Attachments: Soil-Related Resource Concerns

- Custom Soil Resource Report for Millard County, Utah – Eastern Part: Corn Creek EA
- NRCS WebSoil Survey Farmland Classification Map for Corn Creek Study Area
- Corn Creek Reservoir Geotechnical Data Report -- Gerhart Cole, Inc.

United States Department of Agriculture

NRCS

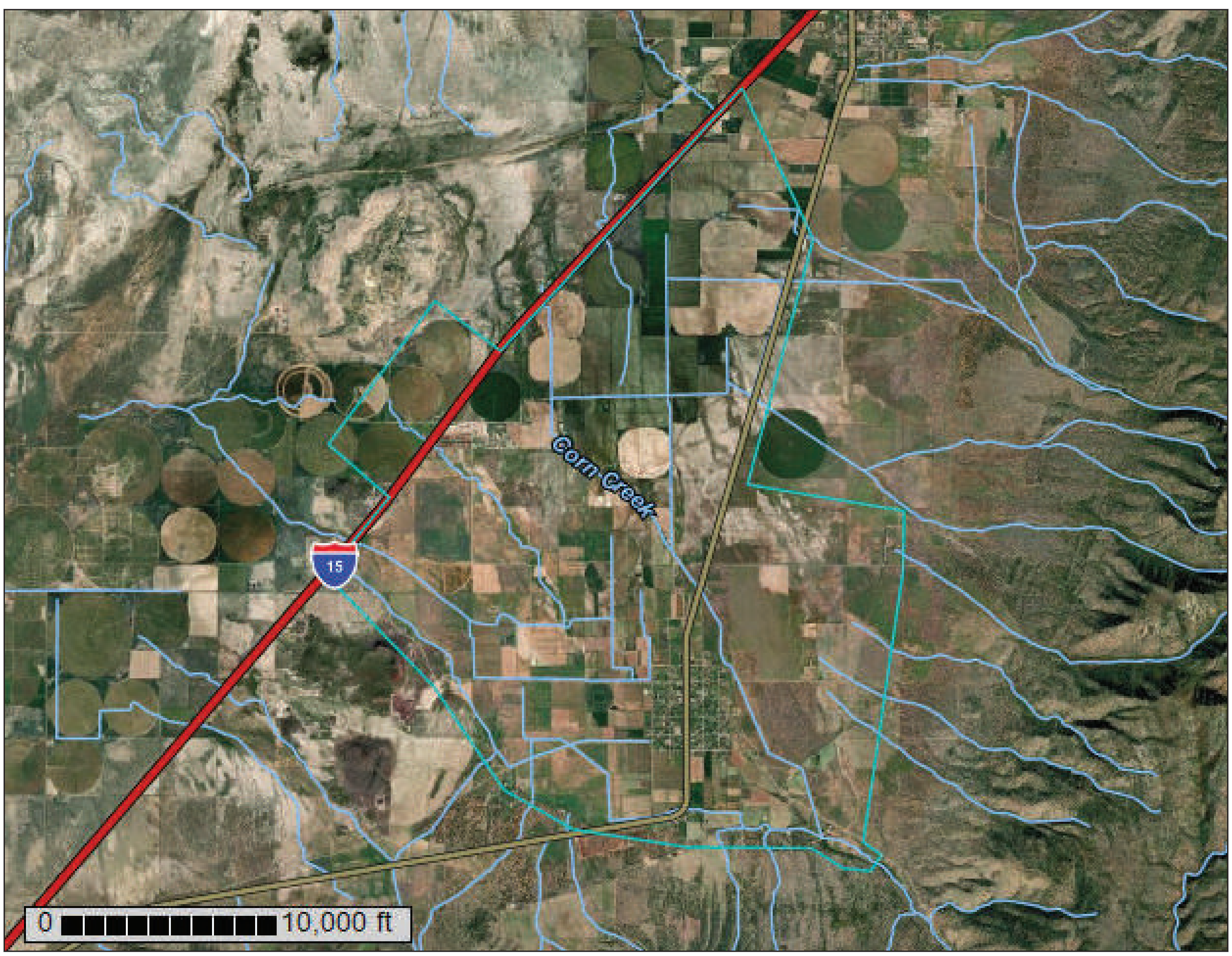
Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Millard County, Utah - Eastern Part

Corn Creek EA Project Area



June 9, 2023

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


112° 30' 26" W
112° 23' 29" W
38° 53' 22" N
38° 46' 11" N
370000
371000
372000
373000
374000
375000
376000
377000
378000
379000
4305000
4304000
4303000
4302000
4301000
4300000
4299000
4298000
4297000
4296000
4295000
4294000
4293000
Corn Creek
15
Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.
Meters
0 500 1000 2000 3000
Feet
0 3000 6000 12000 18000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Millard County, Utah - Eastern Part
Survey Area Data: Version 15, Aug 29, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	79.7	0.6%
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	6.0	0.0%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes	39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	22.8	0.2%
Totals for Area of Interest		**13,201.8**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Millard County, Utah - Eastern Part

3—Ashdown loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: j5cm
Elevation: 4,800 to 5,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Ashdown and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ashdown

Setting

Landform: Alluvial flats, alluvial fans
Landform position (three-dimensional): Rise, talf
Down-slope shape: Concave
Across-slope shape: Concave, convex
Parent material: Alluvium from sandstone and conglomerate

Typical profile

A - 0 to 20 inches: loam
C - 20 to 60 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: R028AY220UT - Semidesert Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Erda

Percent of map unit: 5 percent
Hydric soil rating: No

Boxelder

Percent of map unit: 5 percent
Hydric soil rating: No

Calita

Percent of map unit: 5 percent
Hydric soil rating: No

4—Ashdown loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: j5cz
Elevation: 4,800 to 5,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Ashdown and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ashdown

Setting

Landform: Alluvial fans, alluvial flats
Landform position (three-dimensional): Rise, talf
Down-slope shape: Concave
Across-slope shape: Convex, concave
Parent material: Alluvium from sandstone and conglomerate

Typical profile

A - 0 to 20 inches: loam
C - 20 to 60 inches: loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 2e

Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: R028AY220UT - Semidesert Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Calita

Percent of map unit: 5 percent
Hydric soil rating: No

Erda

Percent of map unit: 5 percent
Hydric soil rating: No

Boxelder

Percent of map unit: 5 percent
Hydric soil rating: No

7—Bandag loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: j5f1
Elevation: 4,700 to 5,200 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 160 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Bandag and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bandag

Setting

Landform: Alluvial flats, alluvial fans
Landform position (three-dimensional): Rise, talf
Down-slope shape: Concave
Across-slope shape: Concave, convex
Parent material: Alluvium from limestone and sandstone

Typical profile

Ap - 0 to 7 inches: loam
C - 7 to 60 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.6 inches)

Interpretive groups
Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: R028AY220UT - Semidesert Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Boxelder
Percent of map unit: 5 percent
Hydric soil rating: No

Erda
Percent of map unit: 5 percent
Hydric soil rating: No

Escalante
Percent of map unit: 5 percent
Hydric soil rating: No

8—Bandag loam, 2 to 5 percent slopes

Map Unit Setting
National map unit symbol: j5fd
Elevation: 4,700 to 5,200 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Bandag and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bandag

Setting
Landform: Alluvial flats, alluvial fans
Landform position (three-dimensional): Rise, talf
Down-slope shape: Concave

Across-slope shape: Concave, convex
Parent material: Alluvium from limestone and sandstone

Typical profile
Ap - 0 to 7 inches: loam
C - 7 to 60 inches: loam

Properties and qualities
Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.6 inches)

Interpretive groups
Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: R028AY220UT - Semidesert Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Erda
Percent of map unit: 5 percent
Hydric soil rating: No

Escalante
Percent of map unit: 5 percent
Hydric soil rating: No

Boxelder
Percent of map unit: 5 percent
Hydric soil rating: No

22—Borvant-Pavant complex, 2 to 15 percent slopes

Map Unit Setting
National map unit symbol: j5cc
Elevation: 5,200 to 6,000 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 45 to 52 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Borvant and similar soils: 55 percent
Pavant and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Borvant

Setting

Landform: Fan remnants
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from limestone and sandstone

Typical profile

A - 0 to 7 inches: very gravelly loam
Bk - 7 to 14 inches: extremely gravelly loam
Bkm - 14 to 18 inches: indurated

Properties and qualities

Slope: 2 to 15 percent
Depth to restrictive feature: 10 to 20 inches to petrocalcic
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.07 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 60 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R028AY320UT - Upland Shallow Hardpan (Pinyon-Utah Juniper)
Hydric soil rating: No

Description of Pavant

Setting

Landform: Fan remnants
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from limestone and sandstone

Typical profile

A - 0 to 4 inches: loam
Bk1 - 4 to 11 inches: loam
Bk2 - 11 to 17 inches: loam
Bkm - 17 to 20 inches: indurated

Properties and qualities

Slope: 2 to 15 percent
Depth to restrictive feature: 10 to 20 inches to petrocalcic
Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.07 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Available water supply, 0 to 60 inches: Very low (about 2.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R028AY320UT - Upland Shallow Hardpan (Pinyon-Utah Juniper)
Hydric soil rating: No

Minor Components

Maple hollow
Percent of map unit: 5 percent
Hydric soil rating: No

Donnardo
Percent of map unit: 5 percent
Hydric soil rating: No

Pober
Percent of map unit: 5 percent
Hydric soil rating: No

23—Boxelder silt loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: j5cd
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 120 to 160 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Boxelder and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Boxelder

Setting
Landform: Lake terraces, lake plains
Landform position (three-dimensional): Tread, rise, talf
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Alluvium from calcareous sediments containing diatomaceous deposits

Typical profile

Ap - 0 to 5 inches: silt loam
Bw - 5 to 18 inches: loam
Bk - 18 to 27 inches: loam
2C - 27 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 60 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: R028AY218UT - Semidesert Silt Loam (Winterfat)
Hydric soil rating: No

Minor Components

Berent

Percent of map unit: 5 percent
Hydric soil rating: No

Bandag

Percent of map unit: 5 percent
Hydric soil rating: No

Pavant

Percent of map unit: 3 percent
Hydric soil rating: No

Mellor

Percent of map unit: 2 percent
Hydric soil rating: No

25—Calita-Erda complex, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: j5cg
Elevation: 4,800 to 5,500 feet

Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 47 to 52 degrees F
Frost-free period: 110 to 150 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Calita and similar soils: 60 percent
Erda and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Calita

Setting

Landform: Alluvial flats
Landform position (three-dimensional): Rise, talf
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium from limestone, sandstone, and quartzite

Typical profile

A - 0 to 8 inches: very fine sandy loam
Bw - 8 to 16 inches: silt loam
Bk - 16 to 60 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: R028AY310UT - Upland Loam (Bonneville Big Sagebrush) North
Hydric soil rating: No

Description of Erda

Setting

Landform: Alluvial fans
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from limestone, sandstone, and quartzite

Typical profile

Ap - 0 to 6 inches: silt loam
A2 - 6 to 18 inches: silt loam
Bw - 18 to 23 inches: silt loam

Bk - 23 to 38 inches: silt loam
BC - 38 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: R028AY310UT - Upland Loam (Bonneville Big Sagebrush) North
Hydric soil rating: No

Minor Components

Borvant

Percent of map unit: 4 percent
Hydric soil rating: No

Oakcity

Percent of map unit: 3 percent
Hydric soil rating: No

Donnardo

Percent of map unit: 3 percent
Hydric soil rating: No

27—Cessna loam, 0 to 5 percent slopes

Map Unit Setting

National map unit symbol: j5cj
Elevation: 4,900 to 5,300 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 49 to 52 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Cessna and similar soils: 90 percent
Minor components: 10 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cessna

Setting

Landform: Stream terraces, alluvial fans
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Concave, convex
Parent material: Alluvium from sedimentary rocks

Typical profile

A1 - 0 to 3 inches: loam
A2 - 3 to 10 inches: loam
Bw1 - 10 to 27 inches: loam
Bw2 - 27 to 60 inches: loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water supply, 0 to 60 inches: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R028AY310UT - Upland Loam (Bonneville Big Sagebrush) North
Other vegetative classification: Upland Loam (Mountain Big Sagebrush) (028AY310UT)
Hydric soil rating: No

Minor Components

Calita

Percent of map unit: 3 percent
Hydric soil rating: No

Donnardo

Percent of map unit: 3 percent
Hydric soil rating: No

Poganeab

Percent of map unit: 2 percent
Landform: Oxbows, flood plains
Landform position (three-dimensional): Dip, talf
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: R028AY024UT - Wet Saline Meadow (Saltgrass)
Hydric soil rating: Yes

Heist

Percent of map unit: 2 percent
Hydric soil rating: No

30—Cloyd-Rock outcrop complex, 5 to 20 percent slopes

Map Unit Setting

National map unit symbol: j5cn
Elevation: 4,800 to 5,000 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Cloyd and similar soils: 65 percent
Rock outcrop: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cloyd

Setting

Landform: Ridges, hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve, crest, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum from travertine

Typical profile

A1 - 0 to 3 inches: gravelly loam
A2 - 3 to 7 inches: cobbly loam
Bk - 7 to 15 inches: gravelly loam
R - 15 to 20 inches: unweathered bedrock

Properties and qualities

Slope: 5 to 20 percent
Depth to restrictive feature: 14 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 50 percent
Available water supply, 0 to 60 inches: Very low (about 2.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R028AY236UT - Semidesert Shallow Loam (Black Sagebrush)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Ridges
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve, crest
Down-slope shape: Convex
Across-slope shape: Convex

Minor Components

Ashdown

Percent of map unit: 4 percent
Hydric soil rating: No

Heist

Percent of map unit: 3 percent
Hydric soil rating: No

Hiko peak

Percent of map unit: 3 percent
Hydric soil rating: No

31—Collard gravelly loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: j5cp
Elevation: 4,800 to 5,500 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Collard and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Collard

Setting

Landform: Fan remnants, alluvial fans
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from quartzite, sandstone, and conglomerate

Typical profile

A - 0 to 9 inches: gravelly loam
Bt - 9 to 17 inches: very cobbly clay loam
C1 - 17 to 28 inches: very cobbly sandy loam
C2 - 28 to 60 inches: very cobbly loamy sand

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Ecological site: R028AY334UT - Upland Stony Loam (Wyoming Big Sagebrush)
Other vegetative classification: Upland Stony Loam (Mountain Big Sagebrush) (028AY334UT)
Hydric soil rating: No

Minor Components

Donnardo

Percent of map unit: 5 percent
Hydric soil rating: No

Borvant

Percent of map unit: 5 percent
Hydric soil rating: No

35—Current Spring-Maple Hollow complex, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: j5ct
Elevation: 5,400 to 6,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Current spring and similar soils: 55 percent
Maple hollow and similar soils: 30 percent
Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Current Spring

Setting

Landform: Hills
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Alluvium and colluvium from limestone, sandstone, and quartzite

Typical profile

A1 - 0 to 5 inches: gravelly loam
A2 - 5 to 13 inches: gravelly clay loam
Bt1 - 13 to 24 inches: very gravelly clay loam
Bt2 - 24 to 41 inches: very gravelly clay
Bt3 - 41 to 60 inches: very gravelly clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water supply, 0 to 60 inches: Low (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R028AY334UT - Upland Stony Loam (Wyoming Big Sagebrush)
Other vegetative classification: Upland Stony Loam (Mountain Big Sagebrush) (028AY334UT)
Hydric soil rating: No

Description of Maple Hollow

Setting

Landform: Fan remnants
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium and colluvium from limestone, sandstone, and quartzite

Typical profile

A1 - 0 to 2 inches: loam
A2 - 2 to 8 inches: clay loam
Bt1 - 8 to 16 inches: clay loam
Bt2 - 16 to 44 inches: clay
Bk - 44 to 60 inches: loam

Properties and qualities

Slope: 15 to 20 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water supply, 0 to 60 inches: High (about 10.6 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R028AY310UT - Upland Loam (Bonneville Big Sagebrush) North
Other vegetative classification: Upland Loam (Mountain Big Sagebrush) (028AY310UT)
Hydric soil rating: No

Minor Components

Pavant
Percent of map unit: 5 percent

Collard
Percent of map unit: 5 percent
Hydric soil rating: No

Borvant
Percent of map unit: 5 percent
Hydric soil rating: No

36—Deseret silt loam, 0 to 1 percent slopes

Map Unit Setting
National map unit symbol: j5cv
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 49 to 52 degrees F
Frost-free period: 115 to 130 days
Farmland classification: Not prime farmland

Map Unit Composition
Deseret and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Deseret

Setting
Landform: Lake terraces
Landform position (three-dimensional): Tread

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium and lacustrine deposits

Typical profile

A - 0 to 4 inches: silt loam
By1 - 4 to 24 inches: silt loam
By2 - 24 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 60 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 20 percent
Maximum salinity: Slightly saline to strongly saline (4.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 15.0
Available water supply, 0 to 60 inches: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: R028AY004UT - Alkali Flat (Black Greasewood)
Hydric soil rating: No

Minor Components

Boxelder

Percent of map unit: 3 percent
Hydric soil rating: No

Uvada

Percent of map unit: 2 percent
Hydric soil rating: No

Uffens

Percent of map unit: 2 percent
Hydric soil rating: No

Berent

Percent of map unit: 2 percent
Hydric soil rating: No

Poganeab

Percent of map unit: 2 percent
Landform: Oxbows, flood plains
Landform position (three-dimensional): Dip, talf
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: R028AY024UT - Wet Saline Meadow (Saltgrass)
Hydric soil rating: Yes

Playas

Percent of map unit: 2 percent
Landform: Depressions on lake terraces
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R028AY132UT - Desert Salty Silt (Iodinebush)
Hydric soil rating: Yes

Kanosh

Percent of map unit: 2 percent
Hydric soil rating: No

37—Donnardo very stony loam, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: j5cw
Elevation: 5,000 to 6,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Donnardo and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Donnardo

Setting

Landform: Fan remnants
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from limestone and sandstone

Typical profile

A - 0 to 8 inches: very stony loam
Bk1 - 8 to 24 inches: very gravelly loam
Bk2 - 24 to 35 inches: extremely gravelly sandy loam
Bk3 - 35 to 60 inches: very cobbly loam

Properties and qualities

Slope: 2 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: R028AY334UT - Upland Stony Loam (Wyoming Big Sagebrush)
Other vegetative classification: Upland Stony Loam (Mountain Big Sagebrush) (028AY334UT)
Hydric soil rating: No

Minor Components

Collard

Percent of map unit: 5 percent
Hydric soil rating: No

Calita loam

Percent of map unit: 3 percent
Hydric soil rating: No

Borvant

Percent of map unit: 2 percent
Hydric soil rating: No

38—Donnardo-Borvant-Collard complex, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: j5cx
Elevation: 4,800 to 5,550 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Donnardo and similar soils: 40 percent
Borvant and similar soils: 25 percent
Collard and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Donnardo

Setting

Landform: Fan remnants
Down-slope shape: Concave
Across-slope shape: Convex

Parent material: Alluvium from limestone and sandstone

Typical profile

A - 0 to 11 inches: gravelly fine sandy loam
Bk1 - 11 to 21 inches: gravelly fine sandy loam
Bk2 - 21 to 60 inches: very cobbly loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: R028AY334UT - Upland Stony Loam (Wyoming Big Sagebrush)
Other vegetative classification: Upland Stony Loam (Mountain Big Sagebrush) (028AY334UT)
Hydric soil rating: No

Description of Borvant

Setting

Landform: Fan remnants
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from limestone and sandstone

Typical profile

A - 0 to 7 inches: very gravelly loam
Bk - 7 to 14 inches: extremely gravelly loam
Bkm - 14 to 18 inches: indurated

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 10 to 20 inches to petrocalcic
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.07 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 60 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: D
Ecological site: R028AY320UT - Upland Shallow Hardpan (Pinyon-Utah Juniper)
Hydric soil rating: No

Description of Collard

Setting

Landform: Fan remnants
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from quartzite, sandstone, and conglomerate

Typical profile

A - 0 to 9 inches: gravelly loam
Bt - 9 to 17 inches: very cobbly clay loam
C1 - 17 to 28 inches: very cobbly sandy loam
C2 - 28 to 60 inches: very cobbly loamy sand

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Ecological site: R028AY334UT - Upland Stony Loam (Wyoming Big Sagebrush)
Other vegetative classification: Upland Stony Loam (Mountain Big Sagebrush) (028AY334UT)
Hydric soil rating: No

Minor Components

Jardal

Percent of map unit: 5 percent
Hydric soil rating: No

Calita

Percent of map unit: 5 percent
Hydric soil rating: No

42—Escalante sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: j5d2
Elevation: 4,700 to 5,200 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Escalante and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Escalante

Setting

Landform: Alluvial flats
Landform position (three-dimensional): Rise, talf
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium from sedimentary rocks

Typical profile

A1 - 0 to 19 inches: sandy loam
A2 - 19 to 33 inches: fine sandy loam
Bk1 - 33 to 44 inches: fine sandy loam
Bk2 - 44 to 46 inches: silt loam
C1 - 46 to 51 inches: loamy fine sand
C2 - 51 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): 2c

Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R028AY226UT - Semidesert Sandy Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Bandag
Percent of map unit: 5 percent
Hydric soil rating: No

Manassa
Percent of map unit: 5 percent
Hydric soil rating: No

Uvada
Percent of map unit: 3 percent
Hydric soil rating: No

Berent
Percent of map unit: 2 percent
Hydric soil rating: No

43—Escalante sandy loam, 2 to 5 percent slopes

Map Unit Setting
National map unit symbol: j5d3
Elevation: 4,700 to 5,200 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Escalante and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Escalante

Setting
Landform: Lake terraces, lake plains, alluvial flats
Landform position (three-dimensional): Tread, rise, talf
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Alluvium from sedimentary rocks

Typical profile
A1 - 0 to 19 inches: sandy loam
A2 - 19 to 33 inches: fine sandy loam
Bk1 - 33 to 44 inches: fine sandy loam

Bk2 - 44 to 46 inches: silt loam
C1 - 46 to 51 inches: loamy fine sand
C2 - 51 to 60 inches: silt loam

Properties and qualities
Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.1 inches)

Interpretive groups
Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R028AY226UT - Semidesert Sandy Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Boxelder
Percent of map unit: 5 percent
Hydric soil rating: No

Bandag
Percent of map unit: 5 percent
Hydric soil rating: No

Mellor
Percent of map unit: 3 percent
Hydric soil rating: No

Berent
Percent of map unit: 2 percent
Hydric soil rating: No

54—Heist-Berent complex, 0 to 15 percent slopes

Map Unit Setting
National map unit symbol: j5dh
Elevation: 4,700 to 5,100 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 46 to 51 degrees F
Frost-free period: 130 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Heist and similar soils: 45 percent
Berent and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Heist

Setting

Landform: Lake terraces, alluvial fans
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, convex
Parent material: Alluvium from limestone, sandstone, and quartzite

Typical profile

A - 0 to 23 inches: fine sandy loam
C1 - 23 to 47 inches: fine sandy loam
C2 - 47 to 57 inches: very gravelly sandy loam
C3 - 57 to 60 inches: sandy loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R028AY226UT - Semidesert Sandy Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Description of Berent

Setting

Landform: Dunes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits from lacustrine deposits

Typical profile

C1 - 0 to 8 inches: loamy fine sand
C2 - 8 to 60 inches: fine sand

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Low (about 5.4 inches)

Interpretive groups
Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R028AB222UT - Semidesert Sand (Four-Wing Saltbush)
Hydric soil rating: No

Minor Components

Dune land
Percent of map unit: 10 percent
Hydric soil rating: No

Boxelder
Percent of map unit: 5 percent
Hydric soil rating: No

57—Hiko Peak fine sandy loam, 2 to 8 percent slopes

Map Unit Setting
National map unit symbol: j5dl
Elevation: 4,800 to 5,200 feet
Mean annual precipitation: 10 to 12 inches
Mean annual air temperature: 48 to 51 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition
Hiko peak and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hiko Peak

Setting
Landform: Alluvial fans
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from quartzite, limestone, and conglomerate

Typical profile

A - 0 to 3 inches: fine sandy loam
Bw - 3 to 16 inches: gravelly loam
Bk1 - 16 to 29 inches: extremely gravelly sandy loam
Bk2 - 29 to 43 inches: extremely gravelly sandy loam
Bk3 - 43 to 49 inches: extremely gravelly loamy sand
BC - 49 to 60 inches: very gravelly sand

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R028AY215UT - Semidesert Gravelly Loam (Wyoming Big Sagebrush) North
Hydric soil rating: No

Minor Components

Boxelder

Percent of map unit: 10 percent
Hydric soil rating: No

Amtoft

Percent of map unit: 5 percent
Hydric soil rating: No

60—Hiko Peak stony fine sandy loam, 5 to 15 percent slopes

Map Unit Setting

National map unit symbol: j5dq
Elevation: 4,800 to 5,300 feet
Mean annual precipitation: 10 to 12 inches
Mean annual air temperature: 45 to 51 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Hiko peak and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hiko Peak

Setting

Landform: Fan remnants, mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave, convex
Across-slope shape: Convex
Parent material: Alluvium from quartzite, sandstone, and conglomerate

Typical profile

A - 0 to 9 inches: stony fine sandy loam
Bk - 9 to 49 inches: very gravelly sandy loam
BC - 49 to 60 inches: very gravelly sandy loam

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R028AY215UT - Semidesert Gravelly Loam (Wyoming Big Sagebrush) North
Hydric soil rating: No

Minor Components

Boxelder

Percent of map unit: 5 percent
Hydric soil rating: No

Heist

Percent of map unit: 5 percent
Hydric soil rating: No

Amtoft

Percent of map unit: 5 percent
Hydric soil rating: No

63—Hiko Peak-Heist complex, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: j5dt
Elevation: 4,700 to 5,000 feet
Mean annual precipitation: 10 to 12 inches
Mean annual air temperature: 48 to 51 degrees F
Frost-free period: 130 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Hiko peak and similar soils: 45 percent
Heist and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hiko Peak

Setting

Landform: Fan remnants, alluvial fans
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from quartzite, sandstone, and conglomerate

Typical profile

A - 0 to 3 inches: fine sandy loam
Bw - 3 to 16 inches: gravelly loam
Bk1 - 16 to 29 inches: extremely gravelly sandy loam
Bk2 - 29 to 43 inches: extremely gravelly sandy loam
Bk3 - 43 to 49 inches: extremely gravelly loamy sand
BC - 49 to 60 inches: very gravelly sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.5 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: B

Ecological site: R028AY215UT - Semidesert Gravelly Loam (Wyoming Big Sagebrush) North
Hydric soil rating: No

Description of Heist

Setting

Landform: Alluvial fans
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from limestone, sandstone, and quartzite

Typical profile

A - 0 to 14 inches: fine sandy loam
C - 14 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.7 inches)

Interpretive groups

Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: A
Ecological site: R028AY226UT - Semidesert Sandy Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Berent

Percent of map unit: 10 percent
Hydric soil rating: No

Oakcity

Percent of map unit: 5 percent
Hydric soil rating: No

64—Hiko Peak-Heist complex, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: j5dv

Elevation: 4,700 to 5,500 feet
Mean annual precipitation: 10 to 12 inches
Mean annual air temperature: 48 to 51 degrees F
Frost-free period: 130 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Hiko peak and similar soils: 50 percent
Heist and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hiko Peak

Setting

Landform: Fan remnants, alluvial fans
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from quartzite, sandstone, and conglomerate

Typical profile

A - 0 to 3 inches: fine sandy loam
Bw - 3 to 16 inches: gravelly loam
Bk1 - 16 to 29 inches: extremely gravelly sandy loam
Bk2 - 29 to 43 inches: extremely gravelly sandy loam
Bk3 - 43 to 49 inches: extremely gravelly loamy sand
BC - 49 to 60 inches: very gravelly sand

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R028AY215UT - Semidesert Gravelly Loam (Wyoming Big Sagebrush) North
Hydric soil rating: No

Description of Heist

Setting

Landform: Alluvial fans
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Alluvium from limestone, sandstone, and quartzite

Typical profile

A - 0 to 14 inches: fine sandy loam
C - 14 to 60 inches: fine sandy loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R028AY226UT - Semidesert Sandy Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Berent

Percent of map unit: 10 percent
Hydric soil rating: No

Donnardo

Percent of map unit: 5 percent
Hydric soil rating: No

Oakcity

Percent of map unit: 5 percent
Hydric soil rating: No

68—Jigsaw-Oakcity complex, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: j5dz
Elevation: 4,700 to 5,200 feet
Mean annual precipitation: 10 to 12 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Jigsaw and similar soils: 45 percent
Oakcity and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Jigsaw

Setting

Landform: Lake plains, lake terraces
Landform position (three-dimensional): Tread, rise, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium from sedimentary rocks

Typical profile

Ap1 - 0 to 4 inches: silt loam
Ap2 - 4 to 9 inches: silt loam
C1 - 9 to 32 inches: silty clay loam
C2 - 32 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Gypsum, maximum content: 35 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 10.8 inches)

Interpretive groups

Land capability classification (irrigated): 2c
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: R028AY220UT - Semidesert Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Description of Oakcity

Setting

Landform: Lake terraces, lake plains
Landform position (three-dimensional): Tread, rise, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Lacustrine deposits and alluvium from sedimentary rocks

Typical profile

A1 - 0 to 5 inches: loam
A2 - 5 to 10 inches: clay loam
Bw - 10 to 15 inches: silty clay loam
C - 15 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Ecological site: R028AY220UT - Semidesert Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Mellor

Percent of map unit: 5 percent
Hydric soil rating: No

Dune land

Percent of map unit: 5 percent
Hydric soil rating: No

Kanosh

Percent of map unit: 3 percent
Hydric soil rating: No

Deseret

Percent of map unit: 2 percent
Hydric soil rating: No

69—Kanosh very fine sandy loam, o to 2 percent slopes

Map Unit Setting

National map unit symbol: j5f0
Elevation: 4,600 to 4,800 feet
Mean annual precipitation: 7 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kanosh and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kanosh

Setting

Landform: Flood plains
Landform position (three-dimensional): Dip, talf
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium from limestone and sandstone

Typical profile

A - 0 to 4 inches: very fine sandy loam
Bk - 4 to 19 inches: fine sandy loam
Bky1 - 19 to 30 inches: fine sandy loam
Bky2 - 30 to 38 inches: fine sandy loam
Bky3 - 38 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 20 percent
Maximum salinity: Strongly saline (16.0 to 32.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7w
Hydrologic Soil Group: B
Ecological site: R028AY132UT - Desert Salty Silt (Iodinebush)
Hydric soil rating: No

Minor Components

Ashdown

Percent of map unit: 2 percent
Hydric soil rating: No

Poganeab

Percent of map unit: 2 percent
Landform: Oxbows, flood plains
Landform position (three-dimensional): Dip, talf
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: R028AY024UT - Wet Saline Meadow (Saltgrass)

Hydric soil rating: Yes

Berent

Percent of map unit: 2 percent
Hydric soil rating: No

Mellor

Percent of map unit: 2 percent
Hydric soil rating: No

Benstot

Percent of map unit: 1 percent
Hydric soil rating: No

Bandag

Percent of map unit: 1 percent
Hydric soil rating: No

81—Lava flows-Shotwell complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: j5fj
Elevation: 4,600 to 5,000 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 110 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Lava flows: 60 percent
Shotwell and similar soils: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows

Setting

Landform: Lava flows
Down-slope shape: Linear
Across-slope shape: Linear

Description of Shotwell

Setting

Landform: Lava flows
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum from basalt and cinders

Typical profile

A - 0 to 3 inches: very cobbly loam
Bw - 3 to 14 inches: loam

R - 14 to 18 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R028AY243UT - Semidesert Shallow Loam (Wyoming Big Sagebrush) North
Hydric soil rating: No

Minor Components

Kessler

Percent of map unit: 5 percent

Cloyd

Percent of map unit: 5 percent
Hydric soil rating: No

Boxelder

Percent of map unit: 5 percent
Hydric soil rating: No

102—Preston fine sand, 2 to 30 percent slopes

Map Unit Setting

National map unit symbol: j5b7
Elevation: 5,200 to 6,200 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Preston and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Preston

Setting

Landform: Dunes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits from lacustrine deposits

Typical profile

A - 0 to 18 inches: fine sand
C - 18 to 60 inches: loamy fine sand

Properties and qualities

Slope: 2 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: R028AY330UT - Upland Sand (Black Greasewood, Indian Ricegrass)
Hydric soil rating: No

Minor Components

Dune land

Percent of map unit: 10 percent
Hydric soil rating: No

Calita

Percent of map unit: 5 percent
Hydric soil rating: No

120—Woodrow silty clay loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: j5bw
Elevation: 4,650 to 4,900 feet
Mean annual precipitation: 8 to 12 inches
Mean annual air temperature: 47 to 52 degrees F
Frost-free period: 110 to 140 days

Farmland classification: Not prime farmland

Map Unit Composition

Woodrow and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodrow

Setting

Landform: Lake terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium and lacustrine deposits

Typical profile

Ap - 0 to 16 inches: silty clay loam
C - 16 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R028AY220UT - Semidesert Loam (Wyoming Big Sagebrush)
Hydric soil rating: No

Minor Components

Mellor

Percent of map unit: 5 percent
Hydric soil rating: No

Manassa

Percent of map unit: 5 percent
Hydric soil rating: No

Oakcity

Percent of map unit: 5 percent
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

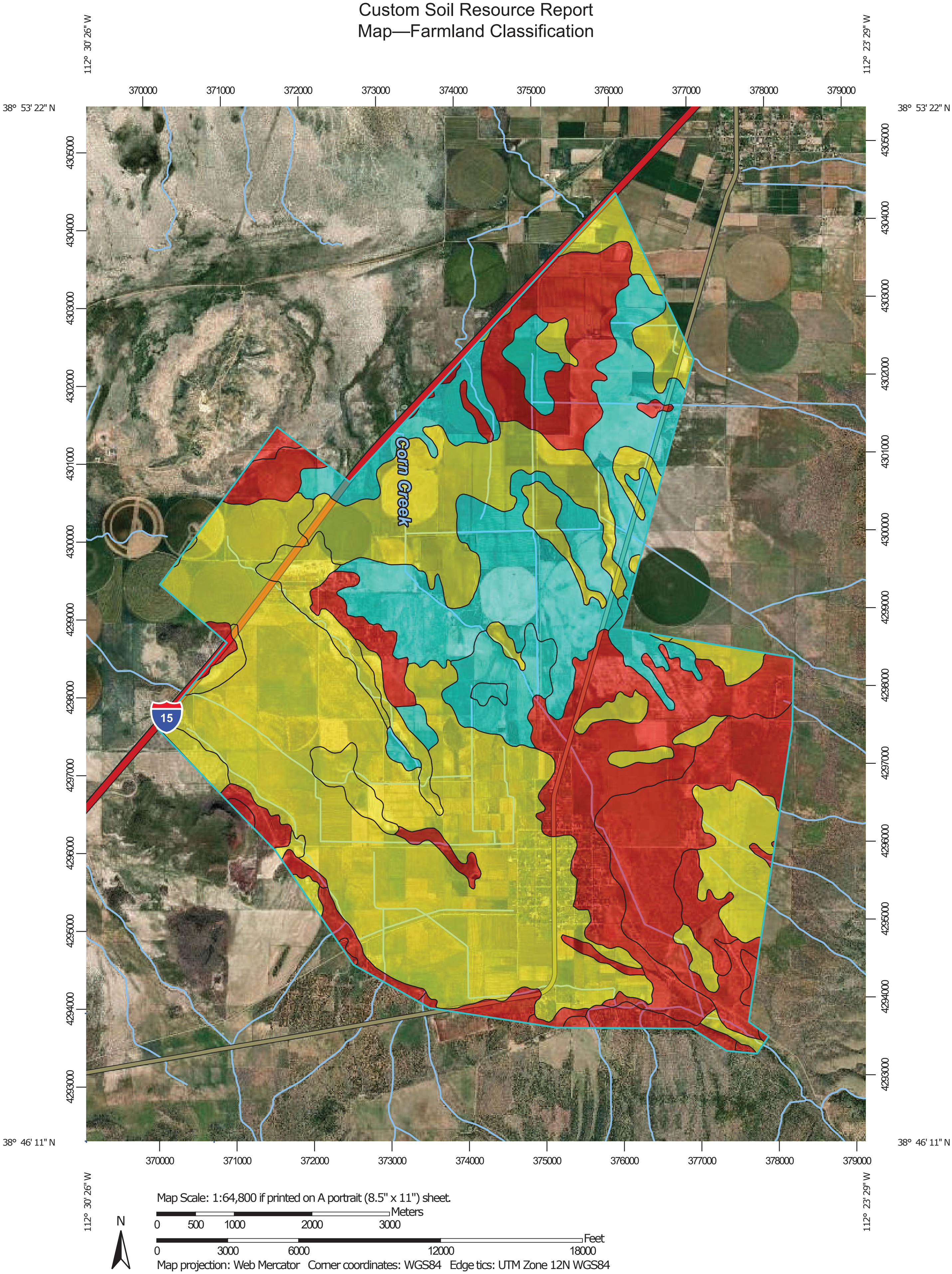
Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Farmland Classification

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Map—Farmland Classification



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated
- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Soil Rating Lines

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season

- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated
- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Soil Rating Points

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated

- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Millard County, Utah - Eastern Part
Survey Area Data: Version 15, Aug 29, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Farmland Classification

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	Prime farmland if irrigated	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	Prime farmland if irrigated	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	Prime farmland if irrigated	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	Prime farmland if irrigated	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	Not prime farmland	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	Farmland of statewide importance	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	Farmland of statewide importance	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	Prime farmland if irrigated	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	Not prime farmland	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	Not prime farmland	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	Not prime farmland	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	Not prime farmland	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	Not prime farmland	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	Not prime farmland	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	Prime farmland if irrigated	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	Prime farmland if irrigated	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	Not prime farmland	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	Not prime farmland	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	Not prime farmland	87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	Not prime farmland	79.7	0.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	Not prime farmland	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	Not prime farmland	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	Not prime farmland	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes	Not prime farmland	39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	Not prime farmland	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	Not prime farmland	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—Farmland Classification

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

Hydric Rating by Map Unit

This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

The thematic map is color coded based on the composition of hydric components. The five color classes are separated as 100 percent hydric components, 66 to 99 percent hydric components, 33 to 65 percent hydric components, 1 to 32 percent hydric components, and less than one percent hydric components.

In Web Soil Survey, the Summary by Map Unit table that is displayed below the map pane contains a column named 'Rating'. In this column the percentage of each map unit that is classified as hydric is displayed.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

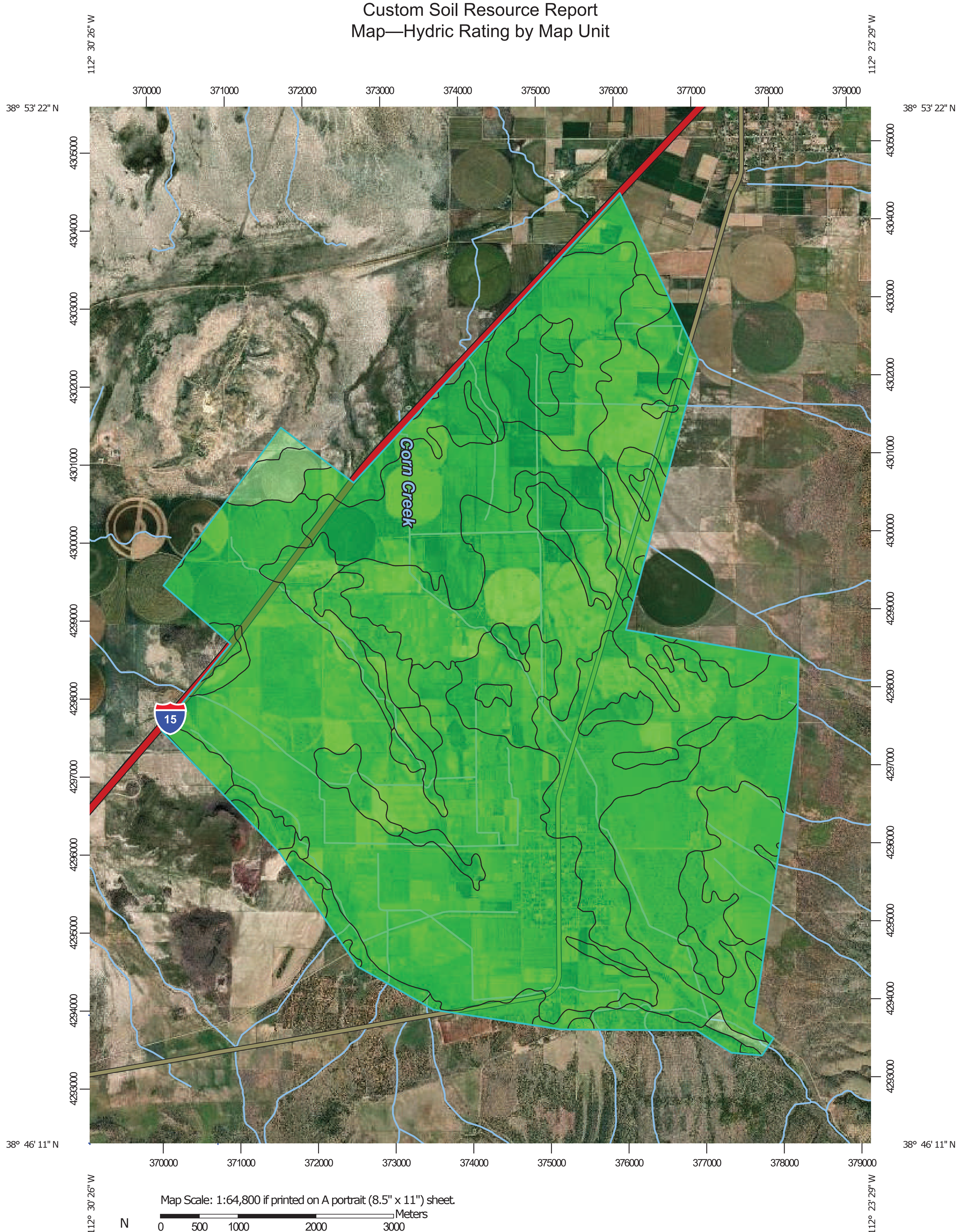
Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Map—Hydric Rating by Map Unit



Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 3000, 6000, 12000, 18000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Lines
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Points
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Survey Area Data: Version 15, Aug 29, 2022

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Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydric Rating by Map Unit

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	0	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	0	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	0	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	0	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	0	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	0	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	0	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	2	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	0	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	0	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	0	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	4	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	0	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	0	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	0	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	0	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	0	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	0	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	0	87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	0	79.7	0.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	0	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	0	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	2	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes	0	39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	0	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	0	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—Hydric Rating by Map Unit

Aggregation Method: Percent Present

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Soil Health

Soil health interpretations are designed to be used as tools for evaluating and managing a soil's capacity to function as a vital living ecosystem that sustains plants, animals, and humans. Example interpretations include compaction, surface sealing, carbon sequestration, resistance and resilience, management systems and practices, and cover crops.

Surface Salt Concentration

Concentration of Salts- Soil Surface

Soil health is primarily influenced by human management, which is not captured in soil survey data at this time. These interpretations provide information on inherent soil properties that influence our ability to build healthy soils through management.

Salts of sodium, calcium, potassium, and magnesium are produced by the weathering of minerals in soils. Some salts can be added to the surface due to aeolian deposition. Excess salts can be concentrated in soils when precipitation is sufficient to move salts within the soil but of insufficient quantity to move the salts out of the soil. Salts move downward with percolating precipitation from the generally convex recharge areas of the landscape to the generally concave discharge areas. Net water movement can be upward in these areas due to evapotranspiration or water movement may be more or less horizontal due to restrictive layers or differences in water transmission rates. Excessive salt concentration in the surface of soil is detrimental to the germination and growth of crops due to the osmotic effects of the ions. Several soil and site properties influence the movement and distribution of salts on the landscape. Excess salts must exist in the soil in order to have movement and surface concentration. The concentration of excess salts in soils is estimated by measuring the electrical conductivity of the soil. The soil must exist in a non-leaching environment. In areas where salt accumulates in the soil, precipitation does not exceed evapotranspiration, thus excess salts do not move vertically or laterally through the soil profile and then into ground or surface waters. The soil surface and subsurface must generally concentrate water flow. Research has shown that in regions where rainfall is limited the concave parts of the landscape also concentrate subsurface water flow as well as surface flow. Salts move through soil when water flows. Most water movement happens when the soil is saturated, thus, the depth to saturation and its temporal persistence influence whether or not salts will remain deep in the profile or be carried to the surface. If the water table remains deep the salts will accumulate deeper in the profile. If the water table is close enough to the surface that capillary rise and evapotranspiration can bring water to the soil surface, salts will accumulate at the surface. The degree to which each of the soil properties considered promotes accumulation of surface salts is rated. The rating of the attribute that contributes the least to surface salinization is taken as the overall rating.

The ratings are both verbal and numerical. Numerical ratings indicate the contributions of the individual soil properties. The ratings are shown in decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil has the most severe propensity for surface salinization (1.00) and the point at which the soil has no propensity for surface salinization (0.00).

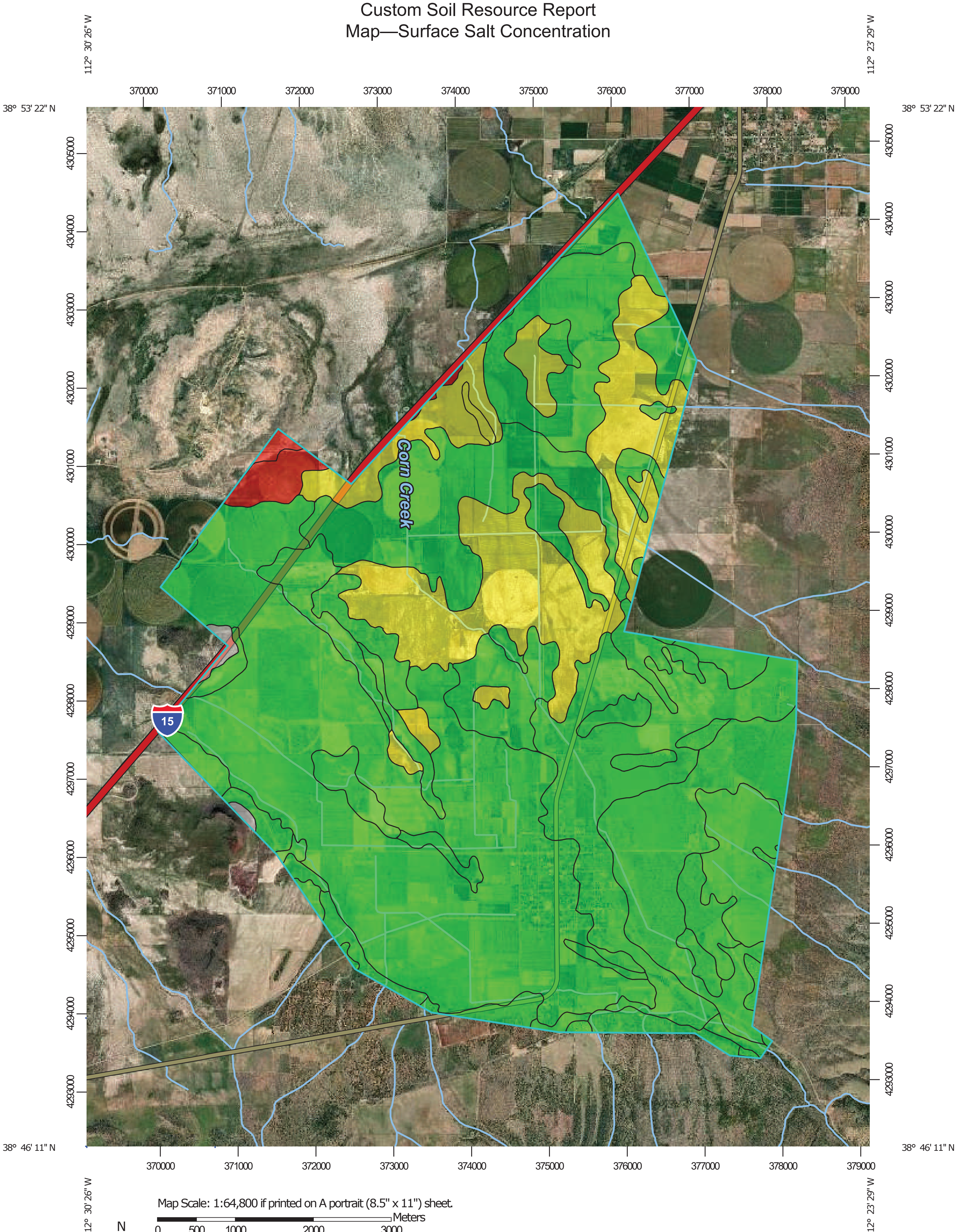
Rating class terms indicate the rate at which the soils are likely to subside considering all the soil features that are examined for this rating. "High surface salinization risk or already saline" indicates that the soil has features that are very favorable for the accumulation of salts at the surface or are already saline. These soils are already limited by excess surface salts. "Surface salinization risk" indicates that the soil has features that are somewhat favorable for surface salinization. Careful management will be needed to avoid damage from salinity. "Low surface salinization risk" indicates that the soil has one or more features that are unfavorable for salinization. These soils exist in climates where salinization does not occur or on landscape positions where salts are unlikely to accumulate.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

This interpretation is being provided for review and comment by the user community. Please forward any feedback to the Soils Hotline soilshotline@lin.usda.gov.

Map—Surface Salt Concentration



Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.

0 500 1000 2000 3000 Meters

0 3000 6000 12000 18000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- High surface salinization risk or already saline
- Surface salinization risk
- Low surface salinization risk
- Not rated or not available

Soil Rating Lines
- High surface salinization risk or already saline
- Surface salinization risk
- Low surface salinization risk
- Not rated or not available

Soil Rating Points
- High surface salinization risk or already saline
- Surface salinization risk
- Low surface salinization risk
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

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Coordinate System: Web Mercator (EPSG:3857)

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Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

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Tables—Surface Salt Concentration

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	Low surface salinization risk	Ashdown (85%)	Non-leaching climate (1.00)	3,976.1	30.1%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
4	Ashdown loam, 2 to 5 percent slopes	Low surface salinization risk	Ashdown (85%)	Non-leaching climate (1.00)	139.6	1.1%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
7	Bandag loam, 0 to 2 percent slopes	Low surface salinization risk	Bandag (85%)	Non-leaching climate (1.00)	1,552.0	11.8%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
8	Bandag loam, 2 to 5 percent slopes	Low surface salinization risk	Bandag (85%)	Non-leaching climate (1.00)	541.8	4.1%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
22	Borvant-Pavant complex, 2 to 15 percent slopes	Low surface salinization risk	Borvant (55%)	Non-leaching climate (1.00)	239.7	1.8%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
			Pavant (30%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
23	Boxelder silt loam, 0 to 2 percent slopes	Surface salinization risk	Boxelder (85%)	Non-leaching climate (1.00)	2,212.8	16.8%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Electrical conductivity (1.00)		
				Existing electrical conductivity, 0-30cm (0.74)		
25	Calita-Erda complex, 0 to 2 percent slopes	Low surface salinization risk	Calita (60%)	Non-leaching climate (1.00)	430.4	3.3%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
			Erda (30%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
27	Cessna loam, 0 to 5 percent slopes	Low surface salinization risk	Cessna (90%)	Non-leaching climate (1.00)	28.2	0.2%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.67)		
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	Low surface salinization risk	Cloyd (65%)	Non-leaching climate (1.00)	0.1	0.0%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
31	Collard gravelly loam, 2 to 5 percent slopes	Low surface salinization risk	Collard (90%)	Non-leaching climate (1.00)	1,262.4	9.6%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	Low surface salinization risk	Current Spring (55%)	Non-leaching climate (1.00)	5.8	0.0%

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
			Maple Hollow (30%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
36	Deseret silt loam, 0 to 1 percent slopes	High surface salinization risk or already saline	Deseret (85%)	Non-leaching climate (1.00)	141.4	1.1%
				Electrical conductivity (1.00)		
				Existing electrical conductivity, 0-30cm (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
37	Donnardo very stony loam, 2 to 15 percent slopes	Low surface salinization risk	Donnardo (90%)	Non-leaching climate (1.00)	49.2	0.4%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	Low surface salinization risk	Donnardo (40%)	Non-leaching climate (1.00)	930.4	7.0%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
			Collard (25%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
			Borvant (25%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
42	Escalante sandy loam, 0 to 2 percent slopes	Low surface salinization risk	Escalante (85%)	Non-leaching climate (1.00)	31.8	0.2%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Electrical conductivity (0.42)		
				Surface shape concentrates salts (0.33)		
43	Escalante sandy loam, 2 to 5 percent slopes	Low surface salinization risk	Escalante (85%)	Non-leaching climate (1.00)	430.4	3.3%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Electrical conductivity (0.42)		
54	Heist-Berent complex, 0 to 15 percent slopes	Low surface salinization risk	Heist (45%)	Non-leaching climate (1.00)	76.7	0.6%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Electrical conductivity (0.10)		
			Berent (40%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Electrical conductivity (0.10)		
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	Low surface salinization risk	Hiko Peak (85%)	Non-leaching climate (1.00)	168.8	1.3%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	Low surface salinization risk	Hiko Peak (85%)	Non-leaching climate (1.00)	87.3	0.7%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	Low surface salinization risk	Hiko Peak (45%)	Non-leaching climate (1.00)	79.7	0.6%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
			Heist (40%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	Low surface salinization risk	Hiko Peak (50%)	Non-leaching climate (1.00)	6.0	0.0%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		
				Electrical conductivity (0.10)		
			Heist (30%)	Non-leaching climate (1.00)		
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Surface shape concentrates salts (0.33)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Electrical conductivity (0.10)		
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	Low surface salinization risk	Jigsaw (45%)	Non-leaching climate (1.00)	653.7	5.0%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Electrical conductivity (0.30)		
69	Kanosh very fine sandy loam, o to 2 percent slopes	High surface salinization risk or already saline	Kanosh (90%)	Non-leaching climate (1.00)	27.9	0.2%
				Electrical conductivity (1.00)		
				Persistent water table (1.00)		
				Existing electrical conductivity, 0-30cm (1.00)		
				Water table at the surface, months (1.00)		
81	Lava flows-Shotwell complex, 0 to 8 percent slopes	Not rated	Lava flows (60%)		39.9	0.3%
			KESSLER (5%)			
			Cloyd (5%)			
			Boxelder (5%)			
102	Preston fine sand, 2 to 30 percent slopes	Low surface salinization risk	Preston (85%)	Non-leaching climate (1.00)	66.6	0.5%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		
				Electrical conductivity (0.10)		
120	Woodrow silty clay loam, 0 to 2 percent slopes	Surface salinization risk	Woodrow (85%)	Non-leaching climate (1.00)	22.8	0.2%
				Water table at the surface, months (1.00)		
				Flooding and ponding (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Electrical conductivity (0.63)		
				Existing electrical conductivity, 0-30cm (0.62)		
Totals for Area of Interest					**13,201.8**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Low surface salinization risk	10,756.6	81.5%
Surface salinization risk	2,235.6	16.9%
High surface salinization risk or already saline	169.3	1.3%
Null or Not Rated	39.9	0.3%
Totals for Area of Interest	**13,201.8**	**100.0%**

Rating Options—Surface Salt Concentration

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Vegetative Productivity

Vegetative productivity includes estimates of potential vegetative production for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture and rangeland. In the underlying database, some states maintain crop yield data by individual map unit component. Other states maintain the data at the map unit level. Attributes are included for both, although only one or the other is likely to contain data for any given geographic area. For other land uses, productivity data is shown only at the map unit component level. Examples include potential crop yields under irrigated and nonirrigated conditions, forest productivity, forest site index, and total rangeland production under of normal, favorable and unfavorable conditions.

Yields of Non-Irrigated Crops (Component): Alfalfa hay (Tons)

These are the estimated average yields per acre that can be expected of selected nonirrigated crops under a high level of management. In any given year, yields may be higher or lower than those indicated because of variations in rainfall and other climatic factors.

In the database, some states maintain crop yield data by individual map unit component and others maintain the data at the map unit level. Attributes are included in this application for both, although only one or the other is likely to contain data for any given geographic area. This attribute uses data maintained at the map unit component level.

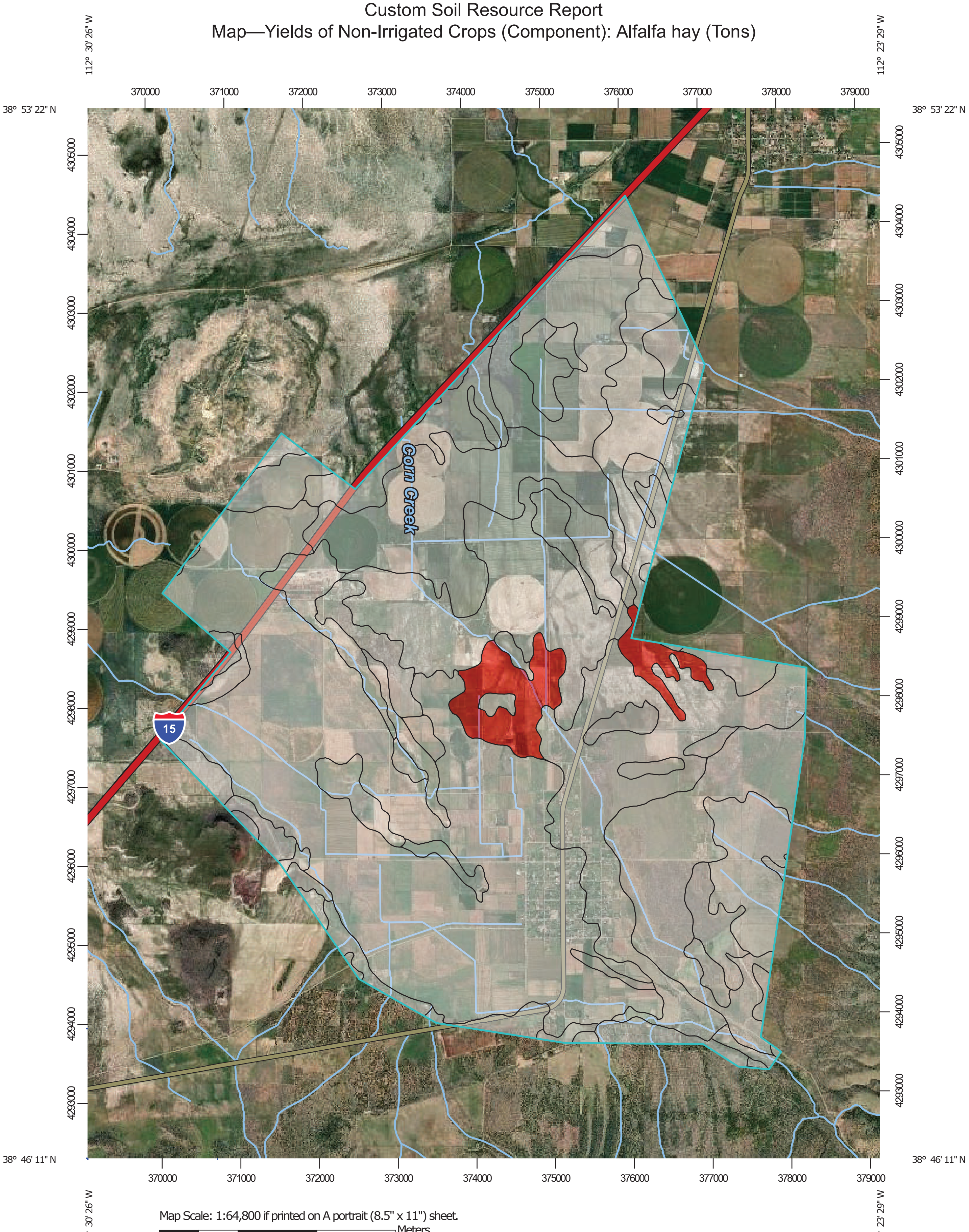
The yields are actually recorded as three separate values in the database. A low value and a high value indicate the range for the soil component. A "representative" value indicates the expected value for the component. For these yields, only the representative value is used.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby areas and results of field trials and demonstrations also are considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for the selected crop. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Map—Yields of Non-Irrigated Crops (Component): Alfalfa hay (Tons)



Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 500 1000 2000 3000

Feet: 0 3000 6000 12000 18000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- = 1.80
- Not rated or not available

Soil Rating Lines
- = 1.80
- Not rated or not available

Soil Rating Points
- = 1.80
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Millard County, Utah - Eastern Part
Survey Area Data: Version 15, Aug 29, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Yields of Non-Irrigated Crops (Component): Alfalfa hay (Tons)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes		3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes		139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes		1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes		541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes		239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes		2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	1.80	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes		28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes		0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes		1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes		5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes		141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes		49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes		930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes		31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes		430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes		76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes		168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes		87.3	0.7%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
63	Hiko Peak-Heist complex, 0 to 2 percent slopes		79.7	0.6%
64	Hiko Peak-Heist complex, 2 to 8 percent slopes		6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes		653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes		27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes		39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes		66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes		22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—Yields of Non-Irrigated Crops (Component): Alfalfa hay (Tons)

Crop: Alfalfa hay

Yield Units: Tons

Aggregation Method: Weighted Average

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: Yes

Yields of Irrigated Crops (Component): Alfalfa hay (Tons)

These are the estimated average yields per acre that can be expected of selected irrigated crops under a high level of management. In any given year, yields may be higher or lower than those indicated because of variations in rainfall and other climatic factors. It is assumed that the irrigation system is adapted to the soils and to the crops grown, that good-quality irrigation water is uniformly applied as needed, and that tillage is kept to a minimum.

In the database, some states maintain crop yield data by individual map unit component and others maintain the data at the map unit level. Attributes are included in this application for both, although only one or the other is likely to have data for any given geographic area. This attribute uses data maintained at the map unit component level.

