Prepared for:
The Wyoming Water Development Commission
Herschler Building
Cheyenne, Wyo.  82002

Mr. Mike Purcell, Director
Mr. Evan Green, Project Manager

Prepared by:
Bearlodge Ltd., Inc.
P.O. Box 130
Sundance, Wyoming

December 5, 1991
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APPENDIX "C"

HULETT WATER SUPPLY PROJECT, LEVEL II

PHASE III REPORT
Phase III of the Hulett Water Supply Project, Level II, includes preliminary designs and cost estimates for the proposed water supply improvements for the Town of Hulett and such site access, investigation and negotiations as is necessary to establish a site to construct the proposed water storage facility and water transmission line.

Design of water supply and storage for a municipality is directly dependent upon the water usage for the town. The water supply facility, in this case the new Madison formation well, should be designed to produce the maximum day demand. The water storage facility should be sized to provide for acceptable fire protection plus a volume equal to the average daily demand for the system. When designing a new facility it is good practice to attempt to project some future requirements, that is design for a given period such that the new construction will be viable for a long period of time. In the case of the Hulett system, a design period of 20 years was selected.

Under the contract for this project, it is directed that information available from the Town of Hulett for population and water consumption rates be used to make the above described design projections. Absent recent information, population projections from the Wyoming Department of Administration and Fiscal Control (DAFC) is to be used along with averages for consumption taken from guidelines form the Wyoming Department of Environmental Quality (DEQ). When this study was initiated, the Town of Hulett had no record information for either water consumption or current population, therefore, the DAFC and DEQ information was used.

DAFC population projections for Northeastern Wyoming do not include specific projections for each town, rather, the County populations are projected. In order to derive a Town of Hulett Population projection it was necessary to correlate Hulett 10 year census data with Crook County 10 year census data. This correlation was then applied to the DAFC Crook County Population projections for the Hulett design population. Table "A" shows the Town of Hulett Populations as well as the Crook County Population figures used in the correlation. The correlation resulted in a 20 year population projection for Hulett of 461 people.
TABLE "A"

HULETT AND CROOK COUNTY 10 YEAR POPULATION DATA

<table>
<thead>
<tr>
<th>YEAR</th>
<th>HULETT</th>
<th>CROOK COUNTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>335</td>
<td>4691</td>
</tr>
<tr>
<td>1970</td>
<td>318</td>
<td>4535</td>
</tr>
<tr>
<td>1980</td>
<td>291</td>
<td>5308</td>
</tr>
<tr>
<td>1990</td>
<td>317 (estimated) by DAFC</td>
<td>5773</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>6378 (DAFC estimate)</td>
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SEE EXHIBIT "8" FOR GRAPHIC CORRELATION AND PROJECTION
The DEQ reference for estimating water demand for Wyoming Municipalities shows an average daily water demand of 125 gallons per capita per day (gpcd) and a maximum daily demand of 340 gpcd. Applying these estimates to the population projection, the 20 year design criteria for the Hulett water supply system indicates a need for 58,000 gallons of storage in excess of the required fire flow storage (one average day demand), and a source production rate requirement of 109 gallons per minute (average flow for the maximum daily demand. As the normal fire demand for Municipalities the size of Hulett is estimated to be a flowrate of 1500 gpm for a period of 2 hours, the fire storage demand is 180,000. Adding the 58,000 gallons for domestic use the total storage requirement for Hulett is projected to be approximately 238,000 gallons.

The recommendation based on the above projections is for an additional 250,000 gallons of storage (to be added to the current 40,000 gallons) for a total of 290,000 gallons of storage for the Town. The recommended production rate for the proposed well is 150 gpm. The projected requirements are estimated on the high side as a conservative approach based on the reliability of the background data for the projections.

During the course of the project, additional information for both population and water consumption were developed based on actual data. The 1990 census was taken which shows a current Town of Hulett Population of 429. In addition, the Town of Hulett personnel started recording water production data from the existing water source. For purposes of this report two months of water demand data were used to correlate with power records for the 1989 and 1990 years water production. Those correlations are shown below in Table "B". This data shows a current average daily demand for Hulett of 124,000 gallons per day and a Maximum Month AVERAGE DAY of 284,000 gpd. Clearly the correlations and projections derived from the DAFC and DEQ data are inadequate for current conditions.
### TABLE "B"

**CORRELATION BETWEEN POWER USED AND GALLONS PUMPED**

<table>
<thead>
<tr>
<th>DATE</th>
<th>KWH USED</th>
<th>GALLONS PUMPED</th>
<th>GALLONS PUMPED PER KWH</th>
</tr>
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<tr>
<td>JAN.9</td>
<td>63</td>
<td>50000</td>
<td>793</td>
</tr>
<tr>
<td>JAN. 10</td>
<td>57</td>
<td>43900</td>
<td>770</td>
</tr>
<tr>
<td>JAN.11</td>
<td>52</td>
<td>39710</td>
<td>764</td>
</tr>
<tr>
<td>JAN.12</td>
<td>48</td>
<td>34500</td>
<td>719</td>
</tr>
<tr>
<td>JAN.13</td>
<td>49</td>
<td>40900</td>
<td>835</td>
</tr>
<tr>
<td>JAN.14</td>
<td>44</td>
<td>38700</td>
<td>880</td>
</tr>
<tr>
<td>JAN.15</td>
<td>48</td>
<td>42600</td>
<td>888</td>
</tr>
<tr>
<td>JAN.16</td>
<td>49</td>
<td>39200</td>
<td>800</td>
</tr>
</tbody>
</table>

**CORRELATION BETWEEN POWER USED AND WATER PUMPED, 1989 & 1990**

<table>
<thead>
<tr>
<th>MONTH</th>
<th>KWH USED</th>
<th>CORRELATION FACTOR</th>
<th>WATER PUMPED (GALLONS)</th>
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<tr>
<td>JAN.</td>
<td>1735</td>
<td>806</td>
<td>1398410</td>
</tr>
<tr>
<td>FEB.</td>
<td>3421</td>
<td>806</td>
<td>2757326</td>
</tr>
<tr>
<td>MAR.</td>
<td>2621</td>
<td>806</td>
<td>2112526</td>
</tr>
<tr>
<td>APR.</td>
<td>2967</td>
<td>806</td>
<td>2391402</td>
</tr>
<tr>
<td>MAY</td>
<td>4503</td>
<td>806</td>
<td>3629418</td>
</tr>
<tr>
<td>JUNE</td>
<td>5730</td>
<td>806</td>
<td>4618380</td>
</tr>
<tr>
<td>JULY</td>
<td>5209</td>
<td>806</td>
<td>4198454</td>
</tr>
<tr>
<td>AUG.</td>
<td>10334</td>
<td>806</td>
<td>8329204</td>
</tr>
<tr>
<td>SEPT.</td>
<td>9748</td>
<td>806</td>
<td>7856888</td>
</tr>
<tr>
<td>OCT.</td>
<td>6439</td>
<td>806</td>
<td>5189834</td>
</tr>
<tr>
<td>NOV.</td>
<td>3212</td>
<td>806</td>
<td>2588872</td>
</tr>
<tr>
<td>DEC.</td>
<td>2863</td>
<td>806</td>
<td>2307578</td>
</tr>
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</table>

