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REPORT OF GEOTECHNICAL INVESTIGATION
FOR

PHASE II SAGE CREEK WATER LINE
RAWLINS, WYOMING
July 29, 1987

J.M. Montgomery Consulting Engineers, Inc.
161 Mallard Drive
Boise, Idaho 83706

Attention: Mr. Dennis Suikonen

Subject: Phase II Sage Creek Waterline
Rawlins, Wyoming

Gentlemen:

At your request and in accordance with our agreement dated May 14, 1987, we have made an investigation of subsurface soil and rock conditions along the route of the proposed Phase II Sage Creek Waterline in Carbon County, near Rawlins, Wyoming.

We have discussed our findings with you as the work progressed, and the report which follows describes our investigations, summarizes our findings, and presents our recommendations.

Subsurface soil and rock at the site consist of clays, sands, shales, and sandstone. There are limited areas along the route where rock excavation may be required and where groundwater will be high. A portion of the line was rerouted to avoid areas of slope instability.

In order for you to better understand this report and the limitations of geotechnical studies with respect to findings, opinions, and recommendations, we have included in the Appendix an information sheet for geotechnical engineering reports. If you have any questions regarding this report, or if we can be of further service, please contact us.

Respectfully submitted,

Walter V. Jones, P.E.
Salt Lake Area Manager

Al Stilley, P.E.
Area Geotechnical Engineer
REPORT
OF
GEOTECHNICAL INVESTIGATIONS

PHASE II SAGE CREEK WATER LINE
RAWLINS, WYOMING

TO
J.M. MONTGOMERY CONSULTING ENGINEERS, INC.
BOISE, IDAHO

PREPARED
BY
NORTHERN ENGINEERING AND TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS
SALT LAKE CITY, UTAH

JULY, 1987
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INTRODUCTION

The purpose of this investigation was to obtain information concerning geologic and subsurface conditions and engineering properties of the subsoil, on which to base recommendations for routing of the proposed Phase II Sage Creek Waterline, south of Rawlins, Wyoming.

Preliminary design details indicate the pipeline will probably be a 20-inch mortar lined and tape coated steel pipe. Minimum depth of cover will be five feet. The pipeline will extend about 10 miles south from the end of the Phase I line. Approximately 8 miles of the pipeline will follow the right-of-way of a county road, while about 2 miles of the pipeline will cross BLM land.

Initially, the south portion of the new pipeline was routed near an existing buried pipeline. During mapping, several landslides, which could affect this portion of the line were discovered. Our letter to you, dated June 22, 1987 outlined the stability problems. An alternate route through the bottom of Sage Creek was recommended. This alternate route is shown on the enclosed drawings. We understand that this alternate route will be used.

SITE INVESTIGATIONS

Initially, the surface geology along the proposed route was mapped. Twenty-seven test pits were then excavated to depths varying from 5.3 to 10.5 feet, at locations shown on the enclosed Drawing Nos. 87-2335-1 through 87-2335-3. Test pit locations were determined by vehicle odometer readings, and elevations were determined by interpolation between contours on USGS topographic maps. The location and elevation of the test pits should be considered accurate only to the degree implied by the method used.

The field investigations were performed under the direction of our geologist/engineer. Continuous logs of the soil conditions were recorded, disturbed samples obtained, and groundwater levels measured during the field exploration program.

LABORATORY INVESTIGATIONS

Samples obtained during the field exploration were taken to the laboratory where they were carefully inspected and visually classified in accordance with ASTM D2487 which is based on the Unified Soils Classification System. A chart of this classification system is shown in the Appendix. Representative samples were selected for tests to determine engineering and physical properties of the soils, in general accordance with ASTM or other approved procedures.

These included: To determine:

Grain-size distribution . . size and distribution of soil particles, i.e., clay, silt, sand, gravel.

Atterberg limits . . . . . . the consistency and stickiness, as well as the range of moisture content within which the material is workable.

(-1-)
Natural moisture . . . . . moisture content representative of field conditions at time sample was taken.

Moisture-density relationship the optimum (best) moisture content for compacting soil and the maximum dry unit weight (density) for a given compactive effort.

Chemical Analysis . . . . Sulfate, chloride and pH tests were conducted to determine the potential for deterioration of buried pipe materials.

Results of all field and laboratory tests are summarized on the enclosed Test Pit Logs, Table and Plates. This information, along with the field observations, was used to prepare the final test pit logs shown in the Appendix. Sampling and testing procedures are further described in the Appendix.

GEOLOGY AND SUBSURFACE CONDITIONS

We understand that the alternate route along the county road, and through the Sage Creek Valley at the south end of the line, will be used. This is the portion shown as the Alternate Route on Drawing Nos. 87-2335-2 and 87-2335-3. Discussion of conditions along the route have been confined to this alternate route.

The proposed waterline route is located in Carbon County, south of Rawlins, Wyoming. It follows the Sage Creek Road for about 8 miles. Approximately one mile after it crosses Sage Creek, the line extends to the west, to near Sage Creek. It then roughly parallels Sage Creek for about one more mile, where it connects with the existing line.

The surface topography outside of the Sage Creek drainage, consists of low rolling hills with broad drainages. The Sage Creek drainage, at the south end of the line has cut a steep drainage about 1/4 mile wide. The bottom of this drainage is relatively flat, but steep sandstone bluffs form the sides of the drainage. Vegetation along the route consists of sagebrush, prairie grasses, and phreatophytic grasses in the creek bottoms.

Route Geology

There is a thin layer of residual or alluvial soil overlying the sedimentary rock along most of the route. The proposed pipeline will traverse several geologic formations. (1)

The north 5.5 miles of the Phase II waterline will traverse the Steele Formation (upper Cretaceous). Along this section of the waterline the Steele Formation is a gray shale interbedded with thin sandstone lenses, with occasional resistant sandstone up to 2 feet in thickness noted in outcrops. The next 2.2 miles of the pipeline will cross the Niobrara Formation (upper Cretaceous). Along this section, the Niobrara Formation is a gray-brown to

black shale interbedded with thin layers of sandstone. The next approximately 1.2 miles of the pipeline will be located in the Frontier Formation (upper Cretaceous). The Frontier Formation is a dark gray to brown sandy shale interbedded with thin layers of sandstone. The next section of the pipeline will follow the lower Cretaceous Mowry Shale. The Mowry Shale is a dense dark-gray shale with occasional layers of very dense siliceous shale. The pipeline will then cross the Thermopolis Shale and the Cloverly Sandstone; both are lower Cretaceous. The Thermopolis Shale is a hard, siliceous dark-gray shale. The Cloverly sandstone is a tan massive sandstone. The line then follows colluvial deposits through the bottom of the Sage Creek drainage. Alluvial deposits are also present near the bottom of drainages. Approximate formation boundaries are shown on the enclosed Drawings.

**Subsurface Profile**

The subsurface profile along the route, except about the south 1 mile of line generally consists of a thin layer of gravel, sand, or clay overlying the sedimentary rock. Most of the sand and clay represent residual soil formed upon the sedimentary rock. From field mapping and interpolation between test pits, we have estimated segments of the proposed pipeline where difficult excavation of bedrock is within 10 feet of the surface. These approximate areas are shown on the enclosed drawing and are summarized below:

<table>
<thead>
<tr>
<th>Approximate Distance From North End of Phase II, Miles</th>
<th>Estimated Depth to Difficult Excavation of Bedrock</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 to 0.6</td>
<td>Greater than 10 feet</td>
</tr>
<tr>
<td>0.6 to 0.8</td>
<td>Less than 10 feet</td>
</tr>
<tr>
<td>0.8 to 1.4</td>
<td>Greater than 10 feet</td>
</tr>
<tr>
<td>1.4 to 1.9</td>
<td>Less than 10 feet</td>
</tr>
<tr>
<td>1.9 to 3.3</td>
<td>Greater than 10 feet</td>
</tr>
<tr>
<td>3.3 to 4.3</td>
<td>Less than 10 feet</td>
</tr>
<tr>
<td>4.3 to 5.6</td>
<td>Greater than 10 feet</td>
</tr>
<tr>
<td>5.6 to 5.8</td>
<td>Less than 10 feet</td>
</tr>
<tr>
<td>5.8 to 7.8</td>
<td>Greater than 10 feet</td>
</tr>
<tr>
<td>*7.8 to 8.0</td>
<td>Less than 10 feet</td>
</tr>
<tr>
<td>8.0 to 9.7</td>
<td>Greater than 10 feet</td>
</tr>
</tbody>
</table>

* depends upon routing adjacent to archeological site

At the creek crossings, the depth to bedrock may be in excess of 10 feet.