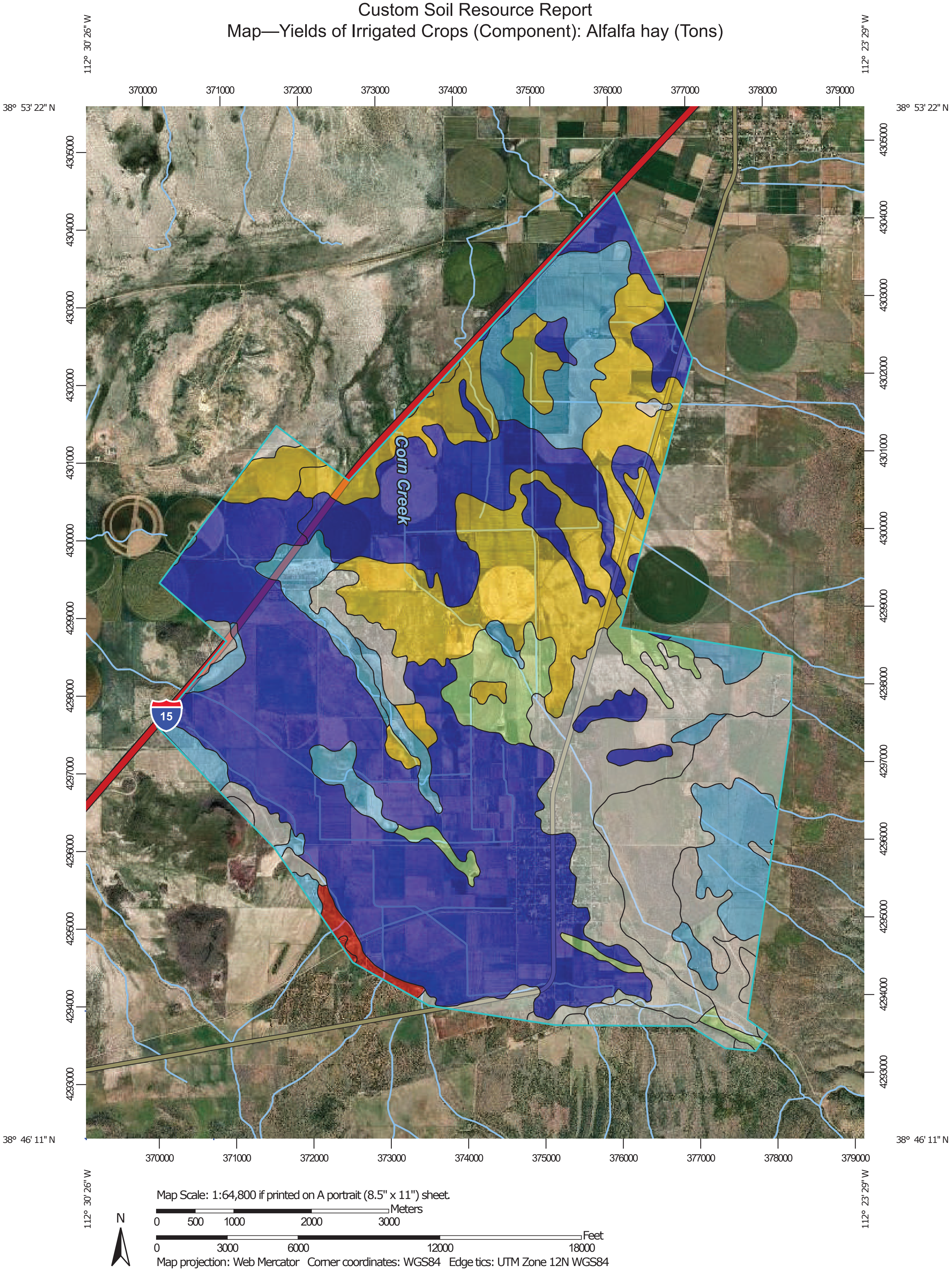
The yields are actually recorded as three separate values in the database. A low value and a high value indicate the range for the soil component. A "representative" value indicates the expected value for the component. For these yields, only the representative value is used.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby areas and results of field trials and demonstrations also are considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for the selected crop. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Custom Soil Resource Report
Map—Yields of Irrigated Crops (Component): Alfalfa hay (Tons)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 3.85
- > 3.85 and <= 4.25
- > 4.25 and <= 4.50
- > 4.50 and <= 4.70
- > 4.70 and <= 5.10
- Not rated or not available

Soil Rating Lines
- <= 3.85
- > 3.85 and <= 4.25
- > 4.25 and <= 4.50
- > 4.50 and <= 4.70
- > 4.70 and <= 5.10
- Not rated or not available

Soil Rating Points
- <= 3.85
- > 3.85 and <= 4.25
- > 4.25 and <= 4.50
- > 4.50 and <= 4.70
- > 4.70 and <= 5.10
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Millard County, Utah - Eastern Part
Survey Area Data: Version 15, Aug 29, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Yields of Irrigated Crops (Component): Alfalfa hay (Tons)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	5.10	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	4.68	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	5.10	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	4.68	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes		239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	4.25	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	4.50	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	4.50	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes		0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes		1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes		5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	4.25	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes		49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes		930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	4.68	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	4.68	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	3.85	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes		168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes		87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	4.45	79.7	0.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	3.75	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	4.70	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes		27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes		39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes		66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	5.10	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—Yields of Irrigated Crops (Component): Alfalfa hay (Tons)

Crop: Alfalfa hay

Yield Units: Tons

Aggregation Method: Weighted Average

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Weighted Average" computes a weighted average value for all components in the map unit. Percent composition is the weighting factor. The result returned by this aggregation method represents a weighted average value of the corresponding attribute throughout the map unit.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Interpret Nulls as Zero: Yes

This option indicates if a null value for a component should be converted to zero before aggregation occurs. This will be done only if a map unit has at least one component where this value is not null.

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Erosion Factors

Soil Erosion Factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

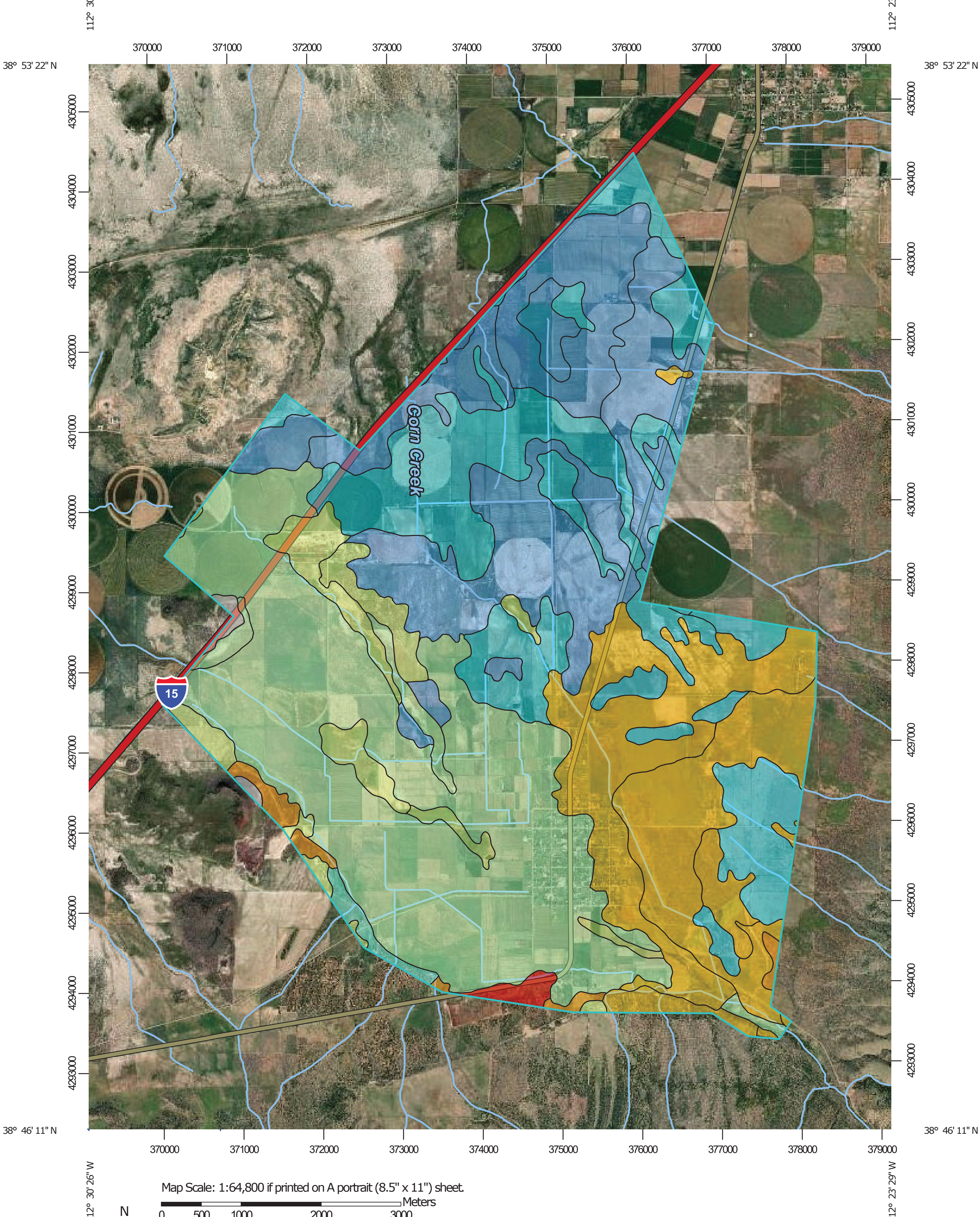
K Factor, Whole Soil

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Factor K does not apply to organic horizons and is not reported for those layers.

Map—K Factor, Whole Soil



Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 3000, 6000, 12000, 18000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Lines
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Points
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Millard County, Utah - Eastern Part
Survey Area Data: Version 15, Aug 29, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	.28	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	.28	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	.37	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	.37	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	.15	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	.43	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	.37	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	.28	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	.20	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	.15	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	.15	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	.43	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	.10	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	.15	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	.24	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	.24	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	.32	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	.24	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	.10	87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	.24	79.7	0.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	.24	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	.43	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	.37	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes		39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	.02	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	.37	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—K Factor, Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Soil Physical Properties

Soil Physical Properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

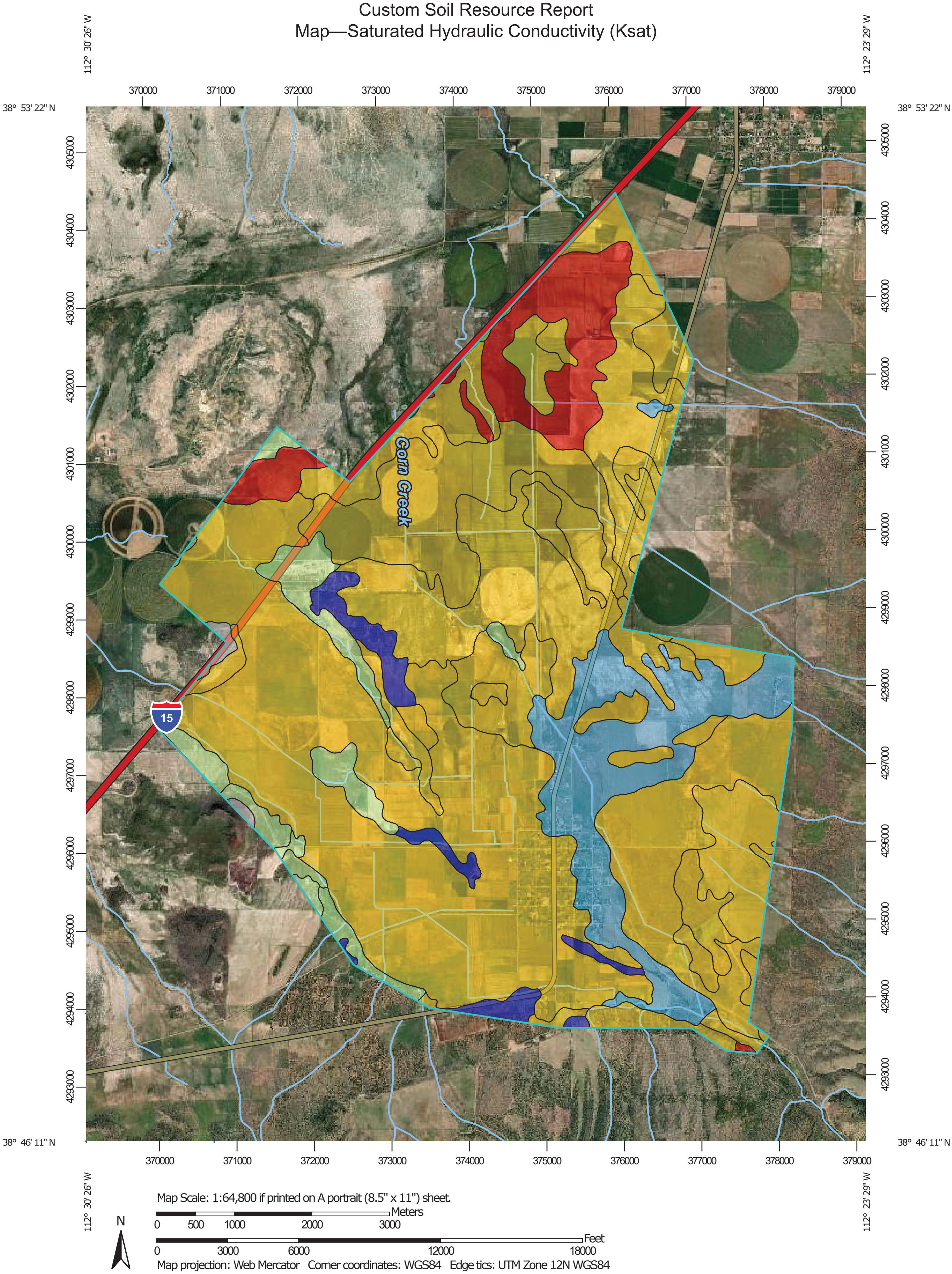
Saturated Hydraulic Conductivity (Ksat)

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity is considered in the design of soil drainage systems and septic tank absorption fields.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

The numeric Ksat values have been grouped according to standard Ksat class limits.

Map—Saturated Hydraulic Conductivity (Ksat)



Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 3000, 6000, 12000, 18000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 3.7809
- > 3.7809 and <= 15.8159
- > 15.8159 and <= 28.2300
- > 28.2300 and <= 55.8467
- > 55.8467 and <= 102.0770
- Not rated or not available

Soil Rating Lines
- <= 3.7809
- > 3.7809 and <= 15.8159
- > 15.8159 and <= 28.2300
- > 28.2300 and <= 55.8467
- > 55.8467 and <= 102.0770
- Not rated or not available

Soil Rating Points
- <= 3.7809
- > 3.7809 and <= 15.8159
- > 15.8159 and <= 28.2300
- > 28.2300 and <= 55.8467
- > 55.8467 and <= 102.0770
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Millard County, Utah - Eastern Part
Survey Area Data: Version 15, Aug 29, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Saturated Hydraulic Conductivity (Ksat)

Map unit symbol	Map unit name	Rating (micrometers per second)	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	9.1700	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	9.1700	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	9.1700	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	9.1700	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	7.1983	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	9.1700	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	8.3345	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	9.1700	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	6.9345	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	55.8467	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	2.8256	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	1.6825	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	9.1700	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	15.8159	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	24.8443	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	24.8443	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	28.2300	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	102.0770	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	25.3459	87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	102.0770	79.7	0.6%

Map unit symbol	Map unit name	Rating (micrometers per second)	Acres in AOI	Percent of AOI
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	102.0770	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	3.7809	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	28.2300	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes		39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	91.7400	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	2.8200	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—Saturated Hydraulic Conductivity (Ksat)

Units of Measure: micrometers per second

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Fastest

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): All Layers (Weighted Average)

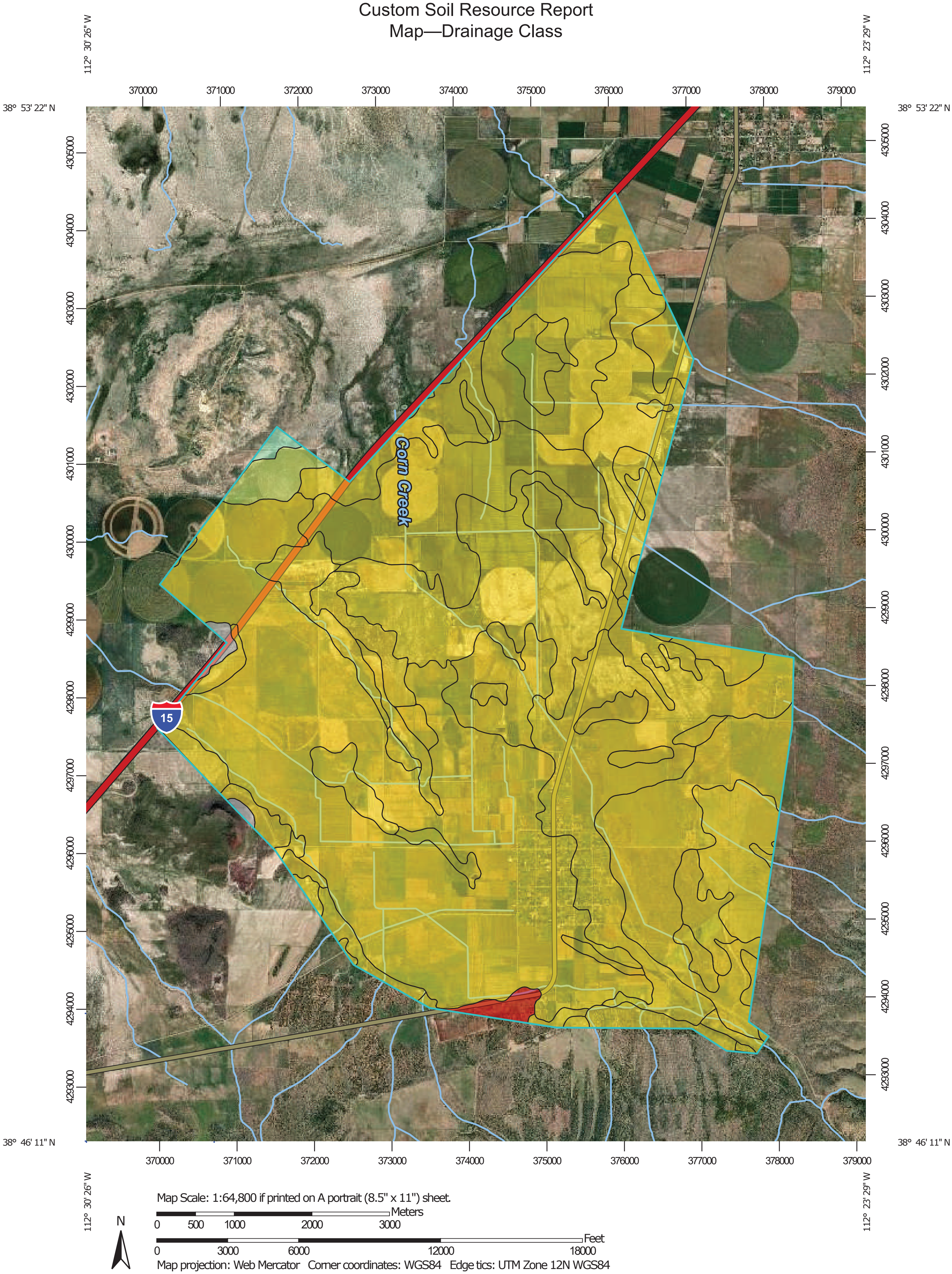
Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Drainage Class

"Drainage class (natural)" refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized-excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the "Soil Survey Manual."

Map—Drainage Class



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Subaqueous
- Not rated or not available

Soil Rating Lines
- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Subaqueous
- Not rated or not available

Soil Rating Points
- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Subaqueous
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Survey Area Data: Version 15, Aug 29, 2022

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Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

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Table—Drainage Class

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	Well drained	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	Well drained	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	Well drained	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	Well drained	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	Well drained	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	Well drained	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	Well drained	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	Well drained	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	Well drained	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	Well drained	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	Well drained	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	Moderately well drained	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	Well drained	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	Well drained	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	Well drained	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	Well drained	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	Well drained	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	Well drained	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	Well drained	87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	Well drained	79.7	0.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	Well drained	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	Well drained	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	Somewhat poorly drained	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes		39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	Excessively drained	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	Well drained	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—Drainage Class

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Water Features

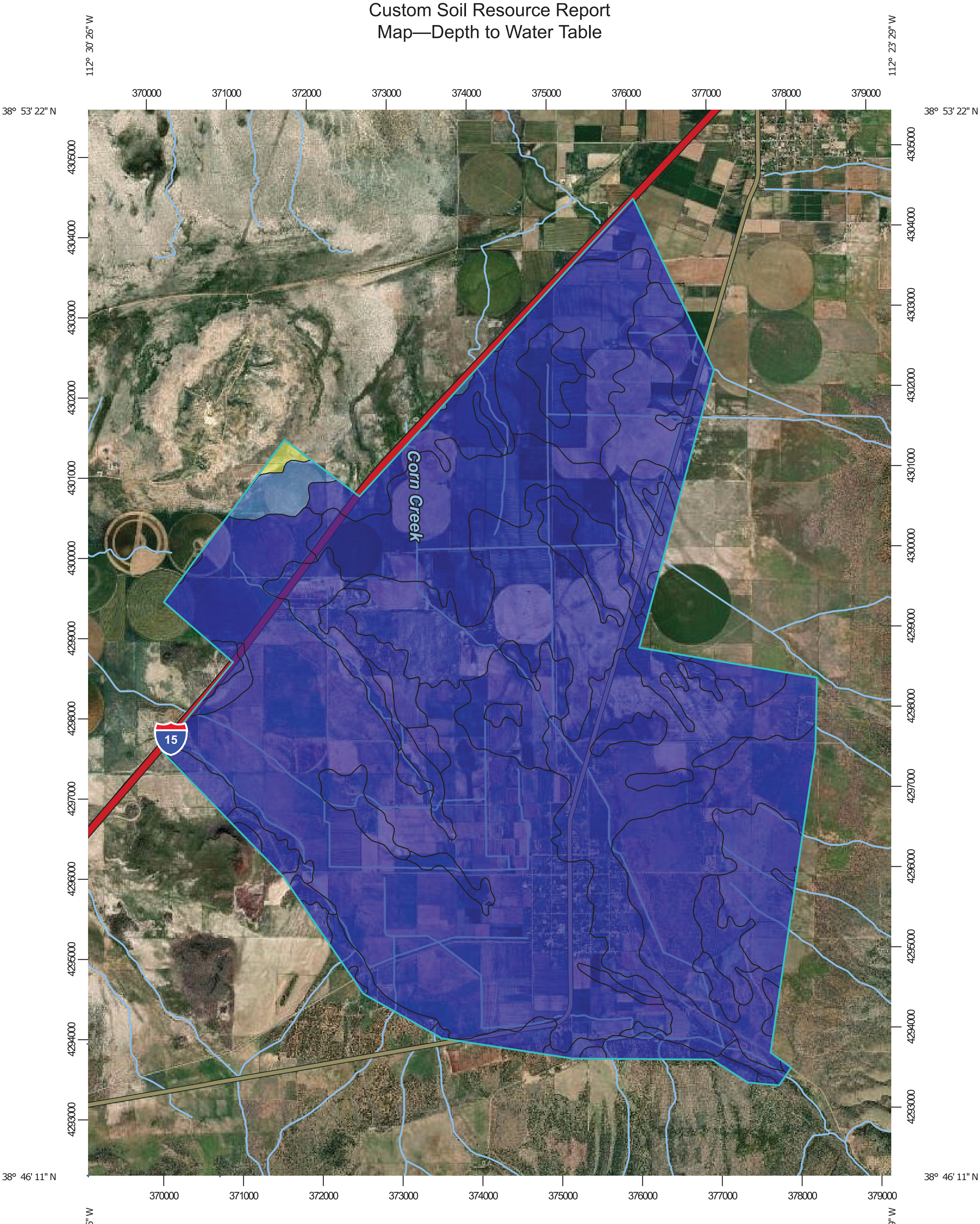
Water Features include ponding frequency, flooding frequency, and depth to water table.

Depth to Water Table

"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—Depth to Water Table



Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 3000, 6000, 12000, 18000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Soil Rating Lines

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Soil Rating Points

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Survey Area Data: Version 15, Aug 29, 2022

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Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Depth to Water Table

Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	>200	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	>200	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	>200	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	>200	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	>200	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	>200	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	>200	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	>200	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	>200	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	>200	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	>200	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	168	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	>200	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	>200	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	>200	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	>200	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	>200	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	>200	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	>200	87.3	0.7%
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	>200	79.7	0.6%

Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	>200	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	>200	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	77	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes	>200	39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	>200	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	>200	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Rating Options—Depth to Water Table

Units of Measure: centimeters

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Interpret Nulls as Zero: No

Beginning Month: January

Ending Month: December

Ecological Sites

Individual soil map unit components can be correlated to a particular ecological site. The Ecological Site Assessment section includes ecological site descriptions, plant growth curves, state and transition models, and selected National Plants database information.

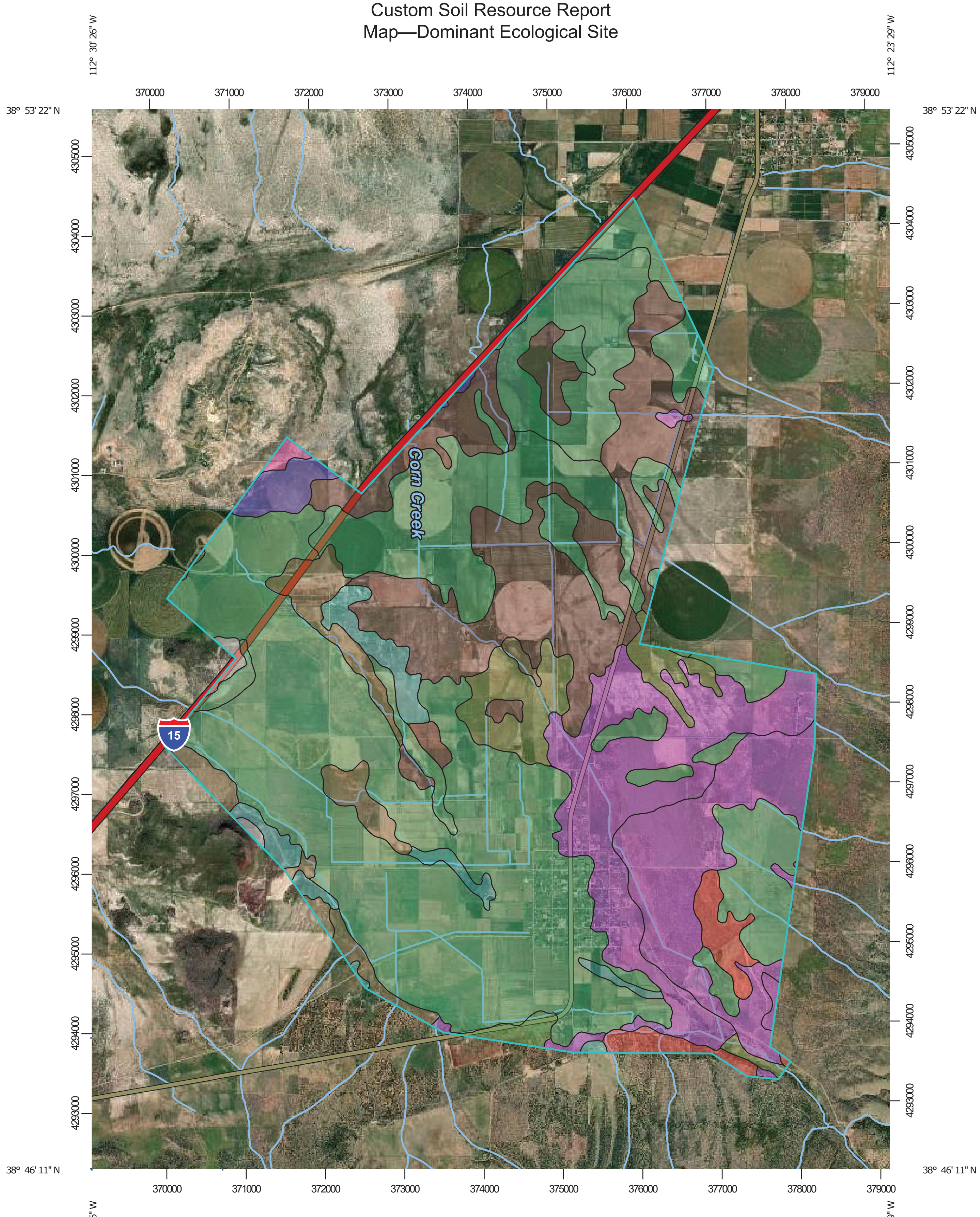
All Ecological Sites —

An "ecological site" is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time; a characteristic hydrology, particularly infiltration and runoff, that has developed over time; and a characteristic plant community (kind and amount of vegetation). The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. For example, the hydrology of the site is influenced by development of the soil and plant community. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species or in total production.

An ecological site name provides a general description of a particular ecological site. For example, "Loamy Upland" is the name of a rangeland ecological site. An "ecological site ID" is the symbol assigned to a particular ecological site.

The map identifies the dominant ecological site for each map unit, aggregated by dominant condition. Other ecological sites may occur within each map unit. Each map unit typically consists of one or more components (soils and/or miscellaneous areas). Each soil component is associated with an ecological site. Miscellaneous areas, such as rock outcrop, sand dunes, and badlands, have little or no soil material and support little or no vegetation and therefore are not linked to an ecological site. The table below the map lists all of the ecological sites for each map unit component in your area of interest.

Map—Dominant Ecological Site



Map Scale: 1:64,800 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 500 1000 2000 3000

Feet: 0 3000 6000 12000 18000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- R028AY004UT
- R028AY132UT
- R028AY215UT
- R028AY218UT
- R028AY220UT
- R028AY226UT
- R028AY236UT
- R028AY310UT
- R028AY320UT
- R028AY330UT
- R028AY334UT
- Not rated or not available

Soil Rating Lines
- R028AY004UT
- R028AY132UT
- R028AY215UT
- R028AY218UT
- R028AY220UT
- R028AY226UT
- R028AY236UT
- R028AY310UT
- R028AY320UT
- R028AY330UT
- R028AY334UT
- Not rated or not available

Soil Rating Points
- R028AY004UT
- R028AY132UT
- R028AY215UT
- R028AY218UT
- R028AY220UT
- R028AY226UT
- R028AY236UT
- R028AY310UT
- R028AY320UT
- R028AY330UT
- R028AY334UT
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Survey Area Data: Version 15, Aug 29, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 2, 2017

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Table—Ecological Sites by Map Unit Component

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	Ashdown (85%)	R028AY220UT — Semidesert Loam (Wyoming Big Sagebrush)	3,976.1	30.1%
		Boxelder (5%)			
		CALITA (5%)			
		Erda (5%)			
4	Ashdown loam, 2 to 5 percent slopes	Ashdown (85%)	R028AY220UT — Semidesert Loam (Wyoming Big Sagebrush)	139.6	1.1%
		Boxelder (5%)			
		CALITA (5%)			
		Erda (5%)			
7	Bandag loam, 0 to 2 percent slopes	Bandag (85%)	R028AY220UT — Semidesert Loam (Wyoming Big Sagebrush)	1,552.0	11.8%
		Boxelder (5%)			
		Erda (5%)			
		ESCALANTE (5%)			
8	Bandag loam, 2 to 5 percent slopes	Bandag (85%)	R028AY220UT — Semidesert Loam (Wyoming Big Sagebrush)	541.8	4.1%
		Boxelder (5%)			
		Erda (5%)			
		ESCALANTE (5%)			
22	Borvant-Pavant complex, 2 to 15 percent slopes	Borvant (55%)	R028AY320UT — Upland Shallow Hardpan (Pinyon-Utah Juniper)	239.7	1.8%
		Pavant (30%)	R028AY320UT — Upland Shallow Hardpan (Pinyon-Utah Juniper)		
		DONNARDO (5%)			
		Maple Hollow (5%)			
		POBER (5%)			
23	Boxelder silt loam, 0 to 2 percent slopes	Boxelder (85%)	R028AY218UT — Semidesert Silt Loam (Winterfat)	2,212.8	16.8%
		Bandag (5%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		BERENT (5%)			
		PAVANT (3%)			
		MELLOR (2%)			
25	Calita-Erda complex, 0 to 2 percent slopes	Calita (60%)	R028AY310UT — Upland Loam (Bonneville Big Sagebrush) North	430.4	3.3%
		Erda (30%)	R028AY310UT — Upland Loam (Bonneville Big Sagebrush) North		
		Borvant (4%)			
		DONNARDO (3%)			
		Oakcity (3%)			
27	Cessna loam, 0 to 5 percent slopes	Cessna (90%)	R028AY310UT — Upland Loam (Bonneville Big Sagebrush) North	28.2	0.2%
		CALITA (3%)			
		DONNARDO (3%)			
		HEIST (2%)			
		Poganeab (2%)	R028AY024UT — Wet Saline Meadow (Saltgrass)		
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	Cloyd (65%)	R028AY236UT — Semidesert Shallow Loam (Black Sagebrush)	0.1	0.0%
		Rock outcrop (25%)			
		ASHDOWN (4%)			
		HEIST (3%)			
		HIKO PEAK (3%)			
31	Collard gravelly loam, 2 to 5 percent slopes	Collard (90%)	R028AY334UT — Upland Stony Loam (Wyoming Big Sagebrush)	1,262.4	9.6%
		Borvant (5%)			
		DONNARDO (5%)			
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	Current Spring (55%)	R028AY334UT — Upland Stony Loam (Wyoming Big Sagebrush)	5.8	0.0%
		Maple Hollow (30%)	R028AY310UT — Upland Loam (Bonneville Big Sagebrush) North		
		Borvant (5%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		COLLARD (5%)			
		PAVANT (5%)			
36	Deseret silt loam, 0 to 1 percent slopes	Deseret (85%)	R028AY004UT — Alkali Flat (Black Greasewood)	141.4	1.1%
		Boxelder (3%)			
		BERENT (2%)			
		Kanosh (2%)			
		Playas (2%)	R028AY132UT — Desert Salty Silt (Iodinebush)		
		Poganeab (2%)	R028AY024UT — Wet Saline Meadow (Saltgrass)		
		UFFENS (2%)			
		Uvada (2%)			
37	Donnardo very stony loam, 2 to 15 percent slopes	Donnardo (90%)	R028AY334UT — Upland Stony Loam (Wyoming Big Sagebrush)	49.2	0.4%
		COLLARD (5%)			
		Calita Loam (3%)			
		Borvant (2%)			
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	Donnardo (40%)	R028AY334UT — Upland Stony Loam (Wyoming Big Sagebrush)	930.4	7.0%
		Borvant (25%)	R028AY320UT — Upland Shallow Hardpan (Pinyon-Utah Juniper)		
		Collard (25%)	R028AY334UT — Upland Stony Loam (Wyoming Big Sagebrush)		
		CALITA (5%)			
		Jardal (5%)			
42	Escalante sandy loam, 0 to 2 percent slopes	Escalante (85%)	R028AY226UT — Semidesert Sandy Loam (Wyoming Big Sagebrush)	31.8	0.2%
		Bandag (5%)			
		MANASSA (5%)			
		Uvada (3%)			
		BERENT (2%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
43	Escalante sandy loam, 2 to 5 percent slopes	Escalante (85%)	R028AY226UT — Semidesert Sandy Loam (Wyoming Big Sagebrush)	430.4	3.3%
		Bandag (5%)			
		Boxelder (5%)			
		MELLOR (3%)			
		BERENT (2%)			
54	Heist-Berent complex, 0 to 15 percent slopes	Heist (45%)	R028AY226UT — Semidesert Sandy Loam (Wyoming Big Sagebrush)	76.7	0.6%
		Berent (40%)	R028AB222UT — Semidesert Sand (Four-Wing Saltbush)		
		DUNE LAND (10%)			
		Boxelder (5%)			
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	Hiko Peak (85%)	R028AY215UT — Semidesert Gravelly Loam (Wyoming Big Sagebrush) North	168.8	1.3%
		Boxelder (10%)			
		AMTOFT (5%)			
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	Hiko Peak (85%)	R028AY215UT — Semidesert Gravelly Loam (Wyoming Big Sagebrush) North	87.3	0.7%
		AMTOFT (5%)			
		Boxelder (5%)			
		HEIST (5%)			
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	Hiko Peak (45%)	R028AY215UT — Semidesert Gravelly Loam (Wyoming Big Sagebrush) North	79.7	0.6%
		Heist (40%)	R028AY226UT — Semidesert Sandy Loam (Wyoming Big Sagebrush)		
		BERENT (10%)			
		Oakcity (5%)			
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	Hiko Peak (50%)	R028AY215UT — Semidesert Gravelly Loam (Wyoming Big Sagebrush) North	6.0	0.0%

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Heist (30%)	R028AY226UT — Semidesert Sandy Loam (Wyoming Big Sagebrush)		
		BERENT (10%)			
		DONNARDO (5%)			
		Oakcity (5%)			
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	Jigsaw (45%)	R028AY220UT — Semidesert Loam (Wyoming Big Sagebrush)	653.7	5.0%
		Oakcity (40%)	R028AY220UT — Semidesert Loam (Wyoming Big Sagebrush)		
		DUNE LAND (5%)			
		MELLOR (5%)			
		Kanosh (3%)			
		DESERET (2%)			
69	Kanosh very fine sandy loam, o to 2 percent slopes	Kanosh (90%)	R028AY132UT — Desert Salty Silt (Iodinebush)	27.9	0.2%
		ASHDOWN (2%)			
		BERENT (2%)			
		MELLOR (2%)			
		Poganeab (2%)	R028AY024UT — Wet Saline Meadow (Saltgrass)		
		Bandag (1%)			
		BENSTOT (1%)			
81	Lava flows-Shotwell complex, 0 to 8 percent slopes	Lava flows (60%)		39.9	0.3%
		Shotwell (25%)	R028AY243UT — Semidesert Shallow Loam (Wyoming Big Sagebrush) North		
		Boxelder (5%)			
		Cloyd (5%)			
		KESSLER (5%)			
102	Preston fine sand, 2 to 30 percent slopes	Preston (85%)	R028AY330UT — Upland Sand (Black Greasewood, Indian Ricegrass)	66.6	0.5%
		DUNE LAND (10%)			
		CALITA (5%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
120	Woodrow silty clay loam, 0 to 2 percent slopes	Woodrow (85%)	R028AY220UT — Semidesert Loam (Wyoming Big Sagebrush)	22.8	0.2%
		MANASSA (5%)			
		MELLOR (5%)			
		Oakcity (5%)			
Totals for Area of Interest				**13,201.8**	**100.0%**

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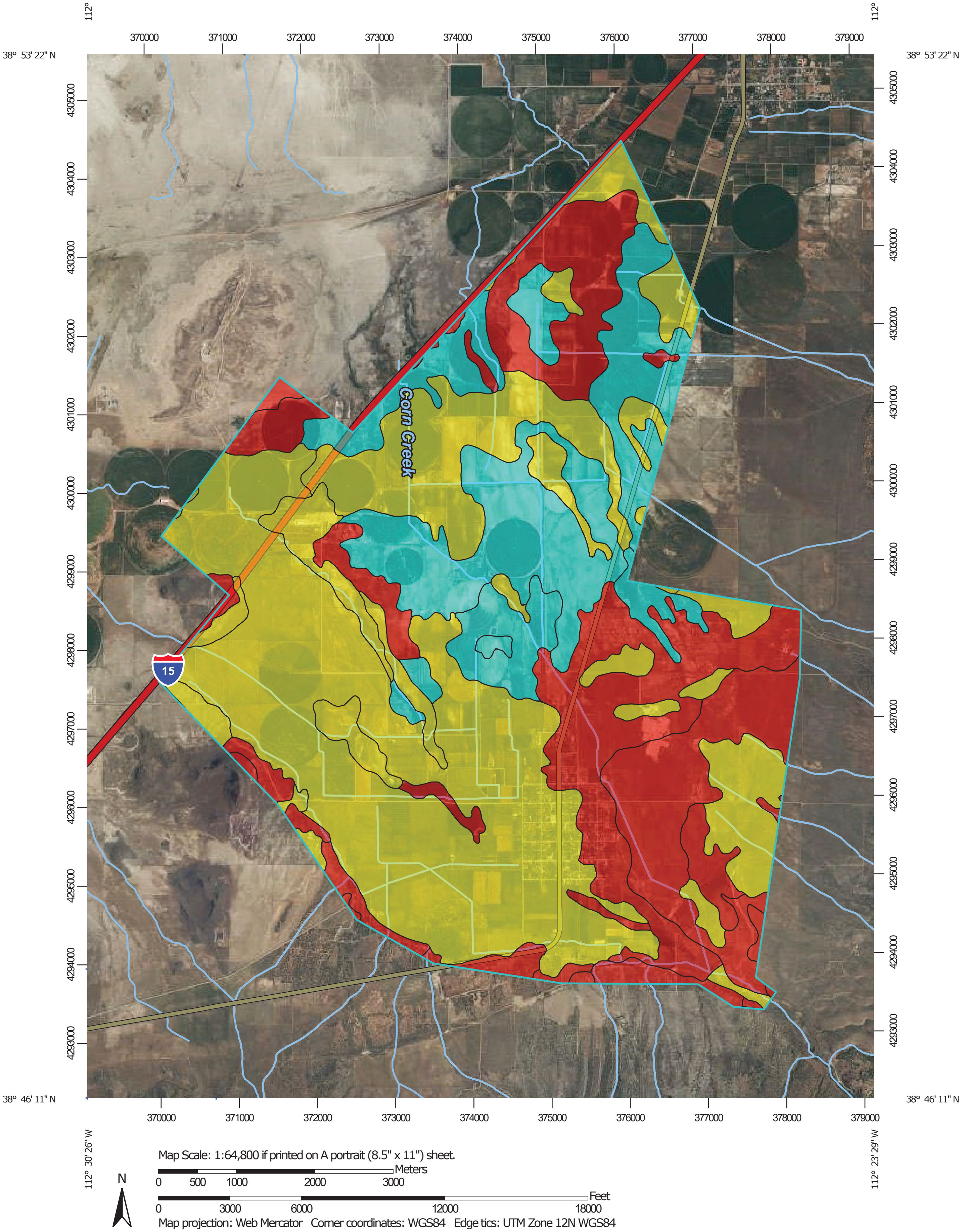
Farmland Classification—Millard County, Utah - Eastern Part
(Farmland Classifications)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated
- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Soil Rating Lines

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season

- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated
- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Soil Rating Points

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated

- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Millard County, Utah - Eastern Part
Survey Area Data: Version 17, Aug 28, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 4, 2021—Jul 7, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Farmland Classification

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ashdown loam, 0 to 2 percent slopes	Prime farmland if irrigated	3,976.1	30.1%
4	Ashdown loam, 2 to 5 percent slopes	Prime farmland if irrigated	139.6	1.1%
7	Bandag loam, 0 to 2 percent slopes	Prime farmland if irrigated	1,552.0	11.8%
8	Bandag loam, 2 to 5 percent slopes	Prime farmland if irrigated	541.8	4.1%
22	Borvant-Pavant complex, 2 to 15 percent slopes	Not prime farmland	239.7	1.8%
23	Boxelder silt loam, 0 to 2 percent slopes	Farmland of statewide importance	2,212.8	16.8%
25	Calita-Erda complex, 0 to 2 percent slopes	Farmland of statewide importance	430.4	3.3%
27	Cessna loam, 0 to 5 percent slopes	Prime farmland if irrigated	28.2	0.2%
30	Cloyd-Rock outcrop complex, 5 to 20 percent slopes	Not prime farmland	0.1	0.0%
31	Collard gravelly loam, 2 to 5 percent slopes	Not prime farmland	1,262.4	9.6%
35	Current Spring-Maple Hollow complex, 15 to 30 percent slopes	Not prime farmland	5.8	0.0%
36	Deseret silt loam, 0 to 1 percent slopes	Not prime farmland	141.4	1.1%
37	Donnardo very stony loam, 2 to 15 percent slopes	Not prime farmland	49.2	0.4%
38	Donnardo-Borvant-Collard complex, 2 to 5 percent slopes	Not prime farmland	930.4	7.0%
42	Escalante sandy loam, 0 to 2 percent slopes	Prime farmland if irrigated	31.8	0.2%
43	Escalante sandy loam, 2 to 5 percent slopes	Prime farmland if irrigated	430.4	3.3%
54	Heist-Berent complex, 0 to 15 percent slopes	Not prime farmland	76.7	0.6%
57	Hiko Peak fine sandy loam, 2 to 8 percent slopes	Not prime farmland	168.8	1.3%
60	Hiko Peak stony fine sandy loam, 5 to 15 percent slopes	Not prime farmland	87.3	0.7%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
63	Hiko Peak-Heist complex, 0 to 2 percent slopes	Not prime farmland	79.7	0.6%
64	Hiko Peak-Heist complex, 2 to 8 percent slopes	Not prime farmland	6.0	0.0%
68	Jigsaw-Oakcity complex, 0 to 2 percent slopes	Not prime farmland	653.7	5.0%
69	Kanosh very fine sandy loam, o to 2 percent slopes	Not prime farmland	27.9	0.2%
81	Lava flows-Shotwell complex, 0 to 8 percent slopes	Not prime farmland	39.9	0.3%
102	Preston fine sand, 2 to 30 percent slopes	Not prime farmland	66.6	0.5%
120	Woodrow silty clay loam, 0 to 2 percent slopes	Not prime farmland	22.8	0.2%
Totals for Area of Interest			**13,201.8**	**100.0%**

Description

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Rating Options

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

DRAFT

Corn Creek Reservoir
DRAFT Preliminary Concept
Geotechnical Data Report

Prepared for
Franson Civil Engineers
June 2022

GC project number: 21-1406

DRAFT

GERHART COLE

PO Box 880
Midvale, Utah 84047
801.849.0055
gerhartcole.com

June 16, 2022

Prepared for:

Mr. Layne Jensen, PE
Franson Civil Engineers
1276 South 820 East, Suite 100
American Fork, Utah 84003
Office: (801) 756-0309
ljensen@fransoncivil.com

Draft
Corn Creek Reservoir
Preliminary Concept Geotechnical Design Report
GCI Project Number 21-1406

Prepared by:

Jed McFarlane, PE
Project Engineer

Richard Buhler, PE
Project Manager

Travis M. Gerber, PhD, PE
Chief Engineer

Reviewed by:

Ryan Cole, PhD, PE, DGE
Principal

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1.1 PROJECT DESCRIPTION

This Geotechnical Design Report presents the results of geotechnical field and laboratory studies and provides preliminary geotechnical design recommendations for Corn Creek Reservoir. We understand the overall project consists of an assessment of the Corn Creek Watershed and to provide increased flood control protection to the town of Kanosh and agricultural lands through funding from the Watershed Act. Natural Resources Conservation Service (NRCS) is overseeing the funding of the overall project and Utah Dam Safety (UDS) regulates the construction and performance of Corn Creek Reservoir. Franson Civil Engineers (FCE) is working with NRCS on the Corn Creek Watershed project, while Gerhart Cole (GC) role is to complete geotechnical studies at Corn Creek Reservoir. We understand the dam primary function is to provide flood control, and there are currently no water storage rights for the reservoir. After flooding events the reservoir will hold water for 5 to 6 months, due to outlet works limitations and to minimize flows downstream and potential flooding in Kanosh. With this large retention time of flood waters, NRCS has requested the geotechnical design consider the dam as a water storage dam rather than a flood control dam.

Corn Creek Reservoir is located just east of Kanosh, Utah as illustrated in Figure 1-1. Corn Creek Dam has also been referred as “Kanosh Dam” in the past. This report will refer to it as Corn Creek Reservoir or Dam. The proposed alignment of the new Corn Creek Dam was provided to us by FCE and formed the basis for developing our field studies and analyses (See Figure 2-1). Preliminary estimates on the required storage are between 500-600 acre-feet. A crest elevation of the dam is 5210 feet which the maximum section being about 50 feet in height.

We understand from FCE the 100-year flood event is about 2,000 cubic feet per second (cfs), and the probable maximum flood (PMF) event is 10,655 cfs. We also understand there will be two spillways, a primary and auxiliary spillway. The primary spillway will handle the 100-year flood event and will be on the northern portion of the embankment and send the water to the north away from Kanosh. The auxiliary spillway will be positioned near the existing channel of Corn Creek and will send water down the existing Corn Creek. The auxiliary spillway will be designed to handle approximately 8,655 cfs, and the remaining 2,000 cfs will pass over the primary spillway. It is our understanding that FCE is also considering rehabilitating of the existing Corn Creek Dam as part of future phases/studies; this assessment however is focused on the proposed alignment shown in Figure 2-1. We also understand from FCE, the existing reservoir or the future reservoir does not and will not have future water storage rights.

1.2 PURPOSE, AUTHORIZATION, AND SCOPE OF WORK

This report presents the results of geotechnical and geologic studies performed by Gerhart Cole, Inc. (GC) in support of project design by Franson Civil Engineers (FCE). This work was completed following the approach discussed in our proposal dated

August 16, 2021, and under GC's Cooperative Reciprocal Service Agreement with FCE, dated December 19, 2016. The scope of services provided includes:

- Geologic / geotechnical assessment and background review.
- Field study program consisting of four test holes using sonic drilling and HQ coring techniques and seismic refraction lines along the proposed dam alignment.
- Laboratory testing of select samples.
- Development of a conceptual dam cross-section, for a single dam alignment, which meets Utah Dam Safety Administrative Rules (R655-10 and R655-11) and NRCS TR-210-60 with a high hazard classification.
- Development of a geotechnical data report.

1.3 BACKGROUND

The original Corn Creek Dam was constructed in the early 1900's to control flooding and provide a source of irrigation water from Corn Creek. The dam was about 25 feet in height with a metal outlet works, concrete spillway, and emergency spillway in the northern embankment.

Due to excessive precipitation and high spring run off a 200-foot section of the dam failed in May 1984. At the time of the failure a section approximately 200 feet long of the embankment soil washed away, causing flooding, mudslides, and damage to main water lines downstream. Corn Creek was temporarily rerouted into an excavated channel along the south abutment of the dam to prevent further damage (Northern, 1985).

Based on records reviewed, we understand portions of the old dam that washed out were reconstructed, and the remaining embankment was raised to a new crest elevation of 5194 feet. No records were found associated with the pre 1984 structure's configuration.

The existing dam is considered a zoned earth dam based on the record drawings, prepared by Sunrise Engineering (1986), and provided in Appendix F. The reconstructed embankment section (see cross-section C of the record drawings) maximum height is approximately 30 feet with 2H:1V upstream and downstream slopes. The drawings show three dam zones,

- Zone 1 - Impervious core, compacted clay, silt or sand,
- Zone 2 - Compacted gravel outer shell, and
- Zone 3 - Compacted gravel toe drain.

Cross-section C (XS-C) from the record drawings shows a key trench excavated 5 to 20 feet to clayey soil. No key trench, cutoff, or other foundation treatments are shown outside of the reconstructed section (XS-C). Embankment modifications for these areas included installing a downstream toe drain, raising the embankment with Zone1 and 2 materials, and constructing 2H:1V upstream and downstream slopes.

Since the dam was reconstructed in 1986 there have been numerous letters from the State of Utah addressing concerns with the structure. On March 27, 2020, UDS notified NRCS that Corn Creek had been added to their prioritization list given the significant seepage through the dam and foundation when the reservoir fills during high water events. In addition, they recommend any rehabilitation focus on providing defensive design measures that control seepage and protects from internal erosion of the foundation and embankment (See Appendix F; UDS, 2020). The following section summarizes some of the key geotechnical information from our review of UDS files and provides a summary of inspection reviews and letters that address geotechnical related issues items.

1.3.1 Background Review Summary

Key information from our background review including Utah Division of Water Rights (UDWR) files (UDWR, 2021) are summarized below:

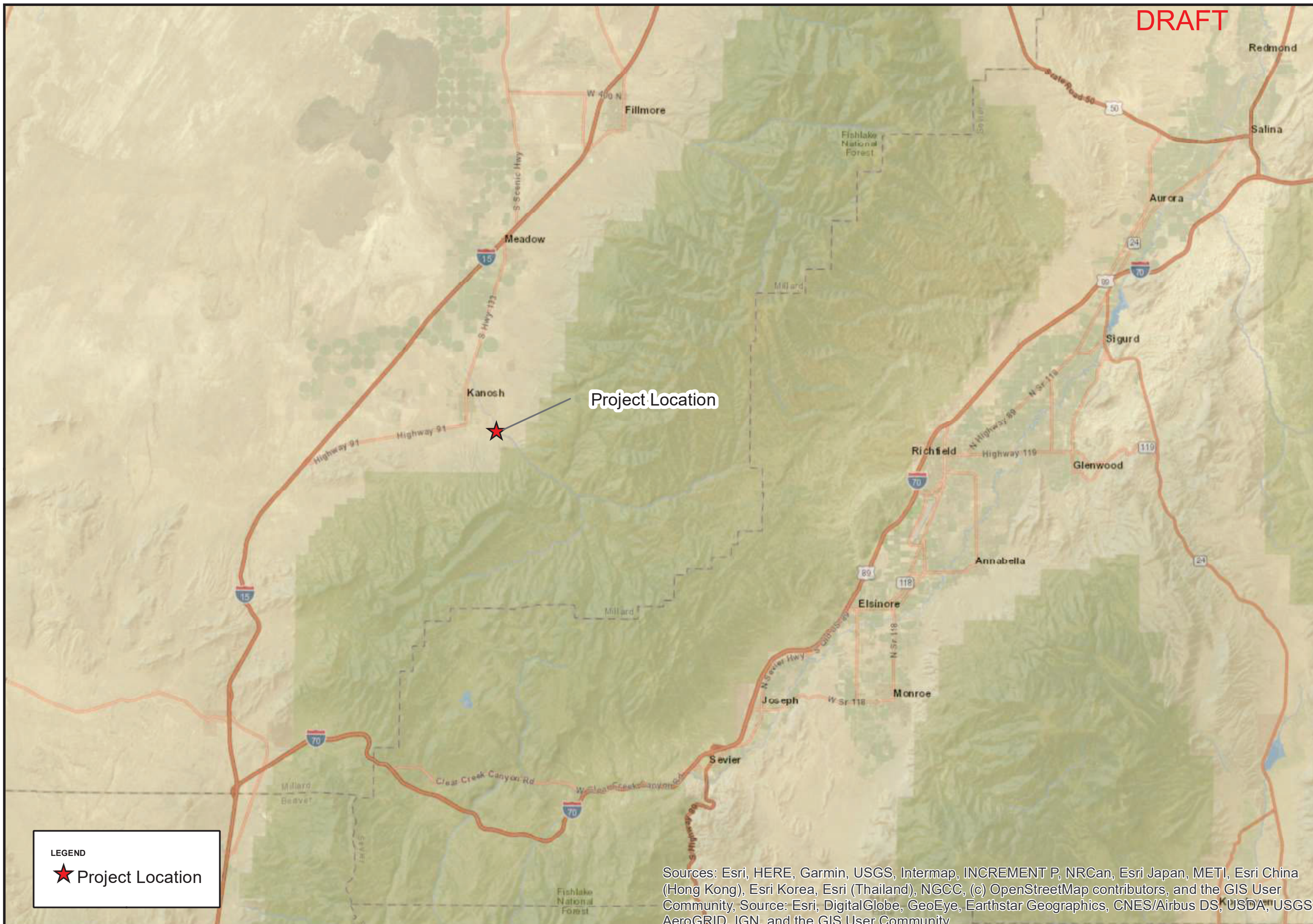
1. April 18, 1984; A staff member of UDWR visits Corn Creek Dam with members of Corn Creek Irrigation Company. They provided the irrigation company guidance on items to watch as the company works on providing more storage to reservoir and how not to jeopardize the safety of the structure
2. May 5, 1984; The Salt Lake Tribune reports that an Earthen Dam (Corn Creek Reservoir) collapsed May 4, 1984. The article stated local officials were cleaning debris from canals and they became concerned by the large flow of water over the top of the dam.
3. June 14, 1985; Geotechnical Investigation Kanosh Dam [Corn Creek Dam] completed by Northern Engineering and Testing, Inc. The report states the original dam washed away during spring runoff of 1984. The geotechnical investigation was completed to develop a stable section for the reconstruction of the dam (Northern, 1985; Appendix F).
4. July 19, 1985; Directing Dam Safety Engineer provides a letter to Sunrise Engineering stating *"he feels the preliminary design of the embankment is adequate providing close attention during construction to ensure filter requirements are met between zones and the drain. We do have some reservations about the foundation. We feel a cutoff trench should be considered to eliminate any lenses in the silty clay level and increase the seepage path along the embankment-foundation interface. We are also concerned about the gravels and sands in the vicinity of DH-17 and feel special treatment should occur in this area."* No records were found how or if these recommendations were implemented.
5. August 20, 1986; Town of Kanosh Corn Creek Dam Project Record Drawings, Sunrise Engineering, Filmore Utah (included in Appendix F).

6. May 9, 1986; Sunrise Engineers provides a letter to Utah Dam Safety stating the dam has been completed and final inspection is May 20, 1986.
7. Between 1986 and 1996; Dam Safety notes in annual inspections a few items to be addressed on the dam in terms of rodent control, vegetation on the dam, clogged drains, and insufficient riprap.
8. December 14, 1994; Letter from State Engineer instructed Corn Creek Irrigation Company to evaluate Corn Creek Reservoir to determine if it meets the minimum standards for existing high hazard dams by at least 1995.
9. May 7, 1996; An additional letter from State Engineer is sent to the Irrigation company advising them they need to complete the evaluation on minimum standards for high hazards dams. In addition, the letter states when the evaluation is completed specifically address two embankment requirements a) A drawdown analysis for the upstream slope, and b) the gravel drain filter requirements and whether it is filter compatible with the dam core and the foundation.
10. June 26, 1998; An order from State Engineer is sent restricting storage on Corn Creek Reservoir.
11. November 9, 1998; Annual inspection from Dam Safety requests new gradation tests be performed on core and drain materials.
12. May 15, 1999; A letter to Irrigation company from State Engineer states that seepage was noted along the right (looking downstream) downstream toe and the area should be monitored wherever storage in the basin is occurring.
13. September 14, 2004; Letter to Irrigation company from State Engineer states *"that a report from Sunrise Engineering addresses the spillway capacities and seismic requirements to bring the dam into compliance with current standards but does not adequately address the geotechnical concerns we [State of Utah] have with the dam."*
14. October 15, 2004; State of Utah rescinds the storage restriction due to a plan to work on spillway, drains, and soil gradation results. (GC was not able to find the letter or the plan to bring the drains into compliance or if a Phase II report was sent to State of Utah.)
15. March 30, 2005; A letter to Irrigation Company from State of Utah stating the gradation testing completed shows the drain does not meet filter criteria. The dam has been put on priority list for construction.
16. May 11, 2009; Annual inspection report from State of Utah states that a small landslide occurred east of the spillway and above the regulating pond.
17. June 9, 2010; A letter from State of Utah to Irrigation company concerning several safety concerns due to high spring runoff:
    a. Stop Logs were placed into entrance of the spillway.
    b. Reservoir water discharged from an unknown pipe at the downstream toe.
    c. Reservoir water was "bubbling up" across the canyon road to the north.
    d. Apparent seepage from the reservoir was observed below the downstream toe of the dam in the maximum section.

The letter goes on to direct the irrigation company to have engineering studies conducted to evaluate the safety concerns brought up in the letter.

18. May 23, 2011; Annual inspection report from State of Utah states that the small landslide pointed out in 2009 inspection has not been repaired. In addition, the letter states, *"Apparent seepage from the reservoir was observed below the downstream toe of the dam in the maximum section. A concentrated flow of approximately 2-3 gpm was observed and the water appeared cloudy with sediment. The flow was sufficient to show evident discoloring of the water that has ponded below the toe. The source of the water is not clearly evident, but this situation is extremely serious and merits your full attention."*
19. May 28, 2013, and April 30, 2015; Annual inspections report from State of Utah states the small landslide has not been repaired pointed out in the 2009 inspection report.
20. February 20, 2019; State of Utah notifies Irrigation company to perform an Earthquake Inspection due to a M4.0 earthquake southwest of Kanosh. Irrigation company reports back to State of Utah that no cracks or ground movement was observed around the dam.
21. March 27, 2020; State of Utah sends a letter to NRCS stating they understand Millard County and Corn Creek Irrigation company are requesting Federal assistance under the Watershed Act. The State informs the NRCS that Corn Creek Debris Basin is on the list of reservoirs needing rehabilitation due to the following concerns to adequately provide flood control protection to the town of Kanosh and agricultural lands (Appendix F).
    a. Significant seepage through the dam foundation when the reservoir fills during high water events.
    b. Project remediation is needed to provide defensive design measures that control seepage and protects from internal erosion of the foundation and the embankment.

These items summarize that since the dam was reconstructed in 1986 there have been significant concerns with the structure and rehabilitation efforts should focus on controlling seepage and reducing risks associated with internal erosion of the foundation and embankment.



GERHART COLE	Vicinity Map	N	0 1.25 2.5 5 Miles
	Corn Creek Reservoir		Figure 1-1

2.1 FIELD STUDIES

Geotechnical and Geologic field studies were completed along the proposed alignment between September 23 and November 2, 2021. These studies included geologic mapping, two seismic refraction lines, and drilling four test holes. A site map showing test hole (TH) and seismic refraction line locations are plotted on Figure 2-1. Test hole locations were developed based on our geologic assessment (see Section 3.0), site accessibility, and proximity to the proposed dam. Test Hole data is summarized along with other information in Table 2-1. All aspects of field studies were overseen by a field geologist and a professional engineer.

2.1.1 Test Hole Drilling and Sampling

All test holes were drilled using sonic drilling/coring and HQ coring methods with casing using a track-mounted Boart Longyear LS600C drill rig equipped with an auto-hammer operated by ConeTec, Inc. under subcontract to GC. The auto-hammer was reported by ConeTec as having an average hammer energy transfer of 82%. The purpose of the sonic drilling method was to be able to advance test holes through gravelly and cobbly soil layers to the deeper bedrock. HQ coring was used to advance through a short section of bedrock in 21-TH-03, but coring was later abandoned due to plugging of the bit and difficulties associated with coring in softer bedrock and sonic was continued to the planned drilling depths

Sonic drilling tooling used included a 4-inch coring bit and 6-inch casing. Drilling was generally completed in 5-foot runs unless blockage necessitated premature terminations. Non-potable water was used from Corn Creek as a drilling fluid with no additives. Test holes 21-TH-01 and 21-TH-04 were backfilled using bentonite grout. Temporary piezometers were installed in test holes 21-TH-02 and 21-TH-03 to measure groundwater levels. Additional information on test hole depths and piezometer information is listed on the test hole logs and summarized in Table 2-1 and Table 2-2.

Sonic core samples were logged during drilling and included field data such as length of recovered core and general lithologic information. Sonic and HQ cores were collected from drilling/coring operations, packaged, and returned to GC's laboratory for testing. Graphical logs of the test holes and photos of sonic cores are included Appendix A. Lines designating boundaries between different materials shown on the logs should be considered approximate; transitions between subsurface materials may be gradual or occur between recovered core segments.

2.1.2 Seismic Refraction Survey

Two seismic refraction surveys were completed within the project area by Sage Earth Science under subcontract to GC. Objectives of the surveys included: a) obtaining a series of seismic P-wave (V_p) refraction and surface shear wave velocity (V_s) profiles; b) providing average shear wave velocity profile of near surface V_{S30} to assess NEHRP seismic class; c) providing information for liquefaction susceptibility evaluations; and d) obtaining seismic P-wave velocity measurements as they may relate to bedrock durability and excavatability. Wave velocities were measured using Multichannel Analysis of Surface Waves (MASW) instruments. The approximate locations of these geophysical profile lines are shown on Figure 2-1; geophysical survey results are included in Appendix B.

The average shear wave velocity V_s for the upper 100 feet was calculated to be 1,433 feet per second (fps) at survey line 2 (see Figure 2-1). This average V_{S30} value was utilized in the Seismic Hazard Evaluation for the dam embankment in Section 3.0. V_s and V_p profiles were also utilized in understanding the thickness of alluvial soils and potential depth to bedrock. Additional information on the soil and bedrock depths and thickness are discussed in Section 3.0

The seismic p-wave data has been differentiated in two general velocity zones. The first zone is considered sediments/low density rock, with a V_p of less than 5,000 fps. The second zone consists of rock with velocities greater than 5,000 fps. The upper end of velocities measured are between 6900 to about 8000 fps. Both survey lines indicated the presence of the two V_p velocity zones within the profiles. V_p survey line 1 shows mainly sediments/low density rock in its profile but near the west end of the survey line the bottom of the profile shows some potential bedrock. V_p survey line 2 shows both zones of sediments/low density rock and bedrock within its profile. It will be noted that drilling completed along this profile would agree with this assessment.

2.1.3 Field Permeability Testing

Permeability testing was completed in each test hole to measure the in-situ hydraulic conductivity for the upper/lower alluvium and the bedrock. Depending on the soil conditions tests were performed over an open interval of soils or just at the end of the sonic casing and were either constant or falling head tests. Results of the field permeability testing is summarized in Table 2-3 with information on the testing method.

2.2 LABORATORY TESTING

Selected soil samples obtained during our field studies were tested in our geotechnical laboratory. Testing included moisture content, Atterberg limits, grain-size distribution, flexible wall hydraulic conductivity, Unconsolidated Undrained (UU) triaxial, Consolidated Undrained (CU) triaxial, Pinhole dispersion, collapse/swell potential, Proctor test, and soluble salt testing. A summary of laboratory test results is included in Table 2-4 with additional data and interpretation in Appendix C.