| AVERAGE MONTHLY DEMAND (1990) | 3948191 |
| AVERAGE DAILY DEMAND          | 3473567 |
| AVERAGE DAILY DEMAND          | 123696  |
There is no clearly defined way to project future usage based on the data as shown above. The 1990 population for Hulett appears as a statistical aberration when viewed with the previous data. In order to provide for some future design criteria a scenario for a water consumption increase of 1% per year was used. On this basis, the average daily demand at the end of a 20 year period would be approximately 150,000 gpd and the maximum daily demand would be 412,500. On this basis, the design for the storage should be approximately 330,000 gallons and the production rate for the well should be 300 gpm. The previously recommended storage of 250,000 gallons new with the 40,000 gallons of existing would be marginally adequate however, the production rate of the well should be established at a minimum of 250 gpm. As the well production capability is in excess of 300 gpm, it would not be necessary to install that size pump at this time. The pump size can be increased at such time as the Town demand would require addition pump capacity. Other piping should however, be sized to accommodate the 300 gpm production figure. The installation of a 300 gpm pump at this time would not be prudent as the capacity in excess of 250 gpm requires additional motor horse power and drop pipe. This would result in an increased cost of production for the water which is not now warranted. As mentioned previously, the larger pump can be installed at such time as it is necessary.

STORAGE TANK LOCATION AND TRANSMISSION LINE ALIGNMENT

Four major criteria were considered when investigating as site for the proposed water storage facility. Those were;
1) Elevation such that the tank high water line would be the same as the existing high water line in the Hulett storage tanks, (secondarily the elevation would allow for a storage "tank" as opposed to a "standpipe" to allow for more efficient utilization of the stored water;
2) Accessibility to the existing Hulett water distribution system;
3) Ability to serve additional area not now included in to Hulett water system;
4) Availability of the land and pipeline easement.

Six sites were evaluated for use as a storage facility site. Those six are described in the MEMO to Evan Green of the Wyoming Water Development Commission (WWDC). The MEMO and associated map are included as Exhibit "1" at the end of this report. The site described as the "Ballou" site or site 1 as selected as the most desirable location. Preliminary negotiations with the landowner, Mr. Ballou, indicated that it would be possible to negotiate for the use
of this site. A survey was prepared and geotechnical testing was performed to determine the suitability of the site for construction of the storage facility. The map resulting from the survey is included as Exhibit "2" and the results of the Geotechnical investigation is included as Exhibit "3". All criteria for the use of this site were favorable, however, the Town of Hulett and the landowner were unable to reach an agreement for the use of the land. This site was then abandon.

Negotiations for the use of site 2 produced indications that this site was available. A survey and geotechnical investigation were performed for this site, the results of which are included as Exhibits "4" and "5" respectively. All investigations indicated that this site is also acceptable. The current plan is to utilize this site for the storage facility.

SAWMILL FIRE PROTECTION

Midway through this project, the Devil's Tower Forest Products sawmill requested that they be allowed to participate in the project in order that a fire flow storage and transmission rate for their sawmill be incorporated into the design of the storage facility and transmission line. The Town of Hulett and the WWDC agreed in principle to this arrangement. It was agreed that preliminary design for those fire flow needs would be incorporated into this study pending final agreement to project funding.

The sawmill fire flow requirements altered the project in two ways. The necessary flow rate to the sawmill was established at 2500 gpm. As this exceeds the town's flow requirement by 1000 gpm it was necessary to size the water line at 10" in diameter as opposed the previous requirement of 8" diameter. The storage requirement increased to a point where the volume of the new tank must now be 500,000 gallons to provide the necessary fire fighting volume. The Town of Hulett and the Sawmill agreed that funding other than from the WWDC or the Town would be used to provide for the additional sizing required to serve the sawmill.

All final conceptual plans and estimates include the sawmill fire suppression requirements.

CONCEPTUAL DESIGN

The conceptual design for the required improvements to the Hulett Water Supply system are divided into four separate areas;
1) Well development and tie to system;
2) Water Transmission from storage to the well and system;
3) Water Storage;
4) Water transmission from the system to the sawmill.

WELL DEVELOPMENT
The well development will consist of installing a pump and motor in the newly constructed Madison water well, the installation of power, motor controls and motor protection and a well control system consisting of valves, meter, sampling point, and a chlorination system.

The chlorination system is provided not as a disinfection system but as a capability to provide a continuous residual in the water distribution system to guard against introduced contamination. As the water source is a deep aquifer with no resident contamination, the only possibility for contamination is that which may be introduced somewhere in the distribution and storage system. For this application, a "Hypochlorination" system is recommended. This type system provides for a solution feed into the system. The solution is mixed and stored in a small reservoir near the point of chlorination. The solution is actually introduced into the water line using a small pressure pump which draws from the reservoir. The pump has a manually set variable flow rate which is adjusted manually by the operator to achieve the desired residual in the system. This type is preferred for smaller applications because unlike gas chlorine, there is no health hazard associated with the chlorine solution and therefore no special storage, handling or operational requirements. The system is designed to provide a feed rate of 0 to 10 parts per million. As the pumping rate is fairly constant, there is no need for a sophisticated control system to vary the feed rate. The only automatic control will consist of a switch to activate the injection pump whenever the well pump is producing. The chlorine will be fed into the well discharge piping.

The well control equipment will consist of an air/vac valve, check valve, water meter, pressure gauge and sampling tap. The preliminary design indicates that this control system will be incorporated in a small building at the well site along with the chlorination system and well control electrical system.

The storage system is anticipated to be a steel tank with nominal dimensions of 32 feet in height and 52 feet in diameter. The tank will be placed on a compacted sand foundation confined in a concrete ring wall. The tank will be designed and constructed in accordance with AWWA standards for steel water tanks.

The transmission system will consist of a 10" diameter water line running from the storage tank to the existing town distribution system and on from that point to the sawmill. As the well lies between the tank and the system, the well discharge will be tied into the 10" transmission line at the nearest point to the well site. Appropriate valves, isolation and blowoff capabilities will be incorporated into the piping system.

The overall improvements layout is included as Exhibit

COST ESTIMATE

The estimated project cost identified by element as defined above are presented in the following table. Cost estimates include a 15% inclusion for engineering fees and a 10% inclusion for contingencies as shown.