Approximately the south one mile of the line will cross colluvial deposits in the Sage Creek drainage. Large blocks of sandstone are evident in areas of creek erosion. These will be very difficult to excavate if encountered in the waterline trench.

Groundwater was encountered only in Test Pit Nos. 15 and 19. Both of these pits were located in drainages. Groundwater can probably be anticipated at locations where the pipeline route crosses drainages or creeks. There are several areas of seepage in the Sage Creek drainage, within the south 1 mile of the line.
The stratification lines shown on the Test Pit Logs represent the approximate boundaries between soil and rock types; the actual in situ transition may be gradual.

DESIGN AND CONSTRUCTION CONSIDERATIONS

Trench Stability

Several methods are normally used to protect workmen in the excavated trench, during placement and backfilling of the pipe. At this location, where the route traverses undeveloped area, and the trench depth is not excessive, it appears that sloping of the excavation walls is the most practical method. If necessary, other methods, such as the use of a trench shield, or braced excavations could be considered.

Rock Excavation

Excavation of the test pits was performed using a Case 580 backhoe. Test pits where backhoe refusal, due to hard rock occurred, were as follows:

<table>
<thead>
<tr>
<th>Test Pit No.</th>
<th>Depth of Excavation at Refusal, Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.6</td>
</tr>
<tr>
<td>7</td>
<td>8.0</td>
</tr>
<tr>
<td>8</td>
<td>9.5</td>
</tr>
<tr>
<td>21</td>
<td>7.3</td>
</tr>
<tr>
<td>23</td>
<td>5.3</td>
</tr>
<tr>
<td>27</td>
<td>6.5</td>
</tr>
</tbody>
</table>

It appears that excavations along most of the route can probably be made to relatively shallow depths with conventional excavation equipment. It is anticipated that very difficult excavation conditions will be encountered in areas as noted previously. In some of these areas, it may be less expensive to trench using rock excavation techniques, such as the use of explosives. We anticipate that excavation conditions will be more difficult along the Phase II portion of the route, than along the Phase I.

We were not able to access the last approximately one mile on the south end of the route with a backhoe due to steep terrain where the line enters the Sage Creek drainage. Hard sandstone is evident on the slopes in this area, and large blocks of sandstone, which apparently have rolled down from the higher elevations, are evident in the erosion channels of Sage Creek. Rock excavation techniques may be required where the line enters the drainage, and if large blocks of sandstone are encountered in the colluvium in the drainage.

Groundwater

It does not appear there are extensive areas of high groundwater along the route. In the north 9 miles of the line, it is expected that groundwater will be encountered mainly at drainage crossings. Considerable groundwater may be encountered at the Sage Creek crossing, depending on the time of year of construction.
Evidence of groundwater seepage or springs was noted in the south one mile of the route, primarily in the area where the line descends from the higher elevations, into the Sage Creek drainage.

At locations where groundwater is encountered, it will be necessary to dewater during construction for proper bedding and backfill compaction. These types of subsurface materials normally have a relatively low permeability and dewatering is usually accomplished by pumping from sumps within the excavation.

Miscellaneous

It will probably be necessary to provide bedding to properly support the pipe and prevent stress concentrations. A recommended bedding configuration with material requirements has been provided in the recommendations. It did not appear that sufficient quantities of granular material suitable for pipe bedding were present along the route.

It appears that most of the in-place materials are suitable for trench backfill. It will be necessary to moisture condition most of the natural materials for proper compaction. If excavation of the bedrock materials produces large size particles it may be necessary to break the particles down, or dispose of the oversize materials in the zone away from the pipe. Recommendations for backfill materials and their placement density are provided.

The results of chemical tests conducted on composite samples obtained from the test pits are provided in the Appendix.

RECOMMENDATIONS

1. While it is the responsibility of the contractor to provide safe working conditions in connection with underground excavations, the following guidelines are provided for planning purposes: Temporary construction excavations deeper than 4 feet should be no steeper than shown below, or be shored.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Slope Inclination, Horizontal to Vertical, Above Groundwater</th>
<th>Below Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay, Silt or Sand</td>
<td>1:1</td>
<td>2:1</td>
</tr>
<tr>
<td>Bedrock</td>
<td>1/4:1</td>
<td>1/2:1</td>
</tr>
</tbody>
</table>

2. On site materials are generally suitable for trench backfill.
3. The following pipe bedding and backfill scheme, or an approved equivalent, should be used:

![Diagram of pipe bedding and backfill scheme]

4. Backfill and bedding should meet the following grading requirements:

<table>
<thead>
<tr>
<th>Screen or Sieve Size</th>
<th>Pipe Bedding</th>
<th>Type I Backfill</th>
<th>Type II Backfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 inch</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3 inch</td>
<td>100</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1 inch</td>
<td>100</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 10</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

5. Pipe bedding and Type I backfill should be compacted to at least 95 percent of maximum dry density, as determined by ASTM D698. If surface settlement is a concern, Type II backfill should be compacted in accordance with the above requirements.

The information provided in this report is based on the observation of surface conditions, combined with interpolation between widely spaced test pits. To a certain extent, the ease of construction of the line will depend...
on the equipment and the construction techniques selected. We have arrived at our conclusions assuming equipment and techniques common to the industry would be used. Variations in the subsurface materials may be exposed during construction. If conditions vary significantly from those encountered in our borings, re-evaluation may be necessary.

If changes in the nature, design, or location of the route are planned, the conclusions reached in this report shall not be considered valid unless the changes are reviewed and modified or verified in writing.
More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, thanks to the Association of Soil and Foundation Engineers (ASFE).

When ASFE was founded in 1969, subsurface problems were frequently being resolved through lawsuits. In fact, the situation had grown to such alarming proportions that consulting geotechnical engineers had the worst professional liability record of all design professionals. By 1980, ASFE-member consulting soil and foundation engineers had the best professional liability record. This dramatic turnabout can be attributed directly to client acceptance of problem-solving programs and materials developed by ASFE for its members' application. This acceptance was gained because clients perceived the ASFE approach to be in their own best interests. Disputes benefit only those who earn their living from others' disagreements.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays, cost-oversruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved; its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of his report may affect his recommendations.

Unless your consulting geotechnical engineer indicates otherwise, your geotechnical engineering report should not be used:
- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

A geotechnical engineer cannot accept responsibility for problems which may develop if he is not consulted after factors considered in his reports development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by the geotechnical engineer who then renders an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those opined to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. For example, the actual interface between materials may be far more gradual or abrupt than the report indicates, and actual conditions in areas not sampled may differ from predictions.

Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact. For this reason, most experienced owners retain their geotechnical consultant through the construction stage, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time. Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy...
of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by the geotechnical engineer based upon his interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, give contractors ready access to the complete geotechnical engineering report. Those who do not provide such access may proceed under the mistaken impression that simply claiming responsibility for the accuracy of subsurface information insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgement and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are not exculpatory clauses designed to foist the geotechnical engineer's liabilities onto someone else. Rather, they are definitive clauses which identify where the geotechnical engineer's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, the Association of Soil and Foundation Engineers has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

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301/565-2733
APPENDIX

EXPLORATION AND LABORATORY TESTING

Exploration

Field exploration is performed using a truck or skid-mounted rotary drilling machine equipped with either augers, tricone rock bits, or coring apparatus. Standard penetration testing and undisturbed sampling can be performed through our hollow-stem auger, which serves as casing. When drilling in large, dense gravel, rock fragments, or bedrock, special casing is usually required to maintain an open hole. The soils are continuously logged by an engineer or geologist and classified by visual examination in accordance with the Unified Soils Classification System.