One composite sample was created from combining similar sonic samples from 21-TH-01 to assess its potential suitability as borrow material. These samples were combined from the following depths: 7,17, 22, and 27 feet. The testing completed on the composite sample included index testing, collapse/swell testing, CU, UU, hydraulic conductivity, double hydrometer, and soluble salt testing.

2.3 GROUNDWATER

Groundwater was observed at the time of drilling in 21-TH-02 and 21-TH-03. Subsequent measurements were taken and are summarized in Table 2-2. Water was also observed in Corn Creek at the time of our field work. Potential fluctuations in groundwater levels should also be anticipated as part of reservoir elevation, potential seasonal variations, localized zones of increased moisture, and with precipitation / runoff events.

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Table 2-1: Field Studies Test Hole Summary
Corn Creek Reservoir

Study Point Identification[a]	Date Started	Latitude[b]	Longitude[b]	Ground Surface Elev. (ft)[d]	Total depth (ft)	Drilling Method	Subcontractor
21-TH-01	11/2/2021	38.783270	-112.416290	5206.0	42.1	6-inch Sonic Coring	ConeTec
21-TH-02	11/1/2021	38.784010	-112.416020	5171.0	56.8	6-inch Sonic Coring	ConeTec
21-TH-03	10/30/2021	38.785390	-112.415690	5162.0	81.0	6-inch Sonic Coring	ConeTec
21-TH-04	10/27/2021	38.785240	-112.413020	5189.0	53.0	6-inch Sonic Coring	ConeTec

Notes:

a) TH=Test Hole (drilled)

b) Latitude/Longitude measurements were obtained with a recreational grade handheld GPS device. The coordinates are based on the WGS84 Datum and have an accuracy of ±30 feet.

c) Groundwater depth could not be measured (NM) due to drilling fluid or not found (NF).

d) Elevations are estimated from ground surface profile provided by FCE.

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Table 2-2: Groundwater Measurements

Corn Creek Reservoir

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Study Point Identification	Surface Elev.	11/1/2021	12/14/2021	1/5/2022	Comments
21-TH-02	5171.0	27.8	23.8	25.5	
21-TH-03	5162.0	53.8	30.0	32.6	

Notes:

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Table 2-3: Field Permeability Testing Results

Corn Creek Reservoir

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Location	Test Depth (ft)	Field Permeability Test Method	Field Hydraulic Conductivity (cm/sec)	Geologic Layer[a,b]	Comments
21-TH-01	37-42	Constant Head Open Interval	5E-06	Bedrock	
21-TH-02	6-8	Falling Head Open Interval	2E-04	Upper Alluvium	
21-TH-02	31	Falling Head End of Casing	1E-01	Lower Alluvium	
21-TH-02	36-37	Constant Head Open Interval	<5E-7	Bedrock	Results are below the practical lower limits of the method.
21-TH-02	46-51	Constant Head Open Interval	<8E-08	Bedrock	Results are below the practical lower limits of the method.
21-TH-02	46-56	Constant Head Open Interval	<1E-07	Bedrock	
21-TH-03	26	Falling Head End of Casing	3E-05	Lower Alluvium	
21-TH-03	46	Falling Head End of Casing	2E-03	Lower Alluvium	
21-TH-03	71-81	Falling Head Open Interval	3E-04	Bedrock	
21-TH-04	19-21	Falling Head Open Interval	3E-04 to 2E-03	Lower Alluvium	
21-TH-04	21	Constant Head End of Casing	1E-05	Lower Alluvium	
21-TH-04	41	Falling Head End of Casing	1.40E-03	Lower Alluvium	

Note: [a] See Figure 3-5 and 3-6

[b]All test holes were advanced using sonic drilling with a 6-inch OD casing

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Table 2-4: Laboratory Test Results Summary
Corn Creek Reservoir

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits					Grain-Size					Grain-Size Analysis (Percent Finer)												Other Tests [a]
					LL (%)	PL (%)	PI (%)	Cohesive Index, CI	Liquidity Index, LI	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	silt (0.005-0.075 mm)	clay (<0.005 mm)	1-in (25 mm)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	
21-TH-01	0-2	10.4								49	30	21			100	100	87	70	59	51	46	42	38	32	27	21	
21-TH-01	4.5-7	15.1								26	25	49			100	100	89	83	78	74	71	69	66	62	57	49	
21-TH-01	7-9	35.2			47	22	25	1.1	0.5	0	13	87	37	50	100	100	100	100	100	100	98	97	95	93	91	87	
21-TH-01	17-18.9	26.9	68.5	87.0	45	24	21	0.9	0.1																		TDS, Perm
21-TH-01	22.5-24.5	23.5			35	18	17	0.9	0.3	2	16	82	41	41	100	100	100	100	99	98	97	97	96	95	92	82	
21-TH-01	27-29	23.8			28	16	12	0.8	0.7	7	12	81	45	37	100	100	100	98	96	93	91	90	89	88	86	81	
21-TH-01	Combined Clay[b]	15.9	107	123.8	34	18	16	0.9	-0.1	12	20	68	37	31	100	100	100	97	91	88	85	83	81	78	74	68	UU, CU, TDS, Perm, Proctor, Coll, DoHy
21-TH-02	2.5-6	11.1			NP	NP	NP			21	28	51	34	17	100	100	86	82	80	79	77	77	76	74	68	51	
21-TH-02	6-8	19.7	94.1	112.6	NP	NP	NP			0	47	53			100	100	100	100	100	100	99	96	91	84	75	53	CU
21-TH-02	11-13.5	19.8								28	33	39			100	100	85	77	74	72	71	69	67	64	55	39	
21-TH-02	16-17.5	15.7	111.7	129.3						0	64	36			100	100	100	100	100	100	99	98	94	82	63	36	Perm
21-TH-02	22-26	5.2								81	14	5			100	71	32	28	23	19	16	14	13	11	9	5.2	
21-TH-02	27-31	6.7								68	24	8			100	88	60	49	39	32	27	23	23	18	14	8.4	
21-TH-02	36-37	17.5			30	16	14	0.9	0.1																		
21-TH-03	0-3	18.8			NP	NP	NP			1	42	57	41	16	100	100	100	100	100	99	99	99	99	98	95	57	
21-TH-03	3-5	5.6			24	16	8	0.5		0	25	75	49	26	100	100	100	100	100	100	100	100	100	99	94	75	
21-TH-03	11-12	6.7								67	20	13			100	100	85	63	43	33	27	24	22	19	17	13	
21-TH-03	12.5-13.5	17.1			23	17	6	0.4	0.0	15	28	57			100	100	100	94	88	85	83	83	82	80	74	57	
21-TH-03	18.5-21	6.1			NP	NP	NP			65	26	9	5.6	3.5	100	100	77	59	44	35	28	25	22	19	16	9.1	

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Table 2-4: Laboratory Test Results Summary
Corn Creek Reservoir

Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits					Grain-Size					Grain-Size Analysis (Percent Finer)												Other Tests [a]
					LL (%)	PL (%)	PI (%)	Cohesive Index, CI	Liquidity Index, LI	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	silt (0.005-0.075 mm)	clay (<0.005 mm)	1-in (25 mm)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	
21-TH-03	36-41	7.6			NP	NP	NP			75	19	6			100	75	46	37	29	25	21	19	16	14	11	6.4	
21-TH-03	46-48.5	5.1								75	16	9			100	53	44	35	29	25	23	21	19	16	12	8.9	
21-TH-03	57-58	11.8			27	14	13	0.9		1	25	74	46	28	100	100	100	100	100	99	98	97	96	93	85	74	
21-TH-04	3-4	10.8			NP	NP	NP			12	37	51	32	19	100	100	100	96	92	88	85	83	80	75	67	51	
21-TH-04	8-9.5	15.9			NP	NP	NP			11	46	43	28	15	100	100	100	95	92	89	87	86	82	73	61	43	
21-TH-04	10-11	17.8			NP	NP	NP			1	38	61			100	100	100	100	100	99	98	97	94	89	79	61	
21-TH-04	11-13 ft [ST-02]	16.7	90.1	105.1	NP	NP	NP			0	52	48			100	100	100	100	100	100	100	99	96	88	75	48	
21-TH-04	11-13	20.8								1	62	37			100	100	100	100	100	99	97	95	90	79	62	37	Perm, Pin
21-TH-04	13.5-14	12.2			NP	NP	NP			1	56	43	29	15	100	100	100	100	100	99	99	98	94	83	68	43	
21-TH-04	16-16.5	22.6			35	21	14	0.7	0.1	40	26	34			100	100	79	72	65	60	57	54	52	48	42	34	
21-TH-04	20-21	7.2			NP	NP	NP			57	29	14			100	70	62	57	49	43	37	32	28	25	21	14	
21-TH-04	32-34	3.7								59	26	15			100	100	86	70	53	41	33	29	26	20	15	15	
21-TH-04	36.3-38	7.7								55	36	9			100	100	90	76	59	45	35	29	24	18	14	9.5	
21-TH-04	41.5-43.5	5.6								65	28	7			100	100	79	62	45	35	28	24	21	16	12	7.3	
21-TH-04	48.5-51	6.6			NP	NP	NP			77	17	6			100	81	47	40	30	23	18	15	13	11	9	5.7	

a) TDS - Total Dissolved Solids Test
UU - Unconsolidated Undrained Triaxial Test
CU - Consolidated Undrained Triaxial Test
Perm - Hydraulic Conductivity Test
Proctor - Laboratory Compaction Characteristics
Pin - Pinhole Dispersion Test
Coll - One-Dimensional Collapse/Swell Poperties
DoHy - Double Hydrometer

b) Combined Clay sample was comprised of clay cores from 21-TH-01 at various depths.

GERHART COLE

Site and Study Location Map

Corn Creek Reservoir

N

0 75 150 300 Feet

Figure 2-1

3.1 REGIONAL GEOLOGIC SETTING

The project is located east of Kanosh in the foothills of the Pavant Range in Millard County, UT. This area is at the edge of the transition between the Basin and Range and the Colorado Plateau physiographic provinces. This transition zone is characterized by a series of alternating, generally north-south trending, normal faults superimposed upon the relatively undeformed, uplifted blocks of the Colorado Plateau (Wannamaker et al., 2001). The region is characterized by narrow mountain ranges and semi-arid to arid alluvial/pluvial valleys formed as a result of tectonic extension. This extension is believed to have initiated during the Early Miocene (approximately 15-17 million years ago) and continues during present time (Lund et al., 1990). The morphology and stratigraphy of the area has also been influenced by volcanism that has occurred as a result of crustal thinning associated with the aforementioned tectonic extension (Hintze and Davis, 2003). A large portion of the Basin and Range Province, including the project area, is part of a system of watersheds topographically restricted from draining into the ocean. Instead, drainage and groundwater accumulate within terminal lakes and playas in the valley bottoms such as the Great Salt Lake.

The project area also lies just above the highest mapped shoreline of one of these lakes, Lake Bonneville. The Bonneville shoreline, representing the highest level or high stand of the lake, is mapped about 2,000 feet west of the project location. Lake Bonneville remained at or near this high stand elevation until about 14,500 years ago when a catastrophic failure near Red Rock Pass in southern Idaho caused a massive flooding of lake waters into the Snake River drainage (Godsey et al., 2005). This event, called the Bonneville flood, caused a drop in lake level of about 360 feet where the lake level restabilized and the Provo shoreline began to form. The shoreline left behind from the Provo stand is mapped a few miles west of the project location.

The Pavant Thrust fault is part of the generally north-south trending Sevier fold-and-thrust belt and carries lower Cambrian through Cretaceous strata to the surface (DeCelles and Coogan, 2006). In the upper portions of the Pavant Range the Pavant Thrust dips shallowly to the east and much of the deformation along the thrust suggests a top-to-the-east sense of shear (DeCelles and Coogan, 2006), but near the project site the Pavant Thrust dips moderately to the west. Erosion associated with the Pavant uplift resulted in alluvial fan deposits, as well as various stream and deltaic deposits going into the paleo-Lake Bonneville. After Lake Bonneville receded, these deposits were exposed to further incision and erosion.

3.2 SURFICIAL SITE GEOLOGY

The geology of the area has been mapped at a scale of 1:100,000 by Hintze (2008) found in Figure 3-1. The structure is located within late Holocene alluvial deposits (Qal1) which are characterized by sand, silt, and clay with lenses of gravel from Corn Creek channel, floodplain, and overbank deposits (Hintze, 2008). To the northeast of the project area additional alluvial deposits (Qal2) are present that are comprised generally of sand and gravel. Following the drop in water level of Lake Bonneville, Corn

Creek incised through these alluvial deposits to create the channel where the Corn Creek Reservoir was constructed. The southwestern bound of the project area is represented by the Miocene to Pliocene Oak City Formation (the youngest portions are approximately 2.6 million years old) which is described as a poorly cemented, sandy, boulder, gravel (Hintze, 2008), but also contains volcanic ash beds and tuffaceous mudstone. Further to the northeast, there are Mesozoic to Paleozoic bedrock units exposed along the Pavant Thrust fault. These units include the Navajo Sandstone, Moenkopi Formation, Chinle Formation, Kaibab Limestone, Queantoweap Sandstone, and the Redwall Limestone. In general, these units dip moderately to the northwest (Hintze, 2008). These units are exposed in low knobs at the base of the Pavant Range as a result of thrust faulting associated with the Pavant Thrust. Some of these low knobs are likely also covered by the Oak City Formation (Hintze and Davis, 2003). Lithologic descriptions for these units can be found in Figure 3-2.

Materials exposed in test holes were interpreted to consist generally of Holocene alluvium, as described above, overlying bedrock of the Oak City Formation (Toc) and the Chinle Formation, Upper Member (TRcu) (see Figure 3-5 and Figure 3-6). As the Chinle Formation is only exposed in one of the test holes, we have interpreted it to be one of the low knobs mentioned above where the Pavant Thrust brought up the older Chinle Formation. Erosion of the Pavant Range and subsequent downslope deposition of the Oak City Formation and more recent alluvium have filled in around it.

3.3 SITE SPECIFIC GEOLOGY

Based on the subsurface studies, the stratigraphy along the proposed dam alignment appears to consist of an alluvial layer overlying bedrock of either the Chinle or Oak City Formation as discussed in Section 3.2. Figure 3-5 provides a cross-section across the proposed dam alignment between test holes 21-TH-01 to 21-TH-03 and approximate depth of bedrock. The alluvial thickness varies from about 25 feet near the south abutment and up to about 60 feet near 21-TH-03. Near the south abutment the fine-grained alluvium consists of medium dense silty/clayey gravels and very stiff to hard clays. Between 21-TH-02 and 21-TH-03, the alluvium is divided between an upper fine-grained and lower coarse-grained alluvium. The upper fine-grained alluvium consists of soft silts, stiff clays, medium dense silty/clayey sands, and medium dense silty gravels. The coarse-grained lower alluvium consists of dense to very dense coarse-grained gravels with cobbles and low fines content. The depth to bedrock was estimated both from the test holes and seismic refraction survey line 2.

Figure 3-6 is the approximate subsurface conditions through the embankment on the north leg of the existing embankment where test hole 21-TH-04 was completed. The dam and subsurface profile developed was based on the findings of 21-TH-04 and the provided as built drawings (Sunrise, 1986). Embankment materials consisted of medium dense silty gravels, stiff silts, and medium dense silty sands. Below the embankment materials, soils recovered showed the upper and lower alluvium materials similar to what was found in the test holes 21-TH-02 and 21-TH-03. 21-TH-04 was not advanced to bedrock (see Figure 3-6).

3.4 GEOLOGIC HAZARDS

Potential geologic hazards to the project appear to generally consist of seismic ground shaking and liquefaction (which will be discussed in Section 3.5.8 of this report), and debris flows/floods. Review of available data (UGS, 2021, Elliott and Harty, 2010, Hintze, 2008) suggests that landslide and surface-fault-rupture hazards are low at the site. Slopes in the Oak City Formation to the south of the reservoir could potentially produce shallow failures if over steepened, but deep-seated failures appear to be unlikely based on available data.

Seasonal fluctuations in precipitation and ground cover within the drainage area of Corn Creek could present flash flood and debris flow hazards. Historic flash flooding has caused debris flows in the Kanosh area (Woolley, 1946). It is unlikely that flash floods and debris flows pose detrimental risks to the project/reservoir once it is complete, as flows should generally be impounded by the reservoir or embankment. However, a potential exists of overtopping the reservoir if the volume of inflow is high enough. During field studies and construction, debris flow hazards have the potential to bury or destroy equipment or erode earthen materials (like the proposed embankment) if not mitigated. The possibility of debris flow should be considered during hydrologic assessments of inflow into the basin to understand if mitigation is warranted.

3.5 SEISMICITY AND SEISMIC EFFECTS

3.5.1 General

The Corn Creek Reservoir project is reconstructing the Corn Creek Dam along the alignment shown in Figure 2-1. Geologically, this site lies at the boundary between the Basin and Range (B&R) Physiographic Province to the west and the Basin and Range – Colorado Plateau Transition (B&R-CPT) Physiographic Province to the east (Stokes, 1986). The B&R consists of a series of alternating, north-south trending, mountains, and valleys, created by tectonic extension, and is frequently referred to as the Great Basin. The area is semi-arid to arid, and a large portion of the province is topographically restricted from draining into the ocean. The Sevier Desert / Black Rock Desert Section of the B&R province, which lies immediately west of the site, is representative of such, although there is also a degree of local, relatively recent volcanism present which is absent elsewhere in the B&R. In contrast, the B&R-CPT is “a broad belt in which geologic features gradational between typical plateau and basin and range features merge and overlap.” (Stokes, 1986). The Pavant Range / Canyon Range, which lies on the east of the site, is a section of the B&R-CPT province. The Pavant Range / Canyon Range was created by ancient thrust faulting which has placed older Paleozoic rocks from the west onto younger Mesozoic rocks to the east and illustrates the B&R-CPT province with its rising peaks of juxtaposed rocks and alluvial valleys (Stokes, 1986). The site also falls within a north-south trending zone known as the Intermountain Seismic Belt (ISB) which extends from northwestern Montana to at least southwestern

Utah (Smith and Arabasz, 1990). In as the site is within the ISB, ground shaking is a notable potential hazard. This hazard can be illustrated in part by earthquakes occurring in 1910 and 1921 near Elsinore, Utah which is approximately 26 km (16 miles) distant from the site, and another larger event in 1901 a little further distant (generally near Richfield). The nominal magnitudes of the 1901 and 1921 events were approximately 6-1/2 and 6, respectively (UUSS, 2021a).

Of the 1901 event, it was reported that towns reporting damage included Richfield, Beaver, Joseph, and Elsinore. “In these locations there were widespread instances of downed chimneys, cracked walls—particularly in stone and brick buildings, roofs damaged by falling chimneys, and broken windows. Dishes and other goods were shaken from cupboards or shelves and broken. People were greatly frightened with some fainting or rushing into the street. No loss of life was reported as a result of this earthquake. However, there were reports of a number of near misses from falling walls and ceilings.” (UUSS, 2021a).

In the1921 Elsinore earthquake, “widespread damage” was reported in the city of Elsinore, including “broken or sunk foundations, downed chimneys and gables, cracked walls and fallen plaster, and damaged roofs and ceilings from falling bricks and cement. Nearly every building the city was damaged” (UUSS, 2021a). Notably, there were also two significant aftershocks (5.7 and about 6) which caused additional damage and structural collapses (UUSS, 2021a).

A map of historic seismicity within 100 km (62 miles) of the site is presented in Figure 3-3. This data, sourced from the University of Utah Earthquake Information Center, represents a compilation of Utah earthquakes from 1850 through 2016 (see Bowman and Arabasz, 2017; UUSS, 2021a; UUSS, 2021b), with post-June 1962 magnitudes uniformly expressed in terms of uniform moment magnitude (whereas magnitudes of other events and catalogs may be expressed in terms of different magnitude types such as Richter (long), surface wave, or body wave). Post-2016 data (2017 through late 2020) derives from the University of Utah Seismograph Stations’ (UUSS) current digital earthquake catalog (UUSS 2021c). Larger magnitude (M) events shown in the figure, within 100 km of the site, are tabulated in Table 3-1, with the largest being the 1901 M ~6-1/2 Southern Utah and 1921 M ~6 Elsinore earthquakes mentioned previously. Quaternary faults mapped in the vicinity (100 km radius) of site are presented in Figure 3-4 (data from USGS, 2021a). It should be noted that no historic fault rupture has occurred within the extent shown in the Figure. Several of the key faults are discussed in the next section of this document.

A review of USGS’ 2014 National Seismic Hazard Maps (NSHM) and their seismic source information (USGS, 2021b) indicates that for the long-term recurrence intervals of design interest for this embankment dam, the probabilistic ground shaking hazard at the site for short periods is dominated by the gridded seismicity (also referred to as background seismicity, or a random earthquake), representing well more than 95% of the hazard. The lack of ground shaking hazard attributable to specific faults is a result of there being no major faults modeled in close proximity to the site.

3.5.2 Key Fault Characterization

3.5.2.1 Pavant / Tabernacle / Beaver Ridge / Meadow–Hatton Area / White Sage Flats Faults [Black Rock Faults]

These faults (the nearest trace of which lies approximately 11 km northwest of the site, west of Interstate 15 are located generally colinear to one another along the same general strike of approximately N15E in the Black Rock Desert (See Figure 3-4). Individual lengths range from about 4 km up to about 30 km, for a total straight-line length across this entire grouping of faults on the order of 57 km. From north to south, the general progression of faults is Pavant, Tabernacle, Beaver Ridge, Meadow–Hatton Area (which are nearest the subject site) and White Sage Flats Faults. A grouping of these faults was proposed by Hoover (1974) as the “Black Rock Faults” (not to be confused with the “Black Rock Area faults” shown in the figure southwest of the faults of Cove Creek Dome). The faults are typically manifest in zones of late Quaternary deformation and faulting in basalt flow and Lake Bonneville deposits (UGS, 2021). As can be seen in Figure 3-4, fault traces are somewhat diffuse. These faults appear to generally dip relatively steeply toward the west and intersect the Sevier Desert Detachment (SDD) at depths of 2 to 5 km, either soling into, or cutting through, it. The SDD itself is generally considered to be a low angle (10 to 15 degrees) thrust fault (inferred from seismic reflection profiles) beneath the Sevier Desert and associated with Cenozoic continental crustal deformation. However, the nature of the SDD and its role/activity as a seismic hazard remains a subject of debate, as do the Black Rock Faults.

The faults comprising the Black Rock Faults are not included in the seismic source model for the 2014 USGS National Seismic Hazard Maps (NSHM; USGS, 2021c), nor are they currently planned for inclusion in the 2023 edition (USGS, 2021d). These faults were linked together for some HAZUS-based loss estimations (Lund, 2014) performed by the state of Utah, resulting in a potential magnitude 7.2 source. However, when the Working Group on Utah Earthquake Probabilities [WGUEP] performed its assessment of earthquake probabilities along the Wasatch Front later in in 2016, they were excluded from consideration (WGUEP, 2016). A somewhat extended discussion is presented by WGUEP in its MP 16-3 document (pages 106 to 109) regarding apparent “missing” seismic moment in seismic sources, as well as discrepancies in geologic and geodetic slip rates, within the area near the site and the end of the Nephi Segment of the WFZ to the north. In that discussion, the SDD and Black Rock Faults are discounted as significant contributors to the seismic hazard, with a best estimate of maximum vertical slip rate of 0.17 mm/year or a more likely rate of 0.06 mm/year (WGUEP, 2016). By way of comparison, the vertical slip rate of the central segments of the Wasatch Fault Zone is on the order of 1.3 to 1.6 mm/year, a difference of about 20 to 25 times).

As discussed by Oviatt (1989, 1991) and WGUEP, the Black Rock Faults cut

"Quaternary volcanic rocks over most of its length and connects four Quaternary volcanic vents. This association with recent volcanism suggests that the displacements along the Black Rock fault zone and the nearby Clear Lake fault zone could be the result of local magma movement and/or subsidence over a magma chamber, rather than tectonic processes" (WGUEP, 2016).

In a slightly more recent study, Stahl and Niemi (2017) concluded that late Quaternary faulting in the Sevier Desert is indeed driven by magmatism ("magma-assisted rifting"). tahl and Niemi state that:

"Rupture of a low-angle normal fault and on populations of high angle faults that sole into such a fault at depth [are] capable of producing earthquakes significantly larger than magnitude 7, whereas dike-induced earthquakes do not usually exceed about magnitude 5.5 and are commonly smaller. This magnitude difference equates to a minimum 200 times difference in seismic moment release and results in vastly differing estimates of maximum earthquake magnitudes and seismic hazard. Our data suggest that the SDD is not actively accumulating strain and is therefore unlikely to generate large earthquakes."

In light of the approaches used by the USGS and WGUEP, and the work of Oviatt; Stahl and Niemi; and others such as McBride et al. (2015), we exclude the Black Rock Faults as a seismic source from our ground shaking hazard analyses.

3.5.2.2 Faults of Cove Creek Dome

Located immediately southwest of the aforementioned Black Rock Faults grouping, the Faults of Cove Creek Dome are somewhat similar to the Black Rock Faults. In this particular case, the faults surround Cove Creek dome which is a "doubly plunging anticline associated with roughly 300 to 400 meters of uplift in Pliocene basalts and lake sediments. … [and] although Quaternary movement has not been demonstrated for the Faults of Cove Creek Dome, the dome itself and nearby faults show evidence for late Quaternary deformation" (UGS, 2021). While the end-to-end straight-line length of the zone is on the order of 19 km, the faults form a cluster or dispersed zone, and have a reported cumulative trace length on the order of 74 km (UGS, 2021). These faults are not included in the seismic source model for the 2014 USGS NSHM (USGS, 2021c), nor are they currently slated for inclusion in the 2023 edition (USGS, 2021d). For reasons similar to those described relative to the Black Rock Faults, we exclude the Faults of Cove Creek Dome as a seismic source from our ground shaking hazard analyses.

3.5.2.3 Faults of Cove Fort Fault Zone

Located generally south of the Faults of Cove Creek Dome is the Cove Fort Fault Zone. This dispersed zone or cluster of short faults occurs in and around the Cove Fort volcanic field and presents both normal and strike-slip faulting. Per UGS (2021), the "intragraben structural patterns recorded in the Cove Fort volcanic field may be similar to deformation within other, generally alluvial-filled, basins of the Great Basin. … Alternatively, the faults may result from local forces related to volcanic eruption." Faulting is generally believed to be of middle to late Quaternary age. Given its proximity and nature, some analogues are commonly drawn between this zone of faulting and that of the Faults of Cove Creek Dome and the Black Rock Faults. The Cove Fort Fault Zone is similarly absent in the seismic source models for the 2014 and 2023 USGS NSHMs (USGS, 2021c and 2021d). Accordingly, we exclude the Cove Fort Fault Zone as an explicit seismic source from our ground shaking hazard analyses.

3.5.2.4 Beaver Basin Eastern Margin Faults

The Beaver Basin Eastern Margin Faults are located along the eastern margin of the Beaver Basin, south-southwest of the site, with the nearest active trace about 37 km distant. These faults present early Holocene faulting. These faults are not included in the seismic source model for the 2014 USGS NSHMs (USGS, 2021c), but they are currently scheduled for incorporation in the 2023 edition (USGS, 2021d). Associated with these faults are the Beaver Basin – Central Basin (Intrabasin) Faults. These latter faults, however, appear to be "related to development of a north-south trending horst and antiform" (UGS, 2021). For deterministic seismic hazard analysis purposes, we have adopted fault parameters in consideration of characterizations by Lund (2014) and USGS (2021a). These parameters include a characteristic moment magnitude of 7.0, a westerly dip of 50 degrees, and seismogenic depth of 15 km. Other parameters for this fault (including derivative source-to-site distance metrics) are presented in Appendix D. The slip rate category for these faults is less than 0.2 mm/yr.

3.5.2.5 Scipio Valley / Scipio – Pavant Range / Maple Grove / Red Canyon Faults

Beginning approximately 36 km northeast of the site, there is a series of generally north-trending, short faults: namely the Red Canyon, Maple Grove, Pavant Range, Scipio, and Scipio Valley Faults. These faults show some evidence of at least one late Quaternary (less than 15,000 years before present) faulting event. Following the precedents of Lund (2014) and WGUEP (2016), we have linked these faults, resulting in a 45 km total length fault with a moment magnitude of 7.1. Some uncertainty exists regarding the dip of the subject faults. In keeping with Utah Dam Safety's practice of conservative interpretation when defining the "maximum credible" event, we assume these faults dip westerly (rather than potentially easterly), placing the rupture plane nearer the subject side, together with a dip angle of 50 degrees and a seismogenic depth of 15 km as typically assumed for Basin and Range faulting. Other parameters for this fault (including derivative source-to-site distance metrics) are presented in Appendix D. The preferred slip rate for this linked fault source is 0.1 mm/yr. (WGUEP, 2016).

3.5.2.6 Elsinore Fault/Fold and Dry Wash Fault/Syncline

These two north-northeast trending structures lie generally east of the site, on the other side (east side) of the Pavant Range, in the Sevier Valley. Interstate 70 generally follows the alignment of these two structures. The closest distance from the site to the nearest inferred trace of the Elsinore Fault/Fold is about 25km. These structures are notable, given their proximity to historic earthquakes (see Figure 3-4). Both are relatively poorly understood. In describing the Elsinore structure, the UGS' fault database (2021) states that "orientations and slip directions of bedrock faults along the Pavant Range front … are incompatible with the existence, as has been inferred from physiography and geology, of a major range-front fault. … Instead, a mapped southeast-facing monocline (which may overlie a major buried fault) appears to be the principal range-front structure." Willis (1988) on the other hand argues that the Elsinore structure is essentially a fault. It should be noted that there is a "a short, 12-meter-high fault scarp at the south end of the monoclinal structure … within an area of local late Quaternary deformation at the juncture with the Dry Wash fault [; however,] on trend with the north end of the structure, Tertiary to Quaternary pediments appear to be unfaulted but are tilted" (UGS, 2021). Middle to late Quaternary faulting is reported for the Dry Wash Fault and Syncline. However, the structure appears to "likely record part" of the deformational history of the Sevier Valley which was formed by "faulting, folding, and removal of salt from underlying Jurassic formations" (UGS, 2021). In our assessment of ground shaking, we have not treated the Elsinore Fault/Fold and Dry Wash Fault/Syncline as active seismic sources.

3.5.3 SITE SPECIFIC CONDITIONS

A subsurface seismic wave velocity profile in the vicinity of the future embankment dam footprint was assessed using shear (s-) wave velocity soundings made by Sage Earth Science (2021) under subcontract to GC. More specifically, both multichannel analysis of surface waves (MASW) and microtremor array measurement (MAM) techniques were used to obtain the shear wave velocity profile. The average shear wave velocity for the first 30 meters (Vs30) of subsurface is approximately 435 m/s (1,426 ft/s). Based on this information and other geotechnical data from the site, coupled with our experience, we consider the site, barring any potential for liquefaction or other atypical/extreme soil conditions (which we understand to be negligible), to present NEHRP seismic Site Class 'C' conditions, Site Class 'C' conditions are commonly referred to as "very dense soil and soft rock."

3.5.4 Hazard Rating

We understand from Franson Civil Engineers that that the State of Utah (Utah Dam Safety) considers that the new embankment dam will be a "high hazard" dam (see Rule R655-10-5). With respect to NRCS [USDA] hazard ratings, we similarly understand the new embankment dam would be classified as having "high hazard potential," typified as being a dam "where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads" (NRSC, 2019).

Per the State of Utah (see Rule R 655-11-5A), with respect to the maximum design earthquake ground motions (referred to as the Maximum Credible Earthquake, MCE), “high and moderate hazard dams will be evaluated using [deterministic-based] ground motion parameters that are at least equal to mean plus one standard deviation predictions (84^{th} percentile). At the discretion of the State Engineer, these values may be reduced to mean (50^{th} percentile) for moderate hazard dams.” Also, dams should be evaluated using probabilistic-based MCE ground motions, with a 5,000-year return interval “for high and moderate hazard dams. At the discretion of the State Engineer, a 2,500-year return interval can be used for moderate hazard dam.” Also, for the State of Utah, the Operating Basis Earthquake (OBE) is defined using probabilistic methods and at least a 200-year return interval.

Per NRCS, maximum design earthquake (MDE) ground motions (also sometimes referred to as a Safety Evaluation Earthquake, SEE) for high hazard potential dams (also referred to as “high consequence” dams) are probabilistic-based with a return period of 10,000 years (which using a time-independent occurrence model correlates to a hazard level of approximately a 0.5 percent probability of exceedance in 50 years (i.e., 0.5PE50)). For OBE assessments, ground motions are to be evaluated probabilistically with a return period of 500 years (i.e., 10PE50). In either case, deterministic-based ground motions need not explicitly be considered.

Given the potential for multiple jurisdictional criteria to be considered for this project, we have adopted the more stringent of the two. Hence, in the case of this embankment dam, MCE and MDE ground motions will be taken as the larger of:

- Probabilistic-based (PSHA) ground motions, corresponding to a 10,000-year return period (which using a time-independent occurrence model nominally correlates to a hazard level of 0.5PE50).

- Deterministic-based (DSHA) ground motions, corresponding to median plus one standard deviation (84^{th} percentile) ground motions.

OBE ground motions will be taken as probabilistic-based (PSHA) ground motions, corresponding to a 500-year return period.

3.5.5 Maximum Credible Earthquake (MCE) / Maximum Design Earthquake (MDE)

In the case of this embankment dam, the MCE / MDE acceleration response spectrum is controlled for all periods of consideration by the 0.5PE50 PSHA-based spectrum derived from site-specific shear wave velocities. This MCE spectrum is shown in Figure 3-7. The DSHA-based spectrum for the most critical rupture scenario (which is a full rupture of the Scipio Valley to Red Canyon linked fault is also shown for reference in this Figure as a dashed line. Additional details regarding the derivation of the MCE /

MDE spectrum which considers both probabilistic and deterministic components are presented hereafter, but in summary, the peak ground acceleration (PGA) of the composite MCE / MDE spectrum is 0.62 g.

3.5.5.1 Probabilistic Ground Motions

Seismic hazard curves for select periods, based on the current USGS earthquake hazard calculator for the B/C boundary ("bedrock") conditions (see USGS, 2021b), are presented in Figure 3-8. The relative contribution of seismic sources to these curves is discussed hereafter. Using these hazard curves and those available for other periods, a "bedrock" B/C boundary condition acceleration response spectrum for a 0.5PE50 (10,000-year return period) hazard level (see Figure 3-9) was developed. This spectrum was subsequently smoothed and corrected for site soil effects a described below to obtain the 0.5PE50 (10,000-year return period) hazard level spectra presented in Figure 3-9. The peak ground acceleration (PGA) for the B/C boundary condition spectrum is 0.51 g, while the PGA for the site conditions corresponding to the measured shear wave velocity profile is 0.62 g.

Site-soil effects have generally been quantified based on NRCS guidance (NRCS, 2014). That guidance directs that short and mid-period correction factors (Fa and Fv) based on US National Earthquake Hazard Reductions Program (NEHRP) site classifications be used, as outlined in ASCE 7-10 (ASCE, 2010). We note that these factors were updated in NEHRP's 2015 "Recommended Seismic Provisions for New Buildings and Other Structures" (FEMA, 2015) and incorporated into the more current ASCE 7-16 (ASCE, 2017). Consequently, we have updated the coefficients accordingly, with the newer coefficients being typically the same or somewhat larger. For the purposes of this project, we have followed the source procedures by which the NEHRP 2015 / ASCE 7-16 site soil correction factors were determined to evaluate and apply correction factors according to each specific period in the spectrum. This approach contrasts with the more typical approach of using/applying correction factors represented by Fa and Fv which are lumped averages and are applied at periods of 0.2 seconds (typifying low-range periods) and 1.0 seconds (typifying mid-range periods), respectively, with a standardized spectral shape with two anchor points (or three points if the coefficient Fpga is considered for PGA). Our more comprehensive approach also permits the factors to be adjusted based on site-specific Vs30 values (not just Site Class). The reader is referred to Kircher & Associates (2015) and Seyhan and Stewart (2014) for additional details.

To evaluate the potential effect of site soil variability on ground response, we have applied soil site correction factors based on representative site class 'C' conditions as reflected in the standard NEHRP site factors as well as site conditions consistent with a site-specific V_{s30} parameter of 435 m/s as discussed previously. As can be seen in Figure 3-9, the spectrum based on typical ("generic") site class 'C' conditions presents appreciable amplification relative to bedrock (B/C boundary) conditions for all periods shown. The site-specific spectrum is only slightly larger in magnitude. This results because the site-specific V_{s30} value is very similar to the typical conditions represented by Site Class C. For purposes of developing design spectra for this project, we use the site-specific V_{s30}-based spectrum.

A deaggregation of the 2014 USGS NSHM ground motions for the 10,000-year (0.5PE50) hazard level indicates that the background or gridded seismicity (i.e., the random earthquake) is the principal contributor to the ground shaking hazard at this site (with the contribution being over 95% of the total for a period of 0.01 seconds [which essentially corresponds to PGA]. The mean magnitude-distance pair is 6.28 and 9.9 km whereas the modal pair is 6.30 and 9.5 km (with a 10% relative contribution to the hazard, as calculated by USGS) for B/C site class boundary conditions (USGS, 2021b). At longer periods (~1.0 seconds), background (gridded) seismicity continues to dominate the ground shaking hazard. At this period, the mean magnitude-distance pair is 6.71 and 13 km, and the modal pair is 6.50 and 9.5 km (with a 12% relative contribution to the hazard, as calculated by USGS) for B/C site class boundary conditions (USGS, 2021b).

3.5.5.2 Deterministic Ground Motions

For our DSHAs, ground motions were computed using the ground motion prediction equation (GMPE) tool developed by the Pacific Earthquake Engineering Research Center (PEER) (Seyhan, 2014). This particular tool calculates uniform hazard horizontal acceleration response spectra using multiple GMPEs developed as part of the NGA-West 2 (NGAW2) project directed by PEER. For this particular study, we used the relationships of Abrahamson et al. [“ASK14”] (2014), Boore et al. [“BSSA14”] (2014), Campbell and Bozorgnia [“CB14”] (2014), and Chiou and Youngs [“CY14”] (2014). Each of these relationships was used to model western US-based seismic sources in USGS’ 2014 National Seismic Hazard Mapping Project (NSHMP). Each relationship was given equal weight in our analyses and averaging of the results was performed in terms of the natural logarithm of the spectral values (also referred to as geometric averaging). We elected not to use the relationship of Idriss [“I14”] (2014) because, although it was used in USGS’ NSHMP, it was weighted lower relative to the other GMPEs (thereby suggesting lower reliability). In our analyses, we have used versions of the GMPEs which provide spectral accelerations on a RotD50-basis rather than a maximum rotated component (MRC).

Apart from the previously discussed V_{s30} parameter, other site “depth” parameters needed to predict ground motions (such as Z1.0) are based on default correlations developed by the respective authors of the GMPE relationships used in the analyses.

Acceleration spectra representing the 50th percentile (median) and 84th percentile (median plus one standard deviation) responses for two key scenario events are presented in Figure 3-10. The scenarios consist of a full rupture of Beaver Basin Faults (East Margin) and a full rupture of the linked Scipio Valley / Scipio-Pavant Range /

Maple Grove / Red Canyon Faults. Fault and site input parameters for these analyses can be found in Appendix D

In Figure 3-10, it can be seen that for the same percentile ground motions, the spectrum produced by the Scipio Valley to Red Canyon linked faults is larger than the Beaver Basin Eastern Margin Faults. This is a result of a closer net proximity to the site for the former rupture plane. One can also see in Figure 3-10 that appreciable uncertainty exists in the ground motion prediction methods, resulting in the median-plus-one standard deviation curves being substantially higher than those based on median curves. The median-plus-one standard deviation PGA of the critical fault rupture event is 0.24 g.

3.5.6 Operating Basis Earthquake

The OBE event is considered to be the event which has the greatest potential to impact the stability of a dam, for this project having a return interval of 500 years. The USGS Unified Hazard Tool (reflecting data from the 2014 edition of the National Seismic Hazard Mapping Project [see USGS, 2021b]) was used to obtain the acceleration response spectrum representing a return period of 500 years. The spectra resulting after adjustments for site-soil conditions as described previously relative to the MCE are shown in Figure 3-11. As can be seen, the spectrum based on typical ("generic") site class 'C' conditions presents appreciable amplification relative to bedrock (B/C boundary) conditions for all periods shown. The site-specific spectrum is slightly larger due to the site being slightly less stiff than typical site class 'C'. For purposes of developing design spectra for this project, we use the site-specific-based spectrum. The corresponding PGA is approximately 0.18 g.

A deaggregation of the hazard at a period of zero (i.e., PGA) before accounting for local soil site effects indicates that OBE ground motions are dominated by background (gridded) events not associated with a particular fault. The calculated mean magnitude-distance pair is 6.13 and 21 km, and the modal pair is 5.30 and 11 km (the latter contributing about 8% to the hazard, as calculated by USGS).

Spectral ordinates of the OBE spectrum are presented in Table 3-2. Unless indicated otherwise, all response spectra presented in this document represent a damping ratio of 5%.

3.5.7 MCE and OBE Summary

Based on our assessments and the preceding discussions, seismic design criteria for Corn Creek Reservoir are:

- MCE: PGA of 0.62g and Mw of 6.7
- OBE: PGA of 0.18g and Mw of 6.1

3.5.8 Liquefaction Potential

A potential concern for seismically active areas is the impact of liquefied foundation soils on buildings and other structures such as earthen embankments. Site specific assessment of this potential hazard using field data collected for this project, we have used Youd et al.'s (2001) method of liquefaction triggering analysis at the existing dam location.

Results of our analyses show that the site is currently not considered liquefiable due to groundwater being deep below the ground surface. However, we understand NRCS is considering classifying the dam as a storage reservoir rather than a flood control structure due to the potential time water could be stored after storm events. Evaluating the liquefaction potential assuming groundwater at the surface based on the SPT blow counts from the test hole logs from this study also show the soil to be non-liquefiable. It should be noted that SPT blow counts were not collected continuously through the fine-grained alluvium due to utilizing sonic drilling techniques and some zones of silty sand and non-plastic silt did not have blowcounts collected.

The coarse-grained alluvium soils are not considered liquefiable due to its relative density being considered dense to very dense with blow counts being greater than 30. In addition, shear wave velocity measurements were utilized to assess the liquefaction potential along the new dam alignment using Andrus and Stokoe (2000) method of liquefaction triggering analysis. Results suggest that the site is not liquefiable.

We recommend additional field studies focus on the liquefaction potential of upper fine-grained material due to the high seismic hazard and consistency of the upper fine-grained alluvium having zones of silty sand and non-plastic silt. It is our opinion; these zones could be liquefiable; therefore, the fine-grained alluvium is recommended to be removed as will be discussed in Section 4.2.2. If the fine-grained alluvium is not removed and is liquefiable the seismic ground shaking hazard would need to be reassessed at this site.

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Table 3-1 Summary of Earthquakes (M>=4.5) Within 100km
Corn Creek Reservoir

Date	Latitude / Longitude	Moment Magnitude (M)	Distance to Site (km/mi)	Event Designation
11/14/1901	38.5 / -112.4	6.6	31.7 / 19.7	6-1/2 (M_L) Southern Utah
1/10/1910	38.683 / -112.15	4.8	25.7 / 16	5.0 (M_L) Elsinore, UT
1/12/1910	38.683 / -112.15	4.8	25.7 / 16	--
9/29/1921	38.683 / -112.15	5.5	25.7 / 16	~6 (M_L) Elsinore, UT
10/1/1921	38.683 / -112.15	4.7	25.7 / 16	--
11/18/1945	38.8 / -112.0	4.8	36.1 / 22.4	5.0 (M_L) Glenwood, UT
6/5/1962	38.0 / -112.1	4.5	91.5 / 56.9	--
7/7/1963	39.5327 / -111.9085	5.1	94 / 58.4	--
10/4/1967	38.5432 / -112.1565	5.1	35 / 21.8	5.2 (M_L) Marysvale, UT
1/30/1989	38.8227 / -111.6142	5.2	69.6 / 43.3	5.4 (M_L) So. Wasatch Plateau, UT
1/3/2011	38.2473 / -112.3398	4.7	60.1 / 37.4	--

Note: 1. Data from University of Utah Earthquake Information Center, Utah Earthquakes Databases, from 1850 through 2016 and 2017 through 2020 (Bowman and Arabasz, 2017; UUSS, 2021a; UUSS, 2021b; UUSS, 2021c)

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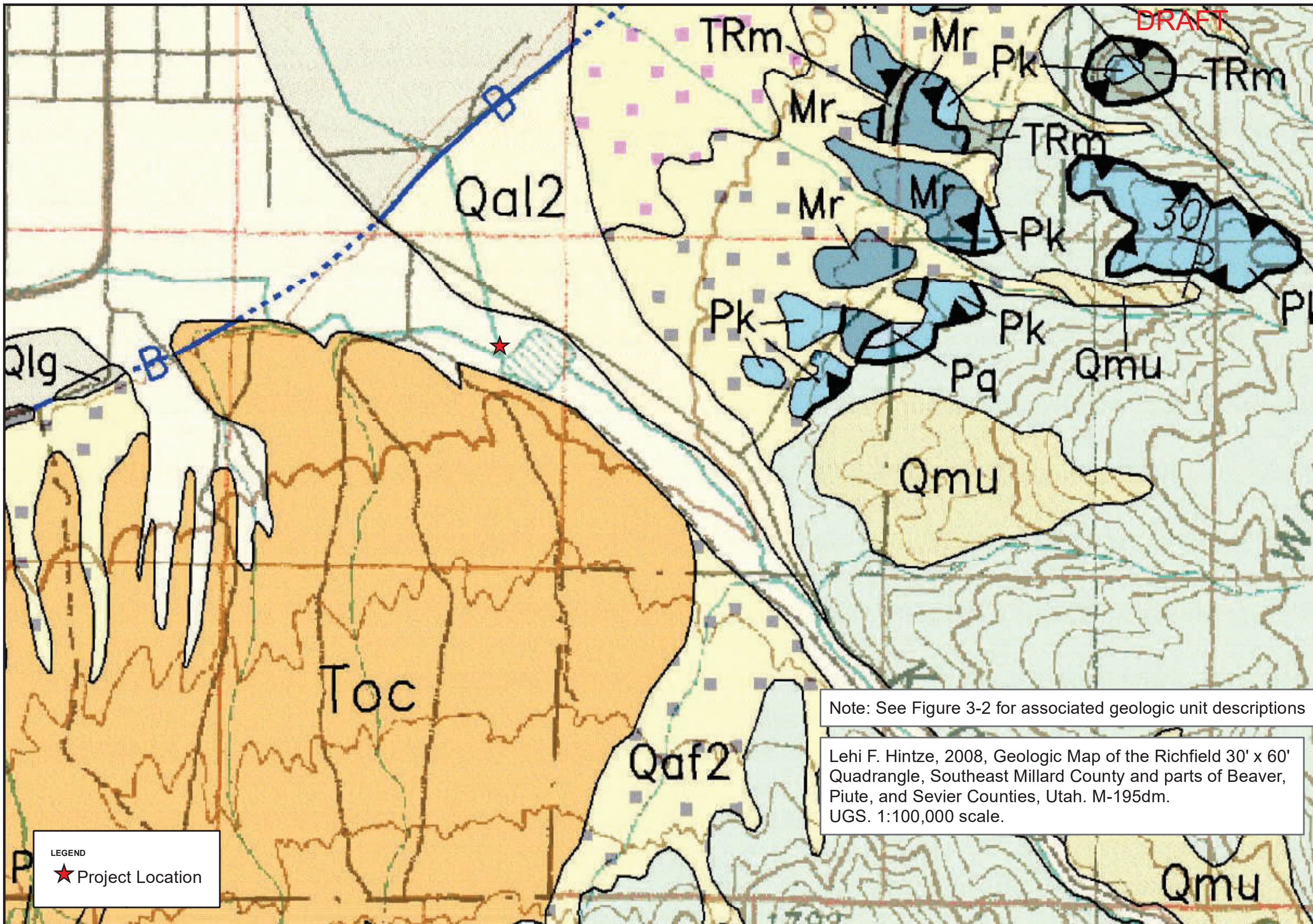
Table 3-2 MCE (MDE) and OBE Response Spectra Values
Corn Creek Reservoir

GERHART COLE

Period (s)	Spectral Acceleration (g)	
	MCE (MDE)	OBE
0.01 (PGA)	0.62	0.18
0.02	0.67	0.19
0.025	0.70	0.20
0.03	0.73	0.21
0.05	0.84	0.24
0.075	1.00	0.29
0.10	1.17	0.35
0.125	1.24	0.37
0.15	1.30	0.38
0.175	1.34	0.39
0.20	1.37	0.40
0.25	1.31	0.38
0.30	1.24	0.36
0.40	1.09	0.31
0.50	0.94	0.26
0.60	0.84	0.23
0.70	0.75	0.20
0.75	0.71	0.19
0.80	0.67	0.18
0.90	0.59	0.15
1.0	0.52	0.13
1.1	0.48	0.12
1.2	0.45	0.11
1.3	0.41	0.10
1.4	0.38	0.10
1.5	0.35	0.09
1.6	0.32	0.08
1.7	0.30	0.07
1.8	0.28	0.07
1.9	0.26	0.06
2.0	0.24	0.06



GERHART COLE

Geologic Map

Corn Creek Reservoir

N

0 500 1,000 2,000 Feet

Figure 3-1

DESCRIPTION OF GEOLOGIC MAP UNITS

Qal_1 Alluvium, late Holocene – Youngest alluvium in the channels, floodplains, and low terraces of the Sevier River, Beaver River, Chalk Creek, Corn Creek, Cove Creek, and other large streams; includes overbank and marsh deposits in abandoned meanders of the Sevier River; consists of sand, silt, and clay with lenses of gravel; silt in lower Pahvant Valley; less than 100 feet (30 m) thick along Sevier River; mostly 0 to 20 feet (0-6 m) thick, but may be thicker locally.

Qal_2 Alluvium, middle and early Holocene – Sand and, silt, and clay in the floodplain of Cove Creek, isolated remnants of older Chalk Creek and Corn Creek sand and gravel near Fillmore and Kanosh (respectively), along a stream near White Sage Flat, in the Pahvant Range along East Creek, and south of the Sevier River southwest of Elsinore; 0 to 30 feet (0-9 m) thick.

Qaf_1 Younger alluvial-fan deposits – Poorly sorted silt, sand, and pebble, cobble, and boulder gravel deposited by streams, sheetwash, debris flows, and flash floods on alluvial fans, and in canyons and mountain valleys; post-Bonneville shoreline in age; mostly 0 to 60 feet (0-18 m) thick, but may be up to 165 feet (50 m) thick along upper Sevier River.

Qaf_2 Older alluvial-fan deposits – Poorly sorted silt, sand, and pebble, cobble, and boulder gravel deposited by streams, debris flows, and flash floods on alluvial fans, and in canyons and mountain valleys above the Bonneville shoreline; includes colluvium in canyons and mountain valleys; on flanks of Mineral Mountains is mostly peasized grus, locally including larger clasts and significant eolian silt; mostly pre-Lake Bonneville in age, but locally includes younger material; up to 200 feet (60 m), or more, in thickness.

Qmu Mass movements, undivided – Masses of soil, sand, rock, and boulders that have moved downslope under the influence of gravity; includes soil creep, slopewash, talus, and fan alluvium, and locally slides and slumps; 0 to 100 feet (0-30 m) thick. Includes dissected older deposits on and near Bull Claim Hill southeast of Richfield.

Qlg Lacustrine gravel – Silty, fine- to coarse-grained sand and gravel in shore zone deposits of Lake Bonneville; 0 to 30 feet (0-9 m) thick.

Toc Oak City Formation – Sandy, bouldery gravel; poorly to well cemented; forms dissected alluvial apron on west side of Pahvant Range; bed of Cudahy Mine pumice, K-Ar dated as 2.6 Ma, is within upper Oak City Formation in map area, so upper Pliocene and Miocene(?) age; base of formation not exposed; estimated thickness as much as 2,000 feet (600 m).

Notes:
1. See Figure 3-1 for Geologic Map (Hintze, 2008).
2. See referenced Geologic Map for additional information on mapping, descriptions shown are the units that are in the vicinity of the project.

DESCRIPTION OF GEOLOGIC MAP UNITS

Units Exposed Along the Pavant Thrust Footwall

Jn Navajo Sandstone – Reddish-brown, fine-grained, cross-bedded, cliffforming sandstone; exposed thickness about 2,000 feet (600 m).

TRm Moenkopi Formation – Interbedded brownish-red sandstone, siltstone, shale, and gray limestone; minor cross-beds, mud cracks, and ripple marks are common; fossil brachiopods and ammonoids abundant locally; maximum thickness 1,876 feet (572 m).

Pk Kaibab Limestone – Gray, medium-crystalline, medium-bedded, dolomitic limestone; locally sandy and contains abundant brown chert; thickness in map area 497 (subsurface) to 1,160 feet (152 - 353 m); lower third of this map unit is likely Toroweap Formation equivalent.

Pq Queantoweap Sandstone – Pinkish- or light-brownish-gray, finegrained, cross-bedded sandstone; locally poorly cemented; thickness 817 feet (249 m).

Mr Redwall Limestone – Upper third is interbedded calcareous sandstone, limestone, and dolomite; middle part is gray, cherty, fossiliferous limestone; basal one-quarter is medium-gray interbedded dolomite and limestone; thickness 1,545 feet (471 m).

? CONTACT-- Dashed where location inferred; queried where speculative on cross sections

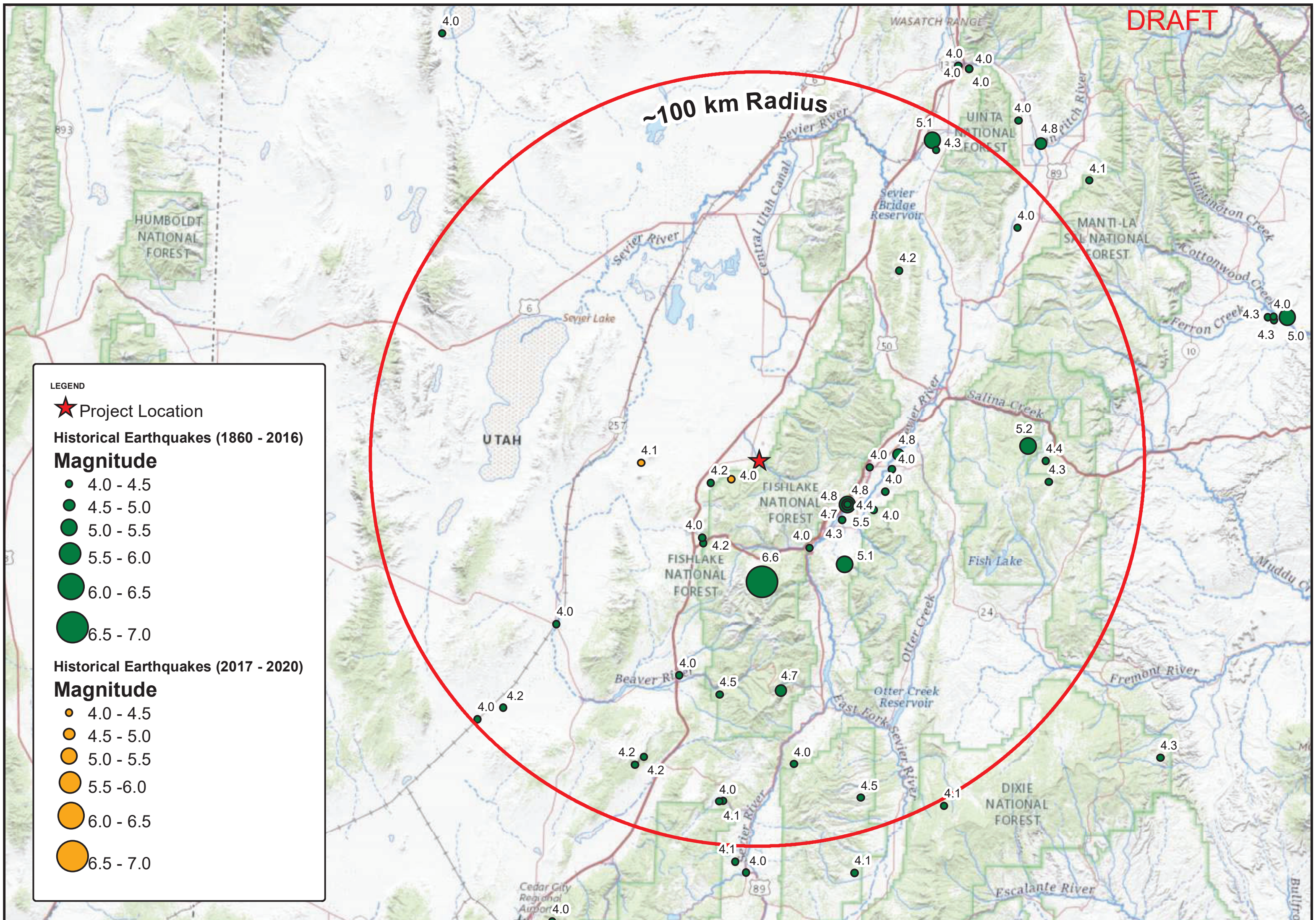
(Map) (Cross section) THRUST FAULT-- Dashed where location inferred; dotted where concealed; barbs on upper plate; arrows show relative movement on cross sections

42 overturned

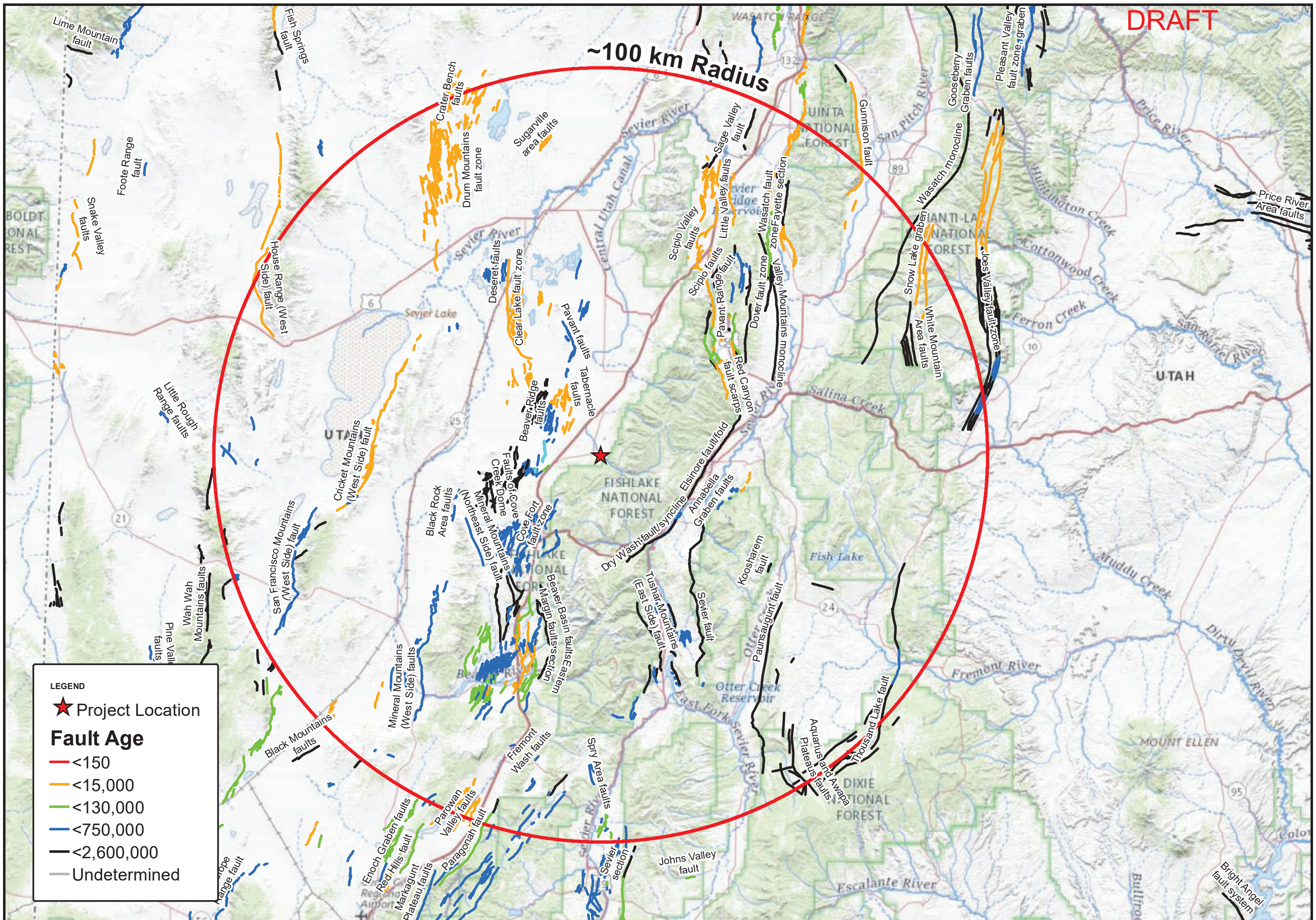
B Bonneville shoreline of Lake Bonneville

Notes: 1. See Figure 3-1 for Geologic Map (Hintze, 2008).

2. See referenced Geologic Map for additional information on mapping, descriptions shown are the units that are in the vicinity of the project.



