger of damage from leakage to any bridge, building or other important structure, shall be encased or of special design as approved by the Assistant Vice President-Engineering of the Railway Company.

Pipe lines laid longitudinally on the railway right of way, 50 feet or less from the centerline of track shall be buried not less than 4’” 6” from the ground surface to top of pipe. Where pipe line is laid more than 50 feet from the centerline of track, minimum cover shall be 3 feet.

If additional tracks are constructed in the future, or Railway Company determines that roadbed should be widened, the casing shall be extended correspondingly.

PIPE LINES CARRYING FLAMMABLE SUBSTANCES

This includes oil, gas, gasoline, petroleum products or other flammable or highly volatile substance under pressure.

APPROVED CASING PIPE:

Steel or Cast Iron for all pressures.

ALL MINIMUM DIMENSIONS MEASURED NORMAL TO 6” OF OUTSIDE TRACK

Inside diameter of casing pipe shall exceed outside diameter of carrier pipe by 2” for carrier pipe less than 8” diameter, 3/4” for 8” to 16” carrier pipe and 3/4” for carrier pipe greater than 16” diameter.

PIPE LINES CARRYING NON-FLAMMABLE SUBSTANCES

This includes steam, water or any non-flammable substance which from its nature or pressure might cause damage if escaping on or in the vicinity of railway property. Sewers and drains do not require casing pipe unless conditions exist which will endanger security of track, but should be of sufficient strength to withstand E-72 railway loading.

APPROVED CASING PIPE:

Steel or Cast Iron for all pressures.

Reinforced Concrete or Corrugated Metal for pressures less than 100 P.S.I.

ALL MINIMUM DIMENSIONS MEASURED NORMAL TO 6” OF OUTSIDE TRACK

CARRIERS PIPE TO MEET CURRENT A.R.E.A. SPECIFICATIONS

Inside diameter of casing pipe shall exceed outside diameter of carrier pipe by 2” for carrier pipe less than 8” diameter, 3/4” for 8” to 16” carrier pipe and 3/4” for carrier pipe greater than 16” diameter.

CASTING PIPE FOR E 72 LOADING

<table>
<thead>
<tr>
<th>WALL THICKNESS FOR STEEL CASING PIPE</th>
<th>DIAMETER OF PIPE INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIPE COATED &amp; Cathodically Protected</td>
<td>UNDER 14</td>
</tr>
<tr>
<td>MIN. THICKNESS</td>
<td>14 AND 16</td>
</tr>
<tr>
<td>0.188</td>
<td>0.250</td>
</tr>
<tr>
<td>0.281</td>
<td>0.406</td>
</tr>
<tr>
<td>0.375</td>
<td>0.500</td>
</tr>
<tr>
<td>0.406</td>
<td>0.531</td>
</tr>
<tr>
<td>0.469</td>
<td>0.563</td>
</tr>
</tbody>
</table>

CAST IRON PIPE:

Installation must be by open trench. Pipe shall conform to American Standards Ass’n. Specification A21 class 150 for 12” and under and class 250 for over 12”. Pipe to have mechanical joints or compression couplings.

REINFORCED CONCRETE PIPE:

Pipe shall conform to current A.S.T.M. C-76 table IV, wall “B”.

CORRUGATED METAL PIPE:

Pipe shall be galvanized, asbestos bonded and asphalt coated.

<table>
<thead>
<tr>
<th>Gage of Metal before galvanizing</th>
<th>Diameter of pipe (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Std. gage</td>
<td>18 and under</td>
</tr>
<tr>
<td>14</td>
<td>24, 30, and 36</td>
</tr>
<tr>
<td>12</td>
<td>42 and 48</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Where the ends of the casing are below ground they shall be suitably protected against the entrance of foreign material, but shall not be tightly sealed.

CARRIERS PIPE TO MEET CURRENT A.R.E.A. SPECIFICATIONS

Inside diameter of casing pipe shall exceed outside diameter of carrier pipe, joints or couplings by 2” for carrier pipe less than 6” in diameter and 4” for carrier pipe 6” in diameter and larger.