COST ESTIMATE FOR HULETT WATER SUPPLY CONSTRUCTION

OCT. 24, 1991

Water transmission from system to sawmill

<table>
<thead>
<tr>
<th>NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>AMOUNT</th>
<th>PRICE</th>
<th>TOTAL PRICE</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>10&quot; PIPE</td>
<td>L.F.</td>
<td>300</td>
<td>$20.00</td>
<td>$6,000.00</td>
</tr>
<tr>
<td>2</td>
<td>10&quot; GATE VALVE</td>
<td>EA.</td>
<td>3</td>
<td>$950.00</td>
<td>$2,850.00</td>
</tr>
<tr>
<td>3</td>
<td>10X6 TEE</td>
<td>EA.</td>
<td>2</td>
<td>$400.00</td>
<td>$800.00</td>
</tr>
<tr>
<td>4</td>
<td>HIGHWAY BORE</td>
<td>L.F.</td>
<td>75</td>
<td>$100.00</td>
<td>$7,500.00</td>
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<td></td>
<td><strong>SUB-TOTAL</strong></td>
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<td></td>
<td><strong>$17,150.00</strong></td>
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<td>DESIGN &amp; CONSTRUCTION</td>
<td></td>
<td></td>
<td></td>
<td>(15%) $2,572.50</td>
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<td></td>
<td>CONTINGENCIES</td>
<td></td>
<td></td>
<td></td>
<td>(10%) $1,972.25</td>
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<td><strong>SUB-TOTAL THIS SECTION</strong></td>
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<td><strong>$21,694.75</strong></td>
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Well development and tie to system

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<th>UNIT</th>
<th>AMOUNT</th>
<th>PRICE</th>
<th>TOTAL PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6&quot; PIPE</td>
<td>L.F.</td>
<td>75</td>
<td>$15.00</td>
<td>$1,125.00</td>
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<tr>
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<td>EA.</td>
<td>3</td>
<td>$425.00</td>
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<tr>
<td>3</td>
<td>6&quot; TEE</td>
<td>EA.</td>
<td>2</td>
<td>$200.00</td>
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</tr>
<tr>
<td>4</td>
<td>6&quot; 90 DEG EL</td>
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<td>$450.00</td>
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<td>5</td>
<td>6&quot; METER</td>
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<td>6</td>
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<td>7</td>
<td>CHLORINATOR</td>
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<td>$2,500.00</td>
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## Water transmission from storage to well and system

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<thead>
<tr>
<th>NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>AMOUNT</th>
<th>PRICE</th>
<th>TOTAL PRICE</th>
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<tbody>
<tr>
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<td>845</td>
<td>$20.00</td>
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<tr>
<td>2</td>
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<td>2</td>
<td>$400.00</td>
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<tr>
<td>3</td>
<td>10&quot; GATE VALVE</td>
<td>EA.</td>
<td>1</td>
<td>$950.00</td>
<td>$950.00</td>
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<tr>
<td></td>
<td>SUB-TOTAL</td>
<td></td>
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<td>$18,650.00</td>
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### Design & Construction Engineering (15%) $2,797.50

### Contingencies (10%) $2,144.75

### Sub-Total This Section $23,592.25

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## Storage Section

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<th>PRICE</th>
<th>TOTAL PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10&quot; GATE VALVE</td>
<td>EA.</td>
<td>2</td>
<td>$950.00</td>
<td>$1,900.00</td>
</tr>
<tr>
<td>2</td>
<td>10X6 TEE</td>
<td>EA.</td>
<td>1</td>
<td>$400.00</td>
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<td>3</td>
<td>BLOW-OFF</td>
<td>EA.</td>
<td>1</td>
<td>$1,000.00</td>
<td>$1,000.00</td>
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<tr>
<td>4</td>
<td>500K TANK</td>
<td>L.S.</td>
<td>1</td>
<td>$175,000.00</td>
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### Sub-Total $178,300.00

### Design & Construction Engineering (15%) $26,745.00

### Contingencies (10%) $20,504.50

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Total Price $20,504.50
SUB-TOTAL THIS SECTION

$225,549.50

GRAND TOTAL ALL SECTIONS

$305,786.50
EXHIBIT "1"

MEMO DESCRIBING SITE ALTERNATIVES
MEMO:

TO: Evan Green
Wyoming Water Development Commission

FROM: Ralph W. Goodson
Bearlodge Ltd. Inc.

DATE: July 10, 1991


A portion of the above referenced Hulett Water Supply Project includes the selection of a location for the construction of a water storage tank to improve the Town of Hulett Municipal Water System. A total of six sites have been reviewed to some degree of detail in order to evaluate the viability of construction at each of those sites. The evaluation included the necessity to maintain the existing water pressure elevation in the Town’s water system, (i.e. the elevation of the proposed tank site must be at the necessary elevation) as well as the proximity to the new well and or Town system, and finally, what effect that location would have on the overall operation of the Town’s water system.

The attached base map has the relative locations of the six sites numbered (one through six) with the order of preference for the site (from a technical view) indicated by the site number. i.e. site no. 1 is the first preference et. cet.

SITE 1

This location is referred to as the "Ballou" site, "Ballou" being the name of the landowner at that location. The elevation at this site will allow of the construction of a tank whose diameter is greater than its height. Tanks of this type are referred to as “Storage Tanks” as opposed to a tank whose height is greater than its diameter. That type of tank is referred to as a "Stand pipe". A storage tank is normally more desirable in that a greater percentage of the stored water is available in the desired pressure range.

Additional assets for this site are the proximity to the Devil’s Tower Forest Products Sawmill which will allow for the Town of Hulett to provide fire protection to the mill, as well a provide Municipal Water Service to this area of the community which lies south of the Alzada Highway. This area is not currently served. Finally, this location places
storage for the mandible system on two sides of the system, thus allowing for water supply from two storage locations to any point of use in the Town's system. This will virtually double the fire flow capability to much of the existing system.

The major liabilities for this site include landowner reluctance to sell or lease the site and a highway bore necessary to install the pipeline under the highway.

SITE 2:
Site two is the location nearest the existing system and well which allows for the construction of a storage tank. This site also provides storage on the opposite side of the system from the existing storage. This site only differs from Site one in that it does not serve any additional area from that already served by the existing system.

The major liabilities for this site include landowner reluctance to sell or lease and the above mentioned fact that no additional population will be served by this installation.

NOTE: The landowner for sites 2, 3 and 4 is Bush Land Development Company (c/o Vicki Neiman). This landowner also owns all of the land around the existing well site. The only option discussed in this siting memo which would NOT required land or right-of-way acquisition from this landowner is option 6.

SITE 3:
This site is immediately adjacent to the well location. The elevation would require the construction of a "Stand Pipe" because it is too low to accommodate a storage tank. The major assets to this site include landowner agreement to negotiate for the property and an extremely short distance to connect to the existing well and system. The use of this site would result in the lowest construction cost for the storage improvement.

The major liabilities include the necessity to construct a stand pipe and the installation would not extend service to additional area.

SITE 4:
This site will accommodate a storage tank. The location is immediately across the highway from the sawmill which wishes fire protection.

Liabilities include distance from the existing system/well and landowner reluctance to negotiate for the land.

SITE 5:
This site will also accommodate a storage tank. The site is the greatest distance from the existing system/well of any of the alternatives. The only major asset for this site is land availability. The landowner has agreed to negotiate for the land.
Major liabilities include distance from the well/system and the fact that the transmission line would cross land owned by Bush Land Development Co.

SITE 6:
This site is included only because it is the site of the existing storage for the Town. The Town has the right to construct storage on this site and the water transmission line is already in place for the existing tanks. This is the only potential site which would require no land or right-of-way acquisition.