GERHART COLE	Historic Earthquakes Map	Figure 3-3
	Corn Creek Reservoir	



GERHART COLE

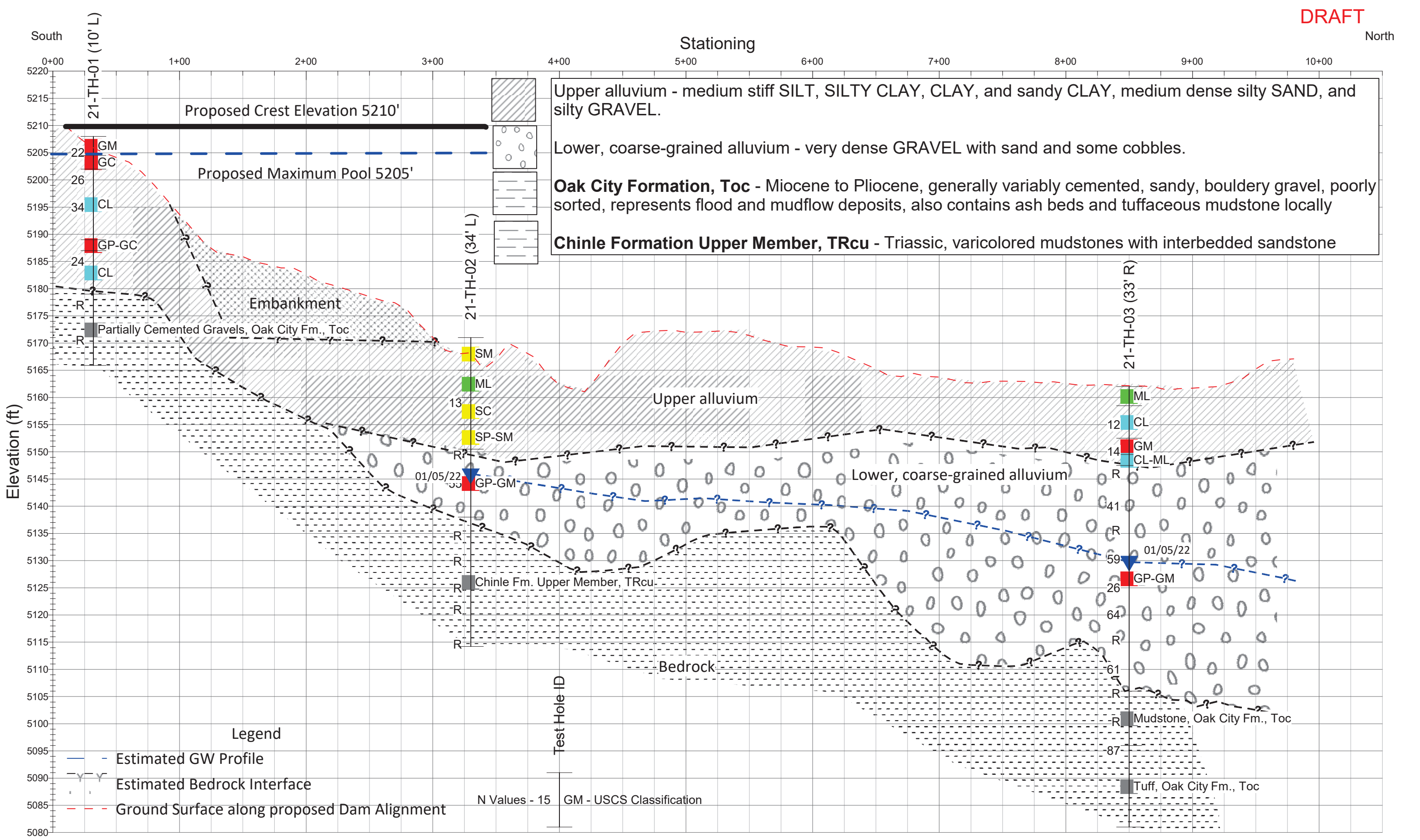
Quaternary Fault Proximity Map

Corn Creek Reservoir

N

0 5 10 20 Miles

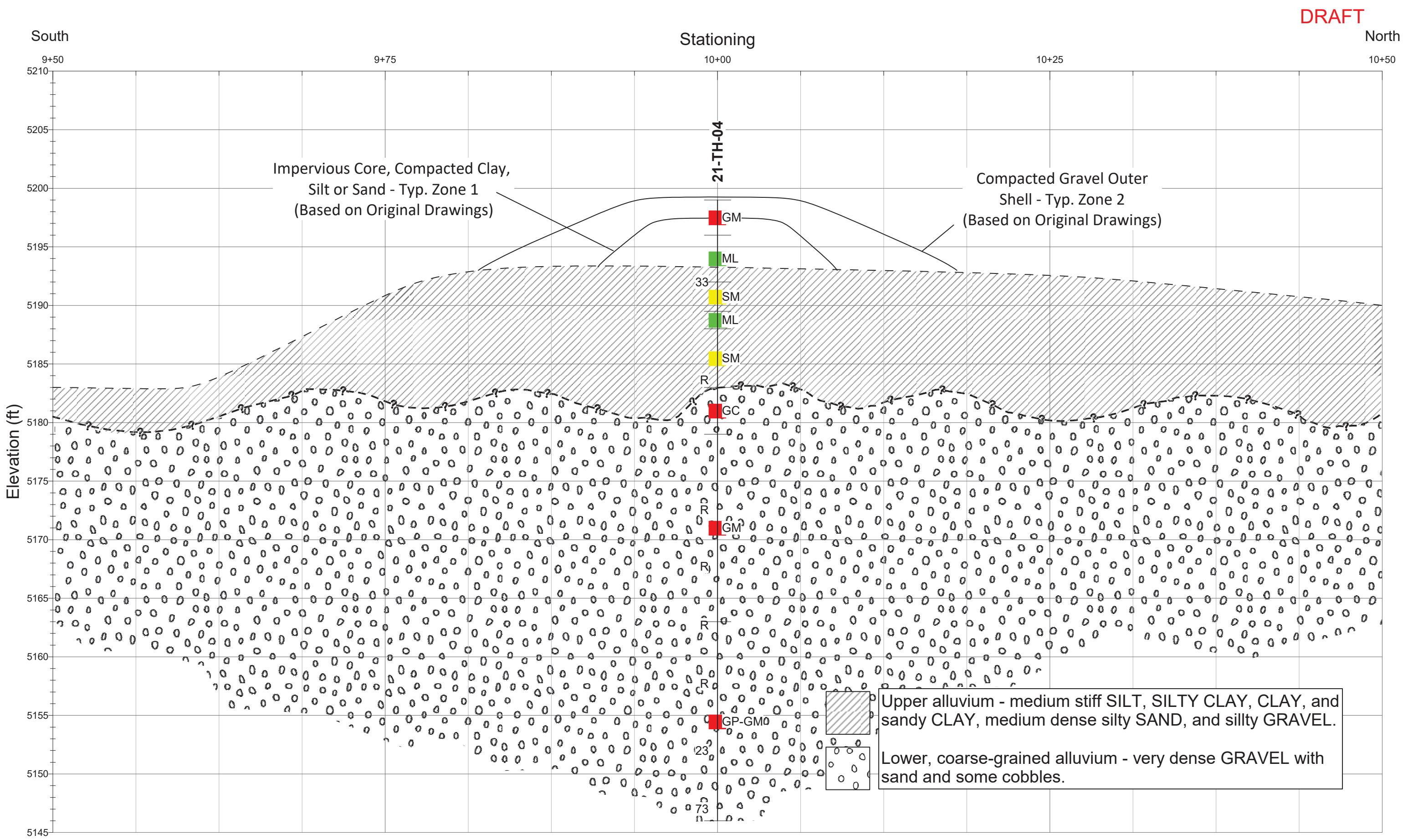
Figure 3-4



Notes:
All blow counts are uncorrected / field values.
The locations of all features shown are based on limited data and are approximate.
This drawing is for information purposes. It is intended to assist in showing features discussed in the attached document.

GERHART COLE

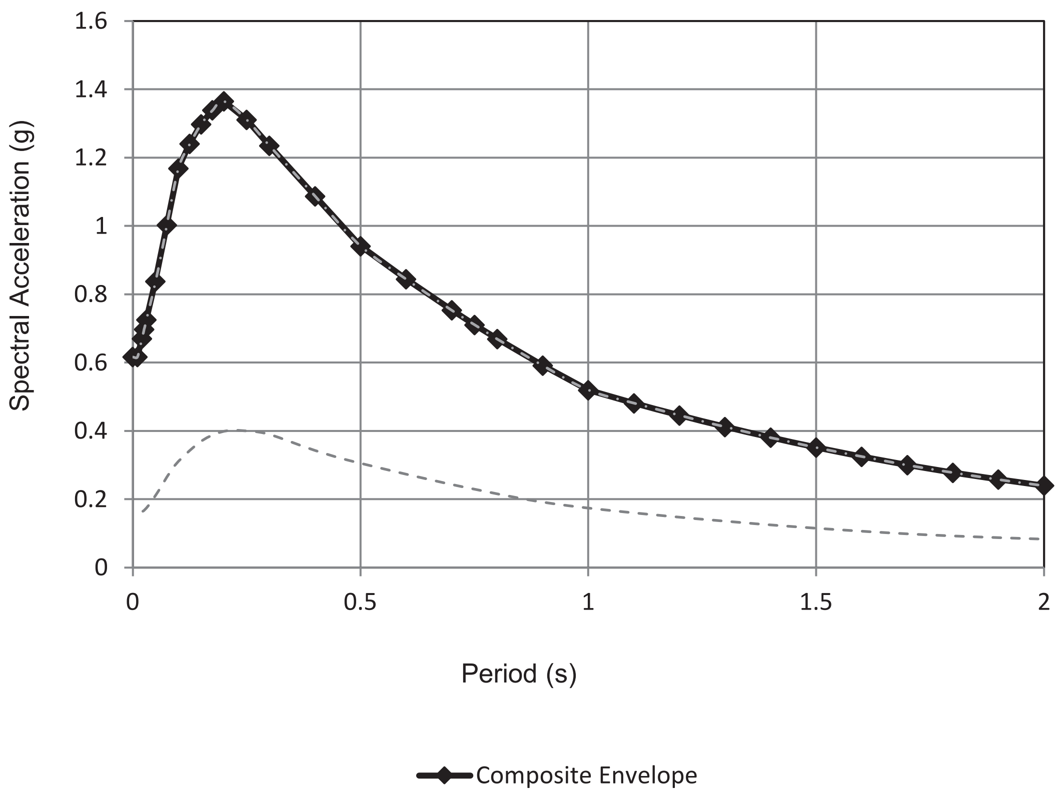
Subsurface Cross Section across Proposed Dam Alignment	
Corn Creek Reservoir	Figure 3-5



Notes:
All blow counts are uncorrected / field values.
The locations of all features shown are based on limited data and are approximate.
This drawing is for information purposes. It is intended to assist in showing features discussed in the attached document.

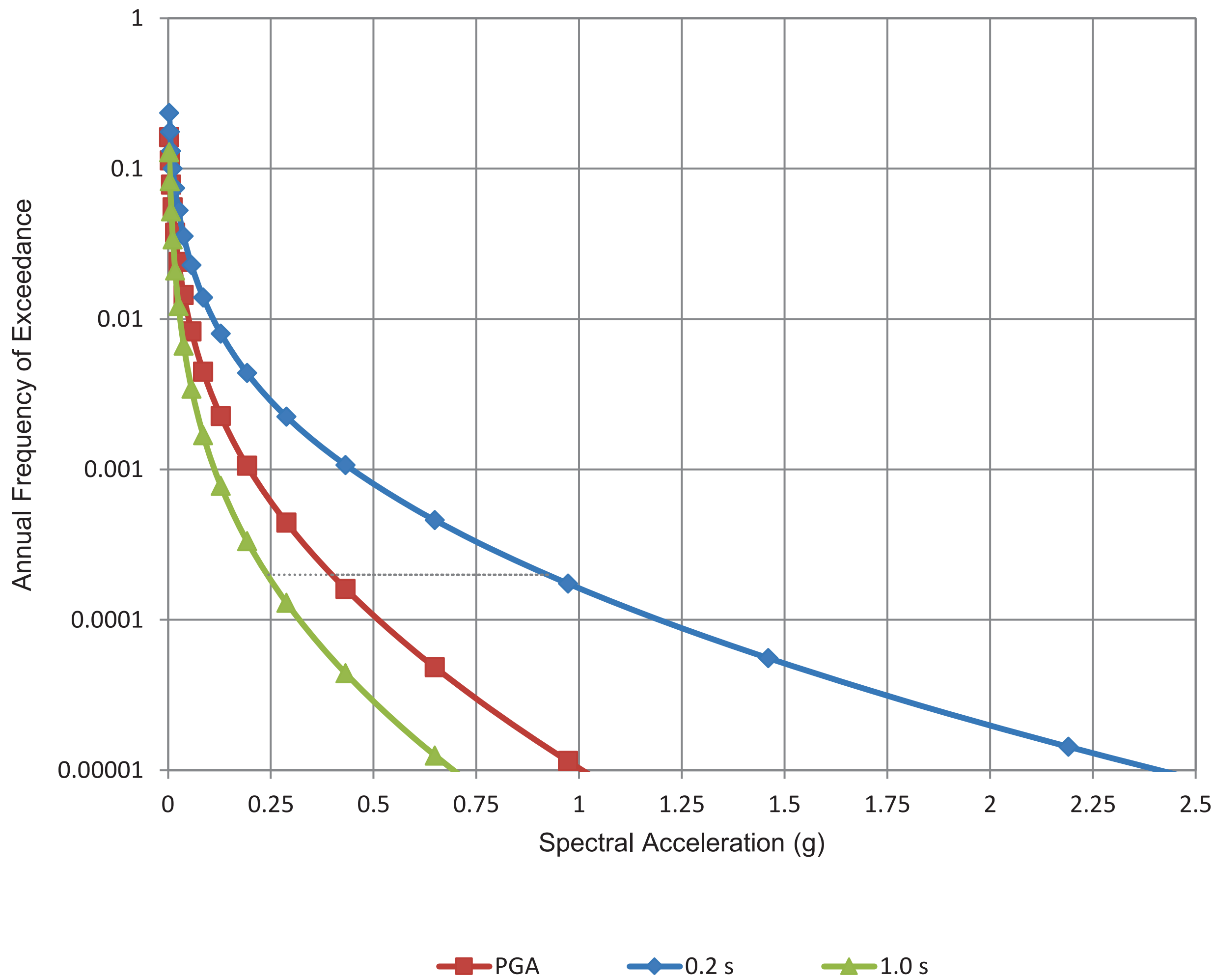
GERHART COLE	Subsurface Cross Section through Dam Section (TH-04)	
	Corn Creek Reservoir	Figure 3-6

DRAFT



GERHART COLE	Combined PSHA and DSHA Results (MCE / MDE Ground Motions)
Corn Creek Reservoir	Figure 3-7

DRAFT

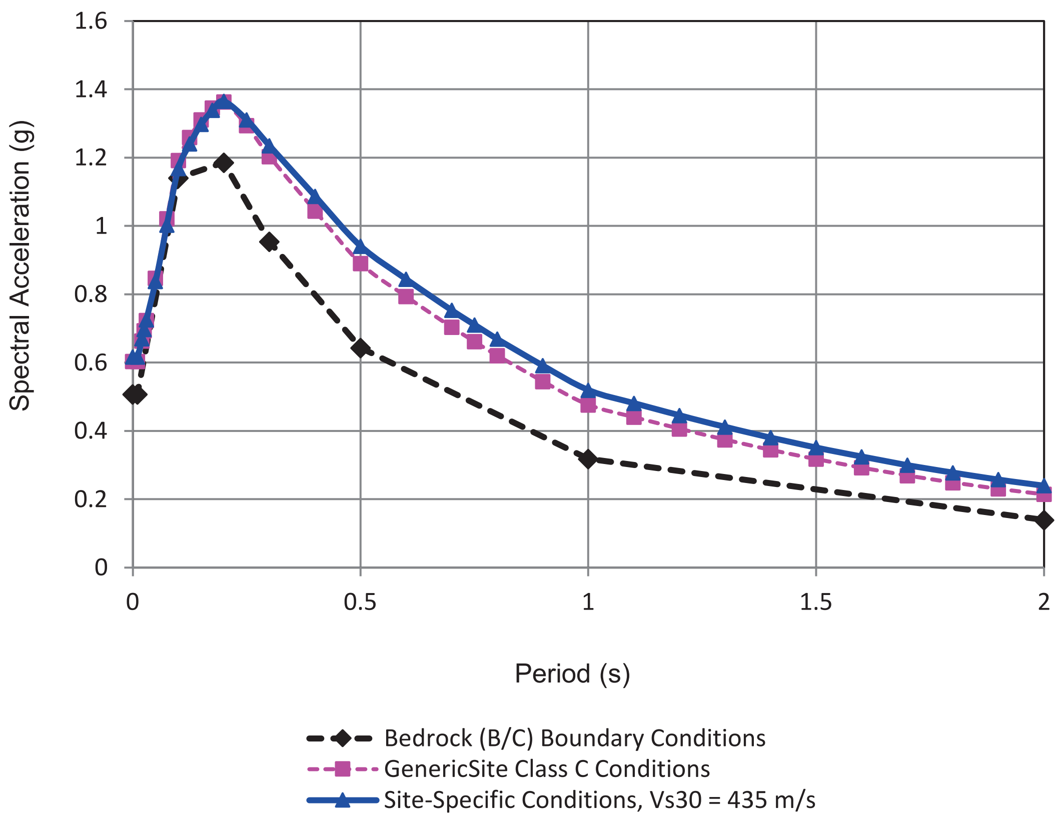


GERHART COLE

Ground Acceleration Hazard Curves
B/C Boundary ("Bedrock") Conditions

Corn Creek Reservoir	Figure 3-8

DRAFT



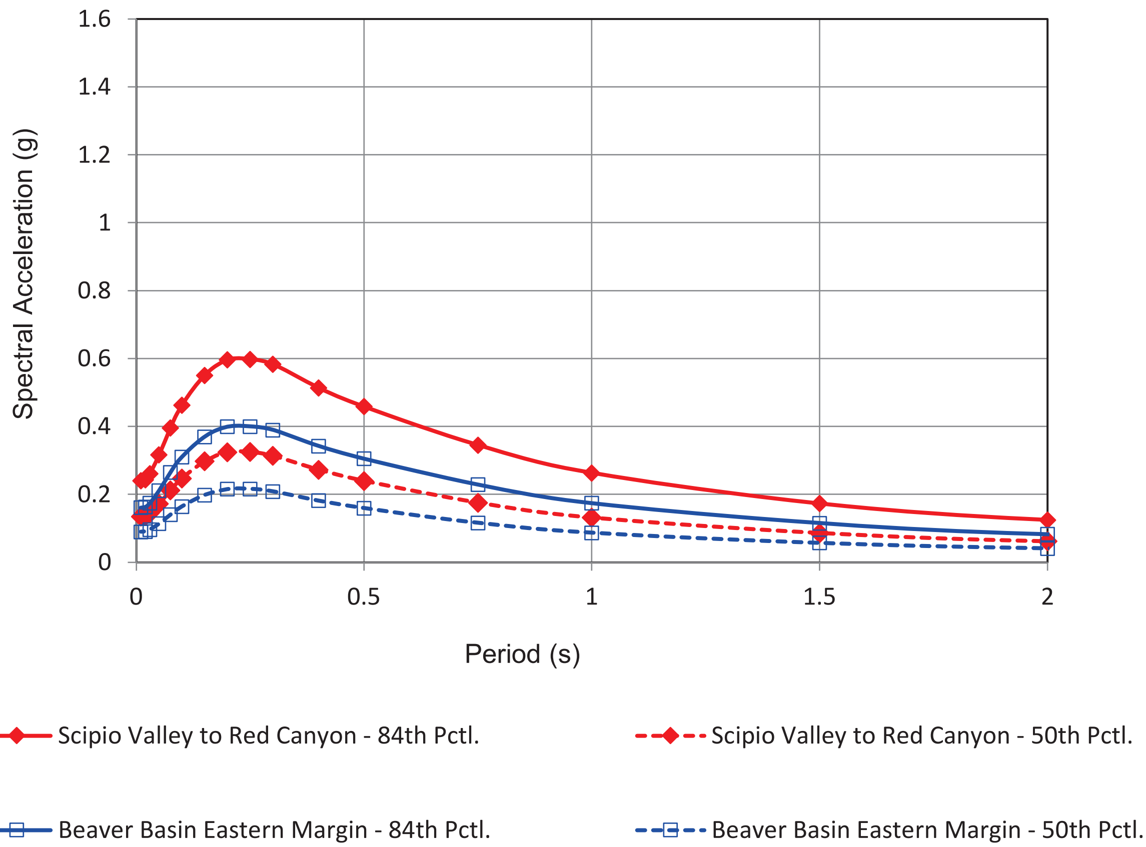
GERHART COLE

PSHA-based Response Spectra
10,000-year Return Period (0.5PE50)

Corn Creek Reservoir

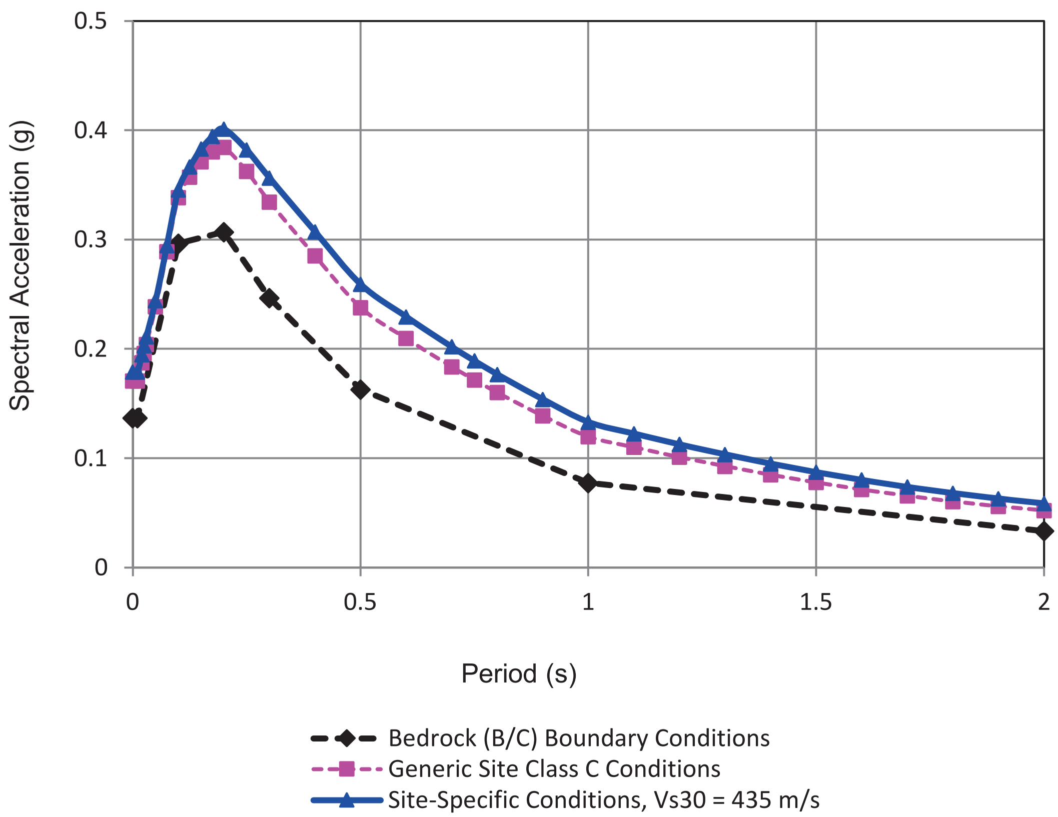
Figure 3-9

DRAFT



GERHART COLE	DSHA-Based Response Spectra Select Seismic Sources / Scenarios	
	Corn Creek Reservoir	Figure 3-10

DRAFT



GERHART COLE	PSHA-based Response Spectra; 500-year Return Period (OBE Ground Motions)
Corn Creek Reservoir	Figure 3-11

4.1 GENERAL

This section of our report discussed preliminary analyses of the new Corn Creek Dam alignment and provides recommendations that we believe will satisfy UDS rules (R655-11) and NRCS TR-60 rules (NRCS, 2019) as the project moves towards final design. The analysis is based on FCE proposed alignment as illustrated in Figure 2-1.

As documented in Section 1.3 several deficiencies have been identified and documented for Corn Creek Dam since it was partially reconstructed in 1986. The main geotechnical concerns include:

- Significant seepage through the dam foundation when the reservoir fills. UDS personnel mentioned in a project meeting December 1, 2021, a significant pond downstream of the embankment when the reservoir stores water. They have noticed the pond being 3-4 feet deep with estimate of flow through the foundation up to 3-4 gpm (UDS, 2021).
- Internal erosion concerns between the embankment material zones and the foundation.

4.2 CONCEPTUAL DESIGN

A preliminary earthen dam configuration was developed based on assessments of existing geometry, field and laboratory data, and the results of stability and seepage analyses. Our analysis resulted in the zoned embankment dam configuration plotted in Figure 4-1 that included 2.5H:1.0V slopes for both the downstream and upstream embankment.

Borrow material evaluations were not included in our scope for this study; however, they are recommended as the project moves forward. Based on our background review and our recent studies several potential borrow areas have been identified and plotted in Figure 2-1. These areas were identified as borrow sources from the Corn Creek Plans (Sunrise, 1986) and the 1985 Geotechnical Report (Northern, 1985).

4.2.1 Spillways

As mentioned in the Section 1.1, FCE is looking to provide both primary and auxiliary spillways. The primary spillway would protect Kanosh from flooding for events up to the 100-year flood event and the auxiliary spillway would address the PMF event. We understand the primary spillway would likely be a conventional concrete spillway and FCE has asked for our support in evaluating embankment protection options to address overtopping protection across the main embankment for the auxiliary spillway. The exact sizing and dimensions of the auxiliary spillway are still being assessed.

Overtopping protection utilizes a layer of durable material to protect the downstream slope and crest should the flood event exceed the main spillway capacity. The protected embankment area is then used as an auxiliary spillway. GC has not assessed overtopping protection and its integration with the dam embankment, however, two different overtopping protections options used successfully for similar applications are discussed by the United States Bureau of Reclamation (USBR) and Helper et al. (2012) and summarized below:

- Roller Compacted Concrete (RCC) – RCC is placed in lifts on the downstream slope and over the crest. Typical dams using RCC overtopping protection are about 35 feet high, with an average spillway discharge of 80 ft^3/s per lineal foot width of spillway, and an average design overflow depth of 5 feet. RCC lifts are typically 2.3 to 3.2 feet thick, depending on slope configuration, and a minimum of 8 feet wide to accommodate compacting equipment. This configuration creates a stepped surface that effectively increases the energy dissipation of the spillway (Hepler et al., 2012).

- Precast Concrete Blocks – There are multiple configurations of precast blocks but typically it is some configuration of cable-tied blocks or articulated concrete blocks (ACB). These blocks are placed on the downstream slope and over the crest to provide erosion protection. Manufacturers have different requirements for placement but typically they all require a smooth subgrade with a geotextile and or a bedding or drainage layer between the subgrade and the block system (Hepler et al., 2012).

4.2.2 Foundation Treatment

As discussed in Section 1.3, seepage issues have been observed and documented since dam reconstructing in 1986. Our field studies found materials with high permeability in the foundation below the dam. We have generalized the foundation materials into an upper and lower alluvium overlying bedrock with hydraulic conductivities (k) ranges summarized below:

- Upper fine-grained alluvium – $1x10^{-6}$ to $1x10^{-3}$ cm/sec (1 to 1,000 ft/year),
- Lower coarse-grained alluvium – $1x10^{-5}$ to $1x10^{-1}$ cm/sec (10 to 100,000 ft/year), and
- Bedrock (Oak City / Chinle formation) – $8x10^{-8}$ to $3x10^{-4}$ cm/s (0.1 to 300 ft/year).

A few potential options for reducing seepage through a foundation include:

- Full-depth key trench on the order of 60 feet deep,
- Partial-depth key trench with a filter blanket,
- Concrete diaphragm, sheet pile or structural cutoff wall (USBR, 2014),
- Slurry wall (soil-bentonite or other type)

Given the alluvial soil thickness (up to 60 feet based on our field data) and the foundation seepage deficiencies documented over the years a soil bentonite slurry wall is probably the most cost-effective method to address foundation seepage. If some seepage is allowed through the foundation and the embankment and foundation can be protected from internal erosion a partial depth slurry wall might be another option. At this time our conceptual section assumes a slurry wall to the bedrock.

A full-depth or partial depth key trench could require dewatering the excavation on the order of 40-60 feet, would be difficult and costly to construct. The reconstructed section the existing dam used a partial depth cutoff trench and has had and has seen significant seepage through the foundation as discussed in Section 1.3. The coarse-grained alluvium would make a concrete diaphragm, sheet pile or structural cutoff wall installation difficult due to dense gravels and cobbles. Given that there are no storage rights, the dam could potentially tolerate more foundation seepage than other dams, but any seepage that does occur needs to be controlled and protected from internal erosion.

Foundation materials at the south abutment consisted of some gravels overlying a lower permeability clay. The measured hydraulic conductivity from an undisturbed sample showed a value of 8.7×10^{-5} cm/s. Due to the shallow nature of the clay (about 6-8 feet) and lower permeability, a key trench with earth fill extending into the clay would be a viable option for the seepage control at the south (left) abutment.

Another potential risk to the foundation of the dam is that the upper fine-grained alluvium is potentially liquefiable as discussed in Section 3.5.8. If the material is found to be potentially liquefiable in future studies, these materials should be removed, and the new embankment is constructed on the coarse-grained alluvium. The fine-grained alluvium could potentially be used as Zone 1 core material as will be discussed in Section 4.2.4. The conceptual cross section shows the removal of the fine-grained alluvium; however, this should be studied as part of future project phases.

4.2.3 Shell Materials (Zone 4)

The shell of the dam may consist of the sand and gravel coarse-grained deposits found onsite that can be economically developed. The 1986 plans designate two potential gravel borrow areas for the shell material, one in the reservoir basin and the second at the left abutment. Figure 2-1 provides the approximate location of these borrow sources. Figure 4-2 provides the 1985 project specifications of the grain size distribution of the gravel shell for the existing Corn Creek Dam (Sunrise, 1985). In addition, on the figure are the grain size distributions from samples collected from the coarse-grained alluvium for this study and a sample collected in 2005 by Sunrise Engineering of the shell material (Sunrise, 2005). The 1985 geotechnical report (Northern, 1985) references the shell material strength used in the analyses has a friction angle between 36 to 40 degrees with a cohesion up to 400 psf which was based on a recompacted sample.

Although borrow sources have not been fully identified at this time, but we do believe a material like the shell of the existing dam would be a viable material for the Zone 4 (shell). Additional studies are recommended as part of future phases to identify potential borrow sources.

4.2.4 Earth Core (Zone 1)

4.2.4.1 Left Abutment Clay

A source of relatively impervious clay core materials was identified near the left abutment in 21-TH-01. Sonic core samples of this material were collected and tested in our laboratory. Fines content of this material ranged from 81 to 87 percent with plasticity indices (PI) ranging from 12 to 25.

A composite or mixed sample of this clayey material was created from sonic core samples for performance testing including hydraulic conductivity, undrained/drained triaxial strength testing, Total Dissolved Salts (TDS), swell potential, and dispersion potential. The Laboratory results can be found in Appendix C.

A k value of $5.8x10^{-7}$ cm/s was measured for a composite sample when prepared at 95% relative compaction (standard Proctor) and at a moisture content near that considered optimum. The drained friction angle of this material when prepared to 95% relative compaction (standard Proctor) was 31 degrees when tested at confining stresses ranging from 2880 to 15,840 psf.

Swell pressures of the composite sample were also measured with values reported in Appendix C. This test suggests this material has a moderate to high swell potential with measured pressures on the order of 2600 psf for the sample compacted 2% dry of optimum moisture content and at 100% relative compaction (standard Proctor). Based on these swell pressures we recommend additional assessment and laboratory testing be completed prior to use of this material is sourced as the Zone 1 Core.

The double hydrometer testing resulted in a nondispersive classification. The soils dispersive characteristics were also assessed based on total salt content relative to the percentage of sodium cations. TDS testing for both a sample collected, and the composite samples was completed. Table 4-1 provides the results and the published correlations relating TDS to dispersivity (Sherard, et. Al 1976) would suggest the material is nondispersive.

This clay deposit seems to be suitable for an earth core if a sufficient quantity exists and swell potential risks are further assessed. The quantity of the material along the left abutment is unknown and effort to excavate and stockpile the clay during construction could be significant. Additional studies are recommended to further assess the quantity of the clay materials along the left abutment.

4.2.4.2 Upper Alluvium

Another option for sourcing the zone 1 core is utilizing the upper fine-grained alluvium. This material appears to have been used for the reconstruction of the dam in 1985. The existing dam core is described as a silt-sand core (Northern, 1985; Sunrise, 1985, 1986) and the Northern (1985) states the material could be sourced from the existing dam or from the existing stockpile downstream of the dam. The downstream stockpile is shown in Figure 2-1 as Borrow Area Zone 1. The 1985 project specifications along with samples collected from the dam (21-TH-04) are plotted in Figure 4-3. It is noted that the project specification for the Zone 1 is relatively tight, and the results from samples collected in 21-TH-04 suggest that constructed core does not meet the project specification.

Sonic cores samples of the upper fine-grained alluvium were collected and tested in our laboratory. Fines content of the upper alluvium materials ranged from 36 to 75 percent with plasticity indices ranging from non-plastic to 14. Hydraulic conductivities from field and laboratory testing ranged from $1.0x10^{-6}$ to $2.0x10^{-4}$ cm/s, these results are based on field permeability and collected undisturbed samples. Northern (1985) suggest the hydraulic conductivity as low as $7x10^{-6}$ cm/s once it was remolded and compacted to 95 percent of maximum dry density at optimum moisture content. These results would suggest this material, although more permeable than if the left abutment clay, could be used for Zone 1.

An undisturbed sample of upper alluvium was collected during the field studies from 21-TH-02 and a consolidated undrained triaxial test was performed. The drained friction angle of this material was of 33 degrees when tested at confining stresses ranging from 720 to 3600 psf. Northern (1985) references a friction angle of 29 degrees and a cohesion of 150 psf in their analyses which was based on a recompacted sample for the core material.

A pinhole dispersion test on the upper fine-grained alluvium suggests the material to be moderately to slightly dispersive (ND3) which suggest defensive measures against internal erosion are needed if used as core material. In general, if the upper fine-grained alluvium is properly mixed and processed, and a filter is placed to protect the core from internal erosion it could be a suitable source for Zone 1 Core material. Similar to the left abutment clay source additional borrow studies will be needed to assess sufficient quantity of this material exists and further to understand dispersive characteristics.

4.2.5 Sand Filter and Drain Materials

As shown in Figure 4-1 a two-stage filter chimney filter is recommended for the embankment. This two-stage filter will protect the core from internal erosion. The calculation for the filter sand and drain gravel has not been completed at this time due to the core source not being identified. Typically the filter sand will consist of a sand similar to the ASTM concrete sand (C-33) and the drain gravel will be something similar to a coarse-grained ASTM C-33 No. 8 stone.

The horizontal filter blanket will have the same materials as the chimney filter as shown on Figure 4-1. The horizontal blanket is to convey any seepage through the dam to a toe drain. It also will help prevent internal/particle erosion from the dam into the foundation or vice versa as has been documented as a concern by UDS (UDS, 2020). If a slurry wall is completed to bedrock, then the horizontal filter blanket might be able to be omitted. If a partial cutoff is installed, then the downstream embankment will need the filter blanket as shown in Figure 4-1.

4.3 SEEPAGE ANALYSIS

Assessments of seepage were performed for the proposed dam geometry using the conceptual cross-section geometry (see Figure 4-1). Analyses were performed using Geo-Slope's Seep/W computer programs as integrated into its GeoStudio 2020 software package. Purposes of the analysis were to evaluate proposed dam seepage and provide an estimate on seepage amounts through the dam and understand different options to limit the foundation seepage as discussed by UDS. Two seepage models were developed one using the left abutment clay source as the Zone 1 material, and the second model using the fine-grained upper alluvium material as the Zone 1 core. The other dam zones and foundation soil parameters were the same in each model. The hydraulic conductivity (k) parameters assigned for the embankment zones were developed based on laboratory testing of composite samples and engineering correlations based on the material characteristics. The foundation k values are based on field permeability testing of lower alluvium and lab testing of undisturbed samples in the upper alluvium. The hydraulic conductivity used in the models are summarized in Table 4-2.

The dam was modeled with a constant head of 5205 feet. The downstream face of the filter/drain and filter blanket was modeled as a seepage face. A slurry wall was included in the model at full depth to bedrock. The ratio of vertical to horizontal permeability for each material in the model used in the analysis is also listed in Table 4-2. A saturated model was used in Seep/W since it would conservatively estimate the total seepage values. The results suggest a total seepage on the order of 460 cubic feet per day per foot of dam with a clay core constructed from the material found in the left abutment. For a core constructed from the fine-grained materials found in the upper alluvium results suggest a total seepage on the order of 3674 cubic feet per day per foot of dam with the full cutoff wall. Seepage results show a total seepage between 8,800 to 10,000 cubic feet per day per foot of dam with no slurry wall cutoff to bedrock. The seepage results for the full cutoff are shown in Appendix E as Figures E-01 through E-06.

We recommend further seepage analyses and studies be completed once the borrow sources are developed for the different dam zones. In addition, different cutoff depths could be analyzed to try to optimize the required foundation cutoff depth.

4.4 STABILITY ANALYSIS

Stability analyses were completed using conceptual cross-section (see Figure 4-1). Analyses were performed using Geo-Slope's Slope/W computer programs as integrated into its GeoStudio 2020 software package. We have used Morgenstern and Price's method of slices to evaluate minimum factors of safety for the upstream and downstream sections of the dam and under the following conditions:

- end of construction,
- steady state long term,
- rapid drawdown conditions
- seismic loading conditions (pseudo-static), and
- post-earthquake.

Discussion about the material strengths from earth dam zones are found in Section 4.2.3 through 4.2.4. Triaxial testing completed by GC shows the left abutment clay to have slightly lower strengths than the upper alluvium material, but the triaxial tests on the upper alluvium was completed on an undistributed sample while the left abutment clay test was on a recompacted sample. The triaxial testing completed by Northern (1995) on the Zone 1 (Core) suggests a drained strength of 29 degrees and 150 psf cohesion which they state was completed on a recompacted sample. Figure 4-3 plots upper fine-grained alluvium, and as discussed in Section 4.2.4.2 the existing core seems to have been sourced from the upper alluvium. At this time, we have used the drained strength as referenced from the Northern (1985) as it is the most conservative value. This strength should be reassessed once a borrow study is completed with additional strength testing.

Foundation strengths were based on triaxial testing of the upper alluvium and standard correlations of SPT blowcounts in the lower alluvium. A summary of the material properties for each zone is presented in Table 4-3.

4.4.1 End of Construction Stability Analysis

Construction conditions were modeled for both upstream and downstream slopes at end of construction with groundwater at a depth of 20 feet as found during the field studies. Total stress parameters were used for the material properties for zone 1 and drained strengths for zone 4 due to it being coarse grained. Results for the downstream and upstream analyses for end of construction are presented in Appendix E. Computed factors of safety for both the upstream and downstream steady state are tabulated in Table 4-4, and meet UDS and NRCS minimum requirements.

4.4.2 Steady State Stability Analysis

The conceptual embankment was modeled using the phreatic level from the seepage analyses in Section 4.3. Drained (effective stress) were used to model the materials as summarized in Table 4-3. Results for the downstream and upstream analyses for steady state seepage are presented in Appendix E. Computed factors of safety for both the upstream and downstream steady state are tabulated in Table 4-4, and meet UDS and NRCS minimum requirements.

4.4.3 Upstream Rapid Drawdown Analyses

Pore pressures in the embankment were conservatively approximated using the same phreatic surface as used in the steady state analyses. Embankment material strength was modeled using a composite strength envelope using the lower bound of effective and total stress envelopes, as suggested by NRCS (2019) for the zone 1 material. The failure surface does not pass through the core material; therefore, the strength of this material is not as critical as the shell material strengths. We have assumed some cohesion for this shell material and the previous investigation did show up to 400 psf cohesion for the shell, and we have conservatively assumed 150 psf. Results are presented in Appendix E. The computed factor of safety for this condition is summarized in Table 4-4 and meet UDS and NRCS minimum requirements.

4.4.4 Pseudo-static Analyses

TR-60 (NRCS, 2019) and UDS prescribe different methodologies for seismic slope stability. UDS requires seismic slope stability analyses for areas where the MCE/OBE design earthquake has a maximum acceleration of 0.2g or less, or 0.35g or less for embankments that consist of clay or are founded on clay or bedrock foundations and the minimum factor of safety should be greater than 1.0 (R655-115C, 1a, UAC 2020). If PGA exceeds the values listed above, then a deformation and settlement analysis should be performed. Based on these rules UDS requires a pseudo-static analysis be completed for the OBE event, and then a deformation analysis be considered under the MCE event.

NRCS TR-60 (2019) states that if the design ground motion exceeds 0.07 g, the potential for loss of shear strength due to liquefaction or cyclic failure under seismic loading should be evaluated.

The conceptual earth fill embankment was modeled using a pseudo-static coefficient equal to one half the design PGA value for the OBE (Kh = 0.09) event. The phreatic surface used from the seepage analysis is discussed in Section 4.3. The results are summarized graphically in Appendix E. Computed factors of safety for this condition are summarized in Table 4-4 and meets State of Utah Dam Safety minimum requirements for the OBE event. Discussion about the deformation analysis is found in Section 4.5.

4.4.5 Post-Earthquake Analyses

Post-earthquake stability analyses were performed assuming a strength reduction in the core of 20 percent and 10% percent for the shell material. The lower coarse-grained alluvium was not reduced due to it not being liquefiable and the upper alluvium material, which has the potential to be liquefiable, was assumed to be removed. The phreatic surface, discussed in Section 4.3, was used in slope stability calculations. The results are summarized graphically in Appendix E for the downstream/upstream face of the embankments. Computed factors of safety for this condition are summarized in Table 4-4 and meet UDS and NRCS minimum requirements.

4.5 DEFORMATION ANALYSIS

The performance of the proposed embankment was evaluated under the MCE seismic conditions using the decoupled dynamic response methodology given by Bray and Travasarou (2007). The crest deformations computed from this simplified approach provides an indication as to the performance of the embankment under seismic loading.

The response spectrum used in the analysis was developed using the site-specific procedure with site coefficients and acceleration parameters consistent with the MCE hazard identified for the site as discussed in Section 3.5. Total stress parameters were utilized for the zone 1 and strengths were reduced by 20%. Drained strengths were used for Zone 4 and those strengths were reduced by 10% due to it being coarse grained material. Yield accelerations were obtained from stability modeling and seismic (inertial) (Figure E-12 and E-19) deformations were computed to be between 9 to 16 inches for both upstream and downstream cases. Due to the critical upstream and downstream slip surfaces not crossing we feel like the maximum deformation will be the 16 inches for the upstream case and the factor of safety against overtopping equals to 3.75 (5 ft/1.33 ft) which satisfies the deformation requirement by UDS for overtopping of dams. Deformation calculations are provided in Appendix E.

An additional assessment of potential deformation was performed using charts Published by Swaisgood (2013), which were developed using case histories of dam performance during seismic events. The dam crest settlement from these case histories was plotted against Peak Ground Acceleration, and regression analyses were performed to create a family of curves which relate PGA and characteristic earthquake magnitude to estimated dam crest settlement, as a function of dam height and alluvial thickness below the dam.

The alluvial thickness, for Corn Creek, was assumed to be 45 feet thick, and the dam height considered was 60 feet, the maximum structural section. A PGA of 0.65 and a Mw of 6.7 was used, as discussed in Section 3.5.7 for the MCE event. This assessment suggests that the estimated crest settlement (mean plus one standard deviation) would be 14 inches which is similar to the Bray and Travasarou (2007) method. If at least 5 feet of freeboard is provided as planned, the dam should perform satisfactorily under the seismic event and will meet UDS FS requirements against deformation.

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Table 4-1 Total Dissolved Salts and Analytical Results

Corn Creek Reservoir

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Test Pit Designation	Sample Depth (ft)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Calcium (meq/L)	Magnesium (meq/L)	Potassium (meq/L)	Sodium (meq/L)	TDS[1]	Percent Sodium
21-TH-01	17-18.17	48100.0	11600.0	4680.0	1230.0	2400.2	954.7	119.8	53.5	3528.2	1.5%
Combined Sample	Various	77000.0	10700.0	3510.0	900.0	3842.3	880.6	89.9	39.2	4851.9	0.8%

Notes: 1) TDS is the sum total of the Calcium, Sodium, Potassium, and Magnesium in meq/L

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Table 4-2: Seepage Parameters for Preliminary Design

Corn Creek Reservoir

GERHART COLE

Material Names	GeoStudio Name	Saturated Vertical Hydraulic Conductivity Selected, ky (cm/sec)	Hydraulic Conductivity Selected, ky (ft/sec)	Hydraulic Conductivity Selected, ky (ft/day)	Vertical / Horizontal Hydraulic Conductivity Ratio, kratio = ky/kx, kv/kh	Hydraulic Conductivity Used in SEEP/W, kx (ft/day)	Data Source
Zone 1	Zone 1 Upper Alluvium	5.5E-04	1.8E-05	1.6E+00	0.1	1.6E+01	GCI Evalulation, Correlations
Zone 1	Zone 1 Left Abutment Clay	5.8E-07	1.9E-08	1.6E-03	0.1	1.6E-02	GCI Evalulation
FilterSand /Drain Gravel	Filter Sand/Drain Gravel	4.2E-01	1.4E-02	1.2E+03	1	1.2E+03	Correlations
Upper Alluvium	Upper Alluvium	1.8E-02	5.9E-04	5.1E+01	1	5.1E+01	GCI Evalulation
Lower Alluvium	Lower Alluvium	1.8E-01	5.9E-03	5.1E+02	1	5.1E+02	GCI Evalulation
Bedrock	Bedrock	4.9E-06	1.6E-07	1.4E-02	1	1.4E-02	GCI Evalulation
Zone 4	Zone 4 (Gravelly Sand)	1.8E-01	5.9E-03	5.1E+02	1	5.1E+02	GCI Evalulation, Correlations

kv = ky

kh = kx

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Table 4-3: Slope Stability Properties
Corn Creek Reservoir

GERHART COLE

		Steady State[1]		Undrained[2]		
Materials Names	Unit Weight (pcf)	Friction Angle, Φ (degrees)	Effective Cohesion (psf)	Friction Angle, Φ (degrees)	Cohesion (psf)	Data Source
Lower Alluvium	125	35	0	35	0	Correlations
Upper Alluvium	120	33	0	25	0	GC Testing
Filter Sand/Drain Gravel	120	34	0	34	0	Correlations
Zone 1	115	29	140	16	320	GC Testing; Northern (1985)
Zone 4 (Gravelly Sand)	136	36	150	- - -	- - -	Correlations

Note:
1) Steady State Parameters - used in Steady State and Pseudo Static Stability Analysis
2) Undrained Parameters - used in End of Construction and Seismic Stability Analysis

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Table 4-4: Slope Stability Summary

Corn Creek Reservoir

Analysis Description	Required Factor of Safety NRCS[1]	Required Factor of Safety Utah Dam Safety[2]	Stability Results - Factor of Safety	Figure
Downstream - End of Construction	1.3	1.3	2.3	E-07
Downstream - Long Term Static	1.5	1.5	2.3	E-08
Downstream - Pseudo Static (MCE/MDE Ground Motions)	--[4]	--[3]	0.9	E-09
Downstream - Pseudo Static (OBE Ground Motions)	--[4]	1.0	1.3	E-10
Downstream - Post Earthquake	1.2	1.2	1.7	E-11
Upstream - End of Construction	1.3	1.3	2.3	E-13
Upstream - Long Term Static	1.5	1.5	2.7	E-14
Upstream - Rapid Drawdown	1.2	1.2	1.3	E-15
Upstream - Pseudo Static (MCE/MDE Ground Motions)	--[4]	--[3]	0.7	E-16
Upstream - Pseudo Static (OBE Ground Motions)	--[4]	1.0	1.3	E-17
Upstream - Post Earthquake	1.2	1.2	1.9	E-18

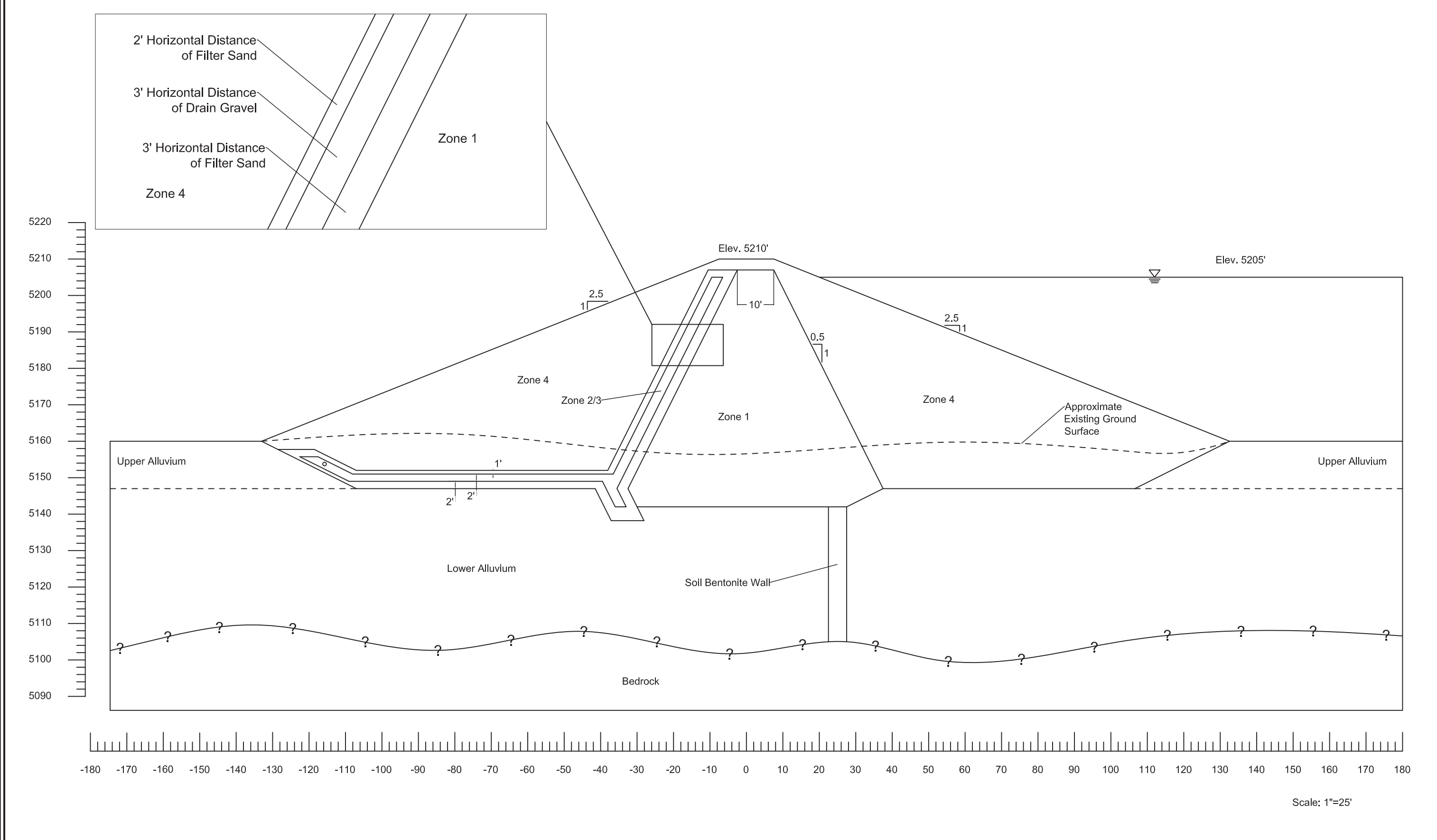
Notes

1) NRCS minimum factor of safety requirements as described in Technical Release (TR) 210-60 Earth Dams and Reservoirs.

2) Minimum Required Factors of Safety [Utah Dam Safety Rules R655-11-6A, R655-11-5C]

3) A deformation analysis is required for dams if PGA is greater than 0.2g but there is no requirement for a minimum Factor of Safety.

4) No minimum factor of safety is prescribed this this case, rather deformations are evaluated to see if they are acceptable.



GERHART COLE
P.O. Box 880 Midvale, Utah (801)849-0055

EARTHCORE CONCEPTUAL CROSS-SECTION

CORN CREEK RESERVOIR

PROJECT NO. 21-1406

FIGURE 4-1

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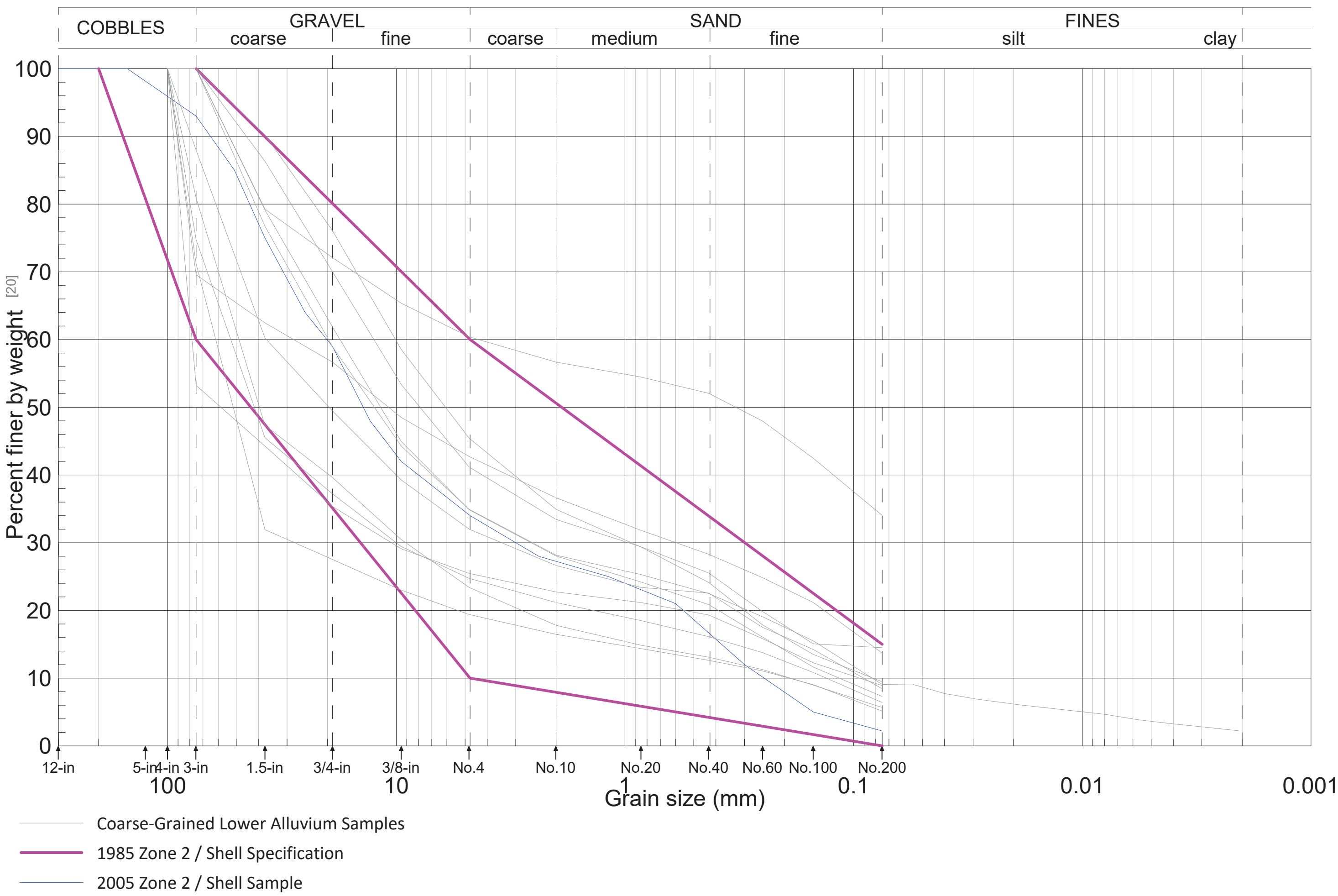
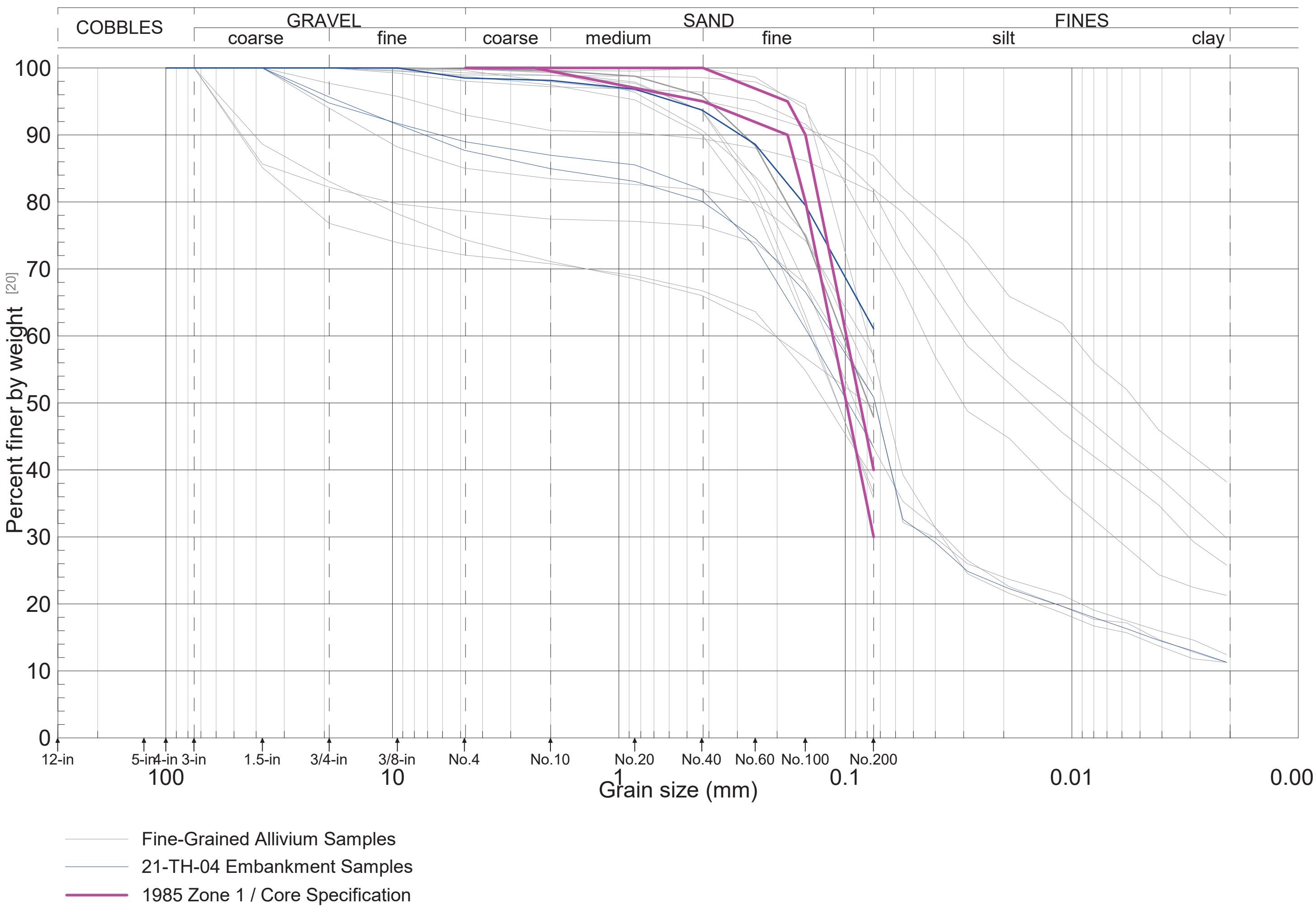


GERHART COLE	Grain Size Analysis - Shell / Zone 4	
	Corn Creek Reservoir	Figure 4-2



GERHART COLE

Grain Size Analysis - Fine Grained Alluvium / Zone 1

Corn Creek Reservoir

Figure 4-3

5.1 CONCLUSION AND RECOMMENDATIONS FOR ADDITIONAL STUDIES

Corn Creek Reservoir has had significant deficiencies due to foundation conditions and questions about internal erosion since it was reconstructed in 1986. A conceptual cross-section has been developed that we believe will mitigate these concerns for a new or the existing dam alignment. Project risks associated with slope stability have been considered as part of our seepage and slope stability analyses in developing a conceptual cross-section for the earth fill dam. *Project risks that will need to be addressed as part of future phases and additional coordination needed for future studies include:*

- Selection of the preferred dam alignment.
- Foundation cutoff preferred depth and overall project objective.
- Availability and location(s) of borrow materials, and studies to understand material quantities and properties.
- Site specific liquefaction assessments. The upper fine-grained alluvium material has a potential for loose to medium dense granular deposits. Additional test holes or CPT soundings should be completed for the fine-grained alluvium if the reservoir is to be considered a storage reservoir for liquefaction analysis. The results of this additional data collection will be important to decide if this material needs to be excavated or can be left in place.
- Additional field studies along the proposed alignment to understand the depth to bedrock for foundation cutoff requirements.
- More detailed embankment performance analyses and detailing will be required to move the project towards. Such analyses include dynamic embankment modeling, seepage analysis in main section and on left abutment, outlet works assessments, filter, and drain requirements.
- Final overtopping protection and design for Auxiliary Spillway.

5.2 LIMITATIONS

The assessments and recommendations presented in this document are based on limited field studies and laboratory testing, as well as our understanding of the project's design and manner of construction. If the project's design or manner of construction changes, or if conditions are found that are different from those described, we should be notified immediately so that we can make revisions as necessary.

This document was prepared solely for the use of the addressee (our Client) for the specified project and may not contain sufficient information for other parties or uses. Also, this document does not constitute a specification and should not be treated or referred to as such in project design drawings or documents.

We represent that our services are performed within the limitations prescribed by our Client, in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation, expressed or implied, and no warranty or guarantee is included or intended. We do not assume responsibility for the accuracy of information provided by others.