Samples of soils are taken at frequent intervals in the boring excavation. Disturbed samples are normally taken by the standard penetration test. This test is made by driving a 2 inch O.D. split-spoon sampler 18 inches into the soil by striking it with a 140 pound hammer dropping 30 inches. The total number of blows required to advance the sampler the second and third 6 inch increments is the standard penetration resistance. Occasionally, a cone penetrometer will be driven continuously from the ground surface to locate soft zones or to simulate the driving of piling into subsurface soils. The cone is 1-13/16 inches in diameter and is driven with the same hammer and dropping distance as the standard penetrometer. Undisturbed samples are obtained from layers of soil that are critical to the analysis. Samples of representative soils are obtained by pushing, or possibly driving, a thin-walled steel sampler into the soil layer. The soil is retained in brass rings of 2.00 to 2.50 inches in diameter and 1.00 inches in height. Normally, the central 6 inch portion of the sample is retained in close-fitting, plastic, waterproof containers which are in turn placed in cushioned boxes for shipment to the laboratory. Occasionally, thin-walled Shelby tubes are used to sample sensitive soils that are easily disturbed.

Under certain conditions and with certain project requirements, in-place vane shear, percolation, resistivity and/or California bearing ratio tests may be performed in accordance with standard procedures.

Laboratory Classification & Testing

The field classification is verified in the laboratory, where all of the samples are classified by an experienced person other than the one who made the field classification. The classification process in the laboratory normally includes estimation of the percents of gravel or rock fragments, sand, silt, and clay fractions, and the liquid and plastic limits. The natural moisture content of all fine-grained soil and bedrock samples is determined.

Based on the classification tests, one or more of each representative type of soil encountered is selected for more detailed analysis. The data from the field and the laboratory investigations is used to prepare the final test boring logs (shown on the Drawing).
Moisture - Natural Density

Moisture content and in-place density tests are utilized to determine local variations in soil consistency. This information can also provide a correlation between soils found at this site and other sites in the general area. The dry unit weight and moisture content of selected undisturbed samples, or of in-place soil layers, and the moisture content of all cohesive or fine-grained samples, are determined.

Laboratory and Field Bearing Ratio (CBR)

The soil sample is compacted in a 6-inch-diameter steel mold to form a 5-inch-thick specimen of a desired density. Under a confining pressure which simulates the overburden weight of the pavement, the specimen is saturated and a 2-inch-diameter piston forced into it. The CBR is the ratio of the actual load required to produce 0.1 inch of deflection to that required to produce 0.1 inch of deflection in a dense, well-graded, crushed gravel.

The field CBR test is performed on in-place soil at natural moisture content in a similar manner.

This semi-empirical index of the strength and deflection characteristics of the soil has been correlated to actual pavement performance to establish design curves for pavement thickness.

Consolidation

The apparatus used for consolidation tests is designed to receive one of the one-inch-high rings of soil as it comes from the field. Loads are applied to the test specimen in several increments, and resulting deformations are recorded at selected time intervals. Porous stones are placed in contact with the top and bottom of the specimen to permit the ready addition or release of water.

Samples are tested at their field moisture content and at increased moisture content where the soils may become saturated during the life of the structure.

Sulfate

The water soluble sulfate concentration of the soil is measured to estimate the potential for sulfate attack on adjacent concrete structures. The analysis is a gravimetric determination of the water soluble sulfate, using barium chloride precipitation of the sulfate. The method for predicting sulfate attack on concrete is described in the Bureau of Reclamation Concrete Manual.
Shear Tests

Direct shear tests are made with a shear machine of the strain control type. The machine is designed so that tests are performed without removing the samples from the brass rings. Samples are tested using a normal or confining load approximately equal to the existing weight of the soil above the point of sampling, or future loads from embankments and foundations.

Samples are also tested at higher and lower normal loads in order to determine the Coulomb shear strength parameters. In some cases, where soils will become wetted during the life of the structures, the samples may be saturated before testing.

Unconfined compression and triaxial shear tests, with or without pore pressure measurement, may be made where conditions warrant their use.
Photograph No. 1 - From near north end of line looking south. Test Pit No. 2 is beyond drainage. (See enclosed drawings for photograph location and direction of view).

Photograph 2 - Looking south at Creek Crossing near Deadman Springs.
Photograph 3 - Looking south along pipeline route with Rasmussen Creek drainage in foreground.

Photograph 4 - Looking south up Sage Creek drainage from near Test Pit 19. Alternate route is located on left of drainage.
Photograph 5 - View of original pipeline route along base of cliff showing landslides. Alternate pipeline route is left of Sage Creek in bottom of drainage. Note large Sandstone blocks in colluvium.
Photograph 6 - Looking north at toe of landslide along original pipeline route. Alternate route avoids this area.
Photograph 7 - Looking west of old dormant landslide on original pipeline route. Alternate route avoids this area.
Photograph 8 - Looking west from east side of Sage Creek at landslides along original route. Alternate route in foreground avoids landslide areas.
### TABLE I

Result of Chemical Analysis

---

**ANALYTICAL REPORT**

July 21, 1987  
Job No: 87-927  
Sheet No. 1 of 2  
Invoice No. 870721-03

NORTHERN ENGINEERING AND TESTING, INC.  
ATTN: MR. AL STILLEY  
P O BOX 281  NORTH SALT LAKE, UT  84054

Report of: Soils Analysis (87-2335)

Sample Identification:

On June 26, 1987, these soil samples were received in our laboratory for analysis. Tests were conducted according to ASA and USDA procedures. The results of the analysis are as follows.

**TEST RESULTS:**

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Sample Description</th>
<th>Depth, feet</th>
<th>pH, standard units</th>
<th>Water Soluble Chloride as Cl, mg/kg</th>
<th>Sulfate, as SO_4, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>89816</td>
<td>Test Pit 1 (18508)</td>
<td>0.3 - 10.0</td>
<td>7.5</td>
<td>66</td>
<td>0.30</td>
</tr>
<tr>
<td>89817</td>
<td>Test Pit 2 (18510)</td>
<td>3.8 - 10.5</td>
<td>7.6</td>
<td>64</td>
<td>0.19</td>
</tr>
<tr>
<td>89818</td>
<td>Test Pit 3 (18511)</td>
<td>0.8 - 8.3</td>
<td>7.6</td>
<td>119</td>
<td>0.44</td>
</tr>
<tr>
<td>89819</td>
<td>Test Pit 4 (18513)</td>
<td>2.5 - 10.0</td>
<td>7.4</td>
<td>39</td>
<td>0.46</td>
</tr>
<tr>
<td>89820</td>
<td>Test Pit 5 (18514)</td>
<td>0.3 - 10.5</td>
<td>7.4</td>
<td>7</td>
<td>0.87</td>
</tr>
<tr>
<td>89821</td>
<td>Test Pit 6 (18515)</td>
<td>0.5 - 10.5</td>
<td>8.2</td>
<td>112</td>
<td>1.41</td>
</tr>
<tr>
<td>89822</td>
<td>Test Pit 7 (18517)</td>
<td>0.3 - 8.0</td>
<td>7.3</td>
<td>14</td>
<td>0.42</td>
</tr>
<tr>
<td>89823</td>
<td>Test Pit 8 (18518)</td>
<td>0.5 - 9.5</td>
<td>7.1</td>
<td>20</td>
<td>0.20</td>
</tr>
<tr>
<td>89824</td>
<td>Test Pit 9 (18519)</td>
<td>0.5 - 10.3</td>
<td>7.2</td>
<td>142</td>
<td>0.74</td>
</tr>
<tr>
<td>89825</td>
<td>Test Pit 10 (18521)</td>
<td>5.8 - 9.7</td>
<td>7.1</td>
<td>80</td>
<td>0.25</td>
</tr>
<tr>
<td>89826</td>
<td>Test Pit 11 (18522)</td>
<td>0.0 - 10.4</td>
<td>7.2</td>
<td>31</td>
<td>0.36</td>
</tr>
<tr>
<td>89827</td>
<td>Test Pit 12 (18523)</td>
<td>0.0 - 10.5</td>
<td>7.4</td>
<td>11</td>
<td>0.56</td>
</tr>
<tr>
<td>89828</td>
<td>Test Pit 13 (18525)</td>
<td>0.0 - 10.0</td>
<td>7.2</td>
<td>7</td>
<td>0.62</td>
</tr>
<tr>
<td>89829</td>
<td>Test Pit 14 (18526)</td>
<td>0.0 - 10.5</td>
<td>7.0</td>
<td>141</td>
<td>0.80</td>
</tr>
<tr>
<td>89830</td>
<td>Test Pit 15 (18527)</td>
<td>0.0 - 8.0</td>
<td>7.2</td>
<td>35</td>
<td>0.31</td>
</tr>
</tbody>
</table>
Mountain States Analytical, Inc.