The major liabilities include no net hydraulic improvements to the system, i.e. this site would not improve the existing flow capabilities to the Town’s system. It would only improve the flow duration characteristics.
EXHIBIT "2"

PLAT FOR SITE 1 INCLUDING TRANSMISSION LINE ROUTE
PROPOSED WATERLINE EASEMENTS

LINE A
A utility easement being 50 feet wide along and 25 feet on either side of the centerline of said utility easement after construction, said easement fall being to a permanent centerline of 25 feet wide, along and 25 feet on either side of said centerline located in the SE 1/4 of Section 12, T.54N., R.65W., where found a brass cap, thence S 43°58'52" E, 209.26 feet to a point on the Northwest corner of said tract.

LINE B
A utility easement being 50 feet wide along and 25 feet on either side of the centerline of said utility easement after construction, said easement fall being to a permanent centerline of 25 feet wide, along and 25 feet on either side of said centerline located in the NE 1/4 of Section 13, T.54N., R.65W., where found a brass cap, thence S 43°58'52" E, 209.26 feet to a point on the Northwest corner of said tract.

LINE C
A utility easement being 50 feet wide along and 25 feet on either side of the centerline of said utility easement after construction, said easement fall being to a permanent centerline of 25 feet wide, along and 25 feet on either side of said centerline located in the NE 1/4 of Section 13, T.54N., R.65W., where found a brass cap, thence S 43°58'52" E, 209.26 feet to a point on the Northwest corner of said tract.

PROPOSED WATER TANK SITE TRACT
A tract of land being a portion of a 64.43-acre tract, described in photobook 120, page 507 on file in the office of the Clerk of Crock County, Wyoming, located in the SE 1/4 of Section 12, T.54N., R.65W., and being more particularly described as follows:
Beginning at the Southeast corner of said section 12, T.54N., R.65W., where found a brass cap, thence E 491.02 feet to a point on the proposed water tank site tract, thence E 453.07 feet to a point on the Northwest corner of said water tank site tract.

LEGEND

- LINE A
- LINE B
- LINE C
- CONSTRUCTION EASEMENT
- PERMANENT EASEMENT
- USED BRASS CAP FOUND
- FENCE LINE

CERTIFICATE OF SURVEY

State of Wyoming

County of Crock

I, Ralph V. Goodwin, of Sundance, Crock County, Wyoming, do hereby certify that the map hereof was drawn from original surveys done by me and under my direct supervision during the month of August 1991, and that these surveys were accurately represented herein.

Ralph V. Goodwin, PE

EXHIBIT 2
EXHIBIT "3"

GEOTECHNICAL EVALUATION FOR SITE 1
September 12, 1991

Bearlodge Ltd.
P. O. Box 130
Sundance, Wyoming 82729

Attention: Mr. Ralph Goodson

SUBJECT: Geotechnical Study for the Proposed Water Storage Tank, Hulett, Wyoming

Job No. 91-4526

Gentlemen:

At your request, we have conducted a geotechnical study for the proposed water storage tank located in Hulett, Wyoming.

Subsurface conditions encountered in the exploratory borings consist of 9 to 9.5 feet of clay, 3.5 to 5 feet of sand and 0 to 6 feet of gravel overlying bedrock to the depth investigated, 30 feet.

The clays are suitable to support anticipated structural loads on the order of 3,000 psf for a steel water tank founded on a gravel mat. A satisfactory foundation is a concrete ring wall placed on the undisturbed clay designed for an allowable bearing pressure of 3,000 psf.

The report which follows describes in detail our investigations, summarizes our findings, and presents our recommendations. It is important that we provide consultation during design, and field services during construction to review and monitor the implementation of the geotechnical recommendations.

If you have any questions regarding this report, please contact us.

Sincerely,

CHEN-NORTHERN, INC.

BY

Kenneth E. Temme, P.E.

KET:bec
GEOTECHNICAL STUDY FOR THE PROPOSED WATER STORAGE TANK
HULETT, WYOMING
JOB NO. 91-4526

PREPARED FOR:
BEARLODGE LTD.
P.O. 130
SUNDANCE, WYOMING 82729
ATTENTION: MR. RALPH GOODSON

PREPARED BY:
CHEN-NORTHERN, INC.
605 NORTH WAREHOUSE ROAD
CASPER, WYOMING 82601

SEPTEMBER 12, 1991
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**TABLE I**

| TABLE I | SUMMARY OF LABORATORY TEST RESULTS |
PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical engineering study for the proposed water storage tank to be located in Hulett, Wyoming. The project site is shown on Fig. 1. The study was conducted for the purpose of developing foundation recommendations for design and construction, and was conducted in accordance with our proposal with Bearlodge Ltd. dated May 15, 1991.

A field exploration program consisting of exploratory borings was conducted to obtain information on subsurface conditions. Samples of the soil and bedrock obtained during the field exploration were tested in the laboratory to determine physical and engineering characteristics. Results of the field exploration and laboratory tests were analyzed to develop recommendations for foundation types, depths and allowable pressures for the proposed construction. The results of the field exploration and laboratory testing are presented herein.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

PROPOSED CONSTRUCTION

It is proposed to construct a new storage tank in the general area noted on Fig. 1.

The new construction will consist of a steel tank approximately 50 feet in diameter and 40 feet in height. We understand that plans are to place the steel tank on a gravel mat at an elevation near the existing grade. Minimal site grading will be done.
If loadings, locations or conditions are significantly different from those described above or as depicted in this report, we should be notified to re-evaluate the recommendations provided herein.

SITE CONDITIONS

At the time of our study, the site was vacant. The proposed location is on top of an existing hill to the south of Town of Hulett, with the Belle Fourche River directly south of the site.

The hill sloped steeply downward to the north, west and south with a difference in elevation across the area investigated on the order of 1.0 foot. The top of the hill is on the order of 30 to 35 feet high.

FIELD EXPLORATION

The field exploration was conducted on August 21, 1991. Three exploratory borings were drilled at the locations shown on Fig. 1 to explore subsurface conditions. Locations of borings were established by tape measuring from existing on-site features, and elevations were established by a level survey using the bench mark as noted on Fig. 1.

The borings were advanced through the overburden soils into the underlying bedrock using 4-inch diameter continuous flight augers. The borings were logged by a representative of Chen-Northern, Inc.

Samples of the subsurface materials were obtained with 2-inch and 1-3/8 inch I.D. spoon samplers. The samplers were driven into the various strata using a 140 pound hammer falling 30 inches. The number of blows required to advance the sampler
each successive 6-inch increment is recorded and the total number of blows required to advance the sampler the sum of the second and third 6-inch increment is the penetration resistance ("N value"). This test is similar to the standard penetration test described by ASTM Method D1586. Penetration resistance values provide an indication of the relative density or consistency of the soils. Depths at which the samples were obtained and the penetration resistance values are shown on the Logs of Exploratory Borings, Fig. 2. The legend and notes explaining the symbolism and presenting pertinent information with respect to the exploratory drilling program are noted on Fig. 3.

During drilling measurements of the groundwater levels were made in the borings. Borings were backfilled with auger cuttings immediately after completion of drilling.

**LABORATORY TESTING**

Samples of the soil and bedrock obtained during the field exploration were observed and classified in accordance with ASTM D2487, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the engineering and physical properties of the soils and bedrock in accordance with ASTM or other generally recognized procedures. Tests performed included natural moisture content, dry unit weight, gradation, Atterberg limits, swell-consolidation and water soluble sulfates.