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Appendix A

Field Studies Data: Test Hole Logs and Sonic Core Photographic Summary

Corn Creek Reservoir

GC Project No.: 21-1406

Table of Contents

Project: Corn Creek Reservoir
Project Location: Millard County, UT
Project Number: 21-1406

LOG OF TEST HOLE 21-TH-01

Date(s) Drilled	11/02/2021 to 11/02/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	42.1
Drill Rig Type	Boart Longyear 600C	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	38.78327 , -112.41629	Ground Surface Elevation (feet)	5206 (Approx.)
Comments		Test Hole Backfill	Bentonite Grout	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
	0					GM	GRAVEL. sandy, with silt - medium dense, dry, dark red to brown, fine to coarse grained sand, fine and coarse grained gravel, (GM)	Run 1: 0-2 ft Bag 1: 28"/24"
	2	SPT	SPT-01	20-13-9-7 22	11			Run 2: 2-7 ft Bag 2: 10"/30" Bag 3: 26"/30"
	3.5					GC	GRAVEL, clayey, with sand, with clay occasional cobbles - medium dense, moist, light brown to dark brown, fine to coarse grained sand, fine and coarse grained gravel, (GC)	
5201	5							
	6					CL	CLAY, with sand - very stiff, moist, red to brown, low plasticity, fine grained sand, (CL)	
	7	SPT	SPT-02	13-12-14-21 26	12			Run 3: 7-12 ft Bag 4: 15"/24" Bag 5: 30"/36"
5196	10							
	12	SPT	SPT-03	12-14-20-28 34	24		-transitions to hard	Run 4: 12-17 ft Bag 6: 27"/18" Bag 7: 27"/24" Bag 8: 19"/18"
5191	15							
	17	ST	ST-04		14			Run 5: 17-22 ft Bag 9: 20"/24" Bag 10: 24"/24" Bag 11: 16"/24" Practical push refusal
5186	20							
	22	SPT	SPT-05	21-14-10-14 24	24			Run 6: 22-27 ft Bag 12: 6"/6" Bag 13: 33"/24" Bag 14: 21"/12" Bag 15: 18"/18"
5181	25							
	27	SPT	SPT-06	4-9-15-19 24	24			Run 7: 27-32 ft Bag 16: 36"/36" Bag 17: 24"/24"
5176	30							

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Project: Corn Creek Reservoir	LOG OF TEST HOLE 21-TH-01
Project Location: Millard County, UT	DRAFT
Project Number: 21-1406	Sheet 2 of 2

Date(s) Drilled	11/02/2021 to 11/02/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	42.1
Drill Rig Type	Boart Longyear 600C	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	38.78327 , -112.41629	Ground Surface Elevation (feet)	5206 (Approx.)
Comments		Test Hole Backfill	Bentonite Grout	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
							GRAVEL, sandy, some clay - very dense, moist, light tan to white, variably cemented with calcium carbonate, fine to coarse grained subrounded gravels, {GP-GC} [OAK CITY FM, Toc]	
			SPT-07	50/1.9" [R]	0			Run 8: 32-37 ft Bag 18: 12"/12" Bag 19: 30"/24" Bag 20: 30"/24"
5171	35							
			SPT-08	49-50/5.5" [R]	7			Run 9: 37-42 ft Bag 21: 32"/24" Bag 22: 14"/12" Bag 23: 30"/24" Constant Head Test 37-42 ft
5166	40							
			SPT-09	50/1" [R]	1		Bottom of Hole at 42.1 feet	
5161	45							
5156	50							
5151	55							
5146	60							

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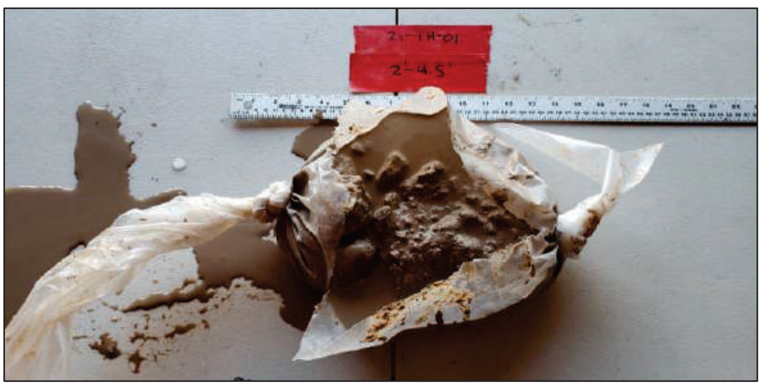
Test Hole Location:	21-TH-01	Run Number:	1, 2	Bag(s)	1, 2	Depth(ft):	0 - 4.5 ft



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-01	Run Number:	2, 3	Bag(s)	3, 4	Depth(ft):	4.5 - 9

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-01	Run Number:	3, 4	Bag(s)	5, 6	Depth(ft):	9 – 13.5

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-01	Run Number:	4, 5	Bag(s)	7, 8	Depth(ft):	13.5 - 17

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-01	Run Number:	5	Bag(s)	9, 10	Depth(ft):	17 - 21

PHOTOGRAPHIC SUMMARY OF SOIL CORE

Corn Creek Reservoir

GERHART COLE

Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-01	Run Number:	5, 6	Bag(s)	11, 12	Depth(ft):	21 – 22.5

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-01	Run Number:	6	Bag(s)	13, 14	Depth(ft):	22.5 – 25.5

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-01	Run Number:	6, 7	Bag(s)	15, 16	Depth(ft):	25.5 - 30

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-01	Run Number:	7, 8	Bag(s)	17, 18	Depth(ft):	30 - 33

PHOTOGRAPHIC SUMMARY OF SOIL CORE

Corn Creek Reservoir

GERHART COLE | Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-01	Run Number:	8	Bag(s)	19, 20	Depth(ft):	33 - 37

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-01	Run Number:	9	Bag(s)	21, 22	Depth(ft):	37 - 40

PHOTOGRAPHIC SUMMARY OF SOIL CORE

Corn Creek Reservoir

GERHART COLE | Figure:

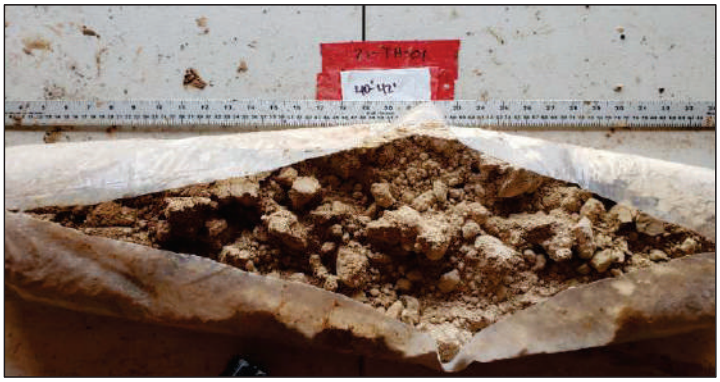
Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-01	Run Number:	9	Bag(s)	23	Depth(ft):	40 - 42



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Project: Corn Creek Reservoir
Project Location: Millard County, UT
Project Number: 21-1406

LOG OF TEST HOLE 21-TH-02

DRAFT

Date(s) Drilled	11/01/2021 to 11/01/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	56.8
Drill Rig Type	Boart Longyear LS600	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	27.82	Latitude / Longitude	38.78401 , -112.41602	Ground Surface Elevation (feet)	5171 (Approx.)
Comments		Test Hole Backfill	Piezometer	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Material Description	Field Notes
	0					SAND, silty, with gravel - medium dense, dry to moist, light brown to brown, fine grained sand, non-plastic fines, (SM)	Run 1: 0-2.5 ft Bag 1: 18"/30"
						-possible gravel	Attempt shelby tube at 2.5 ft, immediate refusal Run 2: 2.5-6 ft Bag 2: 30"/42" Piezometer Construction Details: 0-26 feet - 2-inch Riser 26-36 feet - 2-inch 0.02 slot Screen 0-24 feet - Bentonite Chips 24-38 feet - 10-20 Silica Sand 38-56.8 feet - Bentonite Chips Falling head test 6-8 ft
5166	5						
	6	ST	ST-01		16	SILT, sandy - soft, moist, brown to dark brown, fine grained sand, non-plastic, (ML)	
5161	10						
	11	SPT	SPT-02	5-9-4-2 13	2	SAND, clayey, with gravel, occasional cobbles - medium dense, moist, light brown, fine to coarse grained sand, fine and coarse grained gravel, (SC)	Run 3: 6-11 ft Bag 3: 28"/60" Run 4: 11-16 ft Bag 4: 16"/30" Bag 5: 28"/30"
5156	15						
	16	ST	ST-03		20	SAND, silty - medium dense, moist, light brown to dark red, fine grained sand, (SM) - transitions to gravelly, some cobbles up to 5-inches long	Run 5: 16-21 ft Bag 6: 31"/60"
5151	20						
	21	SPT	SPT-04	20-42-50/3" [R]	6	GRAVEL, with cobbles, with sand, some silt - very dense, moist, light brown, coarse grained sand, fine and coarse grained gravel, rounded cobbles up to 6-inches long, (GP-GM) -frequent sandstone and quartzite cobbles 21-26 ft	Run 6: 21-26 ft Bag 7: 7"/12" Bag 8: 24"/48"
5146	25						
	26	SPT	SPT-05	14-10-45-50/1" 55	7		Run 7: 26-31 ft Bag 9: 6"/12" Bag 10: 16"/48"
5141	30						

GERHART COLE

LOG OF TEST HOLE 21-TH-02

Project: Corn Creek Reservoir
Project Location: Millard County, UT
Project Number: 21-1406

Date(s) Drilled	11/01/2021 to 11/01/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	56.8
Drill Rig Type	Boart Longyear LS600	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	27.82	Latitude / Longitude	38.78401 , -112.41602	Ground Surface Elevation (feet)	5171 (Approx.)
Comments		Test Hole Backfill	Piezometer	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
						GP-GM	GRAVEL, with cobbles, with sand, some silt - very dense, moist, light brown, coarse grained sand, fine and coarse grained gravel, rounded cobbles up to 6-inches long, (GP-GM)	Run falling head test 31 ft
		X	SPT-06	45-50/1" [R]	4		-1 ft cobble layer	Run 8: 31-36 ft Bag 11: 12"/12" Bag 12: 34"/24" Bag 13: 36"/24"
5136	35					TRcu	MUDSTONE, calcareous - varicolored with bands of yellowish brown to red to purplish gray to pale olive brown, occasional sandstone interbeds up to 1-foot thick, sharp contact with overlying gravels, sandstone interbeds generall fine to medium grained quartz sand with calcareous matrix, moderately weathered, [CHINLE Fm., Upper Member, TRcu).	
		X	SPT-07	41-50/5.5" [R]	12		- transitions to light brown to to red to pale olive brown - frequent yellowish brown bioturbation in mudstone	Run 9: 36-41 ft Bag 14: 14"/12" Bag 15: 41"/24" Bag 16: 32"/24"
							- layer of sandstone approximately 6-inches thick	
5131	40							
		X	SPT-08	50/4" [R]	4			Run 10: 41-46 ft Bag 17: 14"/12" Bag 18: 31"/24" Bag 19: 30"/24"
							- layer of sandstone approximately 1-foot thick	
5126	45							
		X	SPT-09	50/4" [R]	4		- transitions to moderately weathered to fresh, moderately hard to soft	Run 11: 46-51 ft Bag 20: 14"/12" Bag 21: 22"/18" Bag 22: 24"/18" Bag 23: 34"/18" Run constant head test 46-56 ft
5121	50							
		X	SPT-10	50/2" [R]	2			Run 12: 51-56 ft Bag 24: 36"/24" Bag 25: 12"/12" Bag 26: 32"/24"
							-very fine grained, soft mudstone, dark red to brown	
5116	55							
		X	SPT-11	49-50/3" [R]	9		Bottom of Hole at 56.8 feet	
5111	60							

GERHART COLE

DRAFT

Test Hole Location:	21-TH-02	Run Number:	1, 2	Bag(s)	1, 2	Depth(ft):	0 - 6

PHOTOGRAPHIC SUMMARY OF SOIL CORE

Corn Creek Reservoir

GERHART COLE

Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-02	Run Number:	3, 4	Bag(s)	3, 4	Depth(ft):	6 – 13.5

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	4, 5	Bag(s)	5, 6	Depth(ft):	13.5 - 21

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	6	Bag(s)	7, 8	Depth(ft):	21 - 26

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	7	Bag(s)	9, 10	Depth(ft):	26 - 31

PHOTOGRAPHIC SUMMARY OF SOIL CORE

Corn Creek Reservoir

GERHART COLE | Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-02	Run Number:	8	Bag(s)	11, 12	Depth(ft):	31 - 34

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	8, 9	Bag(s)	13, 14	Depth(ft):	34 - 37

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-02	Run Number:	9	Bag(s)	15, 16	Depth(ft):	37 - 41

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	10	Bag(s)	17, 18	Depth(ft):	41 - 44

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	10, 11	Bag(s)	19, 20	Depth(ft):	44 - 47

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE

Corn Creek Reservoir

GERHART COLE | Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	11	Bag(s)	21, 22	Depth(ft):	47-49.5

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-02	Run Number:	11, 12	Bag(s)	23, 24	Depth(ft):	49.5 - 53

Notes:

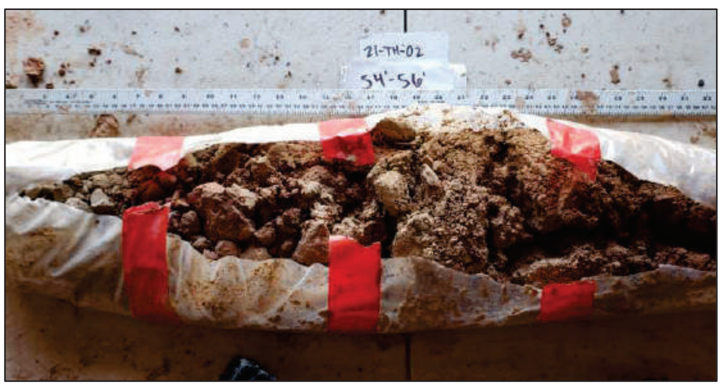
1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-02	Run Number:	12	Bag(s)	25, 26	Depth(ft):	53 - 56



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Project: Corn Creek Reservoir	# LOG OF TEST HOLE 21-TH-03
Project Location: Millard County, UT	DRAFT
Project Number: 21-1406	**Sheet 1 of 3**

Date(s) Drilled	10/30/2021 to 10/31/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	81.0
Drill Rig Type	Boart Longyear LS600	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	53.75	Latitude / Longitude	38.78539 , -112.41569	Ground Surface Elevation (feet)	5162 (Approx.)
Comments		Test Hole Backfill	Piezometer	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
	0						TOPSOIL	Run 1: 0-6 ft
							SILT, sandy, trace gravel - stiff, dry, dark red to brown, fine to medium grained sand, non-plastic, (ML)	Bag 1: 20"/36" Bag 2: 24"/36" Piezometer Construction Details: 0-46 feet - 2-inch Riser 46-57 feet - 2-inch 0.02 slot screen 0-34 feet - Bentonite Chips 34-57 feet - 10-20 Silica Sand 57-81 feet - Bentonite Chips
							CLAY, silty, sandy - stiff, moist, dark red to brown, fine to medium grained sand, low plasticity, (CL)	
5157	5							
			SPT-01	9-6-6-14 12	12		- transitions to trace gravel	Run 2: 6-11 ft Bag 3: 12"/30" Bag 4: 20"/30"
5152	10						GRAVEL, with sand, with silt - medium dense, moist, orange to dark red, fine to coarse grained sand, fine and coarse grained gravel, cobbles, (GM) - clean gravel layer 11-12 ft	
			SPT-02	7-7-7-5 14	5		CLAY. silty, with sand, with gravel - moist, orange to dark red, fine to coarse grained sand, fine and coarse grained gravel, low plasticity, (CL-ML)	Run 3: 11-16 ft Bag 5: 24"/30" Bag 6: 24"/30"
5147	15						GRAVEL, with sand, some silt - very dense, dry, orange to brown, fine to coarse grained sand, fine and coarse grained gravel, (GP-GM) - cobbles up to 4-inches long	
			SPT-03	50/2.5" [R]	0		- interbedded sand and gravel layers 6-inches to 1-ft thick	Run 4: 16-21 ft Bag 7: 16"/30" Bag 8: 21"/30"
5142	20							
			SPT-04	19-22-19-15 41	16			Run 5: Bag 9: 6"/24" Bag 10: 24"/36"
5137	25							
			SPT-05	17-50/5" [R]	8			Run 6: 26-31 ft Bag 11: 20"/30" Bag 12: 27"/30" Run falling head test 26 ft
5132	30							

GERHART COLE

Project: Corn Creek Reservoir
Project Location: Millard County, UT
Project Number: 21-1406

LOG OF TEST HOLE 21-TH-03

Date(s) Drilled	10/30/2021 to 10/31/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	81.0
Drill Rig Type	Boart Longyear LS600	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	53.75	Latitude / Longitude	38.78539 , -112.41569	Ground Surface Elevation (feet)	5162 (Approx.)
Comments		Test Hole Backfill	Piezometer	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
							GRAVEL, with sand, some silt - very dense, dry, orange to brown, fine to coarse grained sand, fine and coarse grained gravel, (GP-GM) - silty sand layer 4-inches thick	
		SPT	SPT-06	13-9-50 59	12			Run 7: 31-36 ft Bag 13: 10"/30" Bag 14: 27"/30"
							- angular to subrounded cobbles up to 5-inches long	
5127	35							
							- transitions to with cobbles	Run 8: 36-41 ft Bag 15: 31"/60"
		SPT	SPT-07	14-12-14-14 26	13			
							- frequent subrounded cobbles up to 5-inches long	
5122	40							
		SPT	SPT-08	12-28-36-50/5" 64	10			Run 9: 41-46 ft Bag 16: 4"/12" Bag 17: 25"/48"
5117	45							
		SPT	SPT-09	21-26-50/4" [R]	2		- cobble, 6-inches long	Run 10: 46-51 ft Bag 18: 18"/30" Bag 19: 16"/30"
5112	50							
		SPT	SPT-10	7-12-49-48 61	10		- silty sand layer, 6-inches thick	Run 11: 61-56 ft Bag 20: 28"/30" Bag 21: 18"/30"
							- crushed gravel and cobbles	
5107	55							
		SPT	SPT-11	38-50/5" [R]	14		MUDSTONE, tuffaceous - red to pale olive brown, soft to moderately hard, possible filled mudcracks with calcareous nodules and iron oxide staining, abundant fine volcanic crystals in very fine mudstone matrix, moderately weathered, [OAK CITY FM., Toc]	Run 12: 56-61 ft Bag 22: 18"/12" Bag 23: 35"/24" Bag 24: 36"/24"
5102	60							

GERHART COLE

Project: Corn Creek Reservoir
Project Location: Millard County, UT
Project Number: 21-1406

LOG OF TEST HOLE 21-TH-03

DRAFT

Date(s) Drilled	10/30/2021 to 10/31/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	81.0
Drill Rig Type	Boart Longyear LS600	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	53.75	Latitude / Longitude	38.78539 , -112.41569	Ground Surface Elevation (feet)	5162 (Approx.)
Comments		Test Hole Backfill	Piezometer	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
		X	SPT-12	34-50-50/3" [R]	15		MUDSTONE, tuffaceous - red to pale olive brown, soft to moderately hard, possible filled mudcracks with calcareous nodules and iron oxide staining, abundant fine volcanic crystals in very fine mudstone matrix, moderately weathered, [OAK CITY FM., Toc] - dense sand and/or weathered sandstone	Run 13: 61-66 ft Bag 25: 18"/23" Bag 26: 47"/24" Bag 27: 36"/24"
5097	65							
		X	SPT-13	24-38-49-50/5.5" 87	14		TUFF - light gray to light brown with red to dark red mottling, abundant fine volcanic crystals in very fine tuffaceous matrix, moderately hard, moderately weathered to fresh, occasional layers of gravelly sand up to 2-feet thick, [OAK CITY FM., Toc]	Switch to HQ coring Run 14 (HQ Coring): 67-69.5 ft Recovery: 16"/30 100 % RQD
5092	70						- transitions to red to gray - gravelly sand layer 74-76 ft	Run 15 (HQ Coring): 69.5-72 ft Recovery: 22"/30" 100 % RQD Driller noted gravel layer at 72 feet preventing HQ bit from advancing, switch back to sonic coring
5087	75							Run 16: 72-76 ft Bag 28: 24"/12" Bag 29: 24"/18" Bag 30: 37"/18" Run 17: 76-81 ft Bag 31: 20"/12" Bag 32: 22"/18" Bag 33: 22"/12" Bag 34: 28"/18"
5082	80						Bottom of Hole at 81 feet	
5077	85							
5072	90							

GERHART COLE

DRAFT

Test Hole Location:	21-TH-03	Run Number:	1	Bag(s)	1, 2	Depth(ft):	0 - 6

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	2	Bag(s)	3, 4	Depth(ft):	6 - 11

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	3	Bag(s)	5, 6	Depth(ft):	11 - 16

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	4	Bag(s)	7, 8	Depth(ft):	16 - 21

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-03	Run Number:	5	Bag(s)	9, 10	Depth(ft):	21 - 26

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	6, 7	Bag(s)	11, 12	Depth(ft):	26 – 31

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Test Hole Location:	21-TH-03	Run Number:	7, 8	Bag(s)	14, 15	Depth(ft):	33.5 - 41

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	9	Bag(s)	16, 17	Depth(ft):	41 – 46

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	10	Bag(s)	18, 19	Depth(ft):	46 - 51

Notes:

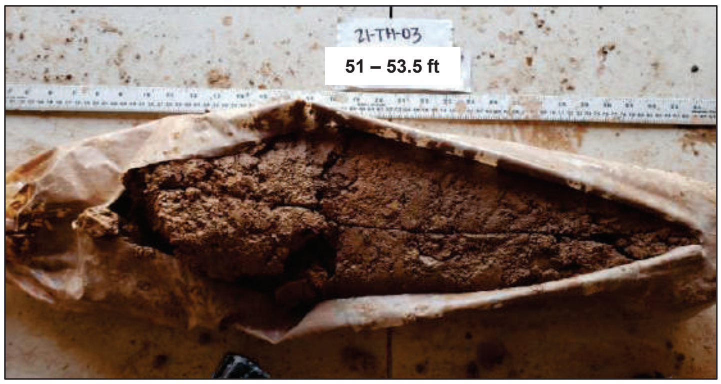
1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	11	Bag(s)	20, 21	Depth(ft):	51 - 56



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	12	Bag(s)	22, 23	Depth(ft):	56 – 59

Notes:

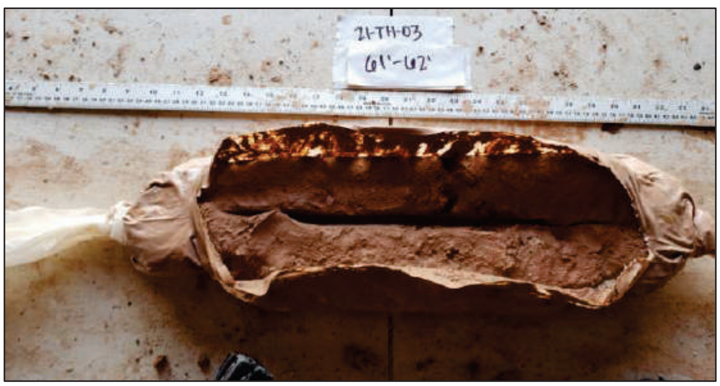
1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	12, 13	Bag(s)	24, 25	Depth(ft):	59 – 62



Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	13	Bag(s)	26	Depth(ft):	62 - 64

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	13, 14, 15	Bag(s)	27, Box 1	Depth(ft):	64 - 72

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	16	Bag(s)	28, 29	Depth(ft):	72 – 74.5

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	16, 17	Bag(s)	30, 31	Depth(ft):	74.5 – 77

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

DRAFT

Test Hole Location:	21-TH-03	Run Number:	17	Bag(s)	32, 33	Depth(ft):	77 – 79.5

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-03	Run Number:	17	Bag(s)	34	Depth(ft):	79.5 – 81

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

Project:	**Corn Creek Reservoir**
Project Location:	**Millard County, UT**
Project Number:	**21-1406**

LOG OF TEST HOLE 21-TH-04

DRAFT

Date(s) Drilled	10/27/2021 to 10/28/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	53.0
Drill Rig Type	Boart Longyear LS600	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	38.78524 , -112.41302	Ground Surface Elevation (feet)	5189 (Approx.)
Comments		Test Hole Backfill	Bentonite Grout	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
	0						GRAVEL, sandy, with silt - moist, light brown to brown, fine to coarse grained sand, fin and coarse grained gravel, (GM), [EMBANKMENT]	
	3						SILT, sandy, with gravel - moist, dark brown to brown, fine grained sand, fine and coarse grained subrounded gravel, (ML), [EMBANKMENT] - gravel transitions out	
5184	5							
	6		SPT-01	12-15-18-14 33	16		- transitions to sandy, trace gravel	
	7						SAND, silty, some gravel - dense, moist, dark brown to brown, fine to coarse grained sand, fine and coarse grained subrounded gravel, (SM), [EMBANKMENT]	
	9.5						SILT, with sand, trace gravel - moist, very soft, dark red to dark brown, fine grained sand, fine grained gravel, (ML), [EMBANKMENT]	
5179	10							
	11		ST-02		28		SAND, silty, trace gravel - medium dense, moist, light brown to dark red, fine to medium grained sand, (SM)	
5174	15							
	16		SPT-03	10-50/3" [R]	9		GRAVEL, clayey, with sand , occasional cobbles - very dense, moist, yellowish brown to brown, fine to coarse grained sand, fine and coarse grained gravel, up to 30% cobbles, cobbles up to 5-inches long, (GC)	
5169	20						GRAVEL, sandy, with silt - very dense, moist, dark red to brown, fine to coarse grained sand, fine and coarse grained gravel, up to 30% cobbles, cobbles up to 5-inches long, (GM) - 6-inch clay layer	
5164	25							
	26		SPT-04	16-50/5.5" [R]	8			
	28.5						- silty sand layer 5-inch thick	
	29.5						- coarse grained sand layer with gravel 6-inch thick	
5159	30							

GERHART COLE

Date(s) Drilled	10/27/2021 to 10/28/2021	Logged By	M. Arnoff	Checked By	J. McFarlane
Drilling Method	Sonic	Drill Bit Size/Type	4-in Core Bit, 6-in Casing, 4.75-in BOD	Total Depth Drilled (feet)	53.0
Drill Rig Type	Boart Longyear LS600	Drilling Contractor	ConeTec (Justin, Ian, Tom)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	38.78524 , -112.41302	Ground Surface Elevation (feet)	5189 (Approx.)
Comments		Test Hole Backfill	Bentonite Grout	Elevation Datum	WGS84

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance	Samples: Recovery, inches	Graphic Log	Material Description	Field Notes
		X	SPT-05	12-50/1" [R]	5		GRAVEL, sandy, with silt - very dense, moist, dark red to brown, fine to coarse grained sand, fine and coarse grained gravel, up to 30% cobbles, cobbles up to 5-inches long, (GM)	
5154	35							
		X	SPT-06	50-50/2" [R]	5		GRAVEL, sandy, some silt - very dense, moist, red to light brown, fine to coarse grained sand, fine and coarse grained subrounded gravel, subrounded cobbles up to 4-inches long, (GP-GM) - gravelly sand layer 1-foot thick	
5149	40							
		X	SPT-07	32-50/2" [R]	8		- transitions to with sand, dark red to light brown	
5144	45							
		X	SPT-08	12-16-7-9 23	5		- transitions to medium dense	
							- transitions to light brown to brown	
5139	50							
		X	SPT-09	22-33-40-50/5.5" 73	16			
							Bottom of Hole at 52.96 feet	
5134	55							
5129	60							

GERHART COLE

DRAFT

Test Hole Location:	21-TH-04	Run Number:	1	Bag(s)	1, 2	Depth(ft):	0 - 3

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	1, 2	Bag(s)	3, 4	Depth(ft):	3 – 6.5

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	2	Bag(s)	5, 6	Depth(ft):	6.5 - 11

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	3	Bag(s)	7, 8	Depth(ft):	11 - 16

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	4	Bag(s)	9, 10	Depth(ft):	16 - 21

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	5	Bag(s)	11, 12	Depth(ft):	21 – 24

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	5, 6	Bag(s)	13, 14	Depth(ft):	24 – 27

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	6	Bag(s)	15, 16	Depth(ft):	27 – 31

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	7	Bag(s)	17, 18	Depth(ft):	31 – 34

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	7, 8	Bag(s)	19, 20	Depth(ft):	34 – 36.25

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

DRAFT

Test Hole Location:	21-TH-04	Run Number:	8	Bag(s)	21, 22	Depth(ft):	36.25 – 41

PHOTOGRAPHIC SUMMARY OF SOIL CORE

Corn Creek Reservoir

GERHART COLE | Figure:

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

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Test Hole Location:	21-TH-04	Run Number:	9	Bag(s)	23, 24	Depth(ft):	41 – 46

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

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Test Hole Location:	21-TH-04	Run Number:	10	Bag(s)	25	Depth(ft):	46 – 49.5

Notes:

1. This photo log is for information purposes only. It is intended to assist in showing features discussed in the attached field logs.

Reference: Log of Referenced Test Hole

PHOTOGRAPHIC SUMMARY OF SOIL CORE	
Corn Creek Reservoir	
GERHART COLE	Figure:

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GERHART COLE

Appendix B

Field Studies Data: Seismic Refraction Survey

Corn Creek Reservoir

GC Project No.: 21-1406

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DRAFT

SAGE EARTH SCIENCE
GEOPHYSICAL SURVEYS

October 7, 2021 Gerhart Cole 2021-10-07.1 (Corn Ck Vs-Vp)

RE: SEISMIC VELOCITY SURVEY V_P AND V_S , CORN CREEK RESERVOIR, UT

Based on the project objective and site conditions, Sage Earth Science conducted a series of seismic P-wave (V_P) refraction and surface shear wave velocity (V_s) profiles at the central Utah site. The objective of the surveys is to determine the compression wave and shear wave velocity profile of the shallow subsurface (0-100 ft.) for the purpose of delineating soil and rock properties.

P-wave survey (refraction)

Given a physical setting of increasing density with depth, and by measuring the travel time of a compression wave (*p-wave*) between known points, the seismic refraction method can be used to determine the depth to a refracting horizon(s), the seismic velocity of the refracting horizon(s), as well as thickness and velocities of the overlying materials.

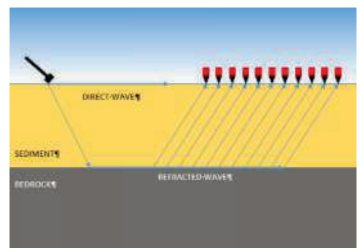

Figure 1 refraction schematic

Approximately 675 feet profile was acquired. The profiles were located at the site as shown in the attached map figure. Data acquisition was performed in accordance with ASTM standard, **ASTM D 5777-00** *Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation.* Results were reduced using PlotRefra™ seismic refraction tomographic inversion software produced by Geometrics Inc.

Shear wave velocity survey (MASW)

Using the same field records obtained for the compression wave refraction survey, shear wave velocity profiles were also developed.

Seismic Surface Waves methods such as MASW (Multichannel Analysis of Surface Waves) and Refraction Micro Tremor (ReMi™) use the dispersive characteristics of surface waves to determine the variation of the seismic shear wave velocity with depth. Velocity data are acquired by analyzing seismic surface waves generated by random sources or by a controlled impulsive source and received by a linear array of geophones.

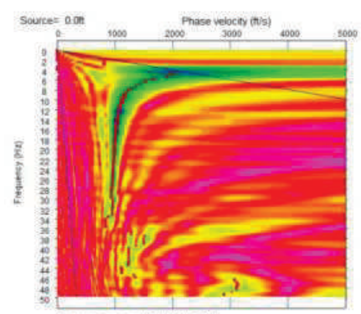

Figure 2 frequency vs velocity plot

A dispersion curve is calculated from the data that shows the phase velocity of the surface wave as a function of frequency or wavelength. A shear wave velocity profile is then modeled from the dispersion curve and the shear wave velocity of the near surface is calculated.

2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

Figure 3 Profile location map

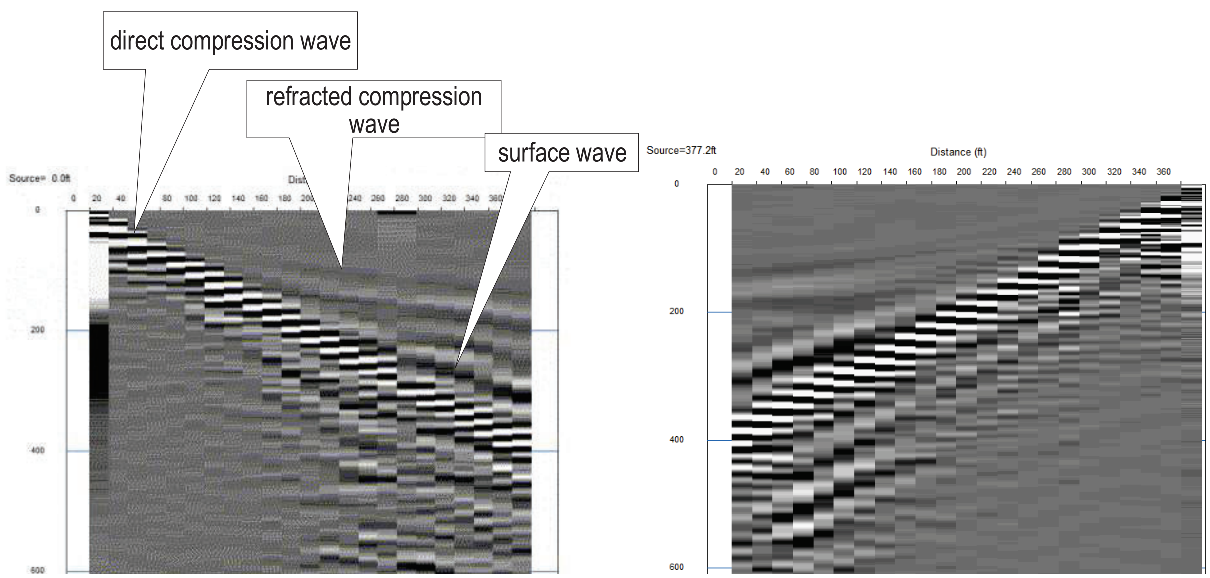

Figure 4. typical field records (truncated)

Table 1. Recording parameters, V_P/V_S 2D profile

Test location	Corn Creek, UT
Test Date	09/23/2021
Recording instrument	DMT Summit Extreme Pro
S/N	SUX1018
geophone natural period	4.5 Hz.
geophone/station spacing	16.4 ft. (5 meters)
number of channels	24
spread length	377 ft.
sample rate	0.25 millisecond
number of samples	8,000 per channel
record length	2.0 seconds
low pass filter	½ nyquist
low cut filter	1 Hz.
seismic source	16-pound sledgehammer
source location	Channels 1,5,10,15,20, and 24
Refraction Analysis software	PlotRefra™ Geometrics, Inc. tomographic inversion
Surface wave Analysis software	SurfSeis™ Geometrics, Inc.

Table 2. Recording parameters - V_{S100}

Test location	Corn Creek, UT
Test Date	09/23/2021
Recording instrument	DMT Summit Extreme Pro
S/N	SUX1018
geophone natural period	4.5 Hz.
geophone/station spacing	16.4 ft. (5 meters)
number of channels	24
spread length	377 ft.
sample rate	4 milli second
number of samples	15,000 per channel
record length	60 seconds
low pass filter	½ nyquist
low cut filter	1 Hz.
seismic source	16-pound sledgehammer (10 min), MAM (passive 20 min)
source location	Channels 1,5,10,15,20, and 24
Surface wave Analysis software	SurfSeis™ Geometrics, Inc.

Discussion

The figures in Appendix A show the compression wave and shear wave velocity profiles at the locations shown in figure 3. Profile locations were staked in the field by the customer.

The seismic velocities V_P mapped across the site are characterized by a contrast between three general velocity zones. The first zone consists of low density materials exhibiting a velocity V_P of less than 4,000 fps. This material is typical near surface sediments or low density weathered rock. The second zone is a moderate velocity zone range of velocity V_P greater than 4,000 fps and less than 8,000 fps. This velocity range is typical for rock. Velocity above 8,000 fps is generally dense rock

The seismic velocities V_S mapped across the site are characterized by a contrast between three general velocity zones. The first zone consists of low density materials exhibiting a velocity V_P of less than 1,500 fps. This material is typical near surface sediments or low density weathered rock. The second zone is a moderate velocity zone range of velocity V_P greater than 1,500 fps and less than 2,000 fps. This velocity range is typical for low density rock. Velocity above 2,000 fps is generally dense rock

As a general guide, quoting from the ASTM standard, **ASTM D 5777-00** *Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation*

> *The seismic refraction method provides the velocity of compressional P-waves in subsurface materials. Although the P-wave velocity can be a good indicator of the type of soil or rock, it is not a unique indicator. .... each type of sediment or rock has a wide range of seismic velocities, and many of these ranges significantly overlap. While the seismic refraction technique measures the seismic velocity of seismic waves in earth materials, it is the interpreter who based on knowledge of the local conditions or other data, or both, must interpret the seismic refraction data and arrive at a geologically reasonable solution*

These velocity ranges and descriptions should be correlated with other site information including test pits, bore holes, and other available supporting information to better characterize the velocity ranges and materials encountered.

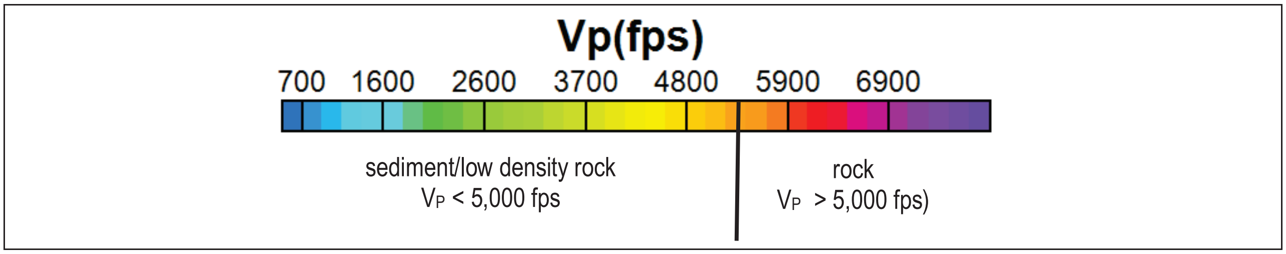

Figure 5a. General compression wave velocity range of materials

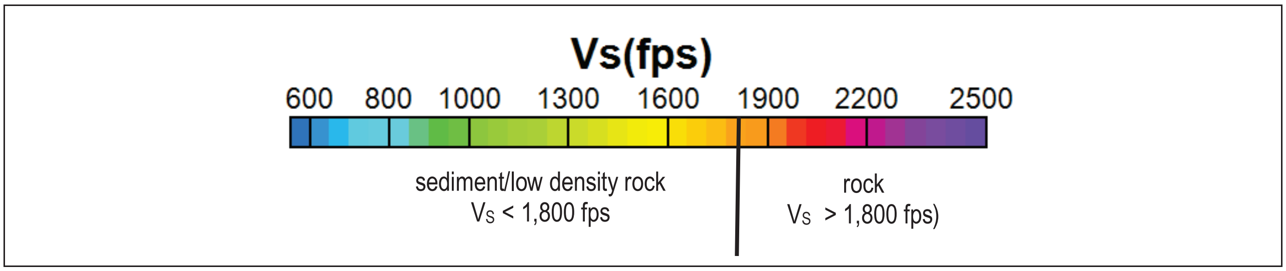

Figure 5b. General shear wave velocity range of materials

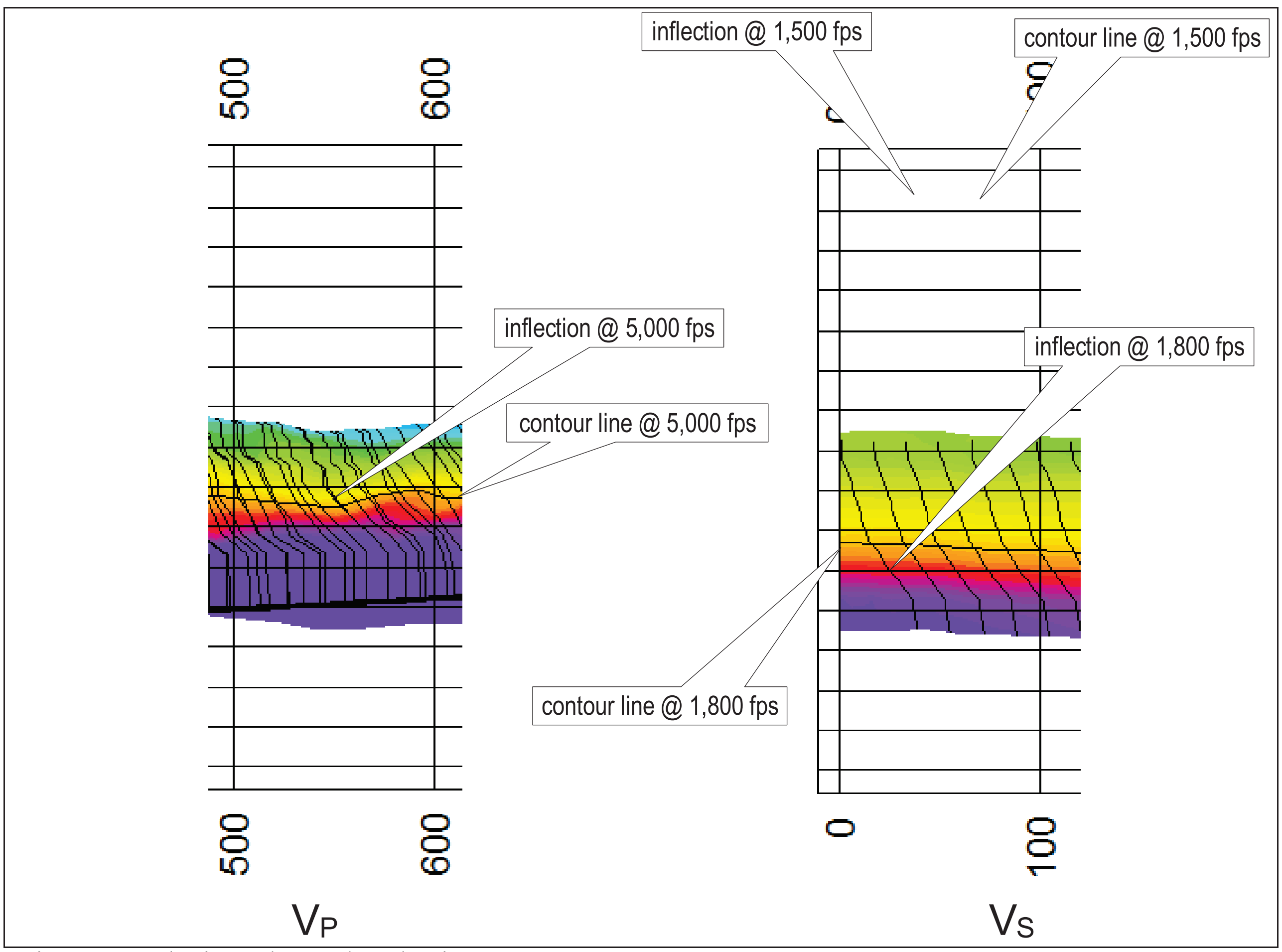

Figure 6. Velocity color scale selection

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V_{S100} Micro Tremor Array Measurement

Seismic Surface Waves methods such as MASW (Multichannel Analysis of Surface Waves), MAM (Microtremor Array Measurements), and ReMi (Refraction Microtremor) use the dispersive characteristics of surface waves to determine the variation of the seismic shear wave velocity with depth. Velocity data are derived by analyzing seismic surface waves generated by a controlled impulse or by random sources and received by an array of geophones.

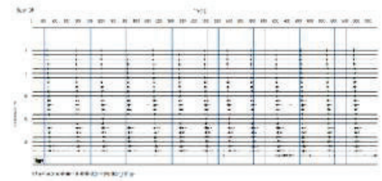


Figure 7. Field record (30 minutes)

A dispersion curve is calculated from the data that shows the phase velocity of the surface wave as a function of frequency or wavelength. A shear wave velocity profile (a 1-D sounding of velocity as a function of depth) is then modeled from the dispersion curve and the shear velocity of the near surface is calculated.

Passive micotremmor data (MAM/passive) were acquired. The passive measurements were suplimented with 10 minutes of sledge hammer blows. This produced a broad spectrum smooth curve generating result to a significantly greater depth than the sledge hammer source alone. The results of the combined microtremor data are presented in this report.

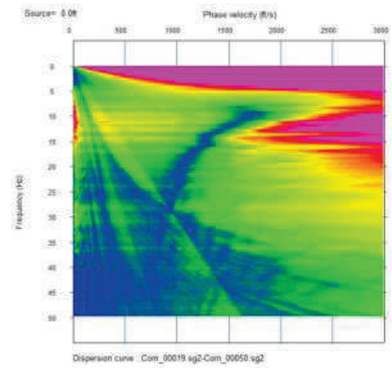


Figure 8 Phase vs. velocity plot (microtremor array measurement/MAM)

Glen Carpenter / principal

APPENDIX A

Velocity Profiles

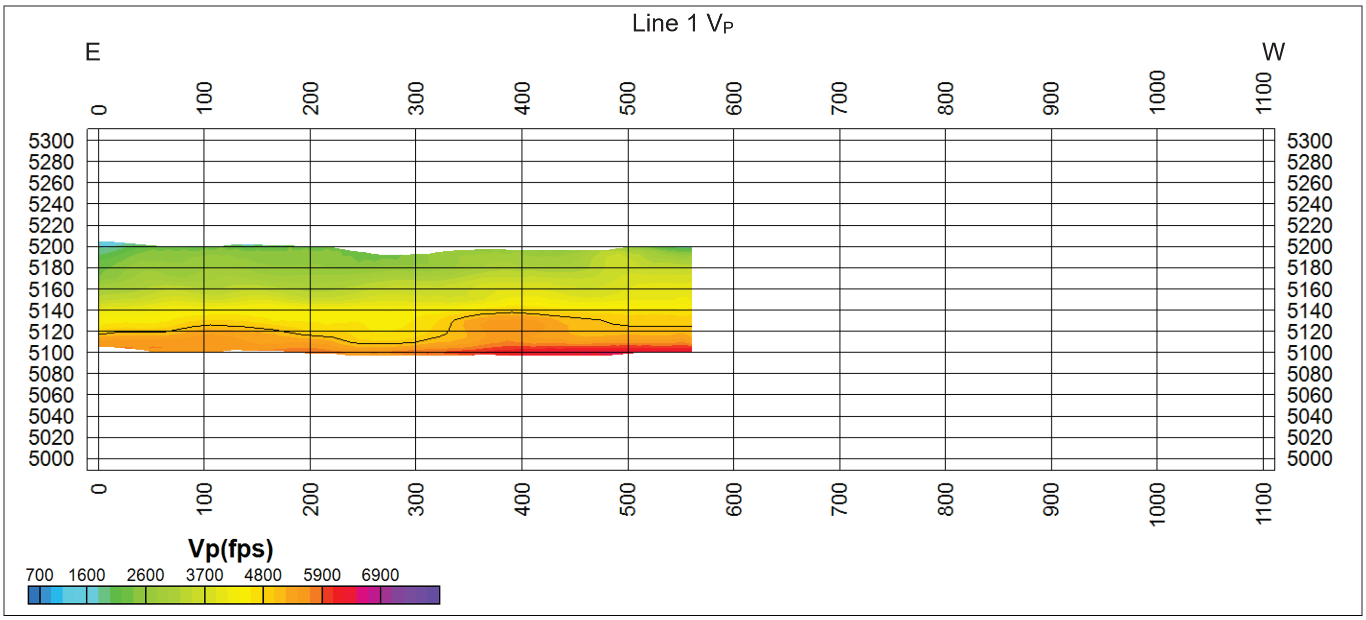
Top profile – refracted compression wave velocity

Lower profile – shear wave velocity (MASW/surface wave)

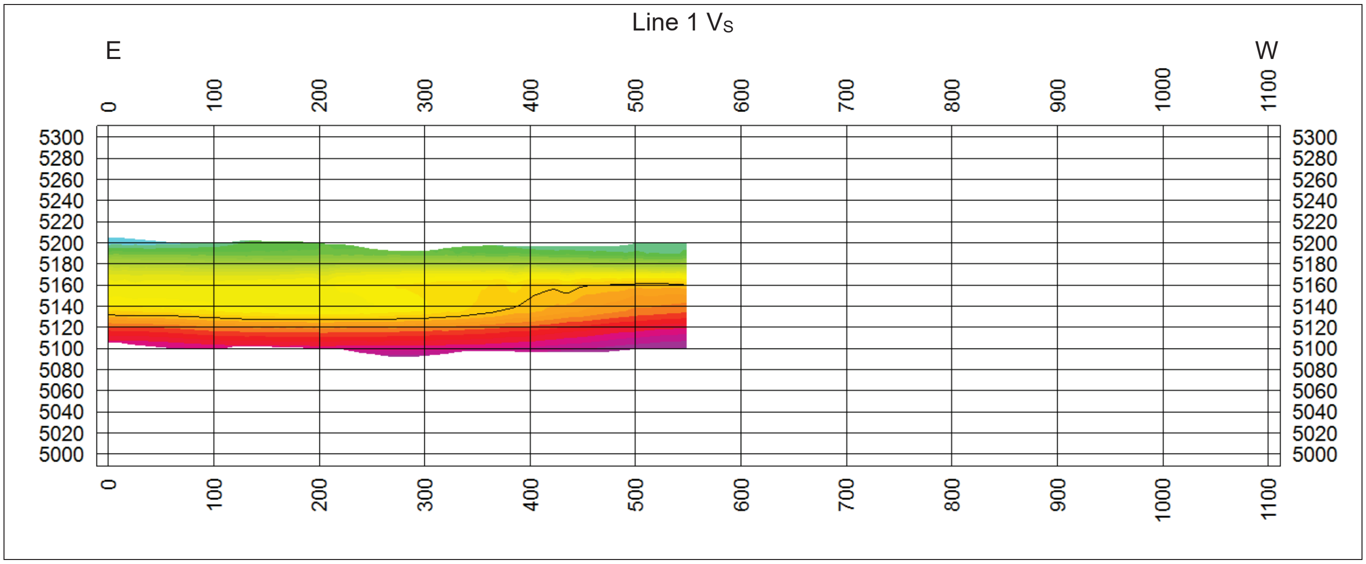
(Distance and color scales are consistent between charts. All distances are measured in feet. Velocity is reported in feet per second.)

Micro Tremor Array Measurement V_{S100}

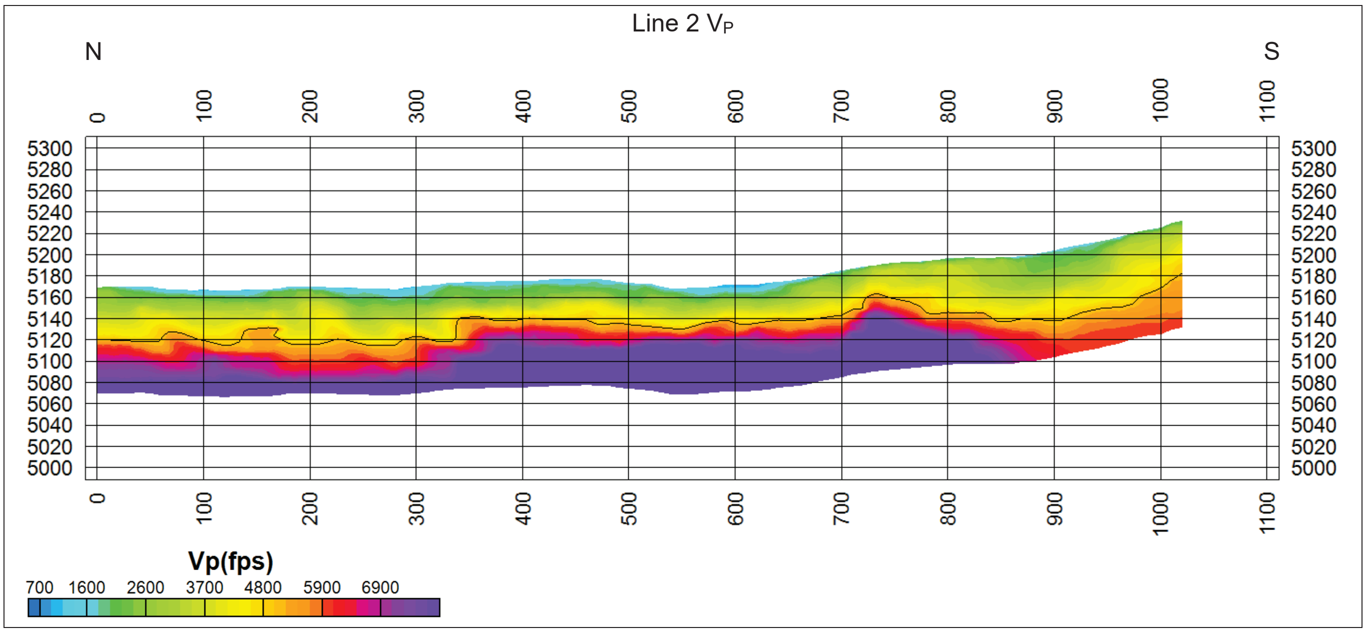
V_{S100} sounding / Phase velocity plot



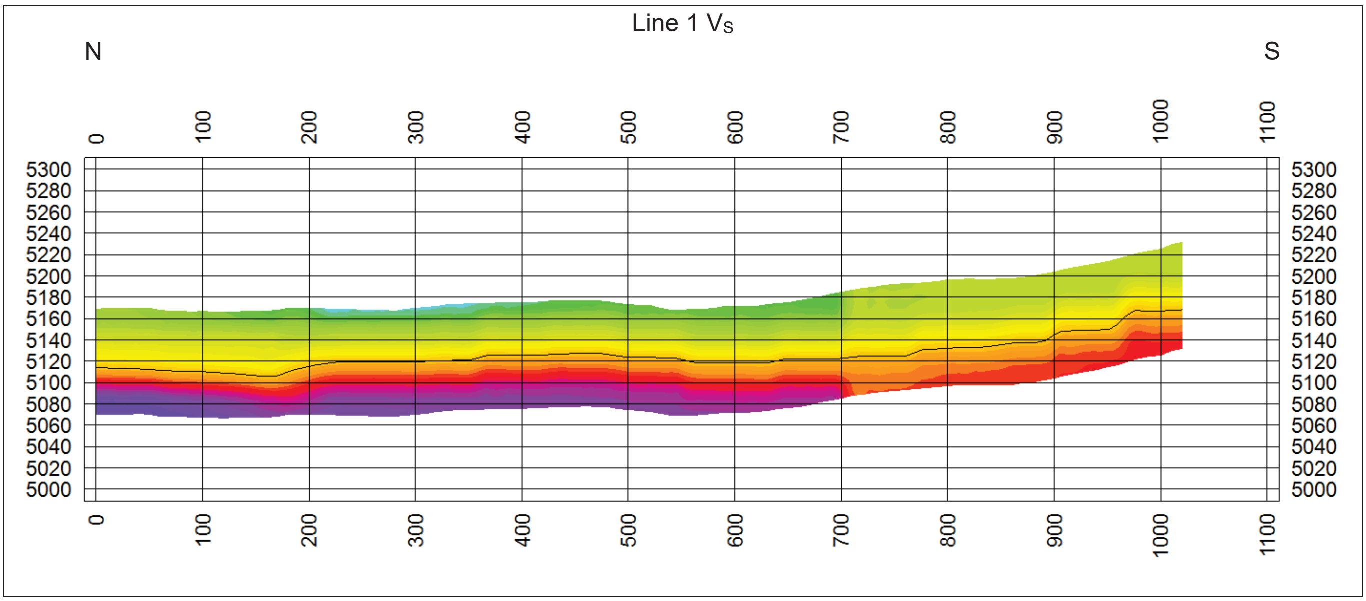
1"=140' horizontal 1"=140' vertical



1"=140' horizontal 1"=140' vertical

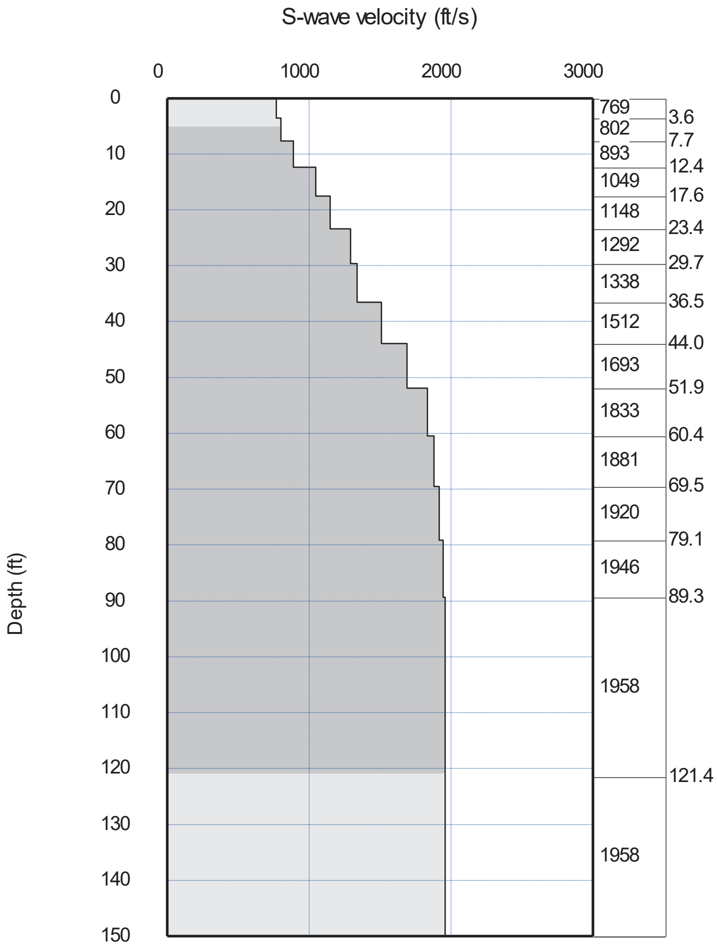


1"=140' horizontal 1"=140' vertical



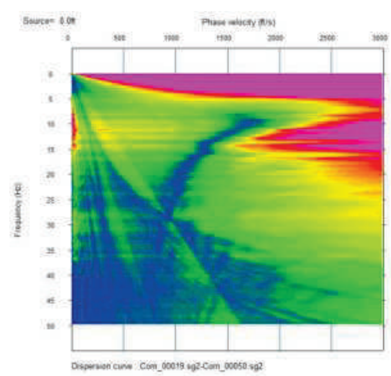
1"=140' horizontal 1"=140' vertical

V_{S100}



S-wave velocity model (inverted) : Corn_00019.sg2-Corn_00050.sg2

Average Vs 100ft = 1432.8 ft/sec



1"=140' horizontal 1"=140' vertical

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GERHART COLE

Appendix C

Summary of Laboratory Test Results
Corn Creek Reservoir

Table of Contents

Description ______ Page No.