SOILS ANALYSIS
(87-2335)

July 21, 1987
Job No. 87-927
Sheet 2 of 2

TEST RESULTS (cont.):

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Sample Description</th>
<th>Depth, standard feet</th>
<th>pH, standard units</th>
<th>Water Soluble Chloride as Cl, mg/kg</th>
<th>Sulfate, as SO4, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>89831</td>
<td>Test Pit 16 (18528)</td>
<td>0.2 - 10.0</td>
<td>7.2</td>
<td>24</td>
<td>0.10</td>
</tr>
<tr>
<td>89832</td>
<td>Test Pit 18 (18529)</td>
<td>0.5 - 8.0</td>
<td>7.4</td>
<td>213</td>
<td>0.22</td>
</tr>
<tr>
<td>89833</td>
<td>Test Pit 19 (18531)</td>
<td>0.5 - 9.7</td>
<td>7.9</td>
<td>36</td>
<td>0.77</td>
</tr>
<tr>
<td>89834</td>
<td>Test Pit 20 (18532)</td>
<td>0.4 - 2.5</td>
<td>7.3</td>
<td>174</td>
<td>0.03</td>
</tr>
<tr>
<td>89835</td>
<td>Test Pit 22 (18535)</td>
<td>1.6 - 6.2</td>
<td>6.9</td>
<td>16</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Reviewed by [Signature]
Northern Engineering and Testing, Inc.

MOISTURE - DENSITY RELATIONSHIP DATA

Client: J.M. Montgomery
Location Sampled: TP-12, 0.0' - 10.5'
Sampled By: Northern
Date: June 1987

Sample No.: 18524
Job No.: 87-2335
Date: July 1987

TEST METHODS
ASTM D698
Method A

Zero Air Voids Curve Assumed
Gs = 2.70

SOIL CONSTANTS
Classification: Shale Claystone
Liquid Limit: 31%
Plasticity Index: 13%
Max. Density: 111.6pcf
Optimum Moisture: 16.8%

SOIL USE
Phase II Sage Creek
Waterline; Rawlins, Wyoming
TP-12, 0.0' - 10.5'

PLATE NO. 2
LOGS OF EXPLORATIONS

EXPLANATION OF ABBREVIATIONS AND DESCRIPTIVE TERMS

SSS (SPT) - Standard penetration resistance test -- results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 2-inch O.D. split sample spoon the second and third 6-inch increments of an 18-inch distance.

LSS - Modified penetration test -- results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 2.5-inch O.D. split sample spoon the second and third 6-inch increments of an 18-inch distance.

CPT - Cone penetration test -- results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 1-13/16-inch-diameter cone one foot.

SRS - Split barrel ring sample 2-inches I.D. for taking undisturbed samples.

LRS - Split barrel ring sampler 2.5-inches for taking undisturbed samples.

STS - Shelby tube sample for taking undisturbed samples (2" to 3-5/16" I.D.).

Sack (SK) or Bag - Sample of disturbed soil placed in canvas sack or plastic bag.

GWL - Groundwater level on day of completion of field investigations.

FD - In-place dry density.

RQD - Rock quality designation (RQD) for the bedrock samples are determined for each core run by summing the length of all sound, hard pieces of core over 4 inches in length, and dividing this number by the total length of the core run. This value, along with the core recovery percentage, is recorded on the drill logs.

GNP - Granular Non-plastic.

PP - Approximate unconfined compressive strength in tons per square foot determined with a hand held pocket penetrometer on the sample in the field.

<table>
<thead>
<tr>
<th>GRAIN SIZES</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Standard Series Sieve Clear Square Sieve Openings</td>
</tr>
<tr>
<td>200 50 16 4 3/4&quot; 3&quot; 6&quot;</td>
</tr>
<tr>
<td>Silts &amp; Clays</td>
</tr>
<tr>
<td>Fine Medium Coarse</td>
</tr>
<tr>
<td>MOISTURE CONDITION (INCREASING MOISTURE -------&gt;)</td>
</tr>
<tr>
<td>Dry</td>
</tr>
<tr>
<td>(PL)</td>
</tr>
<tr>
<td>RELATIVE DENSITY</td>
</tr>
<tr>
<td>CONSISTENCY</td>
</tr>
<tr>
<td>Clays &amp; Silts</td>
</tr>
<tr>
<td>Soft</td>
</tr>
<tr>
<td>Firm</td>
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<tr>
<td>Stiff</td>
</tr>
<tr>
<td>Very Stiff</td>
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<tr>
<td>Hard</td>
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</tbody>
</table>
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D 2487 - 83
(Based on Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests

<table>
<thead>
<tr>
<th>Coarse-Grained Soils</th>
<th>Gravels</th>
<th>Clean Gravels</th>
<th>Gravels with Fines</th>
<th>Sands</th>
<th>Clean Sands</th>
<th>Sands with Fines</th>
<th>Fine-Grained Soils</th>
<th>Silts and Clays</th>
<th>Inorganic</th>
<th>Organic</th>
<th>Highly organic soils</th>
<th>Primarily organic matter, dark in color, and organic odor</th>
<th>Peat</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 50% retained on No. 200 sieve</td>
<td>More than 50% coarse fraction retained on No. 4 sieve</td>
<td>Less than 5% fines</td>
<td>More than 12% fines</td>
<td>50% or more coarse fraction passes No. 4 sieve</td>
<td>Less than 5% fines</td>
<td>More than 12% fines</td>
<td>50% or more passes the No. 200 sieve</td>
<td>Liquid limit less than 50</td>
<td></td>
<td>Liquid limit - oven dried</td>
<td>Liquid limit - not dried</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravels</td>
<td>Gravels with Fines</td>
<td>Gravels with Fines</td>
<td>Sands</td>
<td>Sands</td>
<td>Sands with Fines</td>
<td>Silts and Clays</td>
<td>Liquid limit 50 or more</td>
<td>Silts and Clays</td>
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<td>More than 12% fines</td>
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<tr>
<td>Clean Gravels</td>
<td>Gravels with Fines</td>
<td>Gravels with Fines</td>
<td>Clean Sands</td>
<td>Sands</td>
<td>Sands with Fines</td>
<td>Inorganic</td>
<td>Organic</td>
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<td></td>
<td>More than 12% fines</td>
<td></td>
<td>Less than 5% fines</td>
<td></td>
<td></td>
<td>PI &gt; 7 and plots on or above &quot;A&quot; line</td>
<td>Liquid limit - oven dried</td>
<td>Liquid limit - not dried</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
| | | | | | | PI < 4 or plots below "A" line | OL | Organic clay 
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LOG OF EXPLORATION BORING