Results of all field and laboratory tests are summarized on the enclosed figures and tables. Figures for each of the tests are indicated above. These data, along with visual field logging information, were used to prepare the exploratory boring logs shown on Fig. 2.
SUBSURFACE CONDITIONS

The subsurface conditions were determined by drilling auger borings and the graphic logs of these borings are presented on Fig. 2 with descriptions of the subsoils and bedrock given on Fig. 3.

The subsurface profile consisted of 9 to 9.5 feet of clay, 3.5 to 5 feet of silty to clayey sand and 0 to 6 feet of gravel overlying siltstone-claystone bedrock to the depth investigated, 30 feet. The soils and bedrock encountered are described as follows:

**Clay:** A sandy clay was encountered at the ground surface in each of the three borings. This clay is stiff to very stiff as indicated by the penetration resistance values which ranged from 9 to 21 blows for 12 inches of penetration. The clay settles moderately under load as indicated by the Swell-Consolidation test results presented on Fig. 4. The gradation for typical samples of the clay are presented on Figs. 5 and 6.

**Sand:** A silty to clayey sand was encountered beneath the clay in each boring. This layer varied from 3.5 to 5 feet thick. This layer is medium dense as indicated by the standard penetration resistance values ranging from 14 to 30 blows for 12 inches of penetration. The gradation for typical sample of the sand are presented on Figs. 5 and 6.

**Gravel:** A silty sandy gravel was encountered above bedrock in Borings 2 and 3. This layer is medium dense to dense as indicated by the penetration resistance values of 28 and 47 blows for 12 inches of penetration. This layer was not tested in the laboratory.

**Siltstone-Claystone:** Siltstone-claystone bedrock was encountered in all of the borings. The bedrock is hard to very hard as noted by the penetration resistance values which varied from 30 blows for 12 inches of penetration to 50 blows for no penetration. The bedrock is well cemented at the contact with the overburden soils as
indicated by practical drill rig refusal encountered in Borings 1 and 2. This stratum is very competent.

**Groundwater:** Groundwater was not encountered within the borings at the time of drilling. Numerous factors contribute to fluctuations of water table conditions. The evaluation of such factors is beyond the scope of this study.

**ENGINEERING ANALYSIS/RECOMMENDATIONS**

**SITE GRADING**

**General:** The storage tank will be located on top of an existing hill. With the proposed tank floor elevation near the existing ground surface elevation, we anticipate minimal site grading will be required.

**Site Preparation:** The following recommendations should be followed for site preparation.

1. Any organic material within the proposed planned storage tank dimensions should be removed. All organic material should be wasted.

2. Fill should be approved by the geotechnical engineer, placed in uniform lifts and compacted to the following minimum percentages of the maximum dry densities as determined by ASTM D698.

   A. Below Tank Floors ...................... 100%
   B. Below Footings ........................ 100%
   C. Trench Backfill ....................... 95%

**Site Drainage:** It is critical that positive site drainage be provided. Positive site drainage should be provided to discharge surface waters away from the planned
structure. The following surface drainage criteria should be observed and maintained during the life of the structure.

1. Excessive wetting or drying of the foundation excavation and tank floor areas should be avoided during construction.

2. The ground surface surrounding the exterior of the structure should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 6 inches in the first 10 feet.

FOUNDATIONS

At an assumed bearing elevation of 3896 as shown on our boring logs, the bearing material will consist of clay. Based upon anticipated structural loads, the clays are suitable to support structural loads on the order of 3000 psf. Therefore the structure can be founded on a gravel mat placed uniformly beneath the tank. The gravel should be a minimum of 12 inches thick and should be a course crushed gravel. We recommend the gravel consist of Grading "W" base course aggregate meeting the requirements as outlined in the Wyoming Highway Department Specification for Road and Bridge Construction, Paragraph 703.06. The base course should be placed to at least 100% of standard Proctor density. Under the above conditions we estimate the tank will experience total settlement on the order of 1 inch to 2 inches with differential settlement on the order of 1/2 to 3/4 of the total settlement.

If the tank cannot tolerate differential movements on the order given above, a satisfactory foundation alternative is to found the tank on a concrete ring wall. The following design and construction criteria presented below should be observed for a concrete ring wall.
1. The ring wall placed on the clay should be designed for an allowable soil bearing pressure on the order of 3,000 psf.

2. Footings should be placed at least 48 inches below grade for frost protection.

3. The foundation walls should be designed to resist the forces exerted by an equivalent fluid unit weight of 60 pcf. This assumes that the on-site clays will be used for backfilling.

4. Continuous foundation walls should be reinforced top and bottom to span an unsupported length of at least 12 feet.

5. Areas of loose or soft material encountered within the foundation excavation should be removed and the footings extended to adequate natural bearing material. As an alternate to extending the footings down to the competent material, the loose material may be removed and replaced, compacted to 100% of the maximum standard Proctor density near optimum moisture content. New fill should extend down from the edges of the footings at a 1H:1V projection.

6. A representative of the geotechnical engineer should observe all footing excavations prior to concrete placement.

FOUNDATION CONCRETE

The concentration of water soluble sulfates measured in a typical sample of the clay was on the order of 0.40. This value indicates the conditions are very severe for the potential sulfate attack on concrete. The degree of attack is based on a range of negligible, positive, severe and very severe as presented in the U.S. Bureau of Reclamation's Concrete Manual. We recommend that a Type II modified low C3A or Type V cement be used for all concrete in contact with the on-site soils.
LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated on Fig. 1, and the proposed construction discussed in this report. The nature and extent of subsurface variations across the site may not become evident until construction. During construction, if fill, soil, rock or water conditions appear to be different from those described herein, this office should be advised at once so re-evaluation of the recommendations may be made.

CHEN-NORTHERN, INC.

BY  
Kenneth E. Temme, P.E.

REVIEWED BY  
Thomas J. Pilch  
Project Engineer
Bench Mark: Top of existing 1½" Aluminum cap in rebar. EL = 3893.3'.
Legend:

- Clay (CL), sandy, stiff to very stiff, moist, light brown to brown.
- Sand (SC-SM), silty to clayey, medium dense, occasional gravels, slightly moist to moist, brown.
- Gravel (GM), silty, medium dense to dense, slightly moist, brown.
- Siltstone-Claystone Bedrock, hard to very hard, well cemented at the overburden contact, moist, light brown to red.

Drive Sample. The symbol 16/12 indicates that 16 blows from a 140 lb. hammer falling 30 inches were required to drive a 2-inch I.D. spoon sampler 12 inches.

Standard Drive Sample. The symbol 50/2 indicates that 50 blows from a 140 lb. hammer falling 30 inches were required to drive a 1-3/8 inch I.D. spoon sampler the last 2 inches of an 18-inch drive.

Indicates depth at which practical drill rig refusal was encountered.

Notes:

1) Borings were drilled on August 21, 1991 using 4-inch diameter continuous flight power auger.

2) Borings were located by tape measuring from existing on site features.

3) Boring elevations were established by level survey and reference the bench mark noted on Fig. 1. EL = 3893.3'.