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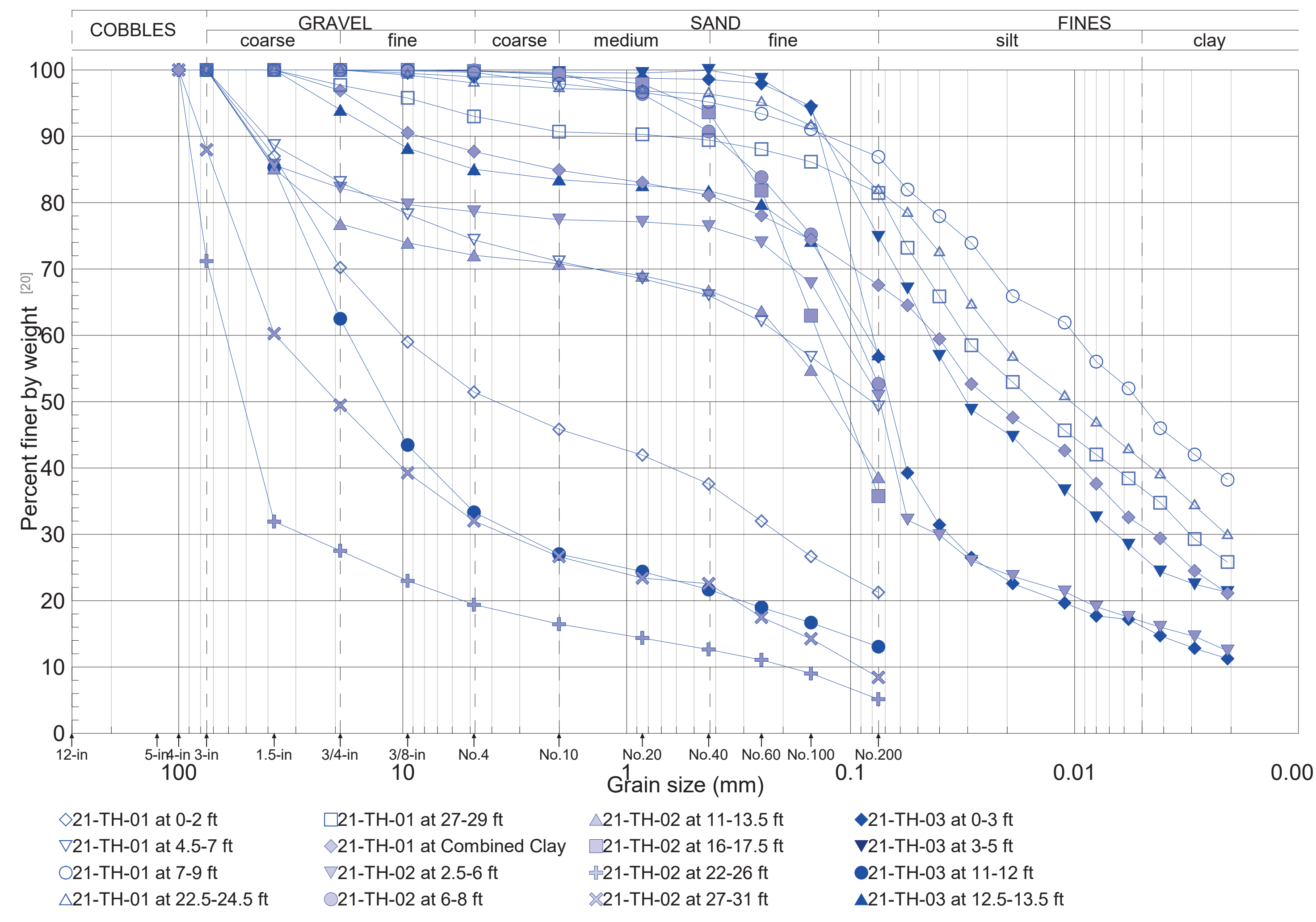
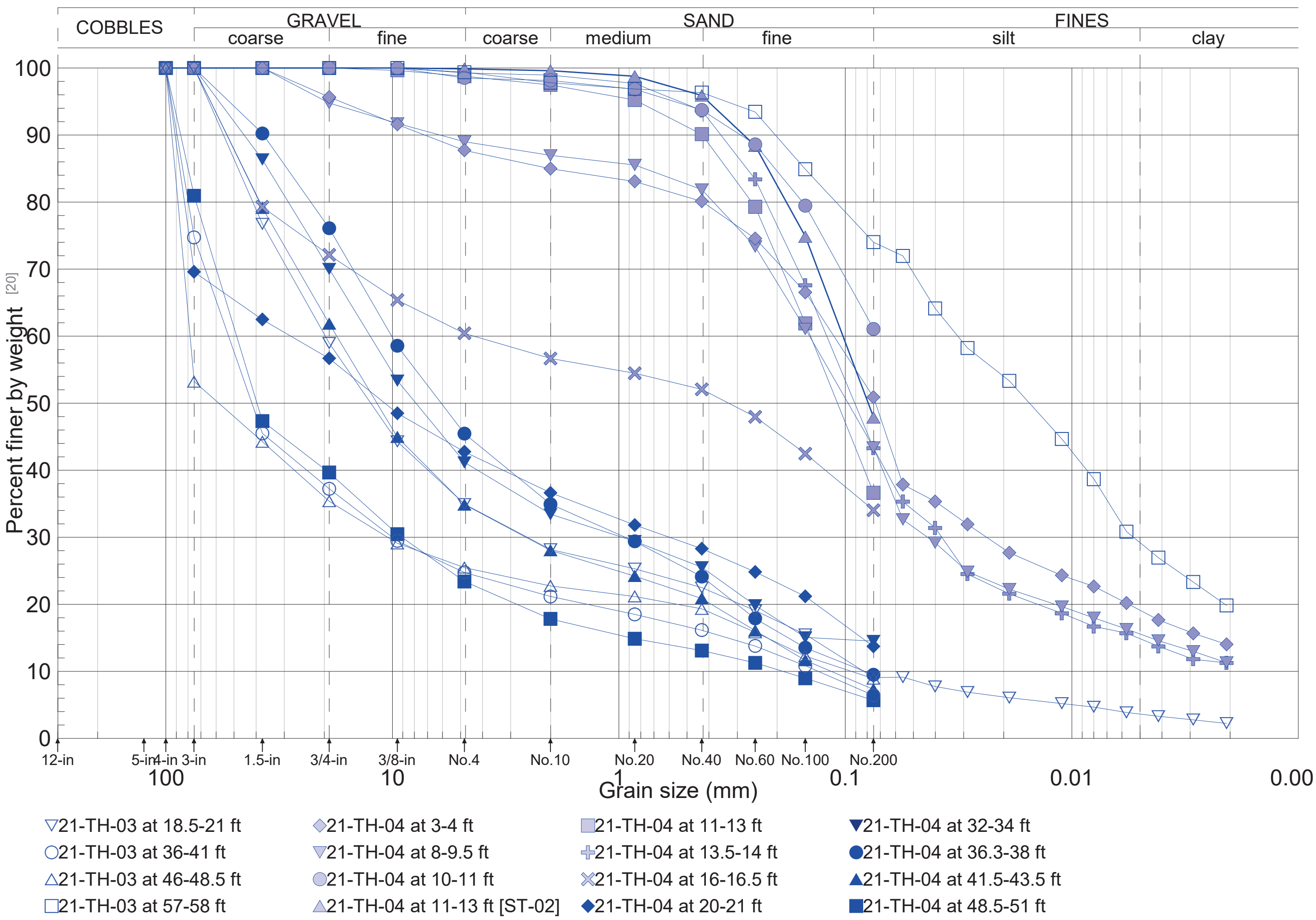


GERHART COLE

Grain-Size Analysis	
Corn Creek Reservoir	Figure C-1

DRAFT



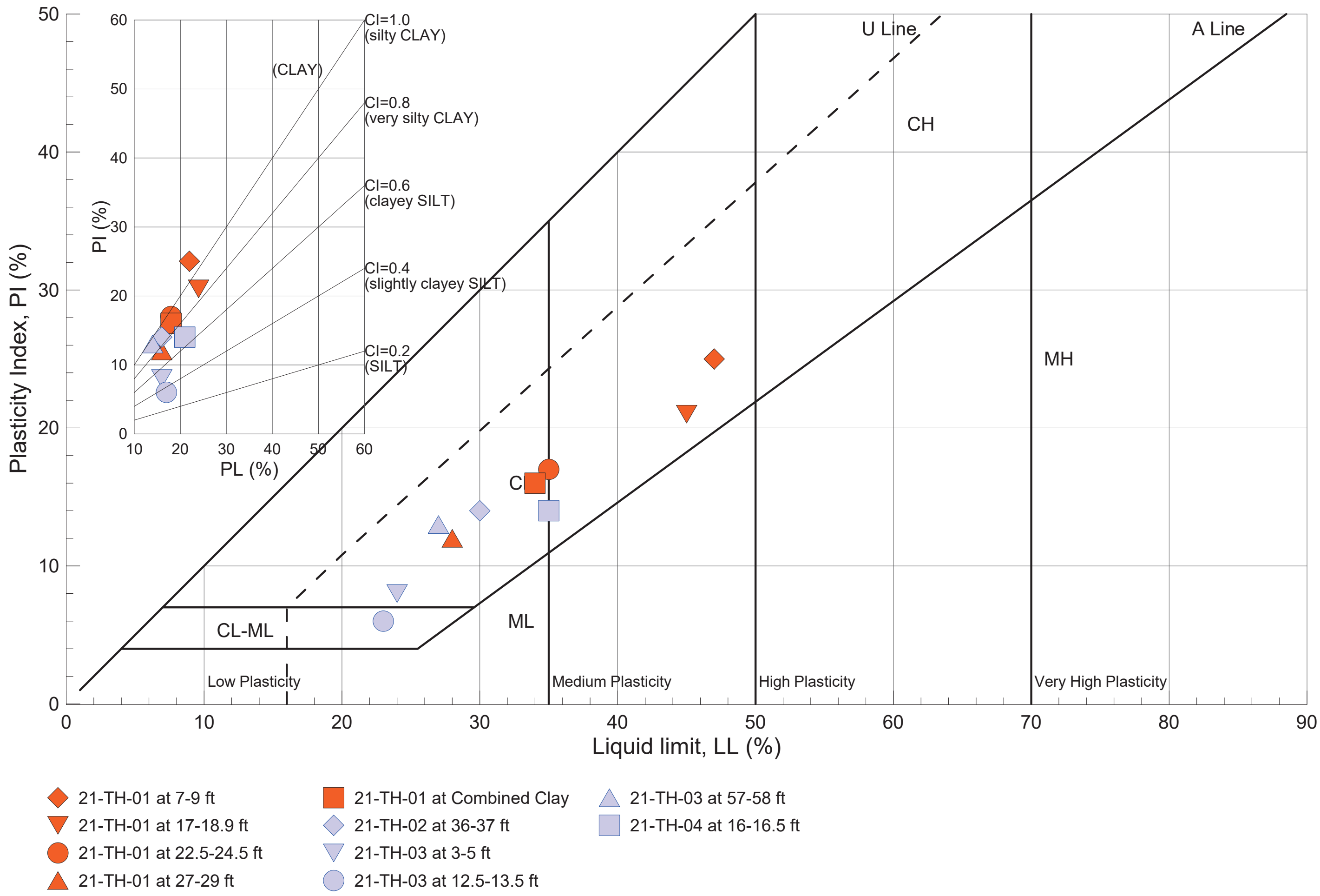
GERHART COLE

Grain-Size Analysis

Corn Creek Reservoir

Figure C-2

DRAFT



GERHART COLE

Casagrande's Plasticity Chart (Atterberg Limits)

Corn Creek Reservoir

Figure C-3

DRAFT

GERHART COLE

Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557

Project: Corn Creek Reservoir
No: 21-1406
Date: 21-Dec-21
Tested by: JC
Reduced by: JC
Reviewed by: RT

TH/TP/Sample: 21-TH-01
Depth: Combined Clay
Location: Kanosh, UT

Comments:

Test Summary

Method: ASTM D698 B
Mold volume (ft^3): 0.0333

Optimum moisture content (%): 16.7
Maximum dry unit weight (pcf): 110.8

Laboratory sample description: rd brown - brown
Engineering Classification: Not requested
As-received moisture content (%): Not requested
Preparation method: Moist
Rammer: Manual
Rock Correction: Yes

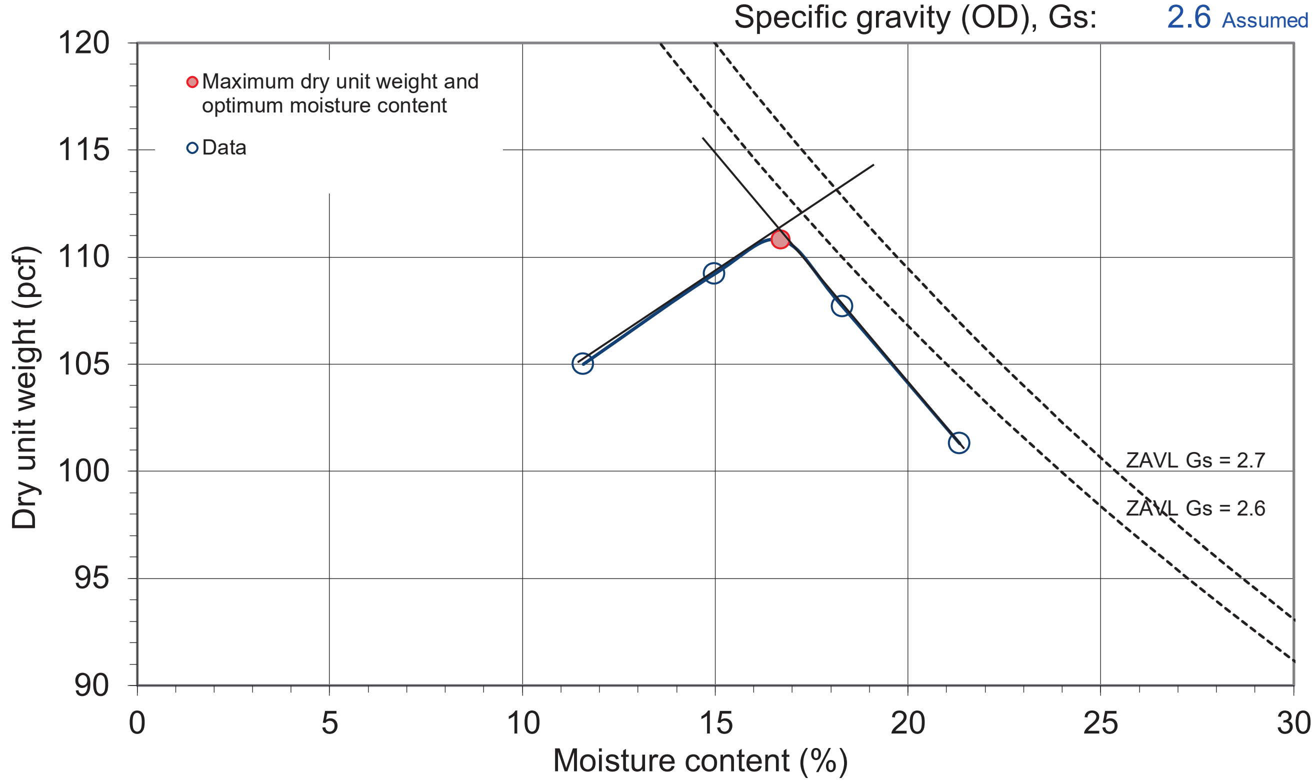
Point Number	+4	+7	+10	+13
Wt. mold + wet soil (g)	6018.40	6145.50	6173.20	6104.90
Wt. mold (g)	4246.55	4246.55	4246.55	4246.55
Moist unit wt., gd (pcf)	117.2	125.6	127.4	122.9
Wet soil + tare (g)	564.53	688.94	723.04	551.8
Dry soil + tare (g)	520.93	614.75	637.93	475.32
Tare (g)	144.34	119.32	172.72	116.74
Moisture content, w (%)	11.6	15.0	18.3	21.3
Dry unit wt., gd (pcf)	105.0	109.2	107.7	101.3

***Correction of Unit Weight and Wat** 3.4 3.3 3.0

(ASTM D4718)

Corrected moisture content (%): 17.0
Corrected dry unit weight (pcf): 114.2

Oversized fraction, +3/8-in. (%): 9.5
Moisture content, +3/8-in. (%): 20.3
Sieve for oversized fraction: 3/8-in.
Specific gravity (OD), Gs: 2.6 Assumed



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DRAFT

One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700

GERHART COLE

Project: Corn Creek Reservoir
No: 21-1406
Location: Kanosh, UT
Date: 29-Dec-21

Tested by: AH
Reduced by: TJ
Checked by: AH
Comments:

TH/TP/Sample: 21-TH-01
Depth: Combined Clay
Laboratory sample description: reddish brown - brown
USCS classification: not requested
Sample type: Compacted to 100% of standard proctor at 2% dry of optimum
Inundation stress (psf): 2600
Swell pressure (psf): N/A
Test method: B
Preparation procedure: trimmed

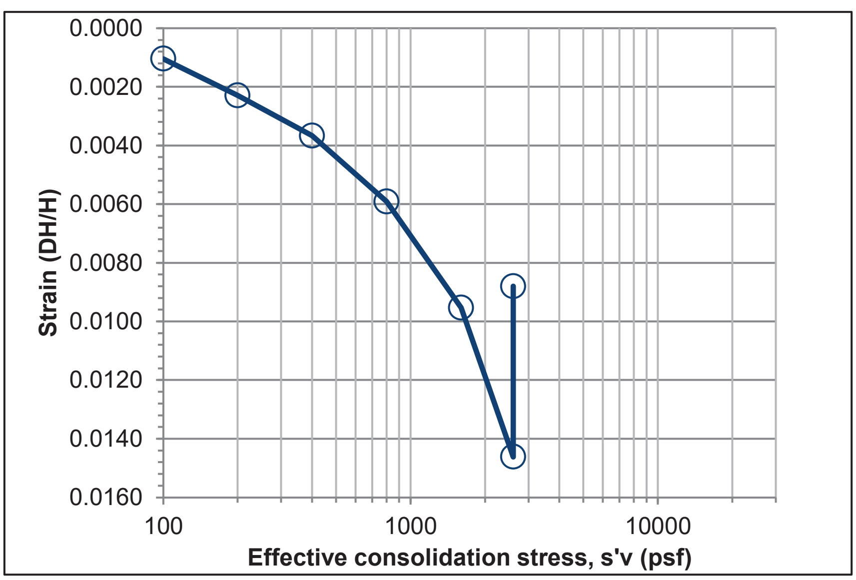
Phase Relationships

		Initial	Final
Height, H (in)	0°	1.0100	-
	90°	1.0200	-
	180°	1.0100	-
	270°	1.0200	-
Avg Height, Havg (in)		1.0150	1.0061
Height, H (cm)		2.578	2.555
Dia., D (in)	0°	2.497	-
	90°	2.492	-
Avg Dia., Davg (in)		2.495	2.495
Dia., D (cm)		6.336	6.336
Wt. rings + wet soil (g)		382.90	389.55
Wt. rings (g)		217.28	217.28
Wet soil + tare (g)		385.78	289.02
Dry soil + tare (g)		357.01	263.78
Tare (g)		140.35	117.51
Moisture cont., w (%)		13.3	17.8
Gs, assumed		2.70	2.70
Mass total (g)		165.6	172.3
Mass of solids (g)		146.2	146.2
Volume (cm^3)		81.3	80.6
Vol. of water (cm^3)		19.4	26.1
Vol. of solids (cm^3)		54.2	54.2
Vol. of voids (cm^3)		27.1	26.4
Vol. of air (cm^3)		7.7	0.4
Area, A (cm^2)		31.5	31.5
Ht. solids, Hs (cm)		1.717	1.717
Void ratio, e		0.501	0.488
Porosity, n		0.334	0.328
Vol.moisture, T		0.239	0.323
Saturation, S (%)		72	99
Dry density (gm/cm^3)		1.799	1.815
Wet unit wt., gm (pcf)		127.2	133.5
Dry unit wt., gd (pcf)		112.3	113.3

Notes:
[a] Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation
[b] Hc = height at end of consolidation of each vert. stress

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc [a] (in)	Hc [b] (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	1.0150	0.0000	0.5011	0
100	0.0011	1.0139	0.0010	0.4996	100
200	0.0023	1.0127	0.0023	0.4977	261
400	0.0037	1.0113	0.0037	0.4956	240
800	0.0060	1.0090	0.0059	0.4923	240
1,600	0.0097	1.0053	0.0095	0.4868	480
2,600	0.0148	1.0002	0.0146	0.4792	1810
2,600	0.0089	1.0061	0.0088	0.4879	1440



Test Results

Swell load (psf)	2600
Swell strain (%)	-0.58

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DRAFT

Triaxial Test - Isotropic Consolidated Sheared Undrained Measuring Pore Pressure (CIU-PP) - *After ASTM D4767 and USBR 5750*

GERHART COLE

Project: Corn Creek Reservoir
No: 21-1406
Location: Kanosh, Utah
Date: 11-Nov-21
Tested by: MGS
Reduced by: MGS
Checked by: AH

TH/TP/Sample: 21-TH-02
Depth: 6-8 ft
Laboratory sample description: dk brown - brown
USCS classification: not requested
Sample type: Rel. undisturbed shelby tube

	Test Number	S1	5 psi	S2	10 psi	S3	25 psi
		Initial	Bef. Shr. MethodB [e]	Initial	Bef. Shr. MethodB [e]	Initial	Bef. Shr. MethodB [e]
Unit weight data	Sample ht., H (in) 0°	4.763		5.745		5.747	
	Sample ht., H (in) 120°	4.819		5.742		5.743	
	Sample ht., H (in) 240°	4.766		5.727		5.741	
	Avg. height, Havg (in)	4.783	4.783	5.738	5.738	5.744	5.744
	Avg. height, Havg (cm)	12.148	12.148	14.575	14.575	14.589	14.589
	ΔHsc (in) [a]		0.000		0.000		0.000
	Sample dia., D (in) top	2.365		2.774		2.809	
	Sample dia., D (in) mid	2.365		2.780		2.789	
	Sample dia., D (in) bot	2.363		2.821		2.862	
	Avg. dia., Davg (in)	2.365	2.292	2.789	2.681	2.812	2.737
	Avg. dia., Davg (cm)	6.006	5.822	7.083	6.809	7.143	6.952
	Avg. area, Aavg (in^2)	4.391	4.127	6.108	5.645	6.212	5.884
	Avg. area, Aavg (cm^2)	28.329	26.623	39.407	36.416	40.074	37.960
	Wt. rings + wet soil (g)	644.20	637.62	1028.56	1094.50	1021.81	1082.91
	Wt. rings (g)	0.00	0.00	0.00	0.00	0.00	0.00
	Volume, Vo (in^3)	21.0	19.7	35.0	32.4	35.7	33.8
	Vo (cm^3)	344.1	323.4	574.3	530.7	584.6	553.8
	Vo (ft^3)	0.0122	0.0114	0.0203	0.0187	0.0206	0.0196
Moisture	Wet soil + tare (g)	282.33	757.15	282.33	1292.23	282.33	1280.59
	Dry soil + tare (g)	255.49	641.89	253.49	1076.02	255.49	1051.56
	Tare (g)	115.08	119.53	115.08	197.73	115.08	197.68
	Moisture content, w (%)	19.1	22.1	20.8	24.6	19.1	26.8
Phase Relationships	Gs, assumed	2.65	2.65	2.65	2.65	2.65	2.65
	Mass total (g)	644.2	660.2	1028.6	1060.7	1021.8	1087.9
	Mass of solids (g)	540.8	540.8	851.2	851.2	857.8	857.8
	Volume (cm^3)	344.1	323.4	574.3	530.7	584.6	553.8
	Volume of water (cm^3)	103.4	119.3	177.4	209.5	164.0	230.1
	Volume of solids (cm^3)	204.1	204.1	321.2	321.2	323.7	323.7
	Volume of voids (cm^3)	140.1	119.3	253.1	209.5	260.9	230.1
	Volume of air (cm^3)	36.7	0.0	75.8	0.0	97.0	0.0
	Void ratio, e	0.686	0.585	0.788	0.652	0.806	0.711
	Porosity, n	0.407	0.369	0.441	0.395	0.446	0.415
	Volumetric moisture, T	0.300	0.369	0.309	0.395	0.280	0.415
	Saturation, S (%) [c]	73.81	100.00	70.07	100.00	62.84	100.00
	Dry density (gm/cm^3)	1.571	1.672	1.482	1.604	1.467	1.549
	Wet unit wt., gm (pcf)	116.9	127.4	111.8	124.8	109.1	122.6
	Dry unit wt., gd (pcf)	98.1	104.4	92.5	100.1	91.6	96.7

Notes:

[a] ΔHsc (in) = change in height during saturation and consolidation

[b] ΔVs = change in volume during saturation, ΔVc = change in volume during consolidation

[c] Saturation before shear set to 100% for phase calculations

[d] Before shear Aavg using method A; where Ac (Method A) = (Vo-DVs - DVc)/(Ho-DHsc)

[e] Before shear Aavg using method B; where Ac (Method B) = (Vwf + Vs)/Hc

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DRAFT

GERHART COLE

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

Project:	**Corn Creek Reservoir**	**TH/TP/Sample:**	**21-TH-02**
No:	**21-1406**	**Depth:**	**6-8 ft**
Location:	Kanosh, Utah	Laboratory sample description:	dk brown - brown
Date:	11-Nov-21	USCS classification:	not requested
Tested by:	MGS	Sample type:	Rel. undisturbed shelby tube

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Test Number		**S1 at 5 psi**	**S2 at 10 psi**	**S3 at 25 psi**
Test information	Total backpressure (psi)	40.0	65.0	55.0
	Skempton B	0.96	0.96	0.96
	t-90 (min)	4.4	1.4	1.4
	t-100 (min)	7.1	38.1	42.0
	t-50 (min)	1.0	0.3	0.3
	Strain rate (%/hr)	1.20	1.20	1.20
	Strain rate (%/min)	0.02	0.02	0.02
	Membrane correction	Yes	Yes	Yes
	Filter paper correction	No filter paper	No filter paper	No filter paper
Max principal stress ratio (s1/s3), failure criteria	Strain at failure, ef (%)	2.80	12.28	6.93
	Time to failure, tf (min)	139.9	614.0	346.6
	Obliquity, s'1/s'3	5.642	4.842	3.896
	Excess pore pressure, u (psi)	2.69	5.56	6.02
	q = q' = (s1+s3)/2 (psi)	5.35	8.52	27.48
	p' = (s'1+s'3)/2 (psi)	7.66	12.96	46.46
	p = (s1+s3)/2 (psi)	10.35	18.52	52.48
	Effective major principal stress, s'1 (psi)	13.01	21.48	73.94
	Effective minor principal stress, s'3 (psi)	2.31	4.44	18.98
	Total major pincipal stress, s1 (psi)	15.70	27.05	79.96
	Total minor pincipal stress, s3 (psi)	5.00	10.00	25.00
	Skemption A at failure, Af	0.25	0.33	0.11
	Secant friction angle, phi-s (deg)	44.3	41.1	36.3
		Effective stress	Total stress	
	Friction angle, phi (deg)	34.7	31.1	
	Cohesion intercept, c (psi)	1.3	0.0	
Peak deviator stress (s1-s3), failure criteria	Strain at failure, ef (%)	15.01	11.04	14.16
	Time to failure, tf (min)	750.6	551.8	708.0
	Deviator stress, s1-s3 (psi)	23.54	17.09	73.24
	Excess pore pressure, u (psi)	-1.84	5.54	-2.39
	q = q' = (s1+s3)/2 (psi)	11.77	8.55	36.62
	p' = (s'1+s'3)/2 (psi)	18.61	13.01	64.02
	p = (s1+s3)/2 (psi)	16.77	18.55	61.62
	Effective major principal stress, s'1 (psi)	30.38	21.55	100.64
	Effective minor principal stress, s'3 (psi)	6.84	4.46	27.39
	Total major pincipal stress, s1 (psi)	28.54	27.09	98.24
	Total minor pincipal stress, s3 (psi)	5.00	10.00	25.00
	Skemption A at failure, Af	-0.08	0.32	-0.03
	Secant friction angle, phi-s (deg)	39.2	41.1	34.9
		Effective stress	Total stress	
	Friction angle, phi (deg)	33.3	36.2	
	Cohesion intercept, c (psi)	1.8	0.0	
	Photo of sample after shearing	**S1 at 5 psi**	**S2 at 10 psi**	**S3 at 25 psi**

Comments:

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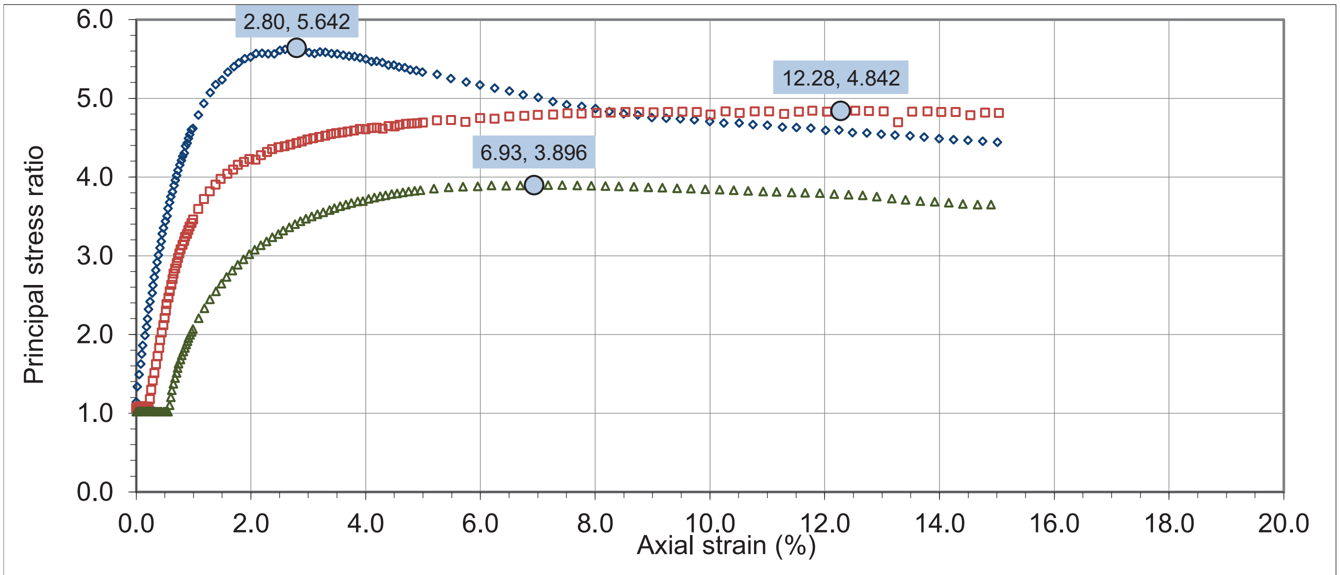
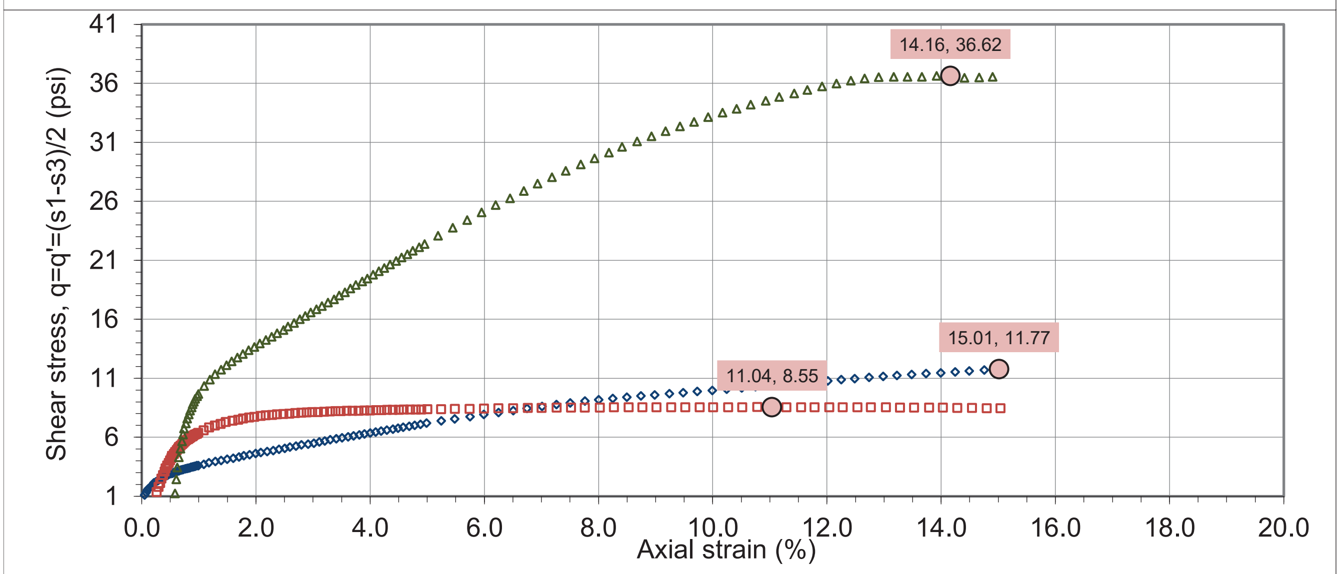
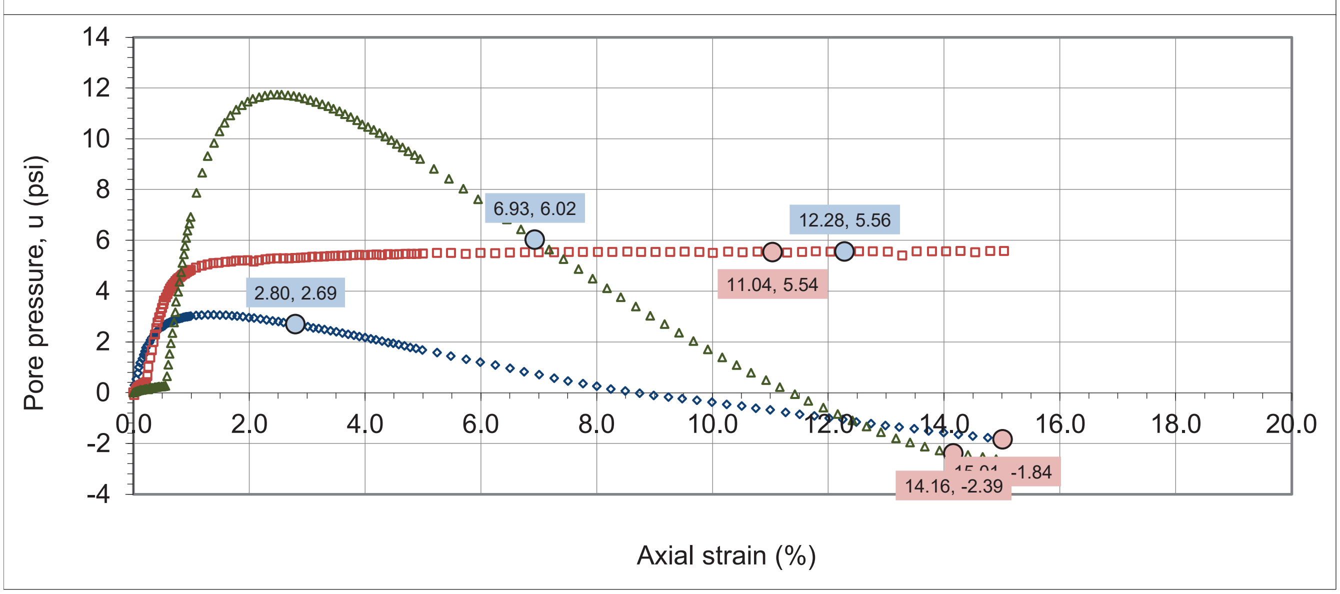
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

Project: Corn Creek Reservoir **TH/TP/Sample:** 21-TH-02
No: 21-1406 **Depth:** 6-8 ft







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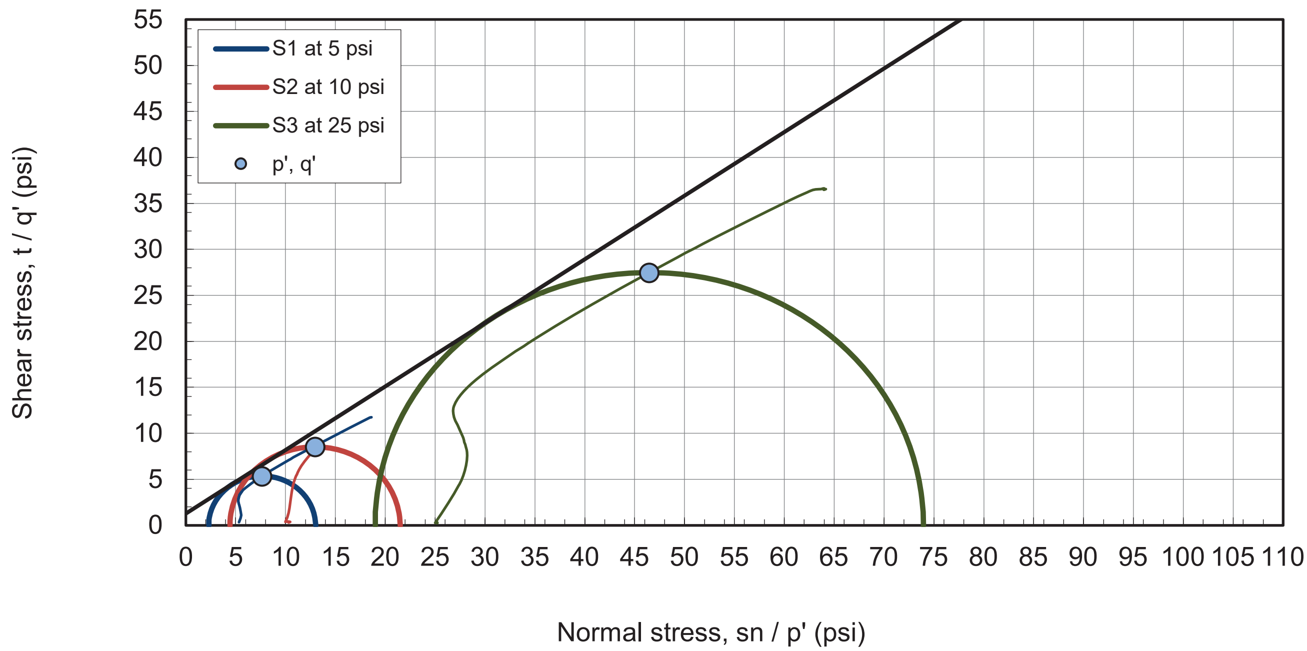
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

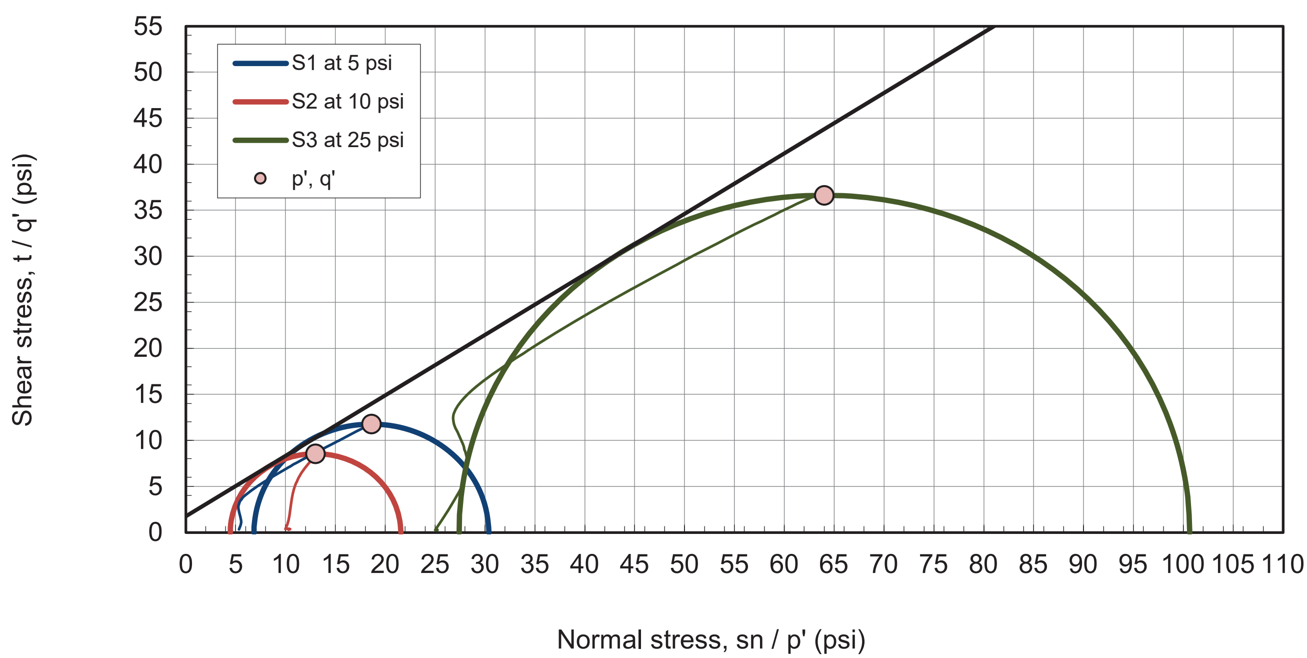
Project: **Corn Creek Reservoir** **TH/TP/Sample:** **21-TH-02**
No: **21-1406** **Depth:** **6-8 ft**

Effective stress results



Max principal stress ratio (s'1/s'3), failure criteria Mohr and p' - q' space plots

Effective stress results



Peak deviator stress (s1-s3), failure criteria Mohr and p' - q' space plots

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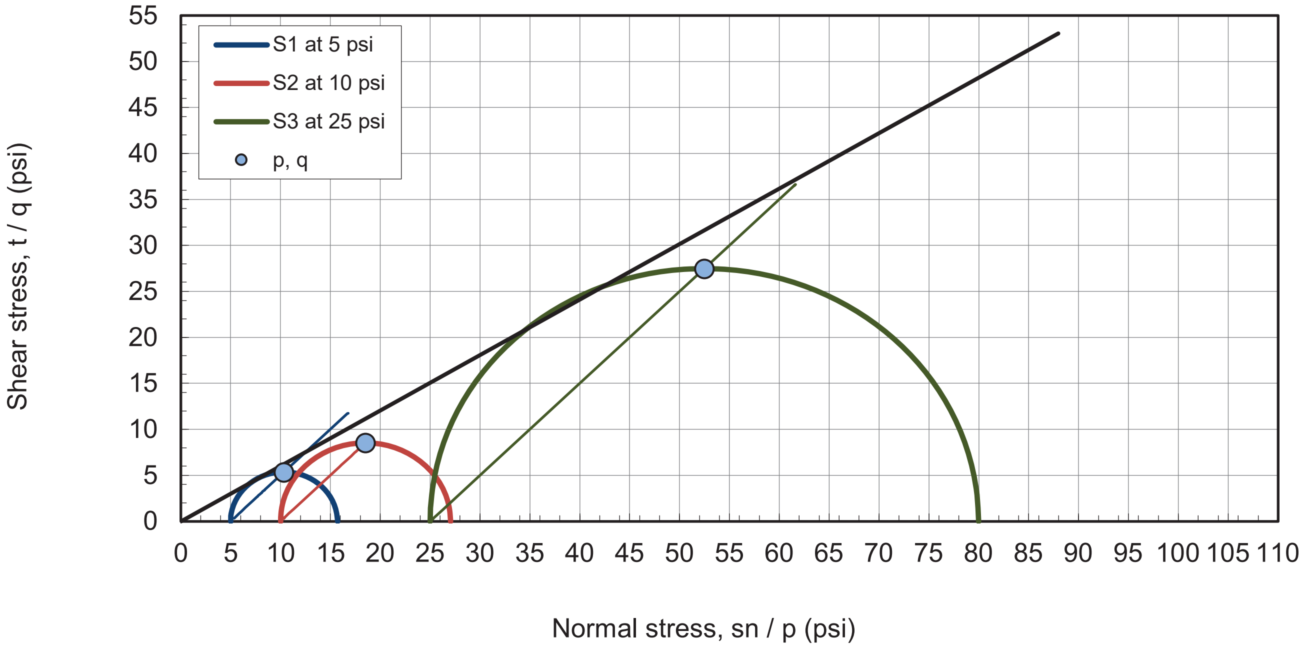
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

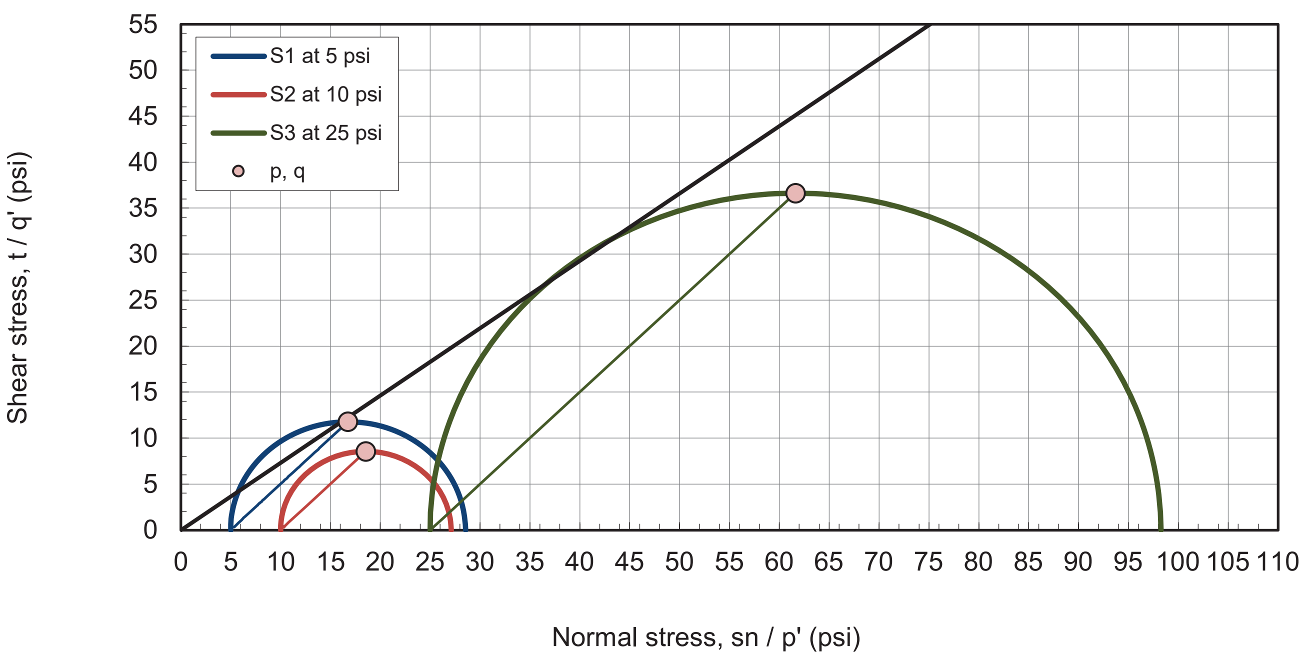
Project: **Corn Creek Reservoir** | **TH/TP/Sample:** **21-TH-02**
No: **21-1406** | **Depth:** **6-8 ft**

Total stress results



Max principal stress ratio (s1/s3), failure criteria Mohr and p - q space plots - effective stress results

Total stress results



Peak deviator stress (s1-s3), failure criteria Mohr and p - q space plots

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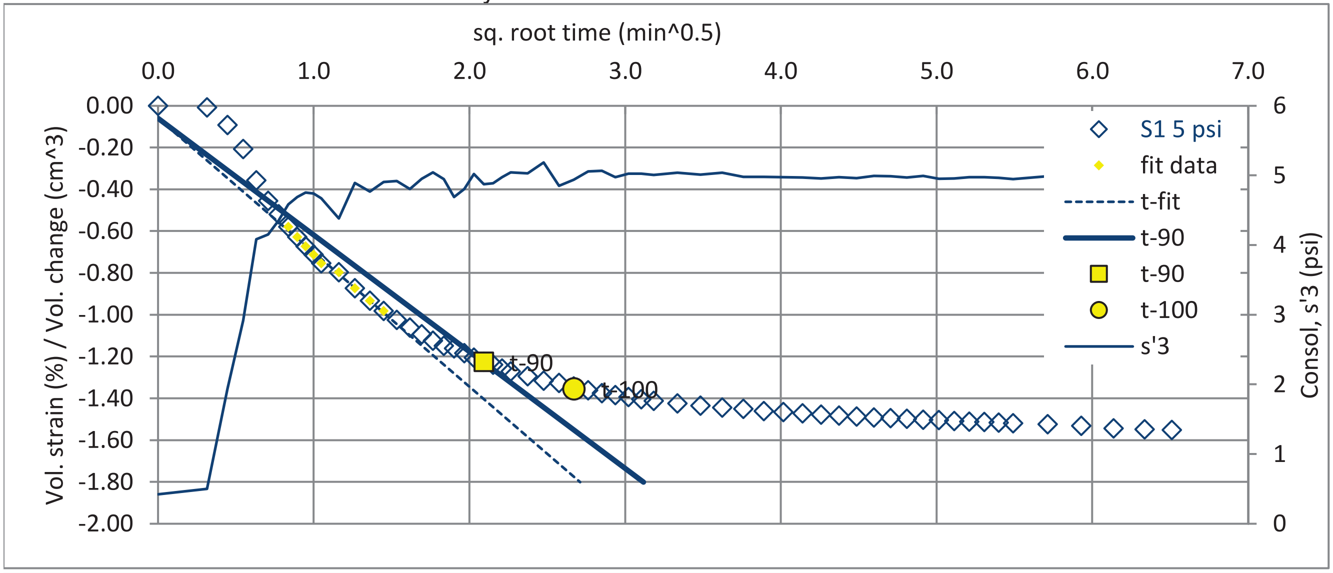
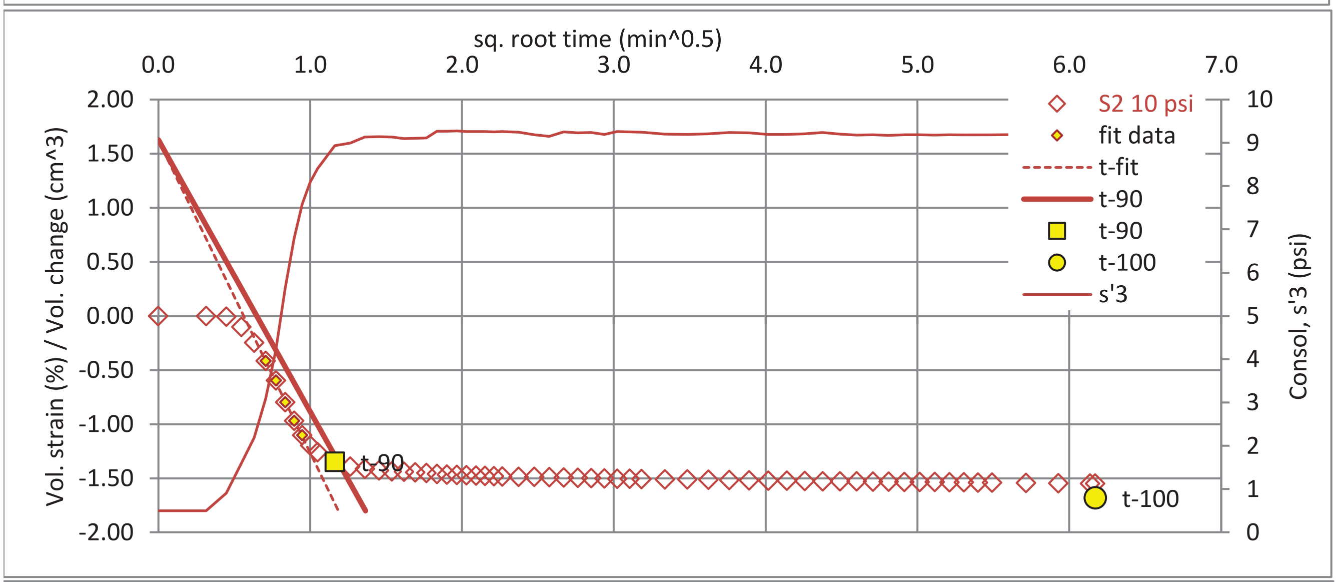
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) - *After ASTM D4767 and USBR 5750*

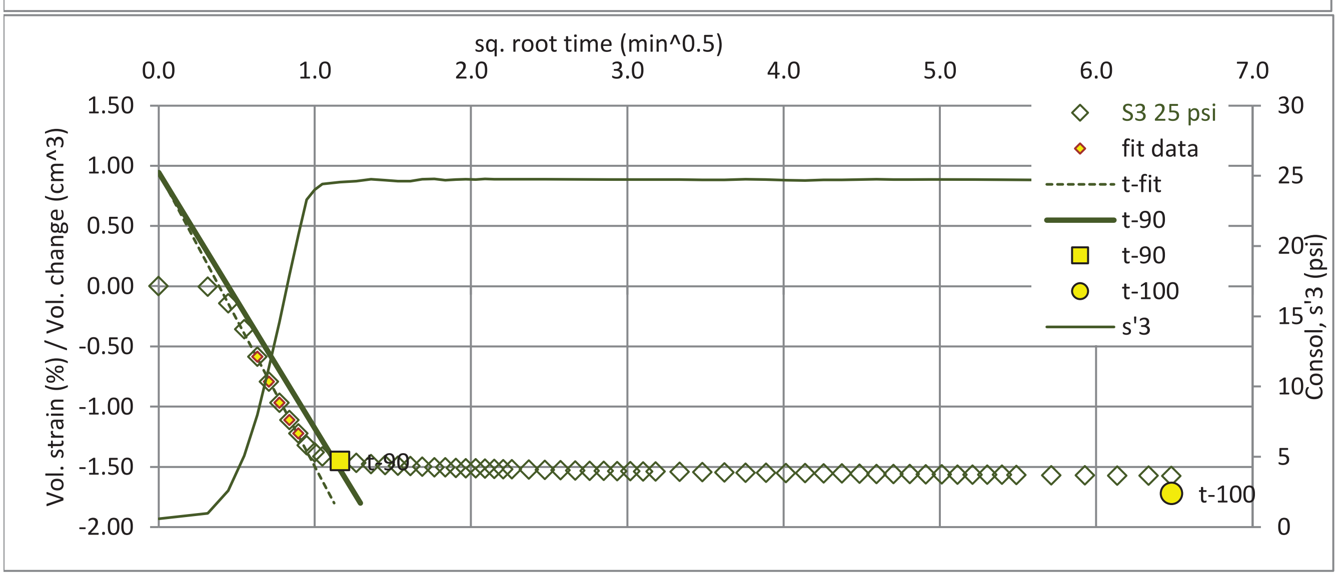
GERHART COLE

Project: **Corn Creek Reservoir** **TH/TP/Sample:** **21-TH-02**
No: **21-1406** **Depth:** **6-8 ft**

Time rate of consolidation data and analysis







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Triaxial Test - Isotropic Consolidated Sheared Undrained Measuring Pore Pressure (CIU-PP) - *After ASTM D4767 and USBR 5750*

GERHART COLE

Project: Corn Creek Reservoir
No: 21-1406
Location: Kanosh, UT
Date: 30-Dec-21
Tested by: AH
Reduced by: AH
Checked by: DAB

TH/TP/Sample: 21-TH-01
Depth: Combined Clay
Laboratory sample description: reddish brown to brown
USCS classification: not requested
Sample type: compacted to 95% of standard proctor at OMC

Section	Test Number	S1 Initial	20 psi Bef. Shr. MethodB [e]	S2 Initial	45 psi Bef. Shr. MethodB [e]	S3 Initial	110 psi Bef. Shr. MethodB [e]
Unit weight data	Sample ht., H (in) 0°	5.945		5.960		5.891	
	Sample ht., H (in) 120°	5.939		5.909		5.924	
	Sample ht., H (in) 240°	5.975		5.913		5.885	
	Avg. height, Havg (in)	5.953	5.891	5.927	5.834	5.900	5.791
	Avg. height, Havg (cm)	15.121	14.962	15.055	14.817	14.986	14.708
	ΔHsc (in) [a]		0.063		0.094		0.109
	Sample dia., D (in) top	2.815		2.799		2.803	
	Sample dia., D (in) mid	2.789		2.818		2.813	
	Sample dia., D (in) bot	2.823		2.815		2.811	
	Avg. dia., Davg (in)	2.804	2.817	2.813	2.812	2.810	2.772
	Avg. dia., Davg (cm)	7.122	7.155	7.144	7.143	7.137	7.042
	Avg. area, Aavg (in^2)	6.175	6.232	6.213	6.212	6.202	6.037
	Avg. area, Aavg (cm^2)	39.839	40.204	40.081	40.075	40.010	38.946
	Wt. rings + wet soil (g)	1190.95	1249.44	1191.39	1237.74	1191.99	1218.73
	Wt. rings (g)	0.00	0.00	0.00	0.00	0.00	0.00
	Volume, Vo (in^3)	36.8	36.7	36.8	36.2	36.6	35.0
	Vo (cm^3)	602.4	601.5	603.4	593.8	599.6	572.8
	Vo (ft^3)	0.0213	0.0212	0.0213	0.0210	0.0212	0.0202
Moisture	Wet soil + tare (g)	439.77	1367.00	377.85	1434.31	397.30	1335.12
	Dry soil + tare (g)	395.69	1151.45	350.43	1229.81	358.05	1148.06
	Tare (g)	120.35	118.06	172.72	196.73	116.74	116.68
	Moisture content, w (%)	16.0	20.9	15.4	19.8	16.3	18.1
Phase Relationships	Gs, assumed	2.65	2.65	2.65	2.65	2.65	2.65
	Mass total (g)	1191.0	1240.7	1191.4	1236.4	1192.0	1211.2
	Mass of solids (g)	1026.6	1026.6	1032.1	1032.1	1025.2	1025.2
	Volume (cm^3)	602.4	601.5	603.4	593.8	599.6	572.8
	Volume of water (cm^3)	164.4	214.1	159.3	204.3	166.8	185.9
	Volume of solids (cm^3)	387.4	387.4	389.5	389.5	386.9	386.9
	Volume of voids (cm^3)	215.0	214.1	214.0	204.3	212.7	185.9
	Volume of air (cm^3)	50.7	0.0	54.7	0.0	46.0	0.0
	Void ratio, e	0.555	0.553	0.549	0.525	0.550	0.481
	Porosity, n	0.357	0.356	0.355	0.344	0.355	0.325
	Volumetric moisture, T	0.273	0.356	0.264	0.344	0.278	0.325
	Saturation, S (%) [c]	76.44	100.00	74.43	100.00	78.40	100.00
	Dry density (gm/cm^3)	1.704	1.707	1.710	1.738	1.710	1.790
	Wet unit wt., gm (pcf)	123.4	128.8	123.3	130.0	124.1	132.0
	Dry unit wt., gd (pcf)	106.4	106.5	106.8	108.5	106.7	111.7

Notes:

[a] ΔHsc (in) = change in height during saturation and consolidation

[b] ΔVs = change in volume during saturation, ΔVc = change in volume during consolidation

[c] Saturation before shear set to 100% for phase calculations

[d] Before shear Aavg using method A; where Ac (Method A) = (Vo-DVs - DVc)/(Ho-DHsc)

[e] Before shear Aavg using method B; where Ac (Method B) = (Vwf + Vs)/Hc

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<u>Compaction specifications:</u>

	Target	As Compacted Avg.
gd (pcf)	105.3	106.6
w (%)	16.7	15.9

DRAFT

Triaxial Test - Isotropic Consolidated Sheared Undrained Measuring Pore Pressure (CIU-PP) - *After ASTM D4767 and USBR 5750*

GERHART COLE

Project:	**Corn Creek Reservoir**	**TH/TP/Sample:**	**21-TH-01**
No:	**21-1406**	**Depth:**	**Combined Clay**
Location:	Kanosh, UT	Laboratory sample description:	reddish brown to brown
Date:	30-Dec-21	USCS classification:	not requested
Tested by:	AH	Sample type:	compacted to 95% of standard

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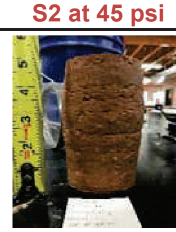
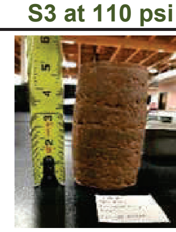
	Test Number	S1 at 20 psi	S2 at 45 psi	S3 at 110 psi
Test information	Total backpressure (psi)	60.0	55.0	55.0
	Skempton B	0.95	0.95	0.95
	t-90 (min)	2.4	2.1	42.7
	t-100 (min)	4.1	3.4	75.2
	t-50 (min)	0.6	0.5	10.0
	Strain rate (%/hr)	1.20	1.20	1.20
	Strain rate (%/min)	0.02	0.02	0.02
	Membrane correction	Yes	Yes	Yes
	Filter paper correction	Yes	Yes	Yes
Max principal stress ratio (s1/s3), failure criteria	Strain at failure, ef (%)	6.77	10.39	9.15
	Time to failure, tf (min)	338.4	519.7	457.5
	Obliquity, s'1/s'3	3.696	3.372	3.259
	Excess pore pressure, u (psi)	12.39	29.80	71.73
	q = q' = (s1+s3)/2 (psi)	10.26	18.04	43.22
	p' = (s'1+s'3)/2 (psi)	17.88	33.24	81.49
	p = (s1+s3)/2 (psi)	30.26	63.04	153.22
	Effective major principal stress, s'1 (psi)	28.14	51.27	124.70
	Effective minor principal stress, s'3 (psi)	7.61	15.20	38.27
	Total major pincipal stress, s1 (psi)	40.53	81.07	196.44
	Total minor pincipal stress, s3 (psi)	20.00	45.00	110.00
	Skemption A at failure, Af	0.60	0.83	0.83
	Secant friction angle, phi-s (deg)	35.0	32.9	32.0
		Effective stress	Total stress	
	Friction angle, phi (deg)	31.3	15.7	
	Cohesion intercept, c (psi)	1.1	1.7	
Peak deviator stress (s1-s3), failure criteria	Strain at failure, ef (%)	14.83	15.23	13.98
	Time to failure, tf (min)	741.4	761.7	699.0
	Deviator stress, s1-s3 (psi)	21.99	37.12	88.02
	Excess pore pressure, u (psi)	11.44	28.95	70.24
	q = q' = (s1+s3)/2 (psi)	11.00	18.56	44.01
	p' = (s'1+s'3)/2 (psi)	19.55	34.61	83.77
	p = (s1+s3)/2 (psi)	31.00	63.56	154.01
	Effective major principal stress, s'1 (psi)	30.55	53.17	127.78
	Effective minor principal stress, s'3 (psi)	8.56	16.05	39.76
	Total major pincipal stress, s1 (psi)	41.99	82.12	198.02
	Total minor pincipal stress, s3 (psi)	20.00	45.00	110.00
	Skemption A at failure, Af	0.52	0.78	0.80
	Secant friction angle, phi-s (deg)	34.2	32.4	31.7
		Effective stress	Total stress	
	Friction angle, phi (deg)	31.0	15.7	
	Cohesion intercept, c (psi)	1.0	2.1	
	Photo of sample after shearing	S1 at 20 psi	S2 at 45 psi	S3 at 110 psi

Comments:

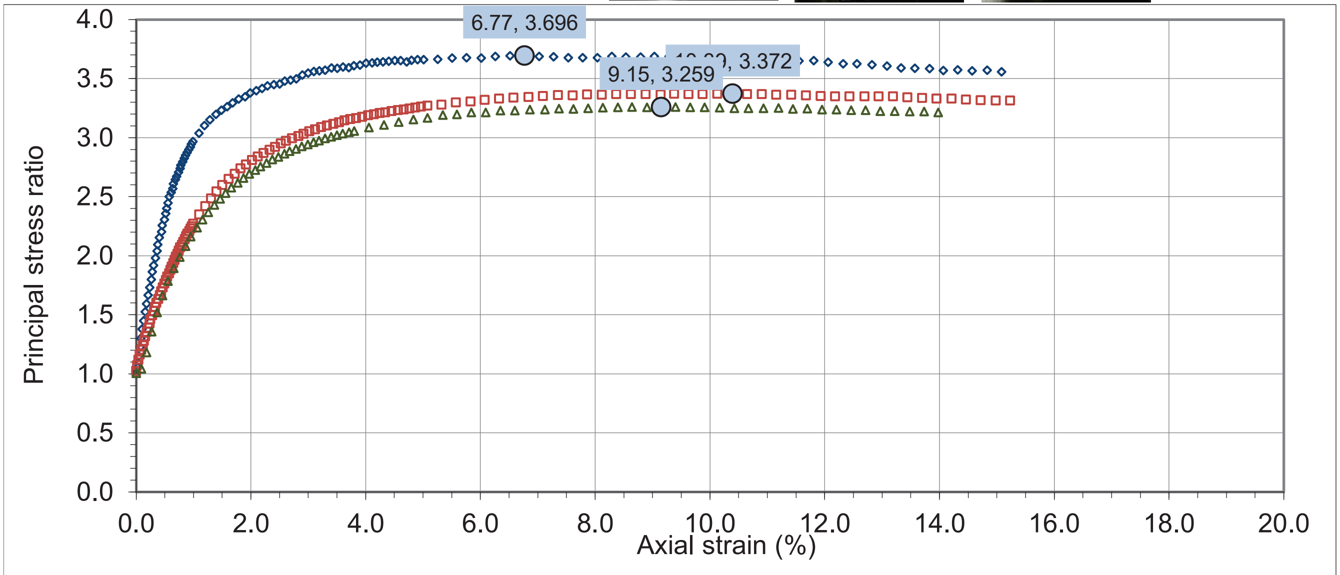




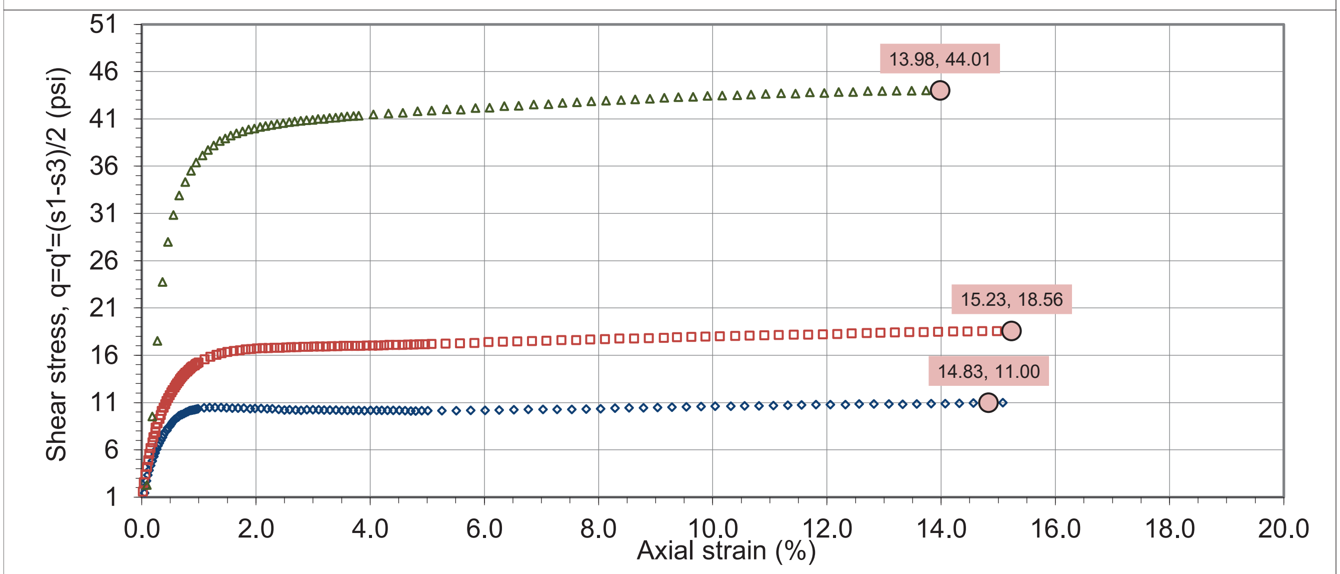
DRAFT

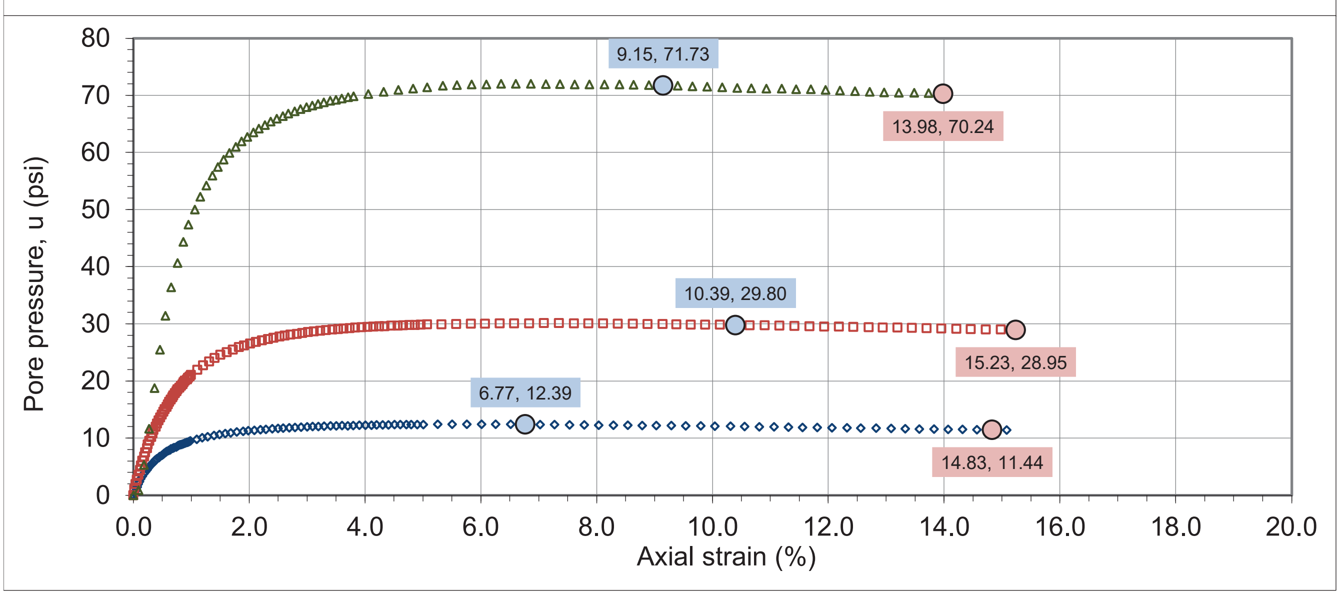
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

Project: **Corn Creek Reservoir** **TH/TP/Sample:** **21-TH-01**
No: **21-1406** **Depth:** **Combined Clay**