PROJECT: Phase II Sage Creek Waterline
Rawlins, Wyoming

JOB NO: 87-2335

DRILL TYPE: SOIL Case 580 Backhoe

ROCK DRILLED BY: City of Rawlins

LOGGED BY: B. Williams

REMARKS: *Composite Sample taken from 0.3' to 10.0' for chemical analysis
See Table 1 for Test Results

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
</tr>
<tr>
<td>0.3</td>
<td>Shale Claystone; soft rock, moist, weathered near surface, lenses of sandy shale, gray-brown</td>
</tr>
<tr>
<td>5.0</td>
<td>Bag</td>
</tr>
<tr>
<td>10.0</td>
<td>BOTTOM OF TEST PIT</td>
</tr>
</tbody>
</table>

GROUNDWATER Not Encountered

LOCATION: Approx. 0.2 miles South of beginning of Project

ELEVATION: TOP OF HOLE Approx. 7128

DATE: HOLE STARTED 6-18-87
COMPLETED 6-18-87

SHEET 1 OF 1

NET 122B
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE: SOIL ROCK**  
Case 580 Backhoe  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**LOCATION:** Approximately 1.2 miles South of beginning of Project  
**ELEVATION: TOP OF HOLE**  
**GROUNDWATER** Not Encountered  
**DATE: HOLE STARTED** 6-18-87  
**COMPLETED** 6-18-87  
**NET** 1228

**LOCATION: Approx. 1.2 miles South of beginning of Project**  
**HOLE NO.** TP-2  
**SHEET 1 OF 1**  
**DRILL TYPE:** SOIL ROCK  
**ELEVATION:** Approx. 7162  
**GROUNDWATER:** Not Encountered  
**DATE:** HOLE STARTED 6-18-87  
**COMPLETED** 6-18-87  
**LOGGED BY:** B. Williams  
**REMARKS:** *Composite sample taken from 3.8' to 10.5' for chemical analysis  
See Table No. 1 for Test Results*

<table>
<thead>
<tr>
<th>DEPTH (Ft)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (N) (GLOWS/FT)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>LL</th>
<th>PI</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td>Silty Sand with Gravel; loose, moist, rounded, brown (SM)</td>
<td>Bag</td>
<td>--</td>
<td>7</td>
<td>GNP</td>
<td>29</td>
<td>47</td>
<td>-24-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>Sandy Shale; soft rock, moist, weathered, brown</td>
<td>Bag*</td>
<td>--</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>BOTTOM OF TEST PIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Composite sample taken from 3.8' to 10.5' for chemical analysis*  
*See Table No. 1 for Test Results*
## LOG OF EXPLORATION BORING

**PROJECT:** Phase II Sage Creek Waterline
**Location:** Rawlins, Wyoming
**Job No.:** 87-2335
**Drill Type:** Soil
**Drilled By:** City of Rawlins
**Logged By:** B. Williams

**HOLE NO.:** TP-3
**Sheet:** 1 of 1
**Location:** Approximately 1.6 miles South of Beginning of Project
**Elevation:** Top of Hole Approx. 7160
**Groundwater:** Not Encountered
**Date:** Hole Started 6-18-87, Completed 6-18-87

### REMARKS:
*Composite sample taken from 0.0’ to 8.3’ for chemical analysis. See Table No. 1 for Test Results*

### CLASSIFICATION AND DESCRIPTION

<table>
<thead>
<tr>
<th>Depth (Ft)</th>
<th>Classification and Description</th>
<th>Sample</th>
<th>S.P.T. (N) (Blows/ft)</th>
<th>Moisture Content (%)</th>
<th>In-Place Dry Density (pcf)</th>
<th>LL %</th>
<th>PI %</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Shale, Claystone; soft rock, moist, weathered near surface, lenses of sandy shale, brown</td>
<td>Bag</td>
<td>--</td>
<td>7</td>
<td>28</td>
<td>9</td>
<td>17</td>
<td>25</td>
<td>-58</td>
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<td></td>
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<tr>
<td>5.0</td>
<td>Sandstone; hard rock, moist, fine-grained, well cemented, brown</td>
<td>Bag</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8.3</td>
<td>Backhoe refusal at 8.6’</td>
<td>Bag</td>
<td>--</td>
<td></td>
<td></td>
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</table>
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE:** SOIL  
Case 580 Backhoe  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**LOCATION:** Approximately 2.1 miles South of Beginning of Project  
**ELEVATION: TOP OF HOLE:** Approx. 7140  
**GROUNDWATER:** Not Encountered  
**DATE: HOLE STARTED** 6-18-87  
**COMPLETED** 6-18-87

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. N ( blows/ft )</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (lb/ft³)</th>
<th>LL %</th>
<th>PI %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Lean Clay with Sand; stiff, moist, brown (CL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Shale, Claystone; soft rock, slightly moist, brown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5.0</td>
<td></td>
<td>Bag*</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td>BOTTOM OF TEST PIT</td>
<td></td>
<td></td>
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</tbody>
</table>

*Composite sample taken from 2.5' to 10.0' for chemical analysis  
See Table No. 1 for Test Results
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335  
**DRILL TYPE:** SOIL  
**ROCK:** Case 580 Backhoe

**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams

**LOCATION:** Approximately 2.5 miles South of Beginning of Project  
**ELEVATION:** TOP OF HOLE 7085  
**GROUNDWATER:** Not Encountered  
**DATE:** HOLE STARTED 6-18-87  
**COMPLETED 6-18-87**

**REMARKS:** *Composite Sample taken from 0.3' to 10.5' for chemical analysis  
See Table No. 1 for Test Results*

### Classification and Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Legend</th>
<th>Topsoil, organic material Lean Clay; firm, moist, salt concentrations, moderate plasticity, brown (CL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td><em>Bag</em></td>
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<tr>
<td>10.0</td>
<td></td>
<td>Bottom of Test Pit</td>
</tr>
<tr>
<td>10.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample Symbol</th>
<th>Sample Density (g/cm³)</th>
<th>Moisture Content (%)</th>
<th>In-Place Dry Density (kg/m³)</th>
<th>LL %</th>
<th>PI %</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>35</td>
<td>12</td>
<td>0</td>
<td>16</td>
<td>-84</td>
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</tbody>
</table>
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335  
**DRILL TYPE:** Soil Case 580 Backhoe

**LOCATION:** Approximately 3.0 miles South of beginning of Project

**ELEVATION: TOP OF HOLE:** 7025

**GROUNDWATER:** Not Encountered

**DATE: HOLE STARTED:** 6-18-87  
**COMPLETED:** 6-18-87

**REMARKS:** *Composite sample taken from 0.5' to 10.5' for chemical analysis, See Table No. 1 for Test Results  
See Plate No. 1 for Additional Test Data*

### CLASSIFICATION AND DESCRIPTION

<table>
<thead>
<tr>
<th>DEPTH (ft.)</th>
<th>LEGEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 - 0.5</td>
<td>FILL, Lean Clay; firm, moist, road embankment, brown</td>
</tr>
</tbody>
</table>

Lean Clay; firm, moist, moderate plasticity, scattered gravels, brown (CL)

<table>
<thead>
<tr>
<th>DEPTH (ft.)</th>
<th>LEGEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>Sack*</td>
</tr>
</tbody>
</table>

Sack*  --  19  29  11  1  11 -88-

<table>
<thead>
<tr>
<th>DEPTH (ft.)</th>
<th>LEGEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0 - 10.5</td>
<td>BOTTOM OF TEST PIT</td>
</tr>
</tbody>
</table>

**NET 122B**
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335  
**DRILL TYPE:** Soil  
**ROCK:** Case 580 Backhoe