4) Water was not encountered in the borings at the time of drilling.

5) WC = Water Content (%)
    DD = Dry Density (pcf)
    LL = Liquid Limit (%)
    PI = Plasticity Index (%)
    NP = Non-plastic
    -200 = Passing No. 200 Sieve (%)
    WSS = Water Soluble Sulfate Content (%)

Fig. 3
**Moisture Content** 8%
**Dry Density** 114 p.c.f.
**Sample of** Sandy Clay
**From** Boring 1 at depth 4.0'

Additional Compression Under Constant Pressure Upon Wetting

**Moisture Content** 13%
**Dry Density** 111 p.c.f.
**Sample of** Sandy Clay
**From** Boring 3 at depth 4.0'

No Movement Upon Wetting

**APPLIED PRESSURE** (k.s.f.)

---

**Chen & Northern, Inc.**
**SWELL-CONSOLIDATION TEST RESULTS**
**Fig. 4**
**HYDROMETER ANALYSIS**

**TIME READINGS**
- 24 Hr
- 7 Hr
- 45 Min
- 15 Min
- 60 Min
- 19 Min
- 4 Min
- 1 Min

**U.S. STANDARD SERIES**
- 200
- 100
- 50
- 40
- 30
- 16
- 10
- 5
- 4
- 3
- 1 1/4
- 3/8
- 1/4

**CLEAR SQUARE OPENINGS**
- 3/8
- 1/4
- 1/8
- 1/16
- 1/32
- 1/64

**PERCENT PASSING**
- 100
- 90
- 80
- 70
- 60
- 50
- 40
- 30
- 20
- 10
- 5
- 2
- 1

**PERCENT RETAINED**
- 0
- 1
- 5
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- 100

**DIA. OF PARTICLE IN MILLIMETERS**

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<th>GRAVEL</th>
<th>SAND</th>
<th>SILT AND CLAY</th>
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<td>72%</td>
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**LIQUID LIMIT**
- 27%

**PLASTICITY INDEX**
- 12%

**SAMPLE OF**
- Sandy Clay

**FROM**
- Boring 1 at depth 4.0'

---

**SIEVE ANALYSIS**

**TIME READINGS**
- 24 Hr
- 7 Hr
- 45 Min
- 15 Min
- 60 Min
- 19 Min
- 4 Min
- 1 Min

**U.S. STANDARD SERIES**
- 200
- 100
- 50
- 40
- 30
- 16
- 10
- 5
- 4
- 3
- 1 1/4
- 3/8
- 1/4

**CLEAR SQUARE OPENINGS**
- 3/8
- 1/4
- 1/8
- 1/16
- 1/32
- 1/64

**PERCENT PASSING**
- 100
- 90
- 80
- 70
- 60
- 50
- 40
- 30
- 20
- 10
- 5
- 2
- 1

**PERCENT RETAINED**
- 0
- 1
- 5
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- 100

**DIA. OF PARTICLE IN MILLIMETERS**

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<th>SILT AND CLAY</th>
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<td>13%</td>
<td>60%</td>
<td>27%</td>
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**LIQUID LIMIT**
- 17%

**PLASTICITY INDEX**
- NP%

**SAMPLE OF**
- Silty Sand With Gravel

**FROM**
- Boring 2 at depth 9.0'
HYDROMETER ANALYSIS

TIME READINGS
24 HR 7 HR
45 MIN 15 MIN 60 MIN 19 MIN 4 MIN 1 MIN

U.S. STANDARD SERIES
200 *100 *50 *40 *30 *16 *10 *6 *4 *2 *1/8 *1/4 *1/2 1" 3/8 5/16 3/4 5/8 1" 1 1/4 2 1/2 3 3/4 5 1/2 6 1/4 8 1/2 10 1/4 12 1/2 15 1/4 20 1/2 30 1/2 40 1/2 50 1/2 60 1/2 70 1/2 80 1/2 90 1/2 100 1/2

CLEAR SQUARE OPENINGS
4 1/4 5 1/2 7 1/4 9 1/4 11 1/4 12 1/2 13 3/4 15 3/4 17 1/2 19 1/2 21 1/2 23 1/4 25 1/4 27 1/2 29 1/2 31 1/2 33 1/2 36 1/2 39 1/2 42 1/2 46 1/8 50 1 56 1/4 64 1/8 1 1/4 1 1/2 2 1/2 3 1/2 4 1 1/2 6 1 1/4

PERCENT PASSING

PERCENT RETAINED

DIA.METER OF PARTICLE IN MILLIMETERS

CLAY TO SILT

SAND

GRAVEL

COBBLES

FINE MEDIUM COARSE FINE COARSE

GRAVEL 0 % SAND 21 % SILT AND CLAY 79 %

LIQUID LIMIT 27 % PLASTICITY INDEX 11 %

SAMPLE OF Sandy Clay FROM Boring 3 at depth 4.0'

SIEVE ANALYSIS

DIA.METER OF PARTICLE IN MILLIMETERS

CLAY TO SILT

SAND

GRAVEL

COBBLES

FINE MEDIUM COARSE FINE COARSE

GRAVEL 8 % SAND 55 % SILT AND CLAY 37 %

LIQUID LIMIT 24 % PLASTICITY INDEX 6 %

SAMPLE OF Silty-Clayey Sand FROM Boring 3 at depth 9.0'

Fig. 6
**TABLE I**
SUMMARY OF LABORATORY TEST RESULTS

<table>
<thead>
<tr>
<th>BORING</th>
<th>DEPTH (feet)</th>
<th>NATURAL MOISTURE (%)</th>
<th>NATURAL DRY DENSITY (p.c.f.)</th>
<th>ATTERBERG LIMITS</th>
<th>UNCONFINED COMPRRESSIVE STRENGTH (p.s.i.)</th>
<th>WATER SOLUBLE SULFATE (%)</th>
<th>GRADATION ANALYSIS</th>
<th>SOIL TYPE</th>
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<tr>
<td></td>
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<td></td>
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<td>+ # 4 (%)</td>
<td>- # 4 (%)</td>
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<tr>
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<td>4.0</td>
<td>8</td>
<td>114</td>
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<td>24</td>
<td>6</td>
<td>8</td>
<td>55</td>
<td>37</td>
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</table>
EXHIBIT "4"

PLAT FOR SITE 2 INCLUDING TRANSMISSION LINE ROUTE
EXHIBIT "5"

GEOTECHNICAL EVALUATION FOR SITE 2
GEOTECHNICAL STUDY FOR
PROPOSED RELOCATED WATER STORAGE TANK
HULETT, WYOMING
November 07, 1991

Bearodge Ltd.
P. O. Box 130
Sundance, Wyoming 82729

Attention: Mr. Ralph Goodson

SUBJECT: Geotechnical Study for the Relocated Proposed Water Storage Tank, Hulett, Wyoming
Chen-Northern Project No. 92-4311

Dear Mr. Goodson:

At your request, we have conducted a geotechnical study for the subject project in Hulett, Wyoming.

Subsurface conditions encountered in the exploratory borings consist of shallow, very hard siltstone and claystone bedrock, typically encountered at or near the ground surface.