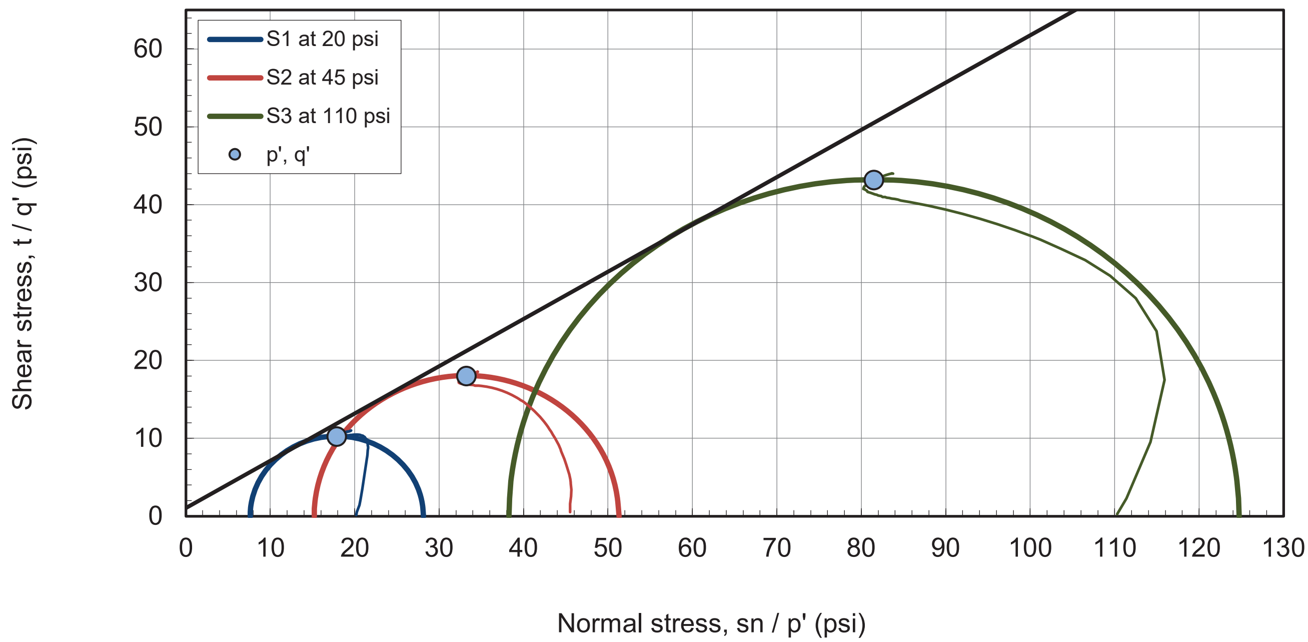
DRAFT

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

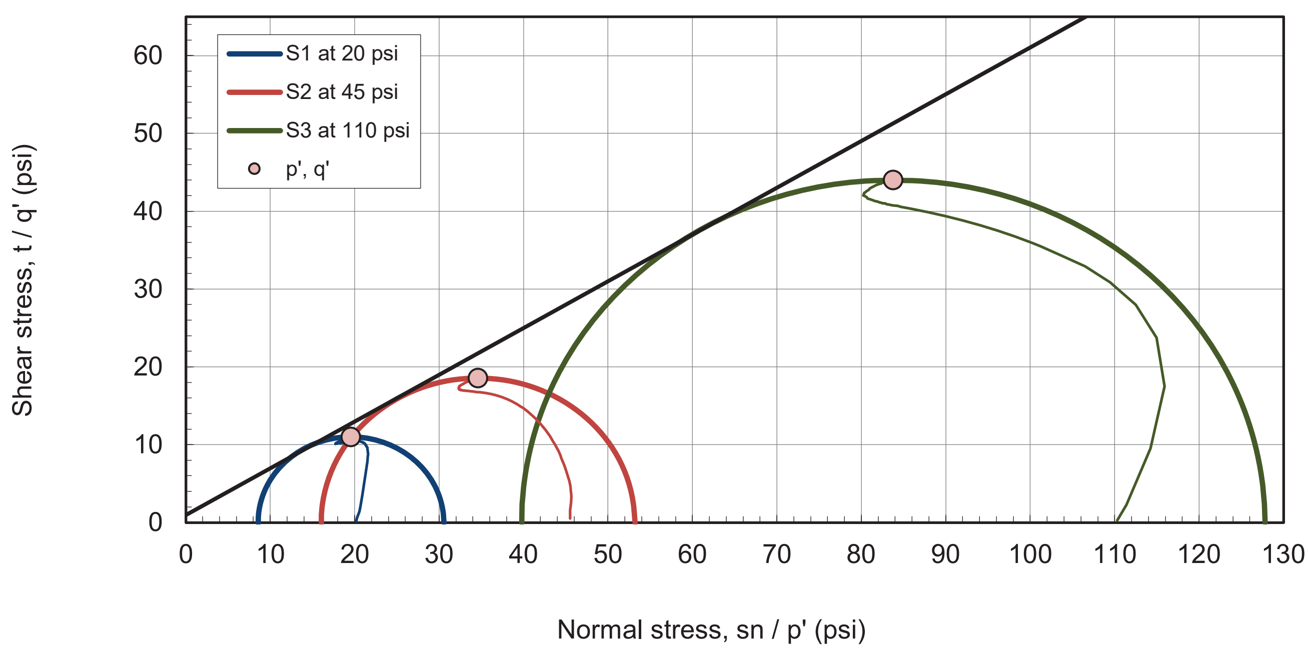
Project:	**Corn Creek Reservoir**	**TH/TP/Sample:**	**21-TH-01**
No:	**21-1406**	**Depth:**	**Combined Clay**

Effective stress results



Max principal stress ratio (s'1/s'3), failure criteria Mohr and p' - q' space plots

Effective stress results



Peak deviator stress (s1-s3), failure criteria Mohr and p' - q' space plots

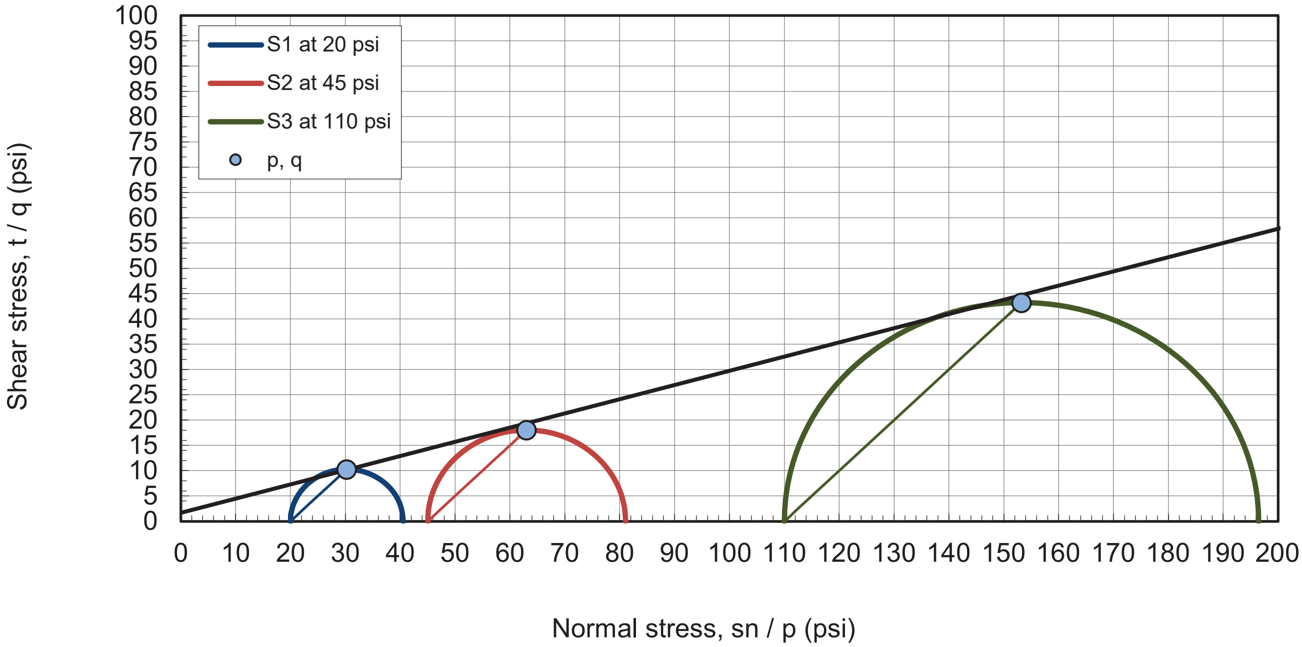
DRAFT

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

GERHART COLE

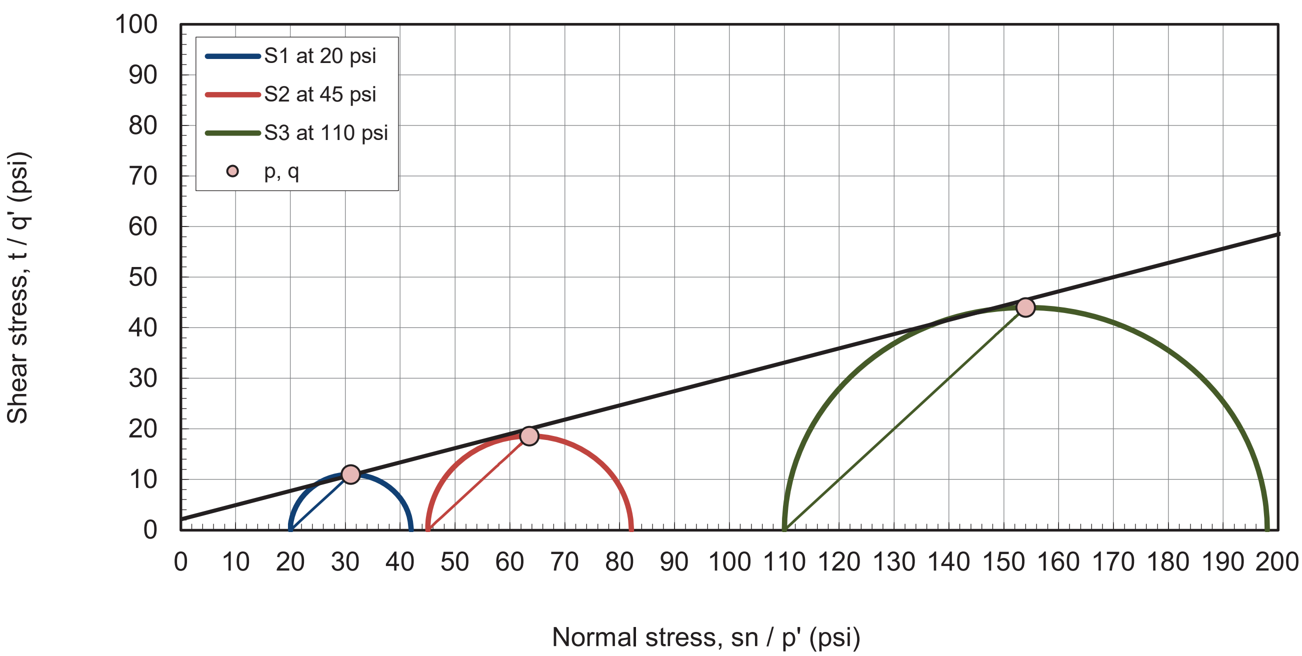
Project: **Corn Creek Reservoir** **TH/TP/Sample:** **21-TH-01**
No: **21-1406** **Depth:** **Combined Clay**

Total stress results



Max principal stress ratio (s1/s3), failure criteria Mohr and p - q space plots - effective stress results

Total stress results



Peak deviator stress (s1-s3), failure criteria Mohr and p - q space plots

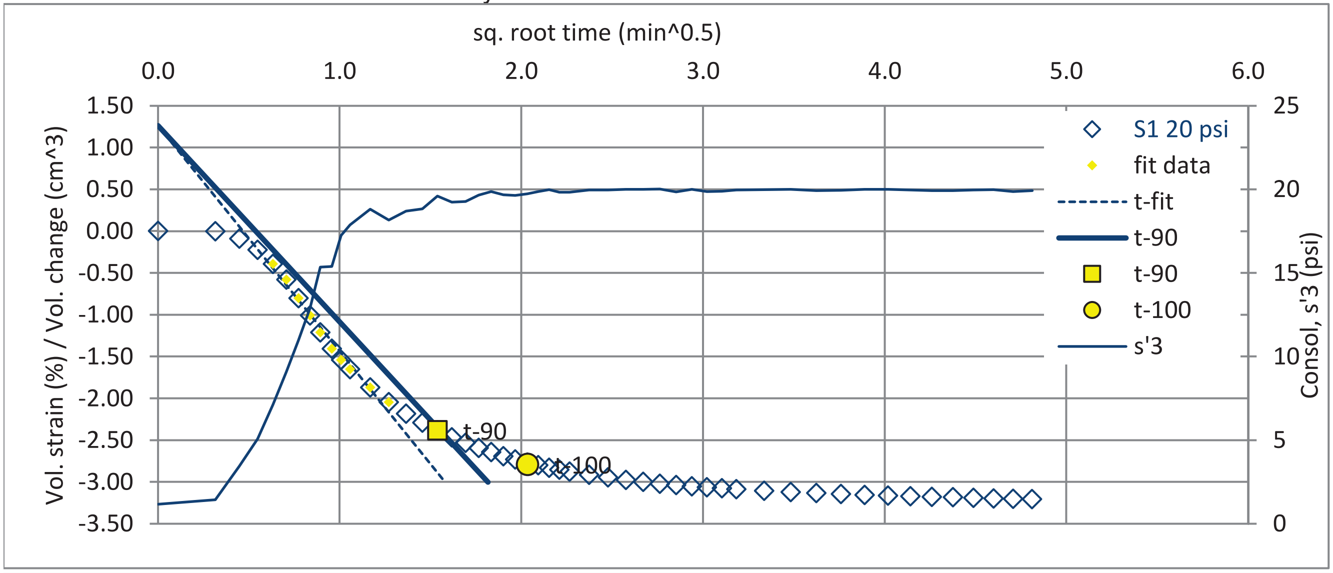
DRAFT

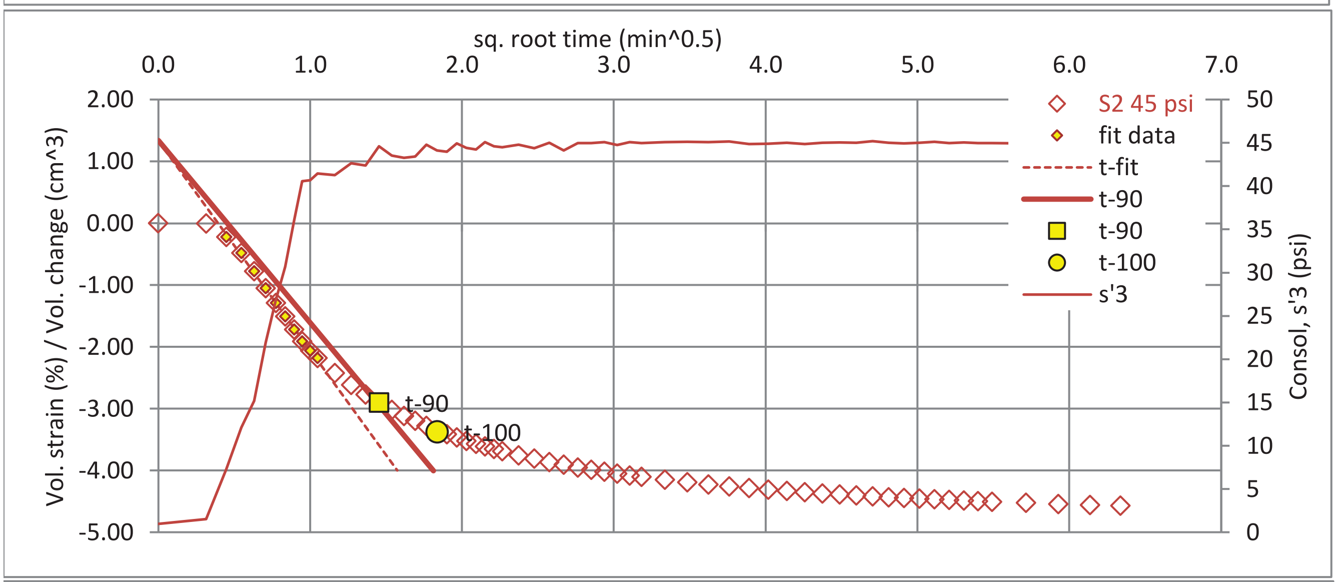
Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) *- After ASTM D4767 and USBR 5750*

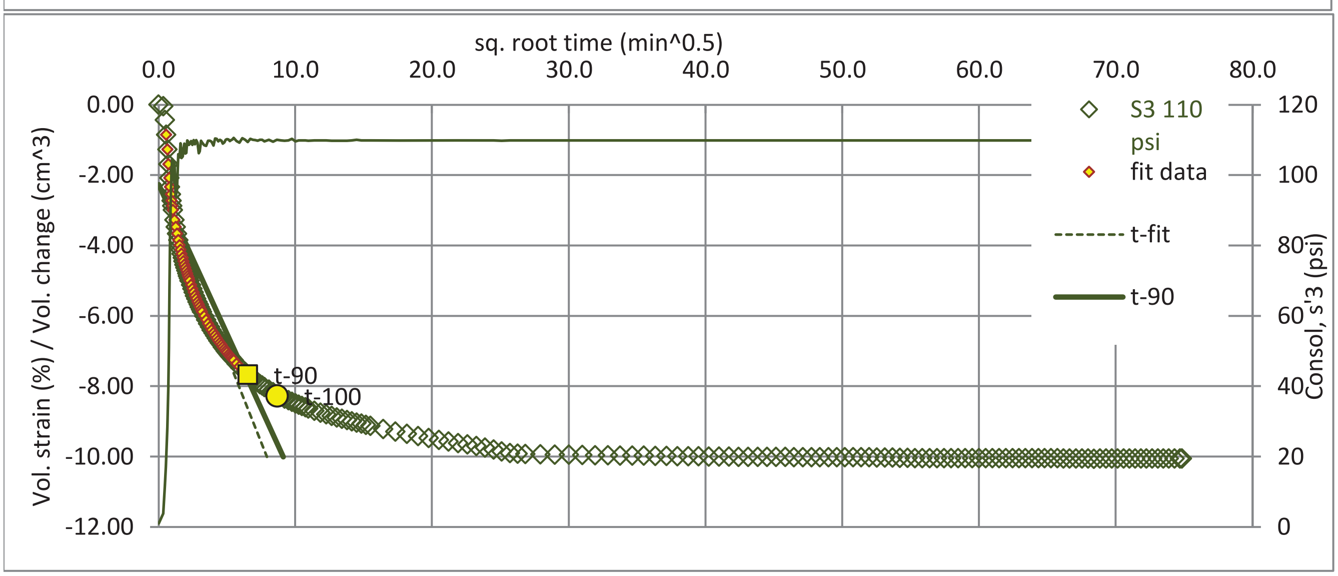
GERHART COLE

Project: **Corn Creek Reservoir** **TH/TP/Sample:** **21-TH-01**
No: **21-1406** **Depth:** **Combined Clay**

Time rate of consolidation data and analysis







DRAFT

Triaxial Test - Unconsolidated Sheared Undrained (UU)

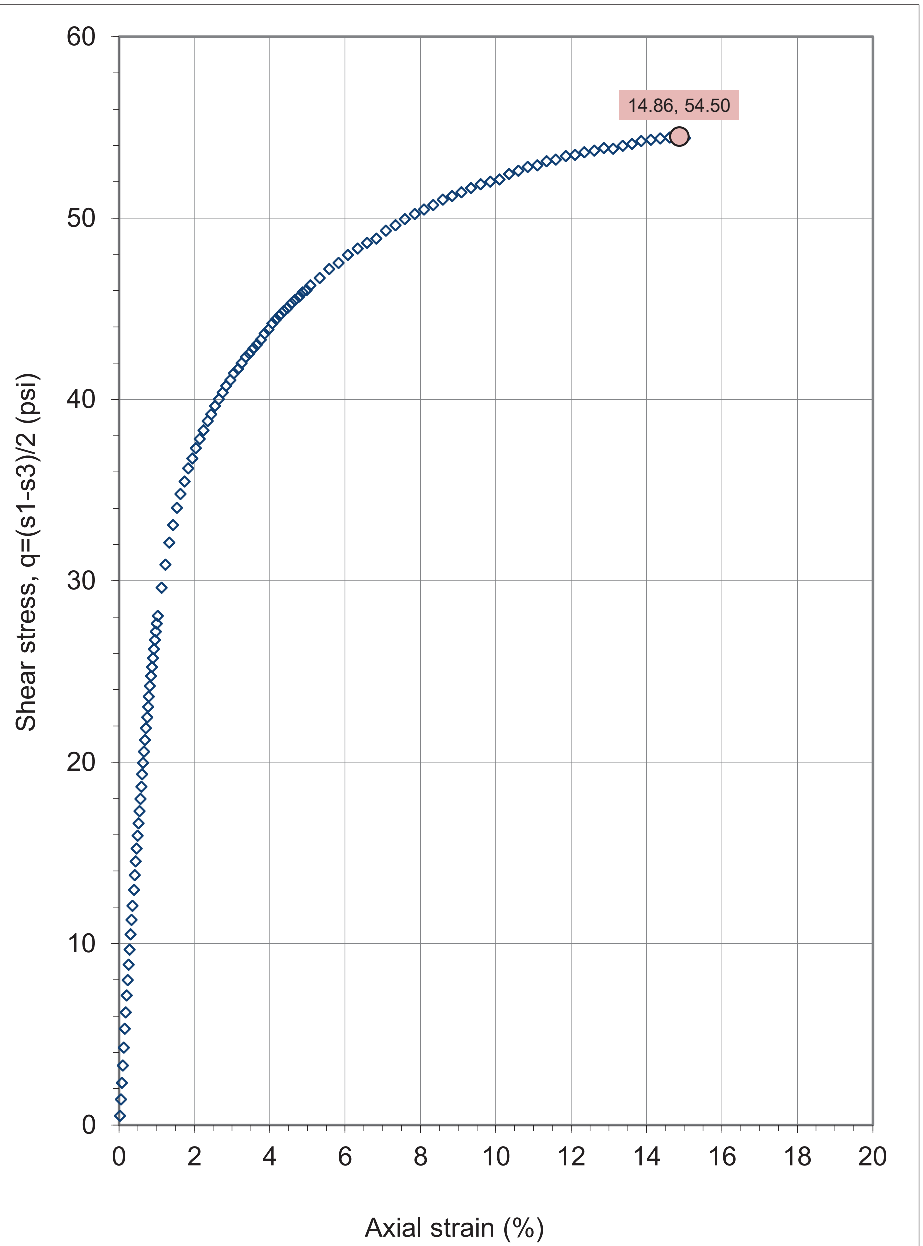
After ASTM D2850, AASHTO T296, and USBR 5745

GERHART COLE

Project:	**Corn Creek Reservoir**	**TH/TP/Sample:**	**21-TH-01**
No:	**21-1406**	**Depth:**	**Combined Clay**
Location:	Kanosh, Utah	Laboratory sample description:	reddish brown to brown
Date:	28-Dec-21	USCS classification:	not requested
Tested by:	AH	Sample type:	compacted to 95% of standard proctor at OMC
Reduced by:	AH		
Checked by:	RT		

Test Number **S1 at 45 psi**

Section	Parameter		Value
Unit weight data	Sample ht., H (in)	0°	5.828
		120°	5.906
		240°	5.901
	Avg. height, Havg (in)		5.878
	Avg. height, Havg (cm)		14.931
	Sample dia., D (in)	top	2.819
		mid	2.809
		bot	2.813
	Avg. dia., Davg (in)		2.813
	Avg. dia., Davg (cm)		7.144
	Avg. area, Aavg (in^2)		6.213
	Avg. area, Aavg (cm^2)		40.081
	Wt. rings + wet soil (g)		1192.60
	Wt. rings (g)		0.00
	Volume, Vo (in^3)		36.5
	Vo (cm^3)		598.5
	Vo (ft^3)		0.0211
Moisture	Wet soil + tare (g)		1386.87
	Dry soil + tare (g)		1223.70
	Tare (g)		195.89
	Moisture content, w (%)		15.9
Phase Relationships	Gs, assumed		2.70
	Mass total (g)		1192.6
	Mass of solids (g)		1029.2
	Volume (cm^3)		598.5
	Volume of water (cm^3)		163.4
	Volume of solids (cm^3)		381.2
	Volume of voids (cm^3)		217.3
	Volume of air (cm^3)		53.9
	Void ratio, e		0.570
	Porosity, n		0.363
	Volumetric moisture, T		0.273
	Saturation, S (%) [c]		75.20
	Dry density (gm/cm^3)		1.720
	Moist unit wt., gm (pcf)		124.4
	Dry unit wt., gd (pcf)		107.4



Results		
	Confining stress, s3 (psi)	45.0
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ef (%)	14.86
	Time to failure, tf (min)	14.9
	Peak shear stress, (s1-s3)/2 (psi)	54.50
	Peak shear stress, (s1-s3)/2 (psf)	7,848
	Peak deviator stress, s1-s3 (psi)	109.00

Photo/Sketch at Failure

Comments:

DRAFT

GERHART COLE

Hydraulic Conductivity Test - Back Pressure, Flexible Wall

after ASTM D5084 Method C

Project: Corn Creek Reservoir | **TH/TP/Sample:** 21-TH-01

No: 21-1406 | **Depth:** 17'-18.17'

Location: Kanosh, UT | Laboratory sample description: reddish brown - brown

Date: 10-Nov-21 | USCS classification: Not requested

Tested by: MGS | Sample type: Undisturbed

Reduced by: BD | Comments:

Reviewed by: MGS

	Initial (o)	Final (f)
Sample Height, H (in)	3.101	2.866
Sample Diameter, D (in)	2.891	2.864
Sample Length, L (cm)	7.877	7.280
Sample Area, A (cm^2)	42.350	41.556
Sample Volume, V (cm^3)	333.57	302.55
Wt. Rings + Wet Soil (g)	464.68	521.73
Wt. Rings (g)	0.00	0.00
Wet Soil + Tare (g)	581.51	638.88
Dry Soil + Tare (g)	483.46	518.21
Tare (g)	120.03	117.85
Weight of solids, Ws (g)	365.95	365.95
Moisture Content, w (%)	26.98	30.14
Wet Unit Wt., g_m (pcf)	87.0	107.7
Dry Unit Wt, g_d (pcf)	68.5	82.7
Volume solids (cm^3)	138.09	138.09
Volume of voids (cm^3)	195.48	164.45
Void ratio, e	1.42	0.80
Porosity, n	0.59	0.44
Volumetric moisture, T	0.30	0.44
Saturation, S (%)	50.5	100.0

Phase Relaionships for Assumed Gs = 2.65

[a] Saturation set to 100% for phase calculations

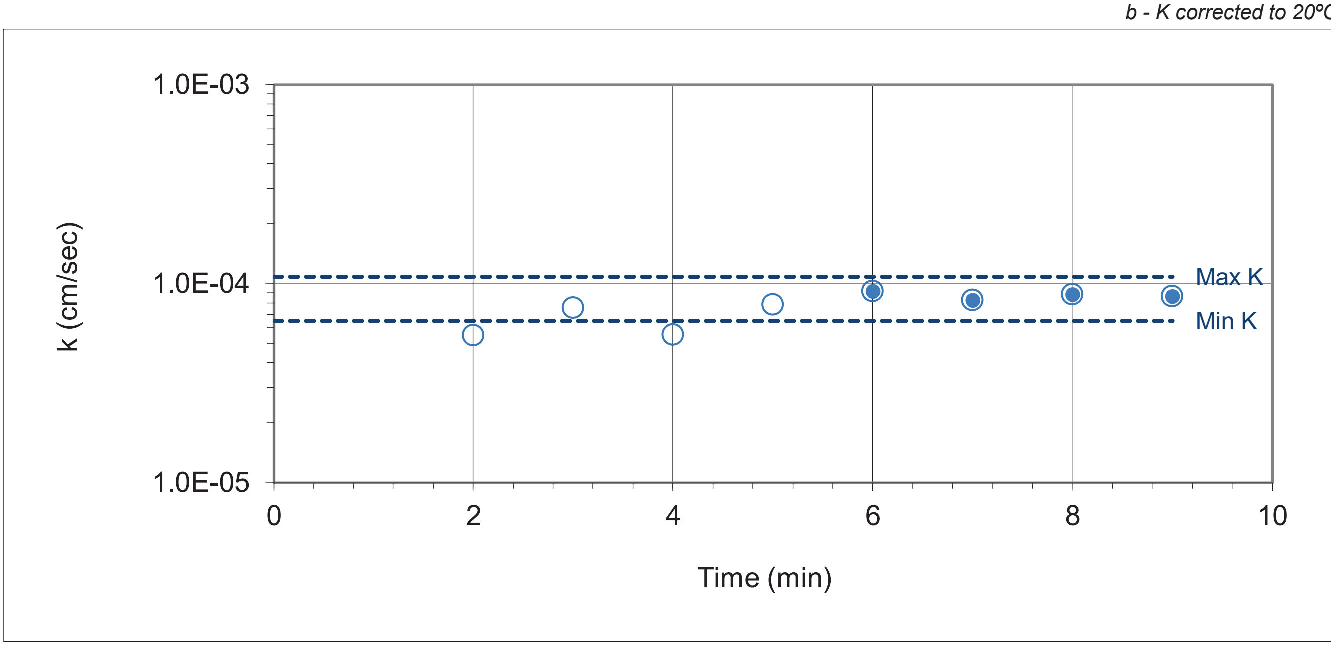
Cell No. / Base No. / Top No.	H1	H2	H3
gw (gm/cm^3)		1.00	Assumed
Permeant liquid used		deaired	
Total backpressure (psi)		45	
Effective horiz. con. stress (psi)		14	
Effective vert. con. stress (psi)		14	

	Initial (o)	Final (f)
B value	0.47	0.96
External Burette (cm^3)	1.00	42.30
Cell Pressure (psi)	2.0	58.0

System volume coefficient (cm^3/psi)	0.18	
System volume change (cm^3)	10.28	
Net sample volume change (cm^3)	-31.02	
Base burette ground length, l_b (cm)	28.9	
Top burette ground length, l_t (cm)	28.9	
Pipet area, api / apo (cm^2)	0.865	0.865
Annulus area, aai / aao (cm^2)	3.433	3.376
Conversion, reading to cm head (cm/rd)	1.156	

K average last 4 values = 8.7E-05

b - K corrected to 20°C



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DRAFT

Project: Corn Creek Reservoir | **TH/TP/Sample:** 21-TH-01

No: 21-1406 | **Depth:** 17'-18.17'

Location: Kanosh, UT | Laboratory sample description: reddish brown - brown

Permeability Data

time (min)	time (sec)	Burrett reading Base	Top	hp (psi)	$h_{(i/f)}$ (cm)	i	K (cm/sec)	Avg. Temp (ºC)	Visc. Ratio Rt	Pore Vol	K^b (cm/sec)
	[pipet]	1.00	24.00	0.0	26.6	3.7					
1.0	60	1.30	24.40	0.0	26.7	3.7	-5.5E-06	20.8	0.98	0.00	-5.4E-06
1.0	60	1.80	23.90	0.0	25.5	3.5	5.6E-05	20.8	0.98	0.00	5.5E-05
1.0	60	2.30	23.10	0.0	24.0	3.3	7.7E-05	20.7	0.98	0.01	7.5E-05
1.0	60	2.90	22.80	0.0	23.0	3.2	5.6E-05	20.4	0.99	0.01	5.5E-05
1.0	60	3.50	22.20	0.0	21.6	3.0	7.9E-05	20.1	1.00	0.01	7.8E-05
1.0	60	4.10	21.50	0.0	20.1	2.8	9.1E-05	19.9	1.00	0.02	9.1E-05
1.0	60	4.70	21.00	0.0	18.8	2.6	8.2E-05	19.9	1.00	0.02	8.3E-05
1.0	60	5.20	20.40	0.0	17.6	2.4	8.8E-05	20.0	1.00	0.02	8.8E-05
1.0	60	5.70	19.90	0.0	16.4	2.3	8.6E-05	20.0	1.00	0.02	8.6E-05

K average last 4 values = 8.7E-05

b - K corrected to 20ºC

DRAFT

Hydraulic Conductivity Test - Back Pressure, Flexible Wall

after ASTM D5084 Method C

GERHART COLE

Project: Corn Creek Reservoir | **TH/TP/Sample: 21-TH-02**

No: 21-1406 | **Depth: 16-17.5 ft**

Location: Kanosh, UT | Laboratory sample description: reddish brown - brown

Date: 10-Nov-21 | USCS classification: Not requested

Tested by: ah | Sample type: Undisturbed

Reduced by: MGS | Comments:

Reviewed by: ah

	Initial (o)	Final (f)
Sample Height, H (in)	2.948	2.863
Sample Diameter, D (in)	2.874	2.740
Sample Length, L (cm)	7.487	7.272
Sample Area, A (cm^2)	41.853	38.048
Sample Volume, V (cm^3)	313.36	276.69
Wt. Rings + Wet Soil (g)	648.87	654.36
Wt. Rings (g)	0.00	0.00
Wet Soil + Tare (g)	449.34	851.70
Dry Soil + Tare (g)	414.74	760.77
Tare (g)	194.73	197.80
Weight of solids, Ws (g)	560.69	560.69
Moisture Content, w (%)	15.73	16.15
Wet Unit Wt., g_m (pcf)	129.3	147.6
Dry Unit Wt, g_d (pcf)	111.7	127.1
Volume solids (cm^3)	211.58	211.58
Volume of voids (cm^3)	101.78	65.10
Void ratio, e	0.48	0.43
Porosity, n	0.32	0.30
Volumetric moisture, T	0.28	0.30
Saturation, S (%)	86.6	100.0
Phase Relaionships for Assumed Gs =	2.65	

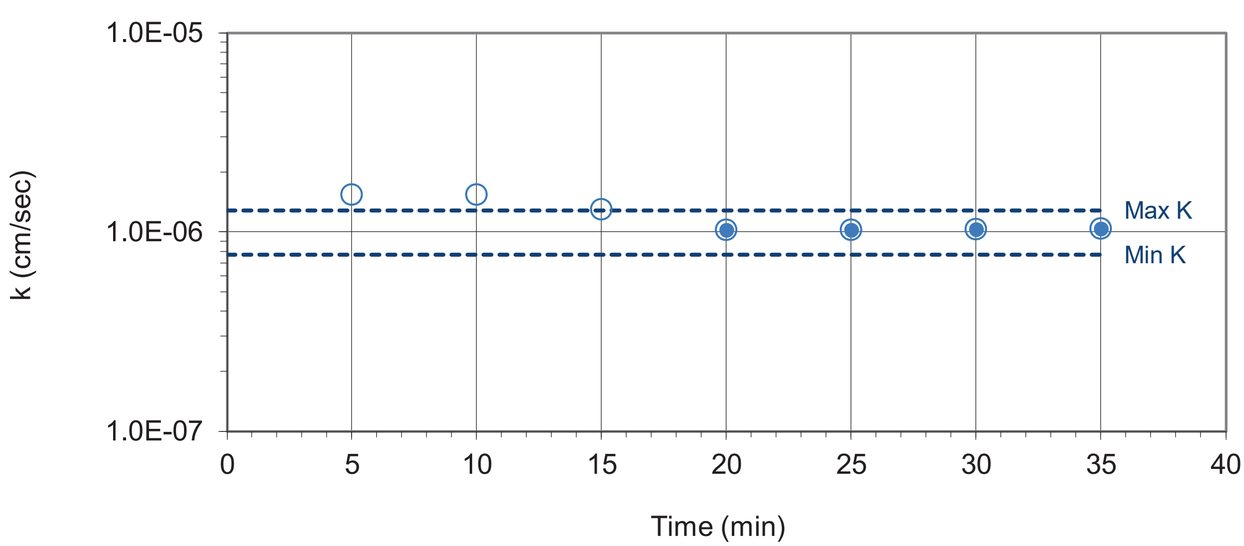
[a] Saturation set to 100% for phase calculations

Cell No. / Base No. / Top No.	F1	F2	F3
gw (gm/cm^3)	1.00	Assumed	
Permeant liquid used	deaired		
Total backpressure (psi)	55		
Effective horiz. con. stress (psi)	13		
Effective vert. con. stress (psi)	13		

	Initial (o)	Final (f)
B value	0.20	0.96
External Burette (cm^3)	8.00	55.10
Cell Pressure (psi)	2.0	67.0
System volume coefficient (cm^3/psi)	0.16	
System volume change (cm^3)	10.43	
Net sample volume change (cm^3)	-36.67	
Base burette ground length, l_b (cm)	28.9	
Top burette ground length, l_t (cm)	28.9	
Pipet area, api / apo (cm^2)	0.865	0.865
Annulus area, aai / aao (cm^2)	3.518	3.345
Conversion, reading to cm head (cm/rd)	1.156	

K average last 4 values = 1.0E-06

b - K corrected to 20ºC



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DRAFT

Project: Corn Creek Reservoir **TH/TP/Sample:** 21-TH-02

No: 21-1406 **Depth:** 16-17.5 ft

Location: Kanosh, UT Laboratory sample description: reddish brown - brown

Permeability Data

time (min)	time (sec)	Burrett reading Base	Burrett reading Top	hp (psi)	$h_{(i/f)}$ (cm)	i	K (cm/sec)	Avg. Temp (ºC)	Visc. Ratio Rt	Pore Vol	K^b (cm/sec)
	[pipet]	1.00	24.00	0.5	61.7	8.5					
5.0	300	1.10	23.80	0.5	61.4	8.4	1.6E-06	20.5	0.99	0.00	1.5E-06
5.0	300	1.30	23.70	0.5	61.0	8.4	1.6E-06	20.8	0.98	0.00	1.5E-06
5.0	300	1.40	23.55	0.5	60.8	8.4	1.3E-06	20.5	0.99	0.00	1.3E-06
5.0	300	1.50	23.45	0.5	60.5	8.3	1.1E-06	21.2	0.97	0.01	1.0E-06
5.0	300	1.60	23.35	0.5	60.3	8.3	1.1E-06	21.2	0.97	0.01	1.0E-06
5.0	300	1.70	23.25	0.5	60.1	8.3	1.1E-06	21.2	0.97	0.01	1.0E-06
5.0	300	1.80	23.15	0.5	59.8	8.2	1.1E-06	21.1	0.97	0.01	1.0E-06

K average last 4 values = 1.0E-06

b - K corrected to 20ºC

DRAFT

Hydraulic Conductivity Test - Back Pressure, Flexible Wall

after ASTM D5084 Method C

GERHART COLE

Project: Corn Creek Reservoir
No: 21-1406
Location: Kanosh, UT
Date: 10-Nov-21
Tested by: ah
Reduced by: MGS
Reviewed by: ah

TH/TP/Sample: 21-TH-04
Depth: 11-13 ft
Laboratory sample description: reddish brown to brown
USCS classification: Not requested
Sample type: Undisturbed
Comments:

	Initial (o)	Final (f)
Sample Height, H (in)	3.086	3.058
Sample Diameter, D (in)	2.833	2.704
Sample Length, L (cm)	7.838	7.766
Sample Area, A (cm^2)	40.668	37.041
Sample Volume, V (cm^3)	318.77	287.68
Wt. Rings + Wet Soil (g)	852.91	610.05
Wt. Rings (g)	316.29	0.00
Wet Soil + Tare (g)	352.23	725.09
Dry Soil + Tare (g)	318.60	596.82
Tare (g)	116.83	116.73
Weight of solids, Ws (g)	459.96	459.96
Moisture Content, w (%)	16.67	26.72
Wet Unit Wt., g_m (pcf)	105.1	132.4
Dry Unit Wt, g_d (pcf)	90.1	104.5
Volume solids (cm^3)	173.57	173.57
Volume of voids (cm^3)	145.20	114.11
Void ratio, e	0.84	0.71
Porosity, n	0.46	0.41
Volumetric moisture, T	0.24	0.41
Saturation, S (%)	52.8	100.0

Phase Relaionships for Assumed Gs = 2.65

[a] Saturation set to 100% for phase calculations

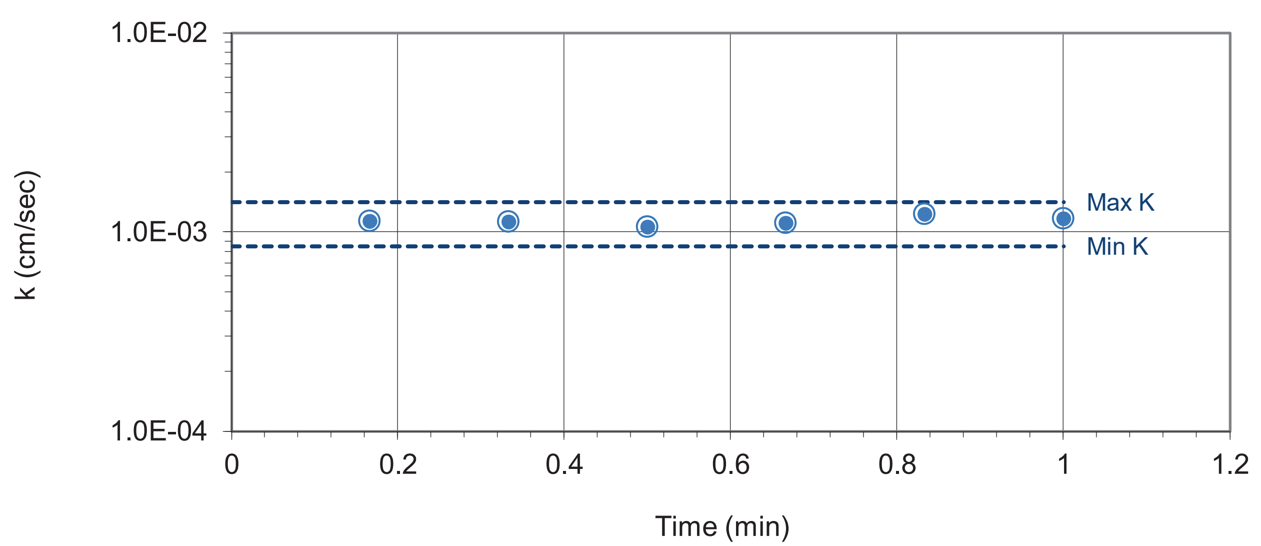
Cell No. / Base No. / Top No.	G1	G2	G3
gw (gm/cm^3)		1.00	Assumed
Permeant liquid used		deaired	
Total backpressure (psi)		55	
Effective horiz. con. stress (psi)		8	
Effective vert. con. stress (psi)		8	

	Initial (o)	Final (f)
B value	0.30	0.98
External Burette (cm^3)	11.10	53.00
Cell Pressure (psi)	2.0	62.0

System volume coefficient (cm^3/psi)	0.18	
System volume change (cm^3)	10.81	
Net sample volume change (cm^3)	-31.09	
Base burette ground length, l_b (cm)	28.9	
Top burette ground length, l_t (cm)	28.9	
Pipet area, api / apo (cm^2)	0.865	0.865
Annulus area, aai / aao (cm^2)	3.325	3.329
Conversion, reading to cm head (cm/rd)	1.156	

K average last 6 values = 1.1E-03

b - K corrected to 20°C



DRAFT

Project: Corn Creek Reservoir **TH/TP/Sample:** 21-TH-04

No: 21-1406 **Depth:** 11-13 ft

Location: Kanosh, UT Laboratory sample description: reddish brown to brown

Permeability Data

time (min)	time (sec)	Burrett reading Base	Top	hp (psi)	$h_{(i/f)}$ (cm)	i	K (cm/sec)	Avg. Temp (ºC)	Visc. Ratio Rt	Pore Vol	K^b (cm/sec)
	[pipet]	1.00	24.00	0.0	26.6	3.4					
0.2	10	2.40	22.65	0.0	23.4	3.0	1.2E-03	20.8	0.98	0.01	1.1E-03
0.2	10	3.60	21.45	0.0	20.6	2.7	1.1E-03	20.8	0.98	0.02	1.1E-03
0.2	10	4.60	20.45	0.0	18.3	2.4	1.1E-03	20.8	0.98	0.02	1.1E-03
0.2	10	5.50	19.50	0.0	16.2	2.1	1.1E-03	20.7	0.98	0.03	1.1E-03
0.2	10	6.40	18.60	0.0	14.1	1.8	1.2E-03	20.7	0.98	0.04	1.2E-03
0.2	10	7.10	17.80	0.0	12.4	1.6	1.2E-03	20.8	0.98	0.04	1.2E-03

K average last 6 values = 1.1E-03

b - K corrected to 20ºC

DRAFT

GERHART COLE

Hydraulic Conductivity Test - Back Pressure, Flexible Wall

after ASTM D5084 Method C

Project: Corn Creek Reservoir | **TH/TP/Sample: 21-TH-01**

No: 21-1406 | **Depth: Combined Clay**

Location: Kanosh, UT | Laboratory sample description: reddish brown to brown

Date: 28-Dec-21 | USCS classification: Not requested

Tested by: AH | Sample type: Undisturbed

Reduced by: AH | Comments:

Reviewed by: MGS

	Initial (o)	Final (f)
Sample Height, H (in)	2.963	2.974
Sample Diameter, D (in)	2.808	2.800
Sample Length, L (cm)	7.527	7.554
Sample Area, A (cm^2)	39.939	39.713
Sample Volume, V (cm^3)	300.62	299.99
Wt. Rings + Wet Soil (g)	594.64	618.80
Wt. Rings (g)	0.00	0.00
Wet Soil + Tare (g)	378.42	744.27
Dry Soil + Tare (g)	343.89	637.29
Tare (g)	144.35	125.69
Weight of solids, Ws (g)	506.92	506.92
Moisture Content, w (%)	17.30	20.91
Wet Unit Wt., g_m (pcf)	123.5	128.8
Dry Unit Wt, g_d (pcf)	105.3	106.5
Volume solids (cm^3)	191.29	191.29
Volume of voids (cm^3)	109.33	108.70
Void ratio, e	0.57	0.55
Porosity, n	0.36	0.36
Volumetric moisture, T	0.29	0.36
Saturation, S (%)	80.2	100.0
Phase Relaionships for Assumed Gs =	2.65	

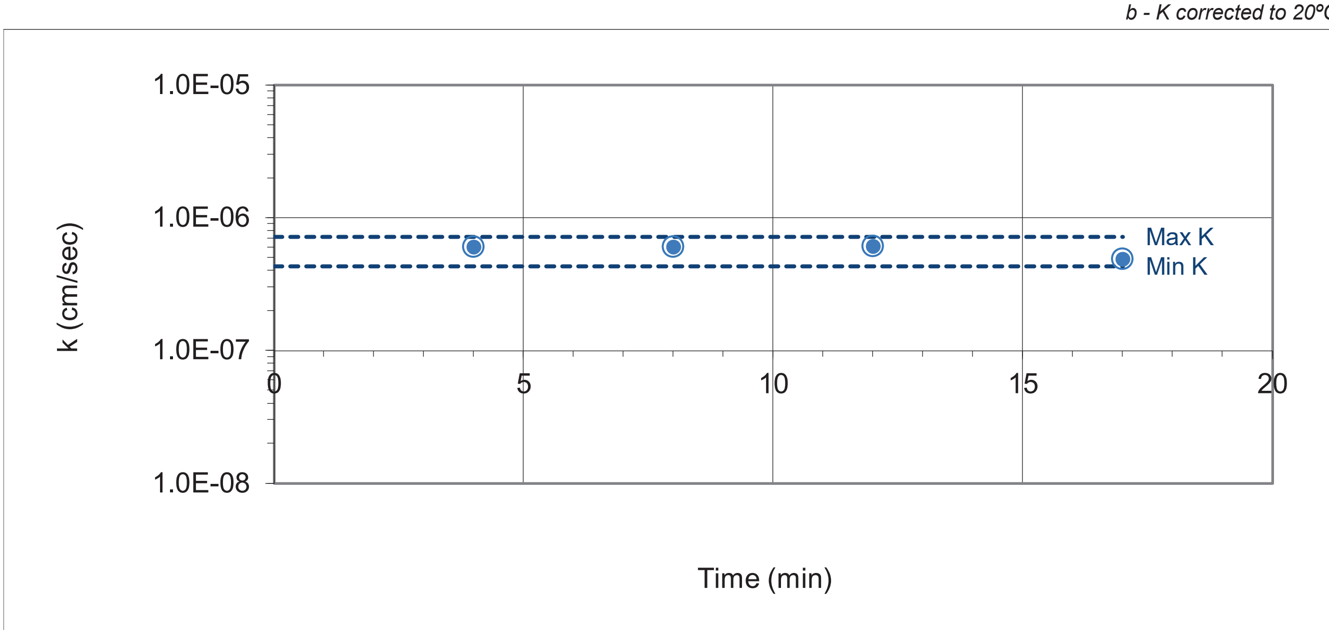
[a] Saturation set to 100% for phase calculations

Cell No. / Base No. / Top No.	B1	B2	B3
gw (gm/cm^3)		1.00	Assumed
Permeant liquid used		deaired	
Total backpressure (psi)		60	
Effective horiz. con. stress (psi)		20	
Effective vert. con. stress (psi)		20	

	Initial (o)	Final (f)
B value	0.17	0.98
External Burette (cm^3)	1.00	10.10
Cell Pressure (psi)	2.0	60.0
System volume coefficient (cm^3/psi)	0.15	
System volume change (cm^3)	8.47	
Net sample volume change (cm^3)	-0.63	
Base burette ground length, l_b (cm)	28.9	
Top burette ground length, l_t (cm)	28.9	
Pipet area, api / apo (cm^2)	0.865	0.865
Annulus area, aai / aao (cm^2)	3.907	3.485
Conversion, reading to cm head (cm/rd)	1.156	

K average last 4 values = 5.8E-07

b - K corrected to 20ºC



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DRAFT

Project: Corn Creek Reservoir **TH/TP/Sample:** 21-TH-01

No: 21-1406 **Depth:** Combined Clay

Location: Kanosh, UT Laboratory sample description: reddish brown to brown

Permeability Data

time (min)	time (sec)	Burrett reading Base	Top	hp (psi)	$h_{(i/f)}$ (cm)	i	K (cm/sec)	Avg. Temp (ºC)	Visc. Ratio Rt	Pore Vol	K^b (cm/sec)
	[pipet]	1.00	24.00	1.0	96.9	12.8					
4.0	240	1.20	23.80	1.0	96.4	12.8	1.6E-06	69.7	0.37	0.00	6.0E-07
4.0	240	1.40	23.60	1.0	96.0	12.7	1.6E-06	69.7	0.37	0.00	6.0E-07
4.0	240	1.60	23.40	1.0	95.5	12.6	1.7E-06	69.5	0.37	0.01	6.1E-07
5.0	300	1.80	23.20	1.0	95.0	12.6	1.3E-06	69.5	0.37	0.01	4.9E-07

K average last 4 values = 5.8E-07

b - K corrected to 20ºC

DRAFT

GERHART COLE

Pinhole Dispersion Test

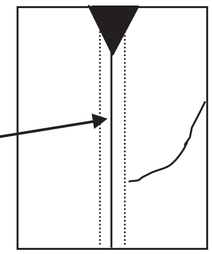
After ASTM D4647 and USBR 5410

Project: Corn Creek
No: 21-1406
Location: Kanosh, UT
Date: 22-Nov-21
Tested by: jc
Reduced by: jc
Checked by: ah

TH/TP/Sample: 21-TH-04
Depth: 11-13 ft
Laboratory sample description: Brown - light brown
USCS classification: Not requested
Compaction specifications: Rel, undisturbed shelby tube

Test type / method: Method A
Sample type: Remolded
Moisture content (%): 17.5
Dry unit weight (pcf): 94.3

Target moisture content (%): as received
Target dry unit weight (pcf): -
Specimen After Test
Final Hole (mm): <=1.5



Dispersive Classification: **ND3 - Moderately to Slightly Dispersive**

		Flow			Turbidity From Side							Particles Falling			
Clock Time	Head (in)	ml	sec	Rate (ml/sec)	Very Dark	Dark	Moderately Dark	Slightly Dark	Barely Visible	Completely Clear	Completely Clear From Top	None	Few	Heavy	Remarks
14:30	2	27.0	60	0.5					X				X		
	2	24.0	60	0.4						X		X			
	2	25.0	60	0.4						X		X			
	2	26.0	60	0.4						X		X			
	2	25.0	60	0.4						X		X			
	2	28.0	180	0.2						X		X			
	2	45.0	120	0.4						X		X			
	2	50.0	60	0.8						X		X			
14:45	7	58.0	60	1.0						X		X			
	7	58.0	60	1.0						X		X			
	7	60.0	60	1.0						X		X			
	7	59.0	60	1.0						X		X			
	7	57.0	60	1.0						X		X			
14:54	15	102.0	60	1.7						X		X			
	15	100.0	60	1.7						X		X			
	15	97.0	60	1.6						X		X			
	15	101.0	60	1.7						X		X			
	15	100.0	60	1.7						X		X			
15:00	40	172.0	60	2.9				X					X		
	40	171.0	60	2.9					X				X		
	40	170.0	60	2.8					X				X		
	40	165.0	60	2.8					X				X		
	40	155.0	60	2.6					X				X		

DRAFT

GERHART COLE

Particle-Size Analysis of Soils with Hydrometer

(after ASTM D422/D4221)

Project: Corn Creek Reservoir
No: 21-1406
Date: 28-Dec-21
Tested by: JC
Reduced by: JC
Reviewed by: AH

TH/TP/Sample: 21-TH-01
Depth: Various
Location: **Kanosh, UT**
Laboratory sample description: reddish brown to brown
Comments:

	Moist	Dry
Split sieve:	Yes	
Split sieve:	3/8"	
Total sample wt. (g):	55175.00	50200.08
+3/8" Coarse fraction (g):	4824.03	4011.2
-3/8" Split fraction (g):	545.11	500.05
Hydrometer fraction (g):	50.02	49.65
Split fraction:	0.920	

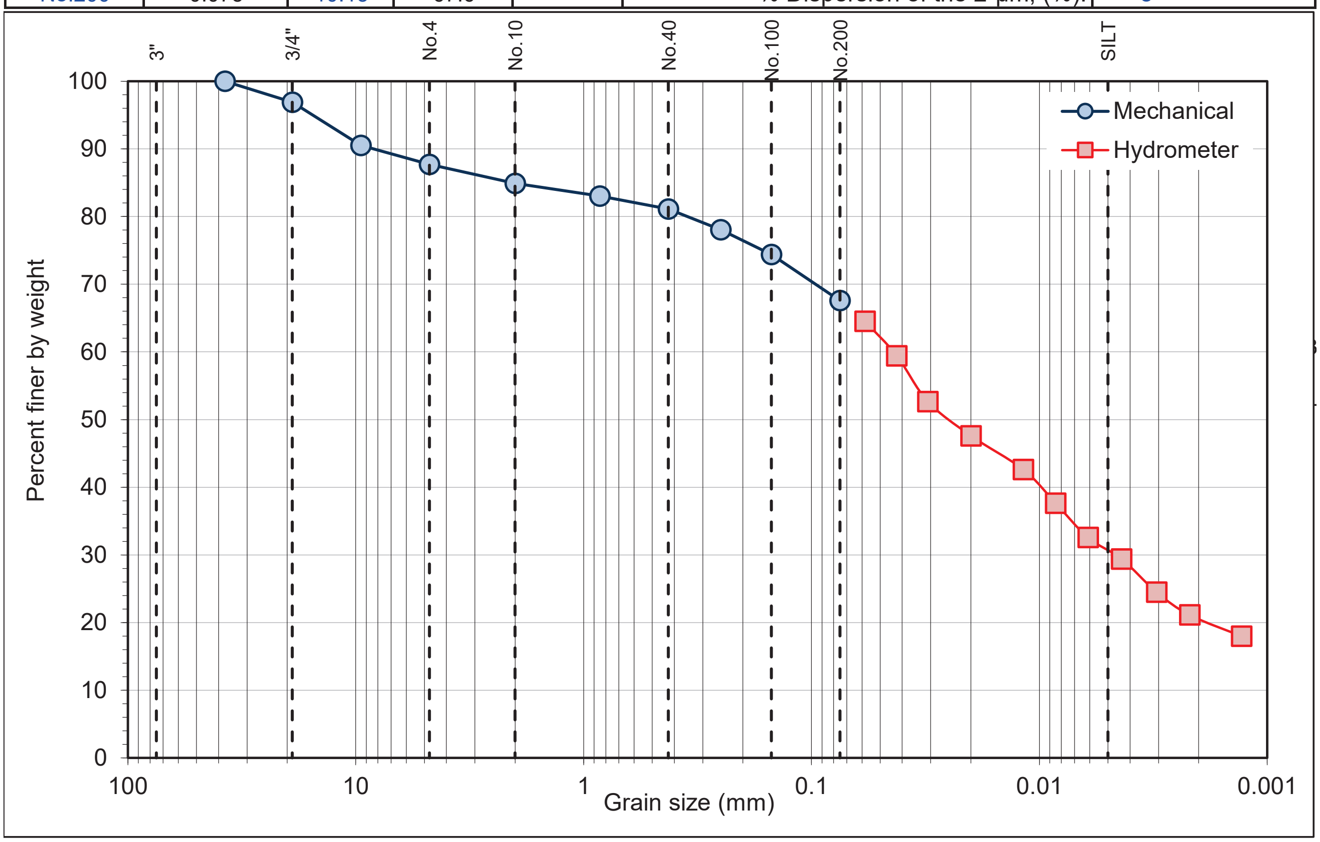
Moisture data	C.F.(+3/8	S.F.(-3/8")	Hyd.(-No.10)
Moist soil + tare (g):	######	662.95	227.11
Dry soil + tare (g):	######	617.89	226.51
Tare (g):	544.32	117.84	146.44
Moisture content (%):	20.26	9.01	0.75

Hydrometer data

Hyd. split:	No.10		Slope:	-0.164
Gs:	2.7	Assumed	Intercept:	16.3
			a:	0.99
Hydrometer Seral #:	546069		Hyd. fraction:	84.89
Dispersion period (min):	10		Dispersion device:	Air-jet

Sieve	Grain Size (mm)	Accum. Wt. Ret. (g	Percent Finer	
12"	300	-	-	
8"	200	-	-	
6"	150	-	-	
4"	100	-	-	
3"	75	-	-	
1.5"	37.5	-	100.0	
3/4"	19	1552.55	96.9	
3/8"	9.5	4759.60	90.5	<=Split
No.4	4.75	23.42	87.7	
No.10	2	38.67	84.9	<=hyd Split
No.20	0.85	1.08	83.0	
No.40	0.425	2.20	81.1	
No.60	0.25	4.00	78.1	
No.100	0.15	6.14	74.4	
No.200	0.075	10.13	67.6	

Elapsed time (min)	Temp. (°C)	Hydrometer Reading	Composite Correction	Grain Size (mm)	% Soil in Suspension
0.5	19.4	43	4.8	0.05826	64.52
1	19.4	40	4.8	0.04228	59.45
2	19.4	36	4.8	0.03088	52.68
5	19.4	33	4.8	0.01999	47.61
15	19.6	30	4.8	0.01177	42.62
30	19.8	27	4.7	0.00848	37.64
60	19.8	24	4.7	0.00612	32.57
120	20.3	22	4.6	0.00436	29.40
250	20.7	19	4.5	0.00306	24.50
500	20.7	17	4.5	0.00219	21.12
1440	21.3	15	4.4	0.00130	18.00
With Dispersion Agent:				0.002	20
Without Dispersion Agent:				0.002	0
% Dispersion of the 2-µm, (%):				0	



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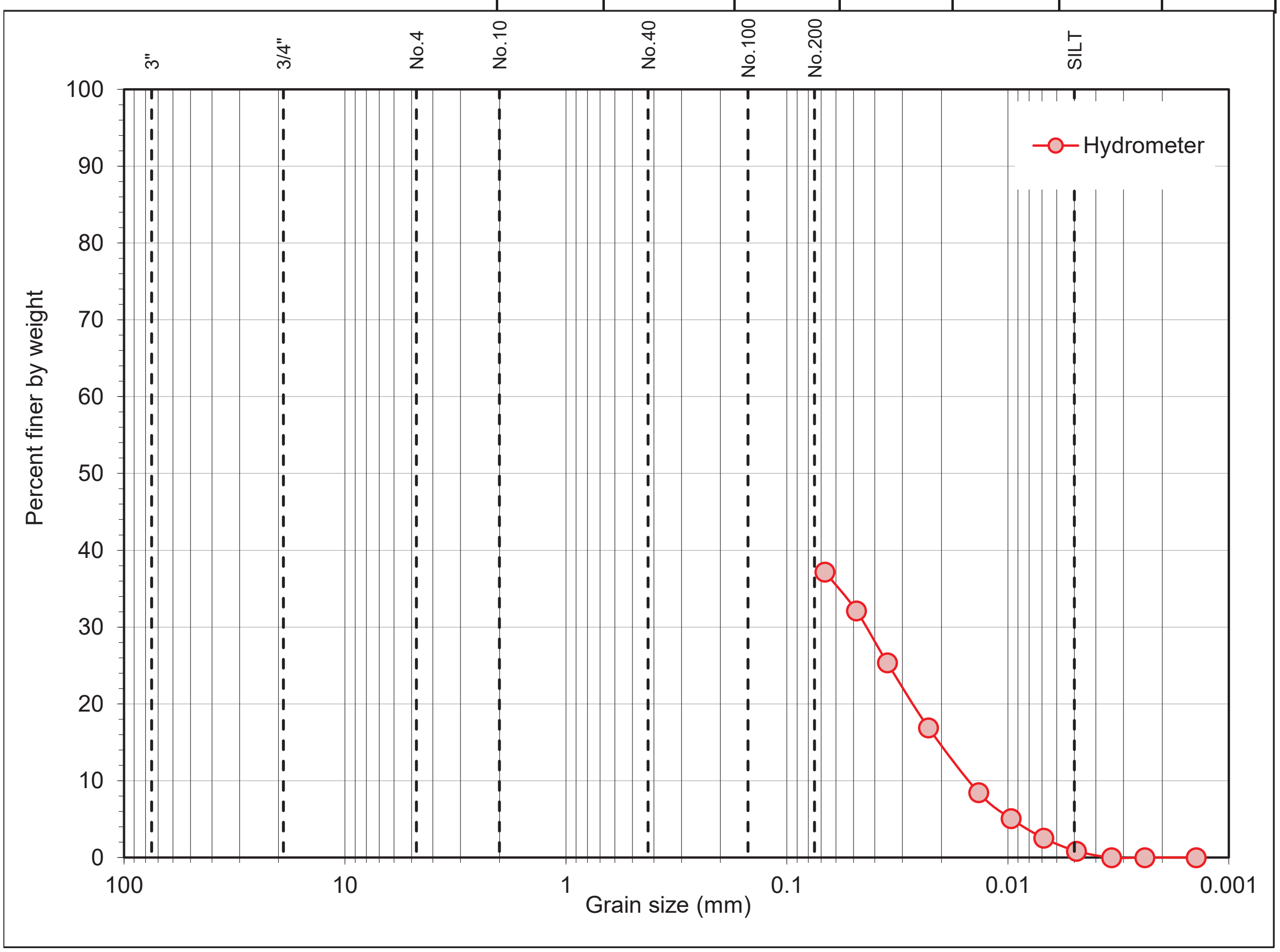
Without Dispersion Agent

Moisture data	C.F.(+3/8	S.F.(-3/8")	Hyd.(-No.10)
Moist soil + tare (g):	######	662.95	220.51
Dry soil + tare (g):	######	617.89	219.80
Tare (g):	544.32	117.84	119.97
Moisture content (%):	20.26	9.01	0.71

Hydrometer data				
			Slope:	-0.164
Hyd. split:	No.10		Intercept:	16.3
Gs:	2.7	Assumed	a:	0.99
Hydrometer Seral #:	546069		Hyd. fraction:	84.89
Dispersion period (min):	0		Dispersion device:	Air-jet

Elapsed time (min)	Temp. (°C)	Hydrometer Reading	Composite Correction	Grain Size (mm)	% Soil in Suspension
0.5	20.5	22	0.0	0.06734	37.20
1	20.5	19	0.0	0.04853	32.13
2	20.5	15	0.0	0.03516	25.36
5	20.5	10	0.0	0.02289	16.91
15	20.6	5	0.0	0.01356	8.45
30	20.6	3	0.0	0.00969	5.07
60	20.7	1.5	0.0	0.00690	2.54
120	20.8	0.5	0.0	0.00490	0.85
250	20.9	0	0.0	0.00340	0.00
500	20.9	0	0.0	0.00240	0.00
1440	21.3	0	0.0	0.00141	0.00



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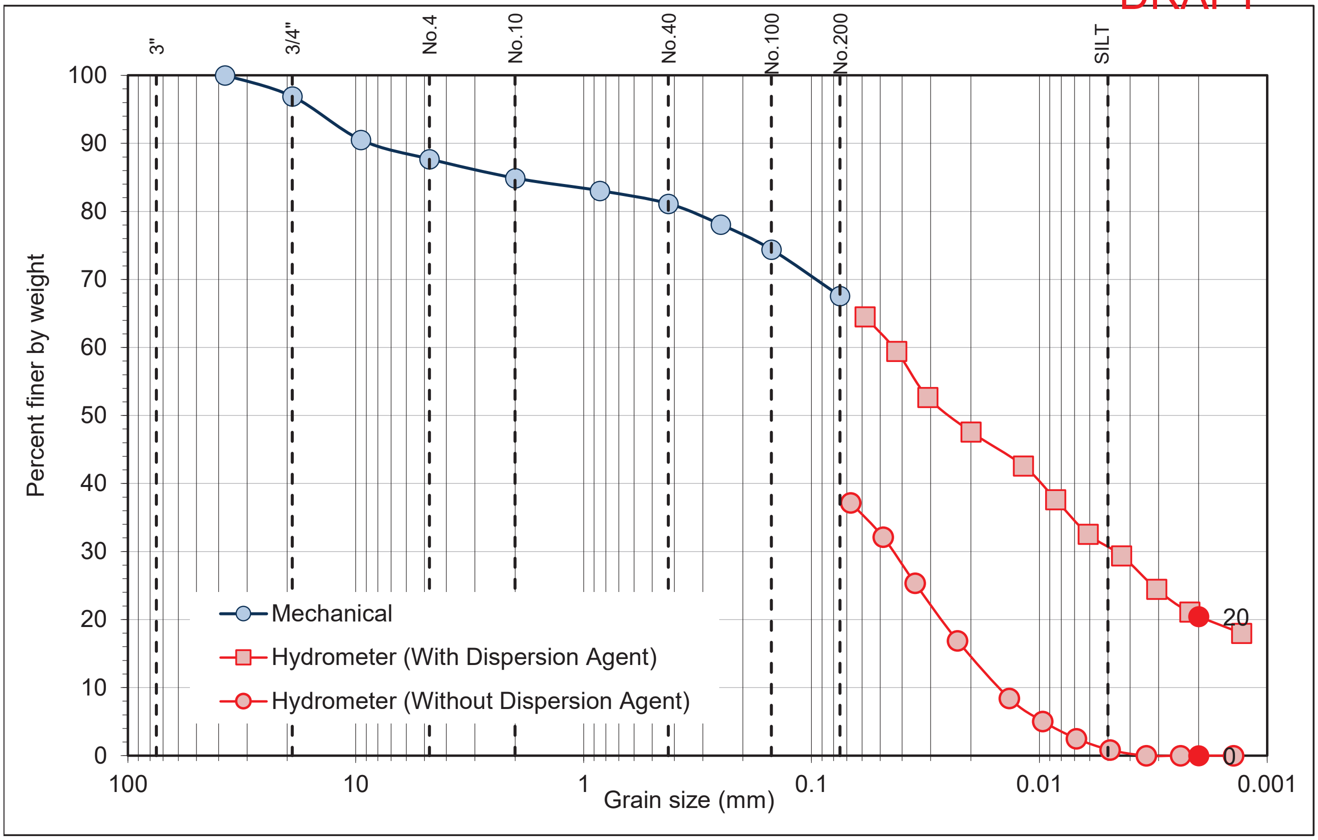

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DRAFT

INORGANIC ANALYTICAL REPORT

Client: Gerhart Cole, Inc. **Contact:** Zach Gibbs
Project: Corn Creek Reservoir / 21-1406
Lab Sample ID: 2111414-001
Client Sample ID: 21-TH-01 @ 17-18.17'
Collection Date:
Received Date: 11/12/2021 1204h

3440 South 700 West
Salt Lake City, UT 84119

Phone: (801) 263-8686
Toll Free: (888) 263-8686
Fax: (801) 263-8687
e-mail: awal@awal-labs.com

web: www.awal-labs.com

Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

Analytical Results TOTAL METALS

Compound	Units	Date Prepared	Date Analyzed	Method Used	Reporting Limit	Analytical Result	Qual
Calcium	mg/kg-dry	11/18/2021 1455h	11/22/2021 1751h	SW6010D	1,250	**48,100**	2
Magnesium	mg/kg-dry	11/18/2021 1455h	11/22/2021 1751h	SW6010D	125	**11,600**	
Potassium	mg/kg-dry	11/18/2021 1455h	11/22/2021 1751h	SW6010D	1,250	**4,680**	
Sodium	mg/kg-dry	11/18/2021 1455h	11/29/2021 1228h	SW6010D	624	**1,230**	

2 - Analyte concentration is too high for accurate matrix spike recovery and/or RPD.
The date collected and expiration status of the sample is unknown as this information was not provided by the client.