**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams

**REMARKS:** *Composite Sample taken from 0.3' to 8.0' for chemical analysis  
See Table No. 1 for Test Results*

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (IM) (BLOWS/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>LL %</th>
<th>PI %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil; organic material</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td>Shale, Claystone; soft to moderately hard rock, moist, layers of sandy shale, weathered near surface, very hard below 6 feet, brown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td>Bag*</td>
<td>--</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td>Backhoe refusal at 8.0'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td><strong>BOTTOM OF TEST PIT</strong></td>
<td></td>
<td></td>
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</tbody>
</table>

**HOLE NO.:** TP-7  
**SHEET:** 1 OF 1  
**LOCATION:** Approximately 3.5 miles South of Beginning of Project  
**ELEVATION:** TOP OF HOLE 7040  
**GROUNDWATER:** Not Encountered  
**DATE:** HOLE STARTED 6-18-87  
**COMPLETED 6-18-87**
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335  
Case 580 Backhoe

**DRILLED BY:** City of Rawlins  
B. Williams

**LOCATION:** Approximately 4.0 miles South of Beginning of Project

**ELEVATION:** TOP OF HOLE 7076

**GROUNDWATER:** Not Encountered

**DATE:** HOLE STARTED 6-18-87  
COMPLETED 6-18-87

**HOLE NO.:** TP-8  
**SHEET:** 1 OF 1

**REMARKS:**  
*Composite sample taken from 0.5' to 9.5' for chemical analysis

See Table No. 1 for Test Results

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (N) (BOWS/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>LL %</th>
<th>P.I. %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Shale, Claystone; soft to moderately hard rock, moist, weathered near surface, becoming hard below 5.5', brown</td>
<td>Bag*</td>
<td>--</td>
<td>8</td>
<td>29</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>Backhoe refusal at 9.5'</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

**BOTTOM OF TEST PIT**
## LOG OF EXPLORATION BORING

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE:** SOIL  
Case 580 Backhoe  
**ROCK**  
City of Rawlins  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**REMARKS:** *Composite sample taken from 0.5' to 10.3' for chemical analysis  
See Table 1 for Test Results*

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (N) (blows/ft)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-SITU DENSITY (pcf)</th>
<th>LL %</th>
<th>PI %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>Silt %</th>
<th>CLAY %</th>
</tr>
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<tbody>
<tr>
<td>0.0</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Shale, Siltstone; soft rock,</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>slightly moist, weathered to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>about 4.5', becoming harder</td>
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</tr>
<tr>
<td></td>
<td>below 7.0', brown</td>
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<tr>
<td>5.0</td>
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<td>Bag*</td>
<td>--</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>10.3</td>
<td>BOTTOM OF TEST PIT</td>
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</table>
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE:** Soil  
**ROCK:** Case 580 Backhoe  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**REMARKS:** *Composite Sample taken from 1.0' to 5.8' for chemical analysis  
See Table No. 1 for Test Results

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. ON (BLOW/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DENSITY (pcf)</th>
<th>L.L. %</th>
<th>P.I. %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Silty Gravel with Sand; medium dense, moist, sandstone and quartz particles, brown (GM)</td>
<td>Bag*</td>
<td>--</td>
<td>5</td>
<td>GNP</td>
<td>42</td>
<td>40</td>
<td>-18-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>Shale, Claystone; soft rock, moist, weathered near contact, gray</td>
<td>Bag</td>
<td>--</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.7</td>
<td>BOTTOM OF TEST PIT</td>
<td></td>
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<td></td>
<td></td>
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</table>

**HOLE NO.:** TP-10  
**SHEET 1 OF 1**  
**LOCATION:** Approx. 5.0 miles South of Beginning of Project  
**ELEVATION:** TOP OF HOLE 7040  
**GROUNDWATER:** Not Encountered  
**DATE:** HOLE STARTED 6-18-87 COMPLETED 6-18-87

NET 122B
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline Rawlins, Wyoming  
**HOLE NO.:** TP-11  
**JOB NO.:** 87-2335  
**DRILL TYPE:** SOIL ROCK  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**LOCATION:** Approx. 5.5 miles South of Beginning of Project  
**ELEVATION:** TOP OF HOLE 7085  
**GROUNDWATER:** Not Encountered  
**DATE:** HOLE STARTED 6-17-87  
**COMPLETED 6-17-87**

**REMARKS:** *Composite sample taken from 0.0' to 10.4' for chemical analysis  
See Table No. 1 for Test Results*

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (Blows/FT)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DENSITY (g/cc)</th>
<th>LL %</th>
<th>P.I. %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Shale, Claystone; soft rock, moist, highly weathered near surface, brown</td>
<td>Bag*</td>
<td>--</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5.0</td>
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<td>10.0</td>
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<td></td>
</tr>
<tr>
<td>10.4</td>
<td>BOTTOM OF TEST PIT</td>
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</tr>
</tbody>
</table>
## LOG OF EXPLORATION BORING

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE: SOIL ROCK**  
Case 580 Backhoe  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**REMARKS:** *Composite sample taken from 0.0' to 10.5' for chemical analysis*

See Table 1 for Test Results, See Plate 2 for Additional Test Data

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Lean Clay with Sand; stiff, moderate plasticity, brown (CL)</td>
</tr>
<tr>
<td>3.0</td>
<td>Shale Claystone; soft rock, moist, salt concentrations, brown</td>
</tr>
<tr>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>BOTTOM OF TEST PIT</td>
</tr>
</tbody>
</table>

**LOCATION:** Approx. 6.0 miles South of Beginning of Project  
**ELEVATION: TOP OF HOLE** Approx. 7085  
**GROUNDWATER** Not Encountered  
**DATE: HOLE STARTED** 6-17-87  
**DATE: HOLE COMPLETED** 6-17-87  
**HOLE NO.:** TP-12  
**SHEET 1 OF 1**
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335

**DRILL TYPE:** Soil

**DRILLED BY:** Case 580 Backhoe

**DRILLED BY:** City of Rawlins

**LOGGED BY:** B. Williams

**LOCATION:** Approx. 6.5 miles South of Beginning of Project

**ELEVATION:** Top of Hole 7120

**GROUNDWATER:** Not Encountered

**DATE: HOLE STARTED** 6-17-87

**DATE: HOLE COMPLETED** 6-17-87

**REMARKS:** *Composite sample taken from 0.0' to 10.0' for chemical analysis

See Table No. 1 for Test Results

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Shale, Claystone; soft rock, moist, highly weathered to 1.5', lenses of sandy shale, gray</td>
</tr>
<tr>
<td>5.0</td>
<td>Bag* -- 10</td>
</tr>
<tr>
<td>10.0</td>
<td>BOTTOM OF TEST PIT</td>
</tr>
</tbody>
</table>

*Composite sample taken from 0.0' to 10.0' for chemical analysis*  
See Table No. 1 for Test Results
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline
Rawlins, Wyoming

**JOB NO.** 87-2335

**DRILL TYPE:** SOIL ROCK

**DRILLED BY:** City of Rawlins

**LOGGED BY:** B. Williams

**HOLE NO.** TP-14

**LOCATION:** Approximately 7.0 miles South of Beginning of Project

**ELEVATION: TOP OF HOLE 7060**

**GROUNDWATER:** Not Encountered

**DATE: HOLE STARTED** 6-17-87

**COMPLETED** 6-17-87

*Composite sample taken from 0.0' to 10.5' for chemical analysis
See Table 1 for Test Results

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (BLOW/FT.)</th>
<th>MOISTURE CONTENT</th>
<th>IN-PLACE DENSITY (pcf)</th>
<th>L.L. %</th>
<th>P.I. %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Shale, Claystone; soft rock, moist, lenses of sandstone, layered, brown</td>
<td>Sack*</td>
<td>--</td>
<td>16</td>
<td>42</td>
<td>16</td>
<td></td>
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<td>10.0</td>
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<td></td>
</tr>
<tr>
<td>10.5</td>
<td>BOTTOM OF TEST PIT</td>
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<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