The surficial bedrock is suitable to support anticipated structural loads on the order of 4,000 psf for a steel water tank founded on a gravel mat. We recommend the use of a concrete ring wall foundation, placed on the undisturbed surficial rock, designed for an allowable bearing pressure of 4,000 psf.

This report describes in detail our investigations, summarizes our findings, and presents our recommendations. It is important that we provide consultation during design, and field services during construction to review and monitor the implementation of the geotechnical recommendations.

If you have any questions regarding this report, please contact us.

Sincerely,

Scott G. Newhouse, P.E.
Project Engineer

Kenneth E. Temme, P.E.
Wyoming Division Manager
GEOTECHNICAL STUDY FOR
PROPOSED RELOCATED WATER STORAGE TANK
HULETT, WYOMING
JOB NO. 92-4311

PREPARED FOR:
BEARLODGE LTD.
P.O. BOX 130
SUNDANCE, WYOMING 82729

ATTENTION: MR. RALPH GOODSON

PREPARED BY:
CHEN-NORTHERN, INC.
605 NORTH WAREHOUSE ROAD
CASPER, WYOMING 82601

NOVEMBER 07, 1991
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    Site Drainage ............................................................................. 5
  Foundations ............................................................................... 6
    Foundation Concrete ............................................................... 7
Limitations ......................................................................................... 8

Figure 1  Location of Exploratory Borings
Figure 2  Logs of Exploratory Borings
Figure 3  Legend and Notes

Table I  Summary of Laboratory Test Results
PURPOSE AND SCOPE OF STUDY

This report presents the results of our geotechnical engineering study for the proposed water storage tank to be located in Hulett, Wyoming. The proposed tank has been relocated from the site evaluated in our previous geotechnical report (dated September 12, 1991) to the project site shown on Fig. 1. This study was conducted in accordance with our Agreement for Geotechnical Engineering Services with Bearlodge Ltd., dated October 18, 1991, to develop foundation recommendations for design and construction.

A field exploration program consisting of 3 exploratory borings was performed to obtain information on subsurface conditions. Samples of the soil and bedrock obtained during the field exploration were tested in the laboratory to determine physical and engineering characteristics. Results of the field exploration and laboratory tests were analyzed to develop recommendations for foundation types, depths and allowable bearing pressures for the proposed construction. The results of the field exploration and laboratory testing are presented herein.

This report has been prepared to summarize the data obtained during this study, and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters, and a discussion of geotechnical engineering considerations related to construction are included in the report.

PROPOSED CONSTRUCTION

Construction of a new water storage tank has been proposed within the general area shown on Fig. 1.
The new construction will consist of a steel tank approximately 50 ft. in diameter and 40 ft. in height. We understand that the steel tank will likely be placed on a gravel mat at an elevation near the existing grade. Because the foundation grade is near the existing grade, minimal site grading should be required.

If loadings, locations, or conditions are significantly different from those described above, or as depicted in this report, we should be notified so that we may re-evaluate the recommendations provided herein.

SITE CONDITIONS

The location of the proposed water tank is on a plateau, on an existing hillside, northwest of the Town of Hulett, about 500 ft. north of State Highway 112. The hillside slopes steeply downward to the south. The site is currently unoccupied, and generally bare of brush or vegetation. The difference in elevation across the tank footprint is on the order of 1.5-2.0 ft.

FIELD EXPLORATION

A Chen-Northern drilling crew performed the field exploration on October 22, 1991. Three exploratory borings were drilled at the locations shown on Fig. 1 to explore subsurface conditions. A Bearlodge Ltd. survey crew established boring locations, and determined surface elevations.

The borings were advanced through the overburden soils into the underlying bedrock using 4 in.- diameter continuous flight augers. A representative of Chen-Northern, Inc. logged the borings.
Samples of the subsurface materials were obtained with a 2 in.- I.D. spoon sampler. The samplers were driven into the various strata using a 140 lb hammer falling 30 in. The number of blows required to advance the sampler each successive 6-in. increment is recorded, and the total number of blows required to advance the sampler the final 12 in. is the penetration resistance ("N value"). This test is similar to the standard penetration test described by ASTM Method D1586. Penetration resistance values provide an indication of the relative density or consistency of the tested soils. Depths at which the samples were obtained, and the penetration resistance values are shown on the Logs of Exploratory Borings, Fig. 2. The legend and notes explaining the symbols and pertinent information with respect to the exploratory drilling program are included on Fig. 3.

During drilling, the crew made measurements of the groundwater levels in the borings. Borings were backfilled with auger cuttings immediately after completion of drilling.

LABORATORY TESTING

Samples of the soil and bedrock obtained during the field exploration were observed and classified in accordance with ASTM D2487, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the engineering and physical properties of the soils and bedrock, in accordance with ASTM, or other generally recognized procedures. Tests performed included natural moisture content, gradation, and Atterberg limits.

Results of all field and laboratory tests are summarized on the enclosed figures and tables. These data, along with visual field logging information, were used to prepare the exploratory boring logs shown on Fig. 2.
SUBSURFACE CONDITIONS

Site subsurface conditions were explored by drilling the 3 exploratory borings described above. The graphic logs of these borings are presented on Fig. 2, with descriptions of the soils and bedrock given on Fig. 3.

The subsurface profile generally consists of siltstone and claystone bedrock, encountered at or near the ground surface, and extending to the depth explored, a maximum depth of 20 ft. The surficial rock is occasionally overlain by a thin layer of sandy clay or topsoil, up to about 2 ft. thick (as encountered in boring B-2). The siltstone and claystone bedrock was encountered in all of the borings. The bedrock is generally very hard, as noted by the penetration resistance, or "N" values, which varied from 70 blows for 4 in. of penetration to 50 blows for no penetration. The bedrock becomes well cemented at relatively shallow depth, as indicated by practical auger refusal encountered in borings B-2 (at 7.5 ft. depth), and B-3 (at 5 ft. depth).

**Groundwater:** Groundwater was not encountered within the borings at the time of drilling. Numerous factors contribute to fluctuations of water table conditions. The evaluation of such factors is beyond the scope of this study. However, due to the site topography, and shallow rock, the presence of groundwater at anticipated foundation depths is unlikely.

ENGINEERING ANALYSIS/RECOMMENDATIONS

SITE GRADING

**General:** The storage tank will be located on a plateau, on an existing hillside. With the proposed tank floor elevation near the existing ground surface elevation, we anticipate minimal site grading will be required.
**Site Preparation:** The following recommendations should be followed for site preparation.

1. Any organic material within the proposed storage tank foundation footprint should be removed. All organic material should be wasted in an appropriate area where no significant earthwork is planned.

2. Fill should be approved by the Geotechnical Engineer, placed in uniform lifts and compacted to the following minimum percentages of the maximum dry densities as determined by ASTM D698 (Standard Proctor).
   
   A. Below Tank Floors .................................. 100%
   B. Below Footings .................................... 100%
   C. Trench Backfill ................................. 95%

Water content of fill soils should be kept within 2% of the optimum water content as determined in ASTM D698.

**Site Drainage:** Providing positive site drainage is critical. Positive site drainage should be provided to discharge surface waters away from the planned structure. The following surface drainage criteria should be observed and maintained during the life of the structure.

1. Excessive wetting or drying of the foundation excavation and tank floor areas should be avoided during construction.

2. The ground surface surrounding the exterior of the structure should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 6 in. in the first 10 ft.
FOUNDATIONS

Based upon anticipated structural loads, the surficial siltstone and claystone strata are suitable to support structural loads on the order of 4,000 psf. Therefore, the structure can be founded on a gravel mat placed uniformly beneath the tank. The gravel should be a minimum of 12 in. thick, and should be a coarse, crushed gravel. We recommend the gravel consist of Grading "W" base course aggregate meeting the requirements as outlined in the Wyoming Highway Department Specification for Road and Bridge Construction, Paragraph 703.06. The base course should be compacted to at least 100% of standard Proctor density, with a water content within 2% of the corresponding optimum content. When the gravel mat is placed as recommended, we estimate the tank will experience total settlement on the order of 3/4 to 1-1/4 in., with differential settlement on the order of 1/2 to 3/4 of the total settlement. Based upon results of field and laboratory testing, tank settlement will be proportional to the placement, and compaction of the foundation gravel.

If the tank cannot tolerate differential movements on the order given above, we recommend the use of a concrete ring wall foundation. The following design and construction criteria should be observed for a concrete ring wall.

1. The ring wall footing should be designed for an allowable soil bearing pressure on the order of to 4,000 psf. However, foundation design should employ a minimum footing width of 18 in. This minimum width will reduce punching or rocking action that may develop if a footing is too narrow.

2. Footings should be placed at least 4 ft. below grade for frost protection. This depth may require some ripping of the surficial rock, but should not require blasting.
3. The foundation walls should be designed to resist the forces exerted by an equivalent fluid unit weight of 60 pcf. This fluid unit weight is recommended assuming the on-site materials will be used for backfilling.

4. Continuous foundation walls should be reinforced top and bottom to span an unsupported length of at least 12 ft.

5. Due to the shallow depth to rock over the tank footprint, and varying depth to which excavating can be practically accomplished, the foundation subgrade may not be level after excavation. If an uneven foundation grade proves to be the case, the footing should be stepped to follow the foundation subgrade. If stepping the footing proves impractical, or inefficient, fill soil may be placed to produce a level, or nearly level, foundation subgrade. Fill placed into footing excavations should have a 2 in. maximum particle size, and be compacted to 100% of the maximum Standard Proctor dry density, with water content within 2% of optimum. If fill is to be placed, the overexcavation should be made wider 1 ft. for every 1 ft. of elevation difference of the step in subgrade.

6. A representative of the Geotechnical Engineer should observe all footing excavations prior to concrete placement.

FOUNDATION CONCRETE

In the course of preparing the previous report for this project, water soluble sulfates were measured in samples taken from the original proposed site. Test data indicated that the conditions on that site are very severe for potential sulfate attack on concrete. This degree of attack is based on the range given in the U.S. Bureau of Reclamation's Concrete Manual: negligible, positive, severe and very severe. While we have not performed such testing for the new, relocated tank site, the potential exists for
similar corrosion conditions on the new site. Therefore, we recommend that a Type II modified low C₃A, or Type V cement be used for all concrete in contact with the on-site soils.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated in Fig. 1, and the proposed construction discussed in this report. The nature and extent of subsurface variations across the site may not become evident until construction. During construction, if fill, soil, rock or water conditions appear to be different from those described herein, this office should be advised at once so re-evaluation of the recommendations may be made.

CHEN-NORTHERN, INC.

Scott G. Newhouse, P.E.
Project Engineer

Kenneth E. Temme, P.E.
Wyoming Division Manager
Proposed Water Storage Tank Tract

Proposed 500,000 Gal. Storage Tank

Existing R.O.W. Easement

Existing 1 Ac. Well Tract

LOCATION OF EXPLORATORY BORINGS Fig. 1
LOGS OF EXPLORATORY BORINGS

Boring 1
EL=3892.7

Boring 2
EL=3893.6

Boring 3
EL=3895.3

Fig. 2
Legend:

- Topsoil and Clay (CL), sandy, dry.
- Sand and Siltstone Fragments, very dense to very hard, dry to slightly moist, grey to grey/brown.
- Siltstone Bedrock, very hard, dry to slightly moist, grey to grey/brown.
- Claystone Bedrock, very hard, dry to slightly moist, red/brown with grey mottling.

Drive Sample. The symbol 50/8 indicates that 50 blows from a 140 lb. hammer falling 30 inches were required to drive a 1-3/8 inch I.D. spoon sampler a distance of 8 inches on an attempted 12-inch drive.

Indicates depth boring caved.

Indicates depth of auger refusal.

Notes:

1) Borings were drilled on October 22, 1991 using 4-inch diameter continuous flight auger.

2) Boring locations and surface elevations were determined by a Bearlodge Ltd. survey crew.

3) Groundwater was not encountered.

4) WC = Water Content (%)
   DD = Dry Density (pcf)
   LL = Liquid Limit (%)
   PI = Plasticity Index (%)
   -200 = Passing No. 200 Sieve (%)
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EXHIBIT "6"

HULETT WATER SUPPLY PROJECT, 1991
CONCEPTUAL DESIGN
Hulett Water Supply Project, 1991
Conceptual Design

Proposed Water Storage Tank Tract

500,000 Gallon Storage Tank

Existing R.O.W. Easement

10' Transmission Line (parallels Existing 6' Waterline) (445 FT.)

New Well

6' Supply Line

Existing 1 Ac. Well Tract

Existing 6' Water Main

10' Transmission Line (to Devils Tower Forest Products Sawmill)

Devils Tower Forest Products Property

Prepared By:
BEARLODGE LTD., INC.
Consulting Engineers & Land Surveyors
P.O. Box 128, 411 Main St., Sundance, WY 82729 (307) 283-3633

Hulett Water Supply Project 1991
Conceptual Design
EXHIBIT "7"

HULETT WATER SUPPLY PROJECT, 1991
WELL SITE DETAIL
HULETT WATER SUPPLY PROJECT, 1991
WELL SITE DETAIL

SCALE 1" = 2'

NOTE: Well House will be insulated and heated for all-year operation.

Prepared By:
BEARLODGE LTD., INC.
Consulting Engineers & Land Surveyors
P.O. Box 138, 611 Main St., Sundance, WY 82729 (307) 283-3633

HULETT WATER SUPPLY PROJECT
1991
Well Site Detail

Drawn By: KOR
Date: 10-16-91
Scale: 1" = 2'

Revised By: KOR
Date: 10-16-91
Sheet 2 of 2

DUCTILE IRON PIPE
A (90° CL)
B (AIR-VAC VALVE)
C (FLOW CONTROL VALVE)
D (DRESSER COUPLER)
E (WATER METER)
F (TEE)
G (BLOW-OFF)
H (RESILIENT WEDGE VALVE)
I (PRESSURE GAUGE)
J (SMOOTH WEDGE SAMPLING TAP)
K (CHECK VALVE)
HULETT POPULATION PROJECTIONS

- Actual Hulett
- Estimated Hulett
- Actual Crook Co.
- Estimated Crook County