3440 South 700 West
Salt Lake City, UT 84119
Phone: (801) 263-8686, Toll Free: (888) 263-8686, Fax: (801) 263-8687
e-mail: awal@awal-labs.com, web: www.awal-labs.com

DRAFT
Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2111414
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: LCS

Lab Sample ID: **LCS-80850** Date Analyzed: 11/22/2021 1744h
Test Code: 6010D-S Date Prepared: 11/18/2021 1455h

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Calcium	951	mg/kg	SW6010D	19.7	100	1,000	0	95.1	80 - 120				
Magnesium	857	mg/kg	SW6010D	3.83	10.0	1,000	0	85.7	80 - 120				
Potassium	909	mg/kg	SW6010D	21.4	100	1,000	0	90.9	80 - 120				
Sodium	918	mg/kg	SW6010D	77.7	100	1,000	0	91.8	80 - 120				

3440 South 700 West
Salt Lake City, UT 84119
Phone: (801) 263-8686, Toll Free: (888) 263-8686, Fax: (801) 263-8687
e-mail: awal@awal-labs.com, web: www.awal-labs.com

DRAFT

Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2111414
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: MBLK

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Lab Sample ID: MB-80850	Date Analyzed: 11/22/2021 1741h												
Test Code: 6010D-S	Date Prepared: 11/18/2021 1455h												
Calcium	< 100	mg/kg	SW6010D	19.7	100								
Magnesium	< 10.0	mg/kg	SW6010D	3.83	10.0								
Potassium	< 100	mg/kg	SW6010D	21.4	100								
Sodium	< 100	mg/kg	SW6010D	77.7	100								

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Salt Lake City, UT 84119
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e-mail: awal@awal-labs.com, web: www.awal-labs.com

DRAFT

Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2111414
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: MS

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Lab Sample ID: **2111414-001AMS**	Date Analyzed: 11/22/2021 1805h												
Test Code: 6010D-S	Date Prepared: 11/18/2021 1455h												
Calcium	44,600	mg/kg-dry	SW6010D	248	1,260	1,258	48100	-280	75 - 125				2
Magnesium	13,200	mg/kg-dry	SW6010D	48.2	126	1,258	11600	125	75 - 125				
Potassium	6,100	mg/kg-dry	SW6010D	269	1,260	1,258	4680	113	75 - 125				
Sodium	2,450	mg/kg-dry	SW6010D	978	1,260	1,258	1230	97.0	75 - 125				

2 - Analyte concentration is too high for accurate matrix spike recovery and/or RPD.

3440 South 700 West
Salt Lake City, UT 84119
Phone: (801) 263-8686, Toll Free: (888) 263-8686, Fax: (801) 263-8687
e-mail: awal@awal-labs.com, web: www.awal-labs.com

DRAFT

Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

American West ANALYTICAL LABORATORIES

QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2111414
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: MSD

Lab Sample ID: 2111414-001AMSD Date Analyzed: 11/22/2021 1808h
Test Code: 6010D-S Date Prepared: 11/18/2021 1455h

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Calcium	45,200	mg/kg-dry	SW6010D	248	1,260	1,258	48100	-232	75 - 125	44600	1.35	20	²
Magnesium	13,000	mg/kg-dry	SW6010D	48.2	126	1,258	11600	108	75 - 125	13200	1.65	20	
Potassium	6,090	mg/kg-dry	SW6010D	269	1,260	1,258	4680	112	75 - 125	6100	0.0725	20	
Sodium	2,440	mg/kg-dry	SW6010D	977	1,260	1,258	1230	95.6	75 - 125	2450	0.735	20	

² - Analyte concentration is too high for accurate matrix spike recovery and/or RPD.

DRAFT

INORGANIC ANALYTICAL REPORT

3440 South 700 West
Salt Lake City, UT 84119

Phone: (801) 263-8686
Toll Free: (888) 263-8686
Fax: (801) 263-8687
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web: www.awal-labs.com

Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

Client: Gerhart Cole, Inc. **Contact:** Zach Gibbs
Project: Corn Creek Reservoir / 21-1406
Lab Sample ID: 2112567-001
Client Sample ID: Combined Sample
Collection Date:
Received Date: 12/21/2021 1701h

Analytical Results TOTAL METALS

Compound	Units	Date Prepared	Date Analyzed	Method Used	Reporting Limit	Analytical Result	Qual
Calcium	mg/kg-dry	12/28/2021 1144h	12/29/2021 1729h	SW6010D	1,060	**77,000**	2
Magnesium	mg/kg-dry	12/28/2021 1144h	12/29/2021 1729h	SW6010D	106	**10,700**	2
Potassium	mg/kg-dry	12/28/2021 1144h	12/29/2021 1740h	SW6010D	212	**3,510**	3
Sodium	mg/kg-dry	12/28/2021 1144h	12/29/2021 1740h	SW6010D	212	**900**	

2 - Analyte concentration is too high for accurate matrix spike recovery and/or RPD.
3 - Matrix spike recoveries and/or high RPDs indicate suspected sample non-homogeneity. The method is in control as indicated by the LCS.
The date collected and expiration status of the sample is unknown as this information was not provided by the client.

3440 South 700 West
Salt Lake City, UT 84119
Phone: (801) 263-8686, Toll Free: (888) 263-8686, Fax: (801) 263-8687
e-mail: awal@awal-labs.com, web: www.awal-labs.com

DRAFT
Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2112567
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: LCS

Lab Sample ID: **LCS-81453** Date Analyzed: 12/29/2021 1728h
Test Code: 6010D-S Date Prepared: 12/28/2021 1144h

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Calcium	966	mg/kg	SW6010D	19.7	100	1,000	0	96.6	80 - 120				
Magnesium	868	mg/kg	SW6010D	3.83	10.0	1,000	0	86.8	80 - 120				
Potassium	930	mg/kg	SW6010D	21.4	100	1,000	0	93.0	80 - 120				
Sodium	944	mg/kg	SW6010D	77.7	100	1,000	0	94.4	80 - 120				

3440 South 700 West
Salt Lake City, UT 84119
Phone: (801) 263-8686, Toll Free: (888) 263-8686, Fax: (801) 263-8687
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DRAFT

Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2112567
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: MBLK

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Lab Sample ID: MB-81453	Date Analyzed: 12/29/2021 1727h												
Test Code: 6010D-S	Date Prepared: 12/28/2021 1144h												
Calcium	< 100	mg/kg	SW6010D	19.7	100								
Magnesium	< 10.0	mg/kg	SW6010D	3.83	10.0								
Potassium	< 100	mg/kg	SW6010D	21.4	100								
Sodium	< 100	mg/kg	SW6010D	77.7	100								

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Salt Lake City, UT 84119
Phone: (801) 263-8686, Toll Free: (888) 263-8686, Fax: (801) 263-8687
e-mail: awal@awal-labs.com, web: www.awal-labs.com

DRAFT

Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2112567
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: MS

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Lab Sample ID: 2112567-001AMS	Date Analyzed: 12/29/2021 1733h												
Test Code: 6010D-S	Date Prepared: 12/28/2021 1144h												
Calcium	72,600	mg/kg-dry	SW6010D	206	1,050	1,047	77000	-413	75 - 125				[2]
Magnesium	12,800	mg/kg-dry	SW6010D	40.1	105	1,047	10700	201	75 - 125				[2]
Lab Sample ID: 2112567-001AMS	Date Analyzed: 12/29/2021 1742h												
Test Code: 6010D-S	Date Prepared: 12/28/2021 1144h												
Potassium	3,970	mg/kg-dry	SW6010D	112	523	1,047	3510	43.0	75 - 125				[3]
Sodium	1,740	mg/kg-dry	SW6010D	407	523	1,047	900	80.2	75 - 125				

[2] - Analyte concentration is too high for accurate matrix spike recovery and/or RPD.
[3] - Matrix spike recoveries and/or high RPDs indicate suspected sample non-homogeneity. The method is in control as indicated by the LCS.

3440 South 700 West
Salt Lake City, UT 84119
Phone: (801) 263-8686, Toll Free: (888) 263-8686, Fax: (801) 263-8687
e-mail: awal@awal-labs.com, web: www.awal-labs.com

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QC SUMMARY REPORT

Client: Gerhart Cole, Inc.
Lab Set ID: 2112567
Project: Corn Creek Reservoir / 21-1406

Contact: Zach Gibbs
Dept: ME
QC Type: MSD

Analyte	Result	Units	Method	MDL	Reporting Limit	Amount Spiked	Spike Ref. Amount	%REC	Limits	RPD Ref. Amt	% RPD	RPD Limit	Qual
Lab Sample ID: 2112567-001AMSD	Date Analyzed: 12/29/2021 1735h												
Test Code: 6010D-S	Date Prepared: 12/28/2021 1144h												
Calcium	62,400	mg/kg-dry	SW6010D	208	1,060	1,056	77000	-1,380	75 - 125	72600	15.2	20	2
Magnesium	10,600	mg/kg-dry	SW6010D	40.5	106	1,056	10700	-11.9	75 - 125	12800	19.0	20	2
Lab Sample ID: 2112567-001AMSD	Date Analyzed: 12/29/2021 1743h												
Test Code: 6010D-S	Date Prepared: 12/28/2021 1144h												
Potassium	3,760	mg/kg-dry	SW6010D	113	528	1,056	3510	22.9	75 - 125	3970	5.40	20	3
Sodium	1,760	mg/kg-dry	SW6010D	410	528	1,056	900	81.8	75 - 125	1740	1.35	20	

2 - Analyte concentration is too high for accurate matrix spike recovery and/or RPD.
3 - Matrix spike recoveries and/or high RPDs indicate suspected sample non-homogeneity. The method is in control as indicated by the LCS.

Appendix D

Seismicity and Seismic Effects
Corn Creek Reservoir
GC Project No.: 21-1406

Table of Contents

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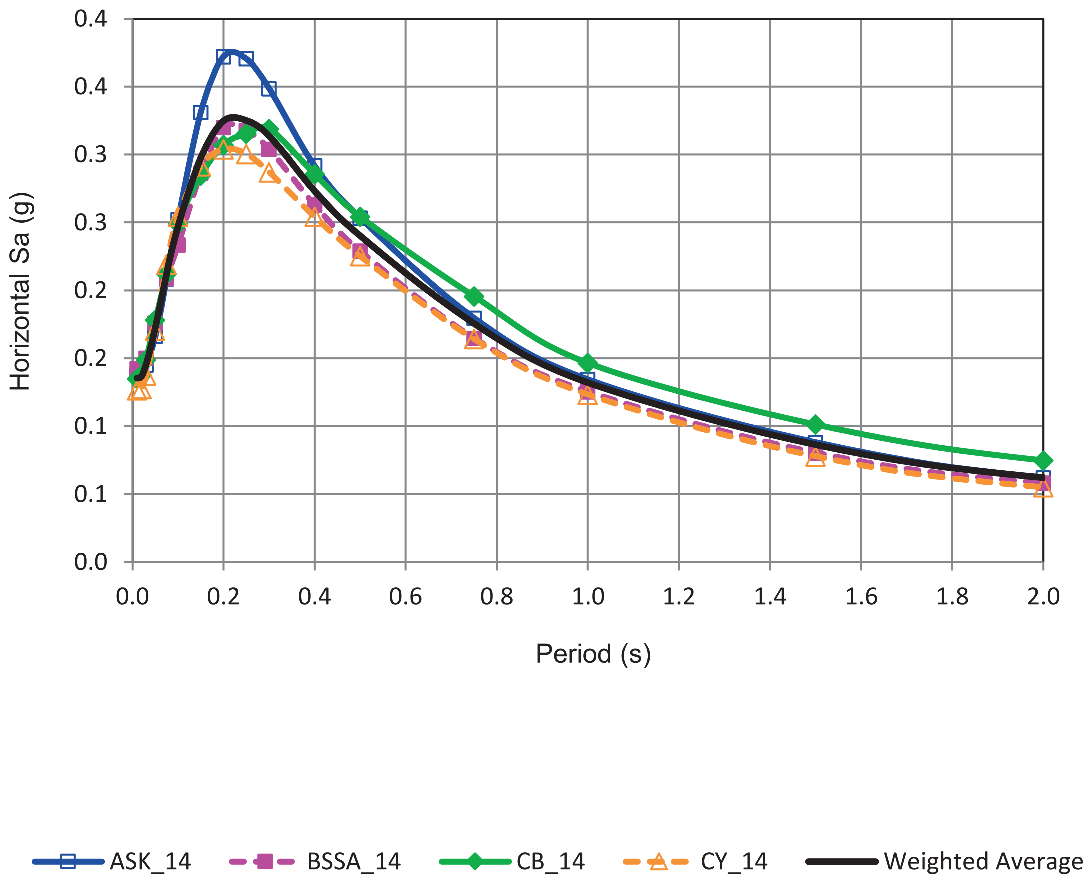


GERHART COLE	Median Spectral Accelerations from GMPEs SVSPRMGRC Linked Faults	
	Corn Creek Reservoir	Figure D-1

DRAFT

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

WEIGHTED AVERAGE of 2014 NGA WEST-2 GMPEs

Last updated: 07 05 14

by Emel Seyhan, PhD, PEER & UCLA -- email: emel.seyhan@gmail.com, peer_center@berkeley.edu

This excel file will be updated as necessary on the PEER website to fix any typos or other errors. Please check the website frequently for new versions at: http://peer.berkeley.edu/ngawest2/databases/

Legend	Pre-defined option	Main input variable	Calculated variable	Input var. flag	Internal variable

GMPE averaging	Geometric	*Weighted average of the natural logarithm of the spectral values*

GMPEs	ASK14	BSSA14	CB14	CY14	I14
Weight	0.25	0.25	0.25	0.25	0

# of std. dev.	1	
Damping ratio (%)	5	*Modification factors are calculated in Sheet DSF*

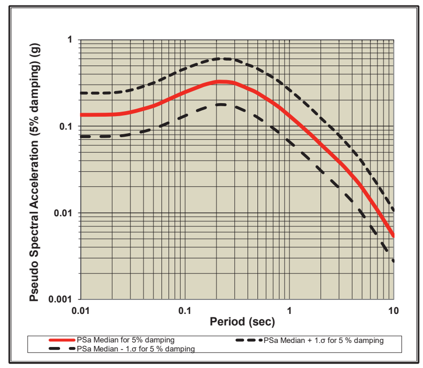
ASK14 Abrahamson & Silva & Kamai 2014 NGA West-2 Model
BSSA14 Boore & Stewart & Seyhan & Atkinson 2014 NGA West-2 Model
CB14 Campbell & Bozorgnia 2014 NGA West-2 Model
CY14 Chiou & Youngs 2014 NGA West-2 Model
I14 Idriss 2014 NGA West-2 Model

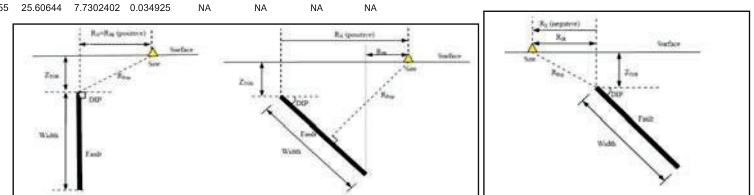
Site / Fault: SVSPRMGRC Linked Faults

RotD50 Horizontal Component of PGA, PGV and *IMs*

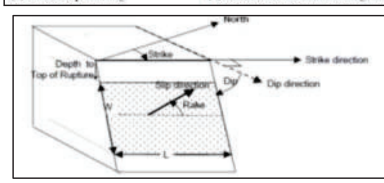
Input variables	Errors and warnings
Mw 7.1	
RRUP (km) 28.2	
RJB (km) 23.8	
RX (km) 34.3	
Ry0 (km) 9.8	*If unknown use 999*
VS30 (m/sec) 435	
U (BSSA13) 0	*1: Unspecified fault mech.*
FRV 0	*1: reverse fault*
FNM 1	*1: normal fault*
FHW 1	*1: hanging wall side*
Δ1π (δεγ) 50	
ZTOR (km) 0.000	*If unknown use 999*
ZHYP (km) 999.000	*If unknown use 999*
Z1.0 (km) 999.000	*If unknown use 999*
Z2.5 (km) 999.000	*If unknown use 999*
W (km) 19.581	*If unknown use 999*
Vs30Flag measured	*Choose options for V_{s30} from the list*
FAS no	*Aftershock effect is not applicable.*
Region California	*Choose region from the list*

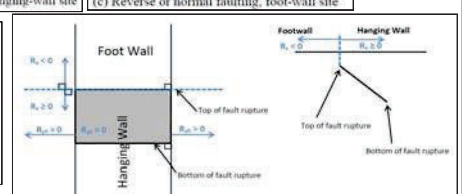
GMP	T (s)	Baseline: 5% Damping				User defined: 5% Damping			
		PSa Median for 5% damping	PSa Median + 1.σ for 5% damping	PSa Median - 1.σ for 5% damping	S_d Median for 5% damping	PSa Median for 5% damping	PSa Median + 1.σ for 5 % damping	PSa Median - 1.σ for 5 % damping	Sd Median for 5 % damping
PSa (g), S_d (cm)	0.01	0.1353721	0.241071	0.0760175	0.000336	0.1353721	0.241071	0.0760175	0.000336
	0.02	0.1367684	0.2439917	0.0766649	0.001358	0.1367684	0.2439917	0.0766649	0.001358
	0.03	0.1453832	0.2617264	0.0807572	0.003248	0.1453832	0.2617264	0.0807572	0.003248
	0.05	0.1726407	0.3169543	0.094035	0.010714	0.1728133	0.3172713	0.094129	0.010725
	0.075	0.2121061	0.3958918	0.1136397	0.029617	0.2127425	0.3970795	0.1139806	0.029706
	0.1	0.2472774	0.4628589	0.1321053	0.061383	0.2480192	0.4642474	0.1325016	0.061568
	0.15	0.2978446	0.5507981	0.1610598	0.166356	0.2984403	0.5518997	0.1613819	0.166689
	0.2	0.3247839	0.5967004	0.1767799	0.322493	0.3254335	0.5978938	0.1771334	0.323138
	0.25	0.3251004	0.598025	0.1767322	0.504387	0.3251004	0.598025	0.1767322	0.504387
	0.3	0.3138641	0.5836447	0.1687853	0.701214	0.3144918	0.584812	0.1691229	0.702616
	0.4	0.2732092	0.5140312	0.1452115	1.08513	0.2734824	0.5145453	0.1453567	1.086215
	0.5	0.2401669	0.458876	0.1256988	1.490457	0.2401669	0.458876	0.1256988	1.490457
	0.75	0.175644	0.3456754	0.0892479	2.452574	0.1758196	0.3460211	0.0893371	2.455026
	1	0.1321837	0.2634561	0.0663205	3.281288	0.1323159	0.2637195	0.0663868	3.284569
	1.5	0.0865325	0.1736911	0.0431103	4.833125	0.086619	0.1738648	0.0431534	4.837958
	2	0.0621756	0.1249542	0.0309378	6.173711	0.0621134	0.1248293	0.0309068	6.167537
	3	0.0391539	0.0786361	0.0194952	8.747494	0.0391539	0.0786361	0.0194952	8.747494
	4	0.0270044	0.0536792	0.0135851	10.72559	0.0269504	0.0535718	0.013558	10.70414
	5	0.0193538	0.0385493	0.0097166	12.01079	0.0192957	0.0384336	0.0096874	11.97476
	7.5	0.0094646	0.0188005	0.0047647	13.21571	0.0094173	0.0187065	0.0047408	13.14963
	10	0.0054544	0.0107333	0.0027718	13.53992	0.0054272	0.0106796	0.002758	13.47222
PGA (g)	0	0.1348432	0.2399383	0.0757807	0.000335	0.1353721	0.241071	0.0760175	0.000336
PGV (cm/s)	-1	14.069255	25.60644	7.7302402	0.034925	NA	NA	NA	NA





(a) Strike slip faulting (b) Reverse or normal faulting, hanging-wall site (c) Reverse or normal faulting, foot-wall site





Courtesy: Jennifer Donahue

Calculated Variables/Flags

ΔDPP 0	*Always 0 for median calcs.*
PGA r (g) 0.107	
Z_{BOT} (km) (CB14) 15	*Enter for default W calcs*
SS 0	*auto calculated*
$V_{s30Flag}$ 1	*measured*
F_{AS} 0	*Aftershock effect is not applicable.*
Region 0	*California*
Option for Sa value 1	*Weighted average of the natural logarithm of the spectral values*

Definition of Parameters

Damping ratio = Viscous damping ratio (%) See Sanaz et al. (2012) PEER Report
PSA = Pseudo-absolute acceleration response spectrum (g)
PGA = Peak ground acceleration (g)
PGV = Peak ground velocity (cm/s)
S_d = Relative displacement response spectrum (cm)
M_w = Moment magnitude
R_{RUP} = Closest distance to coseismic rupture (km), used in ASK13, CB13 and CY13. See Figures a, b and c for illustration
R_{JB} = Closest distance to surface projection of coseismic rupture (km). See Figures a, b and c for illustration
R_X = Horizontal distance from top of rupture measured perpendicular to fault strike (km). See Figures a, b and c for illustration
R_{y0} = The horizontal distance off the end of the rupture measured parallel to strike (km)
V_{S30} = The average shear-wave velocity (m/s) over a subsurface depth of 30 m
U = Unspecified-mechanism factor: 1 for unspecified; 0 otherwise
F_{RV} = Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust
F_{NM} = Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique, thrust and normal-oblique; 1 for normal
F_{HW} = Hanging-wall factor: 1 for site on down-dip side of top of rupture; 0 otherwise
Dip = Average dip of rupture plane (degrees)
Z_{TOR} = Depth to top of coseismic rupture (km)
Z_{HYP} = Hypocentral depth from the earthquake
$Z_{1.0}$ = Depth to Vs=1 km/sec
$Z_{2.5}$ = Depth to Vs=2.5 km/sec
W = Fault rupture width (km)
$V_{s30flag}$ = 1 for measured, 0 for inferred Vs30
F_{AS} = 0 for mainshock; 1 for aftershock
Region = Specific regions considered in the models, Click on Region to see codes
ΔDPP = Directivity term, direct point parameter; uses 0 for median predictions
PGA_r (g) = Peak ground acceleration on rock (g), this specific cell is updated in the cell for BSSA14 and CB14, for others it is taken account for in the macros
Z_{BOT} (km) = The depth to the bottom of the seismogenic crust
Z_{BOR} (km) = The depth to the bottom of the rupture plane
SS = 1 for strike slip, automatically updated in the cell

Input variables with defaults (If entered 999 as input):

Red colored value: The value is used in the code when input is unknown

DEFAULTs	USER defined	ASK14	BSSA14	CB14	CY14	I14
W (km)	19.58			19.497		
$Z_{1.0}$ (km)	999.000	0.325			0.311	
$\delta Z_{1.0}$ (km)	0.000		0.000			
$Z_{2.5}$ (V_{S30}=1100)(km)	999.000			0.398		
$Z_{2.5}$ (V_{S30})(km)	999.000			1.149		
Z_{hyp} (km)	999.00			10.291		
Z_{tor} (km)	0.00			0.064	0.064	
Z_{BOR} (km)	-			15.000		

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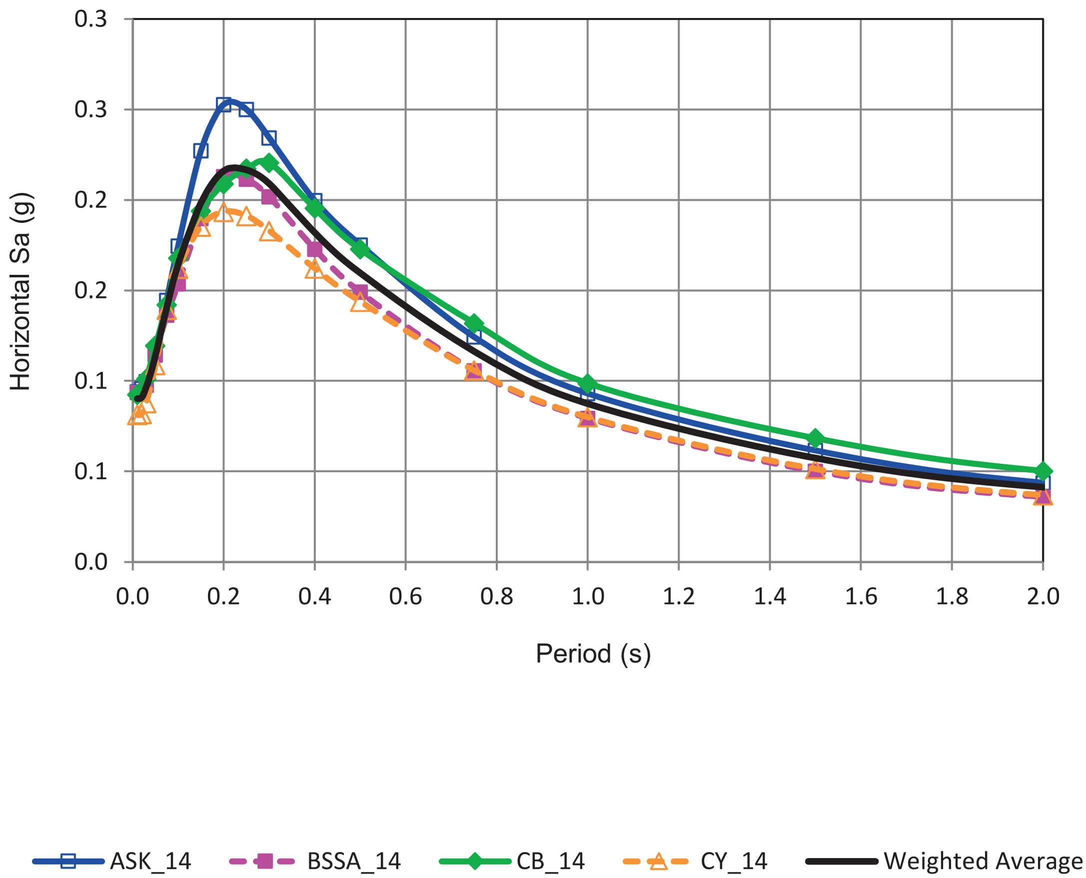

GERHART COLE

Median Spectral Accelerations from GMPEs
Beaver Basin Eastern Margin

Corn Creek Reservoir

Figure D-2

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PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

WEIGHTED AVERAGE of 2014 NGA WEST-2 GMPEs

Last updated: 07 05 14

by Emel Seyhan, PhD, PEER & UCLA -- email: emel.seyhan@gmail.com, peer_center@berkeley.edu

This excel file will be updated as necessary on the PEER website to fix any typos or other errors. Please check the website frequently for new versions at: http://peer.berkeley.edu/ngawest2/databases/

Legend	Pre-defined option	Main input variable	Calculated variable	Input var. flag	Internal variable

GMPE averaging	Geometric	*Weighted average of the natural logarithm of the spectral values*

GMPEs	ASK14	BSSA14	CB14	CY14	I14
Weight	0.25	0.25	0.25	0.25	0

ASK14 Abrahamson & Silva & Kamai 2014 NGA West-2 Model
BSSA14 Boore & Stewart & Seyhan & Atkinson 2014 NGA West-2 Model
CB14 Campbell & Bozorgnia 2014 NGA West-2 Model
CY14 Chiou & Youngs 2014 NGA West-2 Model
I14 Idriss 2014 NGA West-2 Model

# of std. dev.	1	
Damping ratio (%)	5	*Modification factors are calculated in Sheet DSF*

Site / Fault: Beaver Basin Eastern Margin

Input variables | **Errors and warnings**

Variable	Value	Note
Mw	7	
RRUP (km)	37.1	
RJB (km)	37.1	
RX (km)	-15	
Ry0 (km)	34	*If unknown use 999*
VS30 (m/sec)	435	
U (BSSA13)	0	*1: Unspecified fault mech.*
FRV	0	*1: reverse fault*
FNM	1	*1: normal fault*
FHW	0	*1: hanging wall side*
$\Delta\iota\pi$ ($\delta\varepsilon\gamma$)	50	
ZTOR (km)	0.000	*If unknown use 999*
ZHYP (km)	999.000	*If unknown use 999*
Z1.0 (km)	999.000	*If unknown use 999*
Z2.5 (km)	999.000	*If unknown use 999*
W (km)	19.581	*If unknown use 999*
Vs30Flag	measured	*Choose options for V_{s30} from the list*
FAS	no	*Aftershock effect is not applicable.*
Region	California	*Choose region from the list*

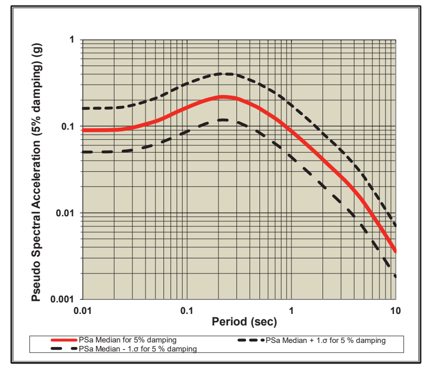
Calculated Variables/Flags

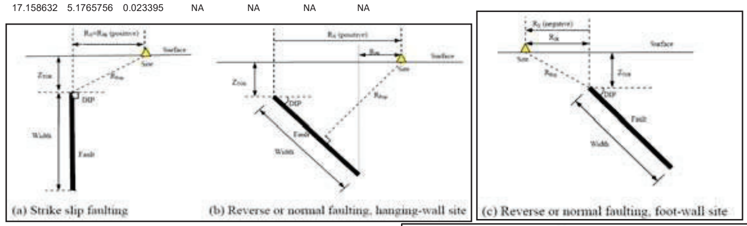
Variable	Value	Note
ΔDPP	0	*Always 0 for median calcs.*
PGA_r (g)	0.069	
Z_{BOT} (km) (CB14)	15	*Enter for default W calcs*
SS	0	*auto calculated*
$V_{s30Flag}$	1	*measured*
F_{AS}	0	*Aftershock effect is not applicable.*
Region	0	*California*
Option for Sa value	1	*Weighted average of the natural logarithm of the spectral values*

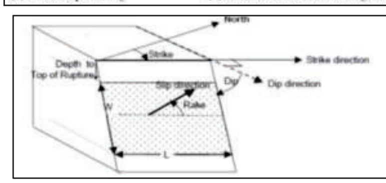
RotD50 Horizontal Component of PGA, PGV and *IMs*

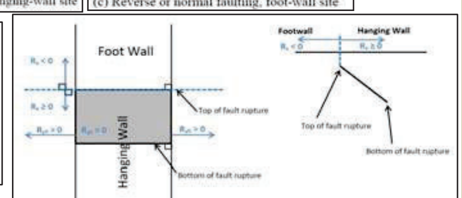
GMP: PSa (g), S_d (cm)

	T (s)	Baseline: 5% Damping				User defined: 5% Damping			
		PSa Median for 5% damping	PSa Median + 1.σ for 5% damping	PSa Median - 1.σ for 5% damping	S_d Median for 5% damping	PSa Median for 5% damping	PSa Median + 1.σ for 5 % damping	PSa Median - 1.σ for 5 % damping	Sd Median for 5 % damping
	0.01	0.0902432	0.1613892	0.0504609	0.000224	0.0902432	0.1613892	0.0504609	0.000224
	0.02	0.0909818	0.1630221	0.0507764	0.000903	0.0909818	0.1630221	0.0507764	0.000903
	0.03	0.0965315	0.1746902	0.053342	0.002157	0.0965315	0.1746902	0.053342	0.002157
	0.05	0.1143514	0.2114675	0.0618358	0.007097	0.1144658	0.2116789	0.0618976	0.007104
	0.075	0.1406423	0.2648396	0.0746877	0.019638	0.1410642	0.2656341	0.0749117	0.019697
	0.1	0.1644219	0.3106877	0.0870152	0.040816	0.1649151	0.3116198	0.0872763	0.040938
	0.15	0.1984884	0.3702755	0.106401	0.110862	0.1988854	0.371016	0.1066138	0.111084
	0.2	0.216033	0.3995997	0.1167925	0.214509	0.2164651	0.4003989	0.1170261	0.214938
	0.25	0.2165331	0.4002077	0.1171556	0.335947	0.2165331	0.4002077	0.1171556	0.335947
	0.3	0.2090288	0.3899105	0.1120592	0.466998	0.2094469	0.3906903	0.1122833	0.467932
	0.4	0.1819119	0.3429311	0.0964973	0.722516	0.1820938	0.343274	0.0965938	0.723238
	0.5	0.1596754	0.3054762	0.0834639	0.990933	0.1596754	0.3054762	0.0834639	0.990933
	0.75	0.1164552	0.229341	0.0591338	1.626102	0.1165716	0.2295703	0.059193	1.627728
	1	0.0874587	0.1743915	0.0438612	2.171048	0.0875462	0.1745659	0.0439051	2.173219
	1.5	0.0574505	0.1153495	0.0286136	3.208803	0.057508	0.1154649	0.0286422	3.212011
	2	0.0413695	0.0831601	0.02058	4.107771	0.0413281	0.0830769	0.0205594	4.103663
	3	0.0262754	0.0527759	0.0130817	5.870277	0.0262754	0.0527759	0.0130817	5.870277
	4	0.0181912	0.0361606	0.0091514	7.22515	0.0181548	0.0360883	0.0091331	7.2107
	5	0.0129756	0.0258451	0.0065144	8.052545	0.0129367	0.0257676	0.0064949	8.028387
	7.5	0.0062896	0.0124936	0.0031663	8.782327	0.0062581	0.0124312	0.0031505	8.738415
	10	0.0036219	0.0071272	0.0018406	8.990862	0.0036038	0.0070915	0.0018314	8.945907
PGA (g)	**0**	0.0898999	0.1606471	0.050309	0.000223	0.0902432	0.1613892	0.0504609	0.000224
PGV (cm/s)	**-1**	9.424593	17.158632	5.1765756	0.023395	NA	NA	NA	NA









Courtesy: Jennifer Donahue

Definition of Parameters

Damping ratio = Viscous damping ratio (%) See Sanaz et al. (2012) PEER Report
PSA = Pseudo-absolute acceleration response spectrum (g)
PGA = Peak ground acceleration (g)
PGV = Peak ground velocity (cm/s)
S_d = Relative displacement response spectrum (cm)
M_w = Moment magnitude
R_{RUP} = Closest distance to coseismic rupture (km), used in ASK13, CB13 and CY13. See Figures a, b and c for illustation
R_{JB} = Closest distance to surface projection of coseismic rupture (km). See Figures a, b and c for illustation
R_X = Horizontal distance from top of rupture measured perpendicular to fault strike (km). See Figures a, b and c for illustation
R_{y0} = The horizontal distance off the end of the rupture measured parallel to strike (km)
V_{S30} = The average shear-wave velocity (m/s) over a subsurface depth of 30 m
U = Unspecified-mechanism factor: 1 for unspecified; 0 otherwise
F_{RV} = Reverse-faulting factor: 0 for strike slip, normal, normal-oblique; 1 for reverse, reverse-oblique and thrust
F_{NM} = Normal-faulting factor: 0 for strike slip, reverse, reverse-oblique, thrust and normal-oblique; 1 for normal
F_{HW} = Hanging-wall factor: 1 for site on down-dip side of top of rupture; 0 otherwise
Dip = Average dip of rupture plane (degrees)
Z_{TOR} = Depth to top of coseismic rupture (km)
Z_{HYP} = Hypocentral depth from the earthquake
$Z_{1.0}$ = Depth to Vs=1 km/sec
$Z_{2.5}$ = Depth to Vs=2.5 km/sec
W = Fault rupture width (km)
$V_{s30flag}$ = 1 for measured, 0 for inferred Vs30
F_{AS} = 0 for mainshock; 1 for aftershock
Region = Specific regions considered in the models, Click on Region to see codes
ΔDPP = Directivity term, direct point parameter; uses 0 for median predictions
PGA_r ***(g)*** = Peak ground acceleration on rock (g), this specific cell is updated in the cell for BSSA14 and CB14, for others it is taken account for in the macros
Z_{BOT} ***(km)*** = The depth to the bottom of the seismogenic crust
Z_{BOR} ***(km)*** = The depth to the bottom of the rupture plane
SS = 1 for strike slip, automatically updated in the cell

Input variables with defaults (If entered 999 as input):

Red colored value: The value is used in the code when input is unknown

DEFAULTs	USER defined	ASK14	BSSA14	CB14	CY14	I14
W (km)	19.58			19.405		
$Z_{1.0}$ (km)	999.000	0.325			0.311	
$\delta Z_{1.0}$ (km)	0.000		0.000			
$Z_{2.5}$ (V_{S30}=1100)(km)	999.000			0.398		
$Z_{2.5}$ (V_{S30})(km)	999.000			1.149		
Z_{hyp} (km)	999.00			10.361		
Z_{tor} (km)	0.00			0.135	0.135	
Z_{BOR} (km)	-			15.000		

GERHART COLE

Appendix E

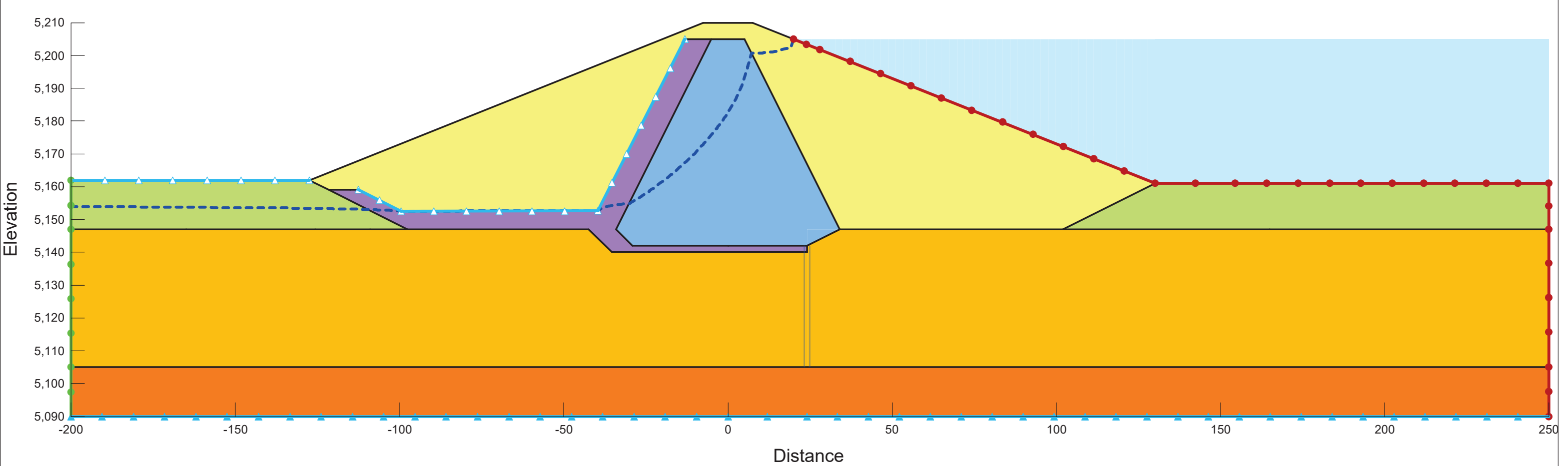
Calculations
Corn Creek Reservoir

Table of Contents

DRAFT

Color	Name	Hydraulic Material Model	Sat Kx (ft/d)	Ky'/Kx' Ratio
	Bedrock	Saturated Only	0.014	1
	Filter Sand/Drain Gravel	Saturated Only	1,200	1
	Lower Alluvium	Saturated Only	510	1
	Upper Alluvium	Saturated Only	51	1
	Zone 1 (Left Abutment Clay)	Saturated Only	0.016	0.1
	Zone 4	Saturated Only	510	0.1

Color	Name	Category	Parameters
	Dowstream Head	Hydraulic	5,154 ft
	No Flow Boundary	Hydraulic	0 ft³/d
	Seepage Face	Hydraulic	0 ft³/d
	US Storage Elevation	Hydraulic	5,205 ft



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GERHART COLE

Seepage Analysis - Left Abutment Clay - Boundary Conditions

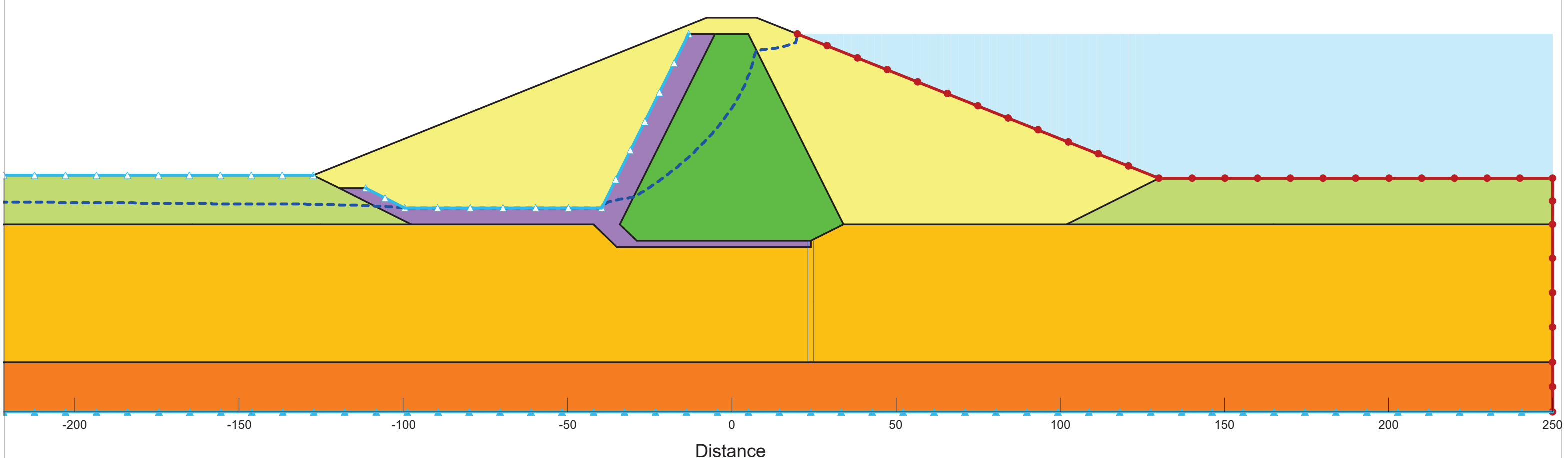
Corn Creek Reservoir

Figure E-01

DRAFT

Color	Name	Hydraulic Material Model	Sat Kx (ft/d)	Ky'/Kx' Ratio
	Bedrock	Saturated Only	0.014	1
	Filter Sand/Drain Gravel	Saturated Only	1,200	1
	Lower Alluvium	Saturated Only	510	1
	Upper Alluvium	Saturated Only	51	1
	Zone 1 Upper Alluvium (Effective Stress)	Saturated Only	16	0.1
	Zone 4	Saturated Only	510	0.1

Color	Name	Category	Parameters
	Dowstream Head	Hydraulic	5,154 ft
	No Flow Boundary	Hydraulic	0 ft³/d
	Seepage Face	Hydraulic	0 ft³/d
	US Storage Elevation	Hydraulic	5,205 ft



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GERHART COLE

Seepage Analysis - Upper Alluvium Core - Boundary Conditions

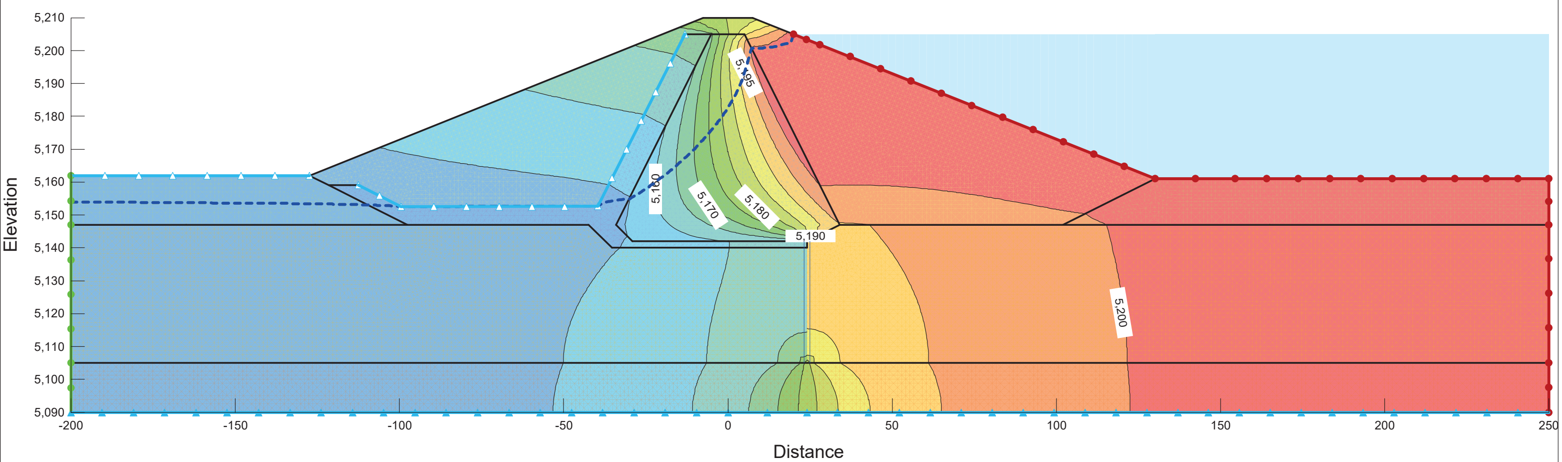
Corn Creek Reservoir

Figure E-02

DRAFT

Color	Name	Hydraulic Material Model	Sat Kx (ft/d)	Ky'/Kx' Ratio
	Bedrock	Saturated Only	0.014	1
	Filter Sand/Drain Gravel	Saturated Only	1,200	1
	Lower Alluvium	Saturated Only	510	1
	Upper Alluvium	Saturated Only	51	1
	Zone 1 (Left Abutment Clay)	Saturated Only	0.016	0.1
	Zone 4	Saturated Only	510	0.1

Color	Name	Category	Parameters
	Dowstream Head	Hydraulic	5,154 ft
	No Flow Boundary	Hydraulic	0 ft³/d
	Seepage Face	Hydraulic	0 ft³/d
	US Storage Elevation	Hydraulic	5,205 ft



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GERHART COLE

Seepage Analysis - Left Abutment Clay - Total Head

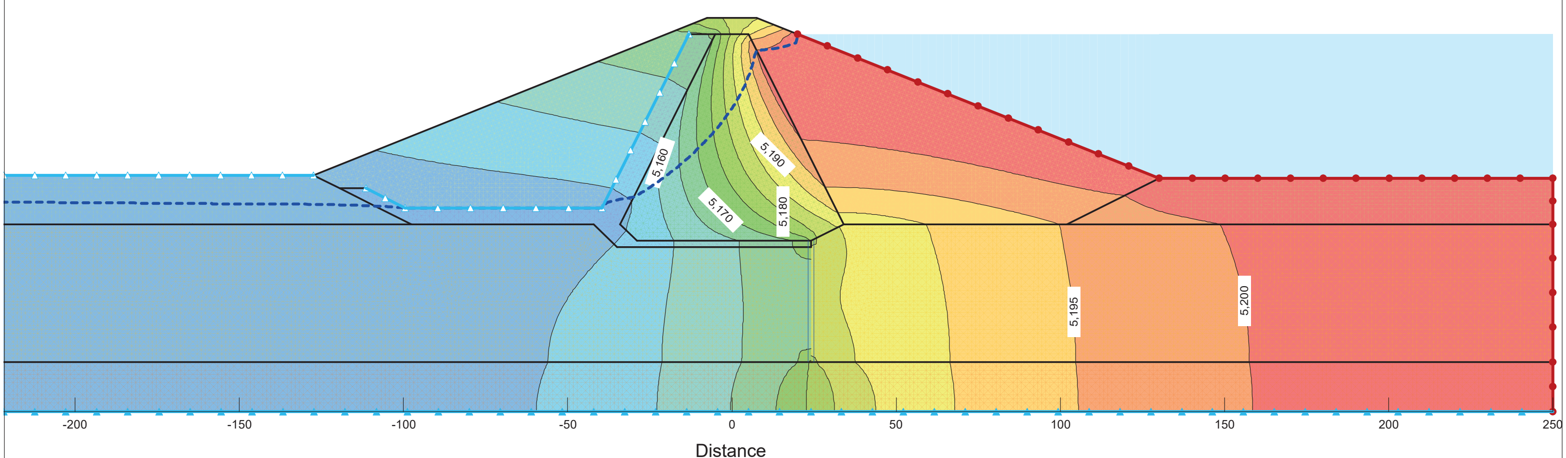
Corn Creek Reservoir

Figure E-03

DRAFT

Color	Name	Hydraulic Material Model	Sat Kx (ft/d)	Ky'/Kx' Ratio
(orange)	Bedrock	Saturated Only	0.014	1
(purple)	Filter Sand/Drain Gravel	Saturated Only	1,200	1
(yellow-orange)	Lower Alluvium	Saturated Only	510	1
(light green)	Upper Alluvium	Saturated Only	51	1
(green)	Zone 1 Upper Alluvium (Effective Stress)	Saturated Only	16	0.1
(yellow)	Zone 4	Saturated Only	510	0.1

Color	Name	Category	Parameters
(green)	Dowstream Head	Hydraulic	5,154 ft
(blue)	No Flow Boundary	Hydraulic	0 ft³/d
(blue)	Seepage Face	Hydraulic	0 ft³/d
(red)	US Storage Elevation	Hydraulic	5,205 ft



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GERHART COLE

Seepage Analysis - Upper Alluvium Core - Total Head

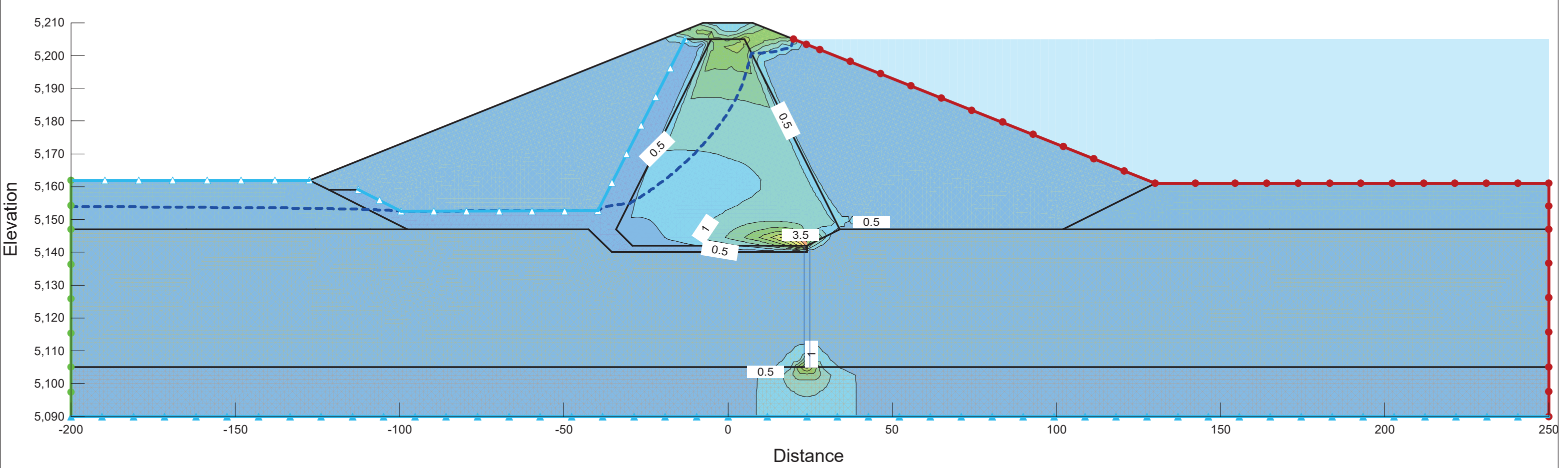
Corn Creek Reservoir

Figure E-04

DRAFT

Color	Name	Hydraulic Material Model	Sat Kx (ft/d)	Ky'/Kx' Ratio
	Bedrock	Saturated Only	0.014	1
	Filter Sand/Drain Gravel	Saturated Only	1,200	1
	Lower Alluvium	Saturated Only	510	1
	Upper Alluvium	Saturated Only	51	1
	Zone 1 (Left Abutment Clay)	Saturated Only	0.016	0.1
	Zone 4	Saturated Only	510	0.1

Color	Name	Category	Parameters
	Dowstream Head	Hydraulic	5,154 ft
	No Flow Boundary	Hydraulic	0 ft³/d
	Seepage Face	Hydraulic	0 ft³/d
	US Storage Elevation	Hydraulic	5,205 ft



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GERHART COLE

Seepage Analysis - Left Abutment Clay - XY Gradient

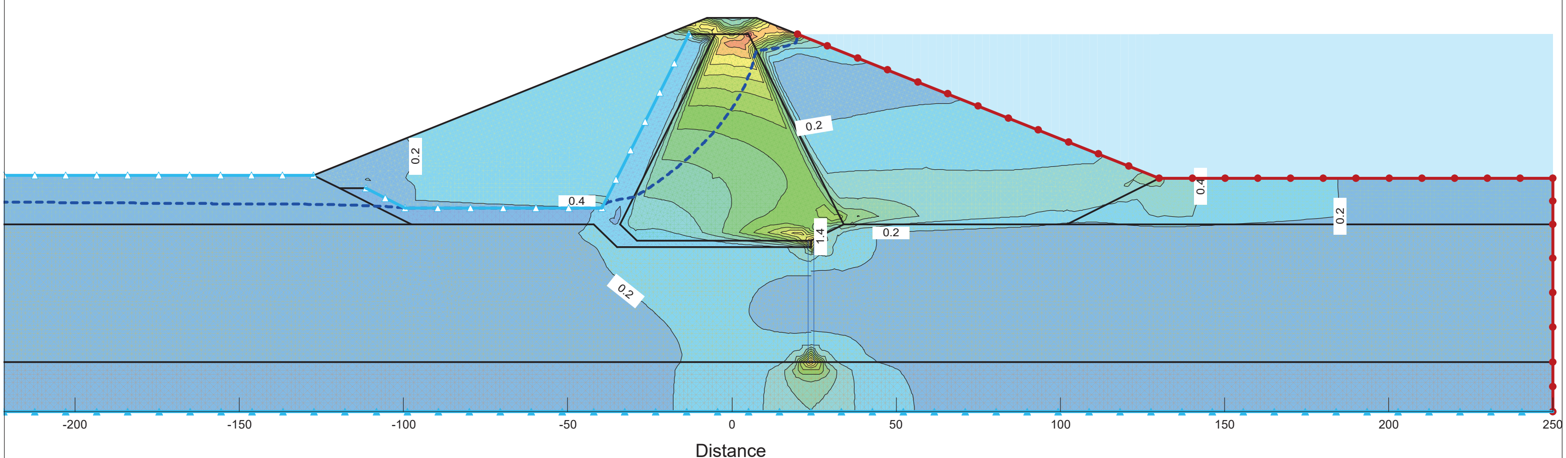
Corn Creek Reservoir

Figure E-05

DRAFT

Color	Name	Hydraulic Material Model	Sat Kx (ft/d)	Ky'/Kx' Ratio
	Bedrock	Saturated Only	0.014	1
	Filter Sand/Drain Gravel	Saturated Only	1,200	1
	Lower Alluvium	Saturated Only	510	1
	Upper Alluvium	Saturated Only	51	1
	Zone 1 Upper Alluvium (Effective Stress)	Saturated Only	16	0.1
	Zone 4	Saturated Only	510	0.1

Color	Name	Category	Parameters
	Dowstream Head	Hydraulic	5,154 ft
	No Flow Boundary	Hydraulic	0 ft³/d
	Seepage Face	Hydraulic	0 ft³/d
	US Storage Elevation	Hydraulic	5,205 ft



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GERHART COLE

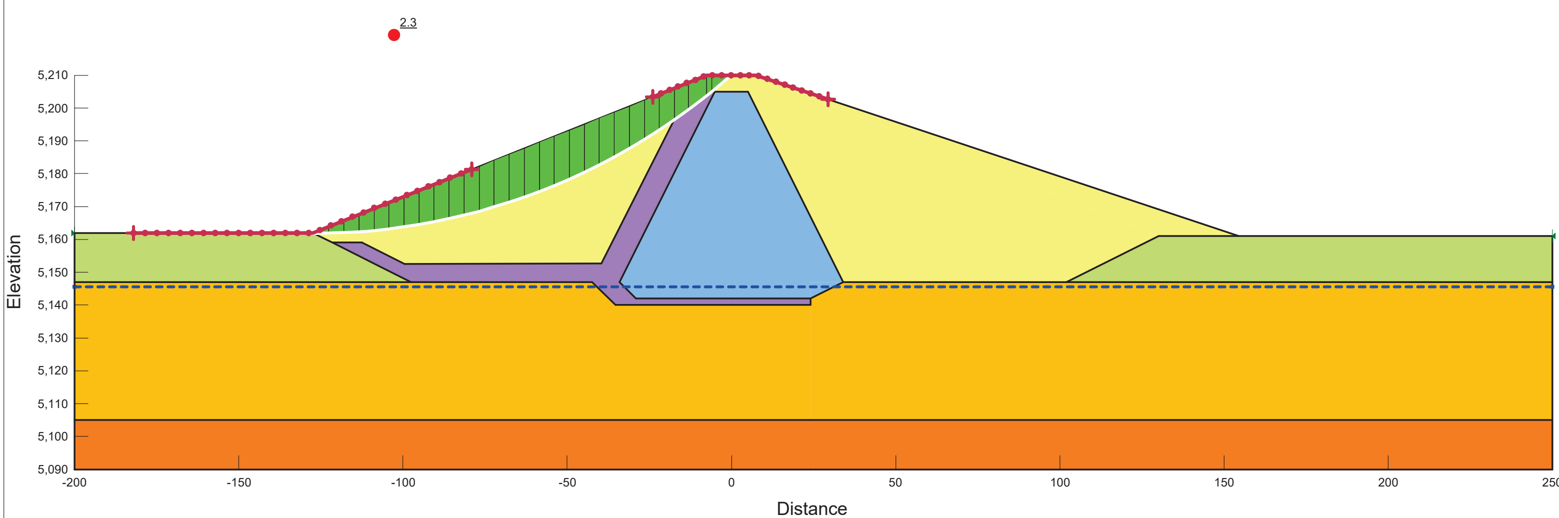
Seepage Analysis - Upper Alluvium Core - XY Gradient

Corn Creek Reservoir

Figure E-06

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
(orange)	Bedrock	Mohr-Coulomb	150	250	35
(purple)	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
(amber)	Lower Alluvium	Mohr-Coulomb	125	0	35
(light green)	Upper Alluvium	Mohr-Coulomb	120	0	33
(blue)	Zone 1 (Total Stress)	Mohr-Coulomb	115	300	16
(yellow)	Zone 4	Mohr-Coulomb	135	150	36



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GERHART COLE