**LOCATION:**
Approximately 7.0 miles South of Beginning of Project

**ELEVATION:** TOP OF HOLE 7060

**GROUNDWATER:**
Not Encountered

**DATE: HOLE**
STARTED 6-17-87
COMPLETED 6-17-87

*Composite sample taken from 0.0' to 10.5' for chemical analysis
See Table 1 for Test Results
### LOG OF EXPLORATION BORING

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming  
**HOLE NO.:** TP-15  
**SHEET 1 OF 1**  
**LOCATION:** Approx. 7.3 miles South of Beginning of Project  
**ELEVATION: TOP OF HOLE** 7090.0  
**GROUNDWATER** 7083.0  
**DATE: HOLE STARTED** 6-17-87  
**COMPLETED** 6-17-87  
**REMARKS:**  
*Composite sample taken from 0.0' to 8.0' for chemical analysis  
See Table No. 1 for Test Results*

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (M) (BLOWS/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>LL %</th>
<th>PI %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Sandy Lean Clay; firm, moist to saturated with depth, brown (CL)</td>
<td>Bag*</td>
<td>20</td>
<td>27</td>
<td>12</td>
<td>0</td>
<td>30</td>
<td>-70 -</td>
<td></td>
<td></td>
<td></td>
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<td>5.0</td>
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<tr>
<td>7.0</td>
<td>GWL (6-17-87)</td>
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<tr>
<td>8.0</td>
<td>BOTTOM OF TEST PIT</td>
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</table>
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335

**DRILL TYPE:** SOIL

**DRILLED BY:** City of Rawlins

**LOGGED BY:** B. Williams

**REMARKS:** *Composite sample taken from 0.2' to 10.0' for chemical analysis  
See Table 1 for Test Results*

---

**CLASSIFICATION AND DESCRIPTION**

**DEPTH (Feet)**  |  **LEGEND**  |  **CLASSIFICATION**  |  **S.P.T. (IN.)**  |  **MOISTURE**  |  **IN-PLACE DENSITY**  |  **LL**  |  **PI**  |  **GRAVEL %**  |  **SAND %**  |  **SILT %**  |  **CLAY %**
---|---|---|---|---|---|---|---|---|---|---|---|
0.0  |  | Topsoil, organic material  |  |  |  |  |  |  |  |  |  |
0.2  |  | Shale, Claystone; soft rock, slightly moist, weathered, brown  |  |  |  |  |  |  |  |  |  |
5.0  |  |  |  |  Bag*  |  |  |  |  |  |  |  |
10.0  |  | BOTTOM OF TEST PIT  |  |  |  |  |  |  |  |  |  |
LOG OF EXPLORATION BORING

PROJECT: Phase II Sage Creek Waterline Rawlins, Wyoming

JOB NO.: 87-2335
DRILL TYPE: SOIL
ROCK: Case 580 Backhoe

DRILLED BY: City of Rawlins
LOGGED BY: B. Williams

REMARKS: *Composite sample taken from 0.5' to 8.0' for chemical analysis
See Table 1 for Test Results

<table>
<thead>
<tr>
<th>DEPTH (Ft)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (Blows/Ft)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (bpcf)</th>
<th>LL</th>
<th>PI</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Lean Clay; firm, moist, scattered gravels, brown (CL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5.0</td>
<td>Bentonitic Shale; soft rock, moist, very high plasticity, white</td>
<td>Bag</td>
<td>--</td>
<td>31</td>
<td>100</td>
<td>67</td>
<td>0</td>
<td>6</td>
<td>-94-</td>
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</table>

BOTTOM OF TEST PIT
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335

**DRILL TYPE:** SOIL  
Case 580 Backhoe

**DRILLED BY:** City of Rawlins

**LOGGED BY:** B. Williams

**REMARKS:** *Composite sample taken from 0.5' to 9.7' for chemical analysis  
See Table No. 1 for test results*

### CLASSIFICATION AND DESCRIPTION

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (N) (BLOWS/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>LL %</th>
<th>PI %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Shale, Claystone; soft rock,</td>
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<td>moist to saturated with depth,</td>
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</tr>
<tr>
<td></td>
<td>carbonaceous, black</td>
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</tr>
<tr>
<td>5.0</td>
<td>GWL (6-17-87)</td>
<td>Bag*</td>
<td>--</td>
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<td></td>
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</tr>
<tr>
<td>9.7</td>
<td>BOTTOM OF TEST PIT</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**LOCATION:** Approx. 9.0 miles South of Beginning of Project

**ELEVATION: TOP OF HOLE** 7150.0  
**GROUNDWATER** 7145.0

**DATE:** HOLE STARTED 6-17-87  
**COMPLETED 6-17-87**
LOG OF EXPLORATION BORING

PROJECT: Phase II Sage Creek Waterline Rawlins, Wyoming
JOB NO: 87-2335
DRILL TYPE: SOIL Rock Case 580 Backhoe
DRILLED BY: City of Rawlins
LOGGED BY: B. Williams
REMARKS: *Composite sample taken from 0.4' to 2.5' for chemical analysis
See Table No. 1 for Test Results

<table>
<thead>
<tr>
<th>DEPTH (Ft)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (N) (BLOWS/FT)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-SITU DENSITY (pcf)</th>
<th>LL %</th>
<th>P.I. %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>Fat Clay; stiff, moist, high plasticity, brown (CH)</td>
<td>Bag*</td>
<td>--</td>
<td>20</td>
<td>70</td>
<td>48</td>
<td>13</td>
<td>-87-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Shale, Siltstone; moderately hard rock, slightly moist, weathered near contact, brown</td>
<td>Bag</td>
<td>--</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

BOTTOM OF TEST PIT
LOG OF EXPLORATION BORING

PROJECT: Phase II Sage Creek Waterline Rawlins, Wyoming
JOB NO: 87-2335
DRILL TYPE: SOIL Case 580 Backhoe
DRILLED BY: City of Rawlins
LOGGED BY: B. Williams
REMARKS: *Composite sample taken from 1.5' to 7.3' for chemical analysis
See Table No. 1 for Test Results

HOLE NO. TP-21
SHEET 1 OF 1
LOCATION: Approx. 10.0 miles South of Beginning of Project
ELEVATION: TOP OF HOLE 7450
GROUNDWATER Not Encountered
DATE: HOLE STARTED 6-17-87 COMPLETED 6-17-87

CLASSIFICATION AND DESCRIPTION

<table>
<thead>
<tr>
<th>DEPTH (Ft)</th>
<th>LEGEND</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td>Topsoil, organic material</td>
</tr>
<tr>
<td>0.5</td>
<td></td>
<td>Lean Clay; firm, moist, brown (CL)</td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td>Shale, Claystone; moderately hard rock, moist, layered, gray-brown</td>
</tr>
<tr>
<td>5.0</td>
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<td>Bag*</td>
</tr>
<tr>
<td>7.3</td>
<td></td>
<td>Backhoe refusal at 7.3'</td>
</tr>
</tbody>
</table>

BOTTOM OF TEST PIT

See Table No. 1 for Test Results
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**HOLE NO.:** TP-22

**JOB NO.:** 87-2335

**DRILL TYPE:** SOIL

**ROCK:** Case 580 Backhoe

**DRILLED BY:** City of Rawlins

**LOGGED BY:** B. Williams

**LOCATION:** Approx. 10.2 miles South of Beginning of Project

**ELEVATION:** TOP OF HOLE 7400

**GROUNDWATER:** Not Encountered

**DATE:** HOLE STARTED 6-17-87  
COMPLETED 6-17-87

**REMARKS:** *Composite Sample taken from 1.6' to 6.2' for chemical analysis
See Table No. 1 for Test Results

### CLASSIFICATION AND DESCRIPTION

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. N (BLOW/Ft.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>LL %</th>
<th>PL %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Sandy Lean Clay; firm, moist, scattered shale fragments, brown (CL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>Shale, Claystone; soft rock, very moist, weathered, gray</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td>Bag</td>
<td>--</td>
<td>17</td>
<td>48</td>
<td>29</td>
<td>13</td>
<td>29</td>
<td>-58</td>
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<tr>
<td>9.0</td>
<td><strong>BOTTOM OF TEST PIT</strong></td>
<td>Bag</td>
<td>--</td>
<td>31</td>
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</tr>
</tbody>
</table>

**NET 1228**
## LOG OF EXPLORATION BORING

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming  

**JOB NO.:** 87-2335  

**DRILL TYPE:** SOIL Case 580 Backhoe  

**ROCK DRILLED BY:** City of Rawlins  

**LOGGED BY:** B. Williams  

**REMARKS:**

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T./WY (BLOWS/FT)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (SG)</th>
<th>L.L.</th>
<th>P.I.</th>
<th>GRANUL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
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</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Topsoil, organic material</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Sandy Lean Clay; firm, moist, scattered sandstone gravels, brown (CL)</td>
<td>Bag</td>
<td>--</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>Shale, Claystone; soft to hard rock, moist, brown</td>
<td>Sack</td>
<td>--</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>Backhoe refusal at 5.3'</td>
<td>Bag</td>
<td>--</td>
<td>15</td>
<td></td>
<td></td>
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</tbody>
</table>

**BOTTOM OF TEST PIT**

**HOLE NO.:** TP-23  

**SHEET 1 OF 1**

**LOCATION:** Approx. 10.4 miles South of Beginning of Project  

**ELEVATION:** TOP OF HOLE Approx 7420  
GROUNDWATER Not Encountered  

**DATE:** HOLE STARTED 6-17-87  
COMPLETED 6-17-87
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
**Location:** Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE:** Case 580 Backhoe  
**HOLE NO.:** TP-24  
**LOCATION:** Approx. 0.4 miles South of Test Pit 16 on Sage Creek Road  
**ELEVATION:** Top of Hole 7090  
**GROUNDWATER:** Not Encountered  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**DATE:** Hole Started 7-15-87, Completed 7-15-87  

### LOGGED BY:

B. Williams

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T. (B/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>L.L. %</th>
<th>P.I. %</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>Silt %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Lean Clay with Sand; firm, very moist, brown (CL)</td>
<td>Bag*</td>
<td>--</td>
<td>29 12 1 43 -56-</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5.0</td>
<td>10.4</td>
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<td></td>
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</tr>
</tbody>
</table>

**REMARKS:** *Composite Sample taken from 0.0' to 10.4' for chemical analysis*

**CLASSIFICATION AND DESCRIPTION**

Lean Clay with Sand; firm, very moist, brown (CL)
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**HOLE NO.:** TP-25  
**SHEET:** 1 OF 1

**JOB NO.:** 87-2335

**DRILL TYPE:** Soil and Rock

**DRILLED BY:** Case 580 Backhoe

**LOCATION:** Approx. 0.9 miles South of Test Pit 16 on Sage Creek Road

**ELEVATION:** Top of Hole 7300

**GROUNDWATER:** Not Encountered

**DATE:** Hole Started 7-15-87  
**COMPLETED:** 7-15-87

**LOGGED BY:** B. Williams

**REMARKS:** *Composite sample taken from 0.6' to 6.0' for chemical analysis*

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
<th>SAMPLE SYMBOL</th>
<th>S.P.T./N (BLOWS/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>IN-PLACE DRY DENSITY (pcf)</th>
<th>LL (%)</th>
<th>PI (%)</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
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<tr>
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<td>Topsoil, organic material</td>
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<tr>
<td>0.6</td>
<td>Silty Sand with Gravel; loose, moist, scattered gravel and cobbles to 5&quot;, brown (SM)</td>
<td>Bag*</td>
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<tr>
<td>6.0</td>
<td>Silty Gravel with Sand; medium dense, moist, rounded sandstone gravels, brown (GM)</td>
<td>Bag</td>
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## LOG OF EXPLORATION BORING

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE:** Soil  
**ROCK:** Case 580 Backhoe  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**REMARKS:**

<table>
<thead>
<tr>
<th>DEPTH (Feet)</th>
<th>CLASSIFICATION AND DESCRIPTION</th>
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<th>S.P.T. (N) (BLOWS/FT.)</th>
<th>MOISTURE CONTENT (%)</th>
<th>INPLACE DRY DENSITY (psf)</th>
<th>L.L. %</th>
<th>P.I. %</th>
<th>GRAVEL %</th>
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<tr>
<td>0.8</td>
<td>Poorly Graded Gravel with Sand; medium dense, moist, scattered cobbles and boulders to 1.5 feet in diameter, brown (GP)</td>
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</table>

**HOLE NO.:** TP-26  
**LOCATION:** Approx. 1.5 miles South of Test Pit 16 on Sage Creek Road  
**ELEVATION: TOP OF HOLE:** 7360  
**GROUNDWATER:** Not Encountered  
**DATE: HOLE STARTED:** 7-15-87  
**COMPLETED:** 7-15-87
**LOG OF EXPLORATION BORING**

**PROJECT:** Phase II Sage Creek Waterline Rawlins, Wyoming  
**JOB NO.:** 87-2335  
**DRILL TYPE:** SOIL ROCK  
**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams  
**REMARKS:** *Composite Sample taken from 3.0' to 4.6' for chemical analysis*

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<th>CLASSIFICATION AND DESCRIPTION</th>
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<th>S.P.T. (Ni) (BLOWS/FT.)</th>
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<td>Lean Clay; stiff, moist, moderate plasticity, brown (CL)</td>
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<td>4.6</td>
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<td>Shale, Siltstone, moderately hard rock, moist, gray-black</td>
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</table>

**HOLE NO.:** TP-27  
**LOCATION:** Approx. 1.7 miles South of Test Pit 16 on alternate route  
**ELEVATION: TOP OF HOLE:** 7360  
**GROUNDWATER:** Not Encountered  
**DATE: HOLE STARTED:** 7-15-87  
**COMPLETED:** 7-15-87
# LOG OF EXPLORATION BORING

**PROJECT:** Phase II Sage Creek Waterline  
Rawlins, Wyoming

**JOB NO.:** 87-2335  
**DRILL TYPE:** SOIL  
**ROCK**

**DRILLED BY:** City of Rawlins  
**LOGGED BY:** B. Williams

**HOLE NO.:** TP-28  
**LOCATION:** Approx. 1.9 miles South of Test Pit 16 on Alternate Route  
**ELEVATION: TOP OF HOLE:** 7320  
**GROUNDWATER:** Not Encountered  
**DATE: HOLE STARTED:** 7-15-87  
**COMPLETED:** 7-15-87

<table>
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<td>Topsoil, organic material</td>
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<td>0.5</td>
<td>Lean Clay with Sand; firm, moist, medium plasticity, tan (CL)</td>
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<td>3.7</td>
<td>Shale, Claystone; moderately hard rock, moist, gray-black</td>
<td>Bag</td>
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*NET 122B*
J. M. MONTGOMERY CONSULTING ENGINEERS
BOISE, IDAHO
PHASE II SAGE CREEK WATERLINE
RAWLINS, WYOMING

GEOLOGIC KEY

Qal QUATERNARY ALLUVIUM
Ks STEELE SHALE
Ks NIOBRARRA FORMATION
Kf FRONTIER FORMATION
Kr MOWRY SHALE
Kt THERMOPOLIS SHALE
Kc Cloverly FormatioN
\ , STRIKE AND DIP
\ OF OUTCROP
Qc COLLUVIAL DEPOSITS

KEY

ESTIMATED DEPTH TO DIFFICULT
EXCAVATION OF BEDROCK LESS
THAN 10 FEET
INDICATES PHOTO REFERENCE
IN REPORT
QUESTION MARKS DENOTE UNCERTAINTY
OF PHASE II WATERLINE ROUTE

FOR A CONTINUATION OF THIS DRAWING, SEE DRG. NO. 87-2335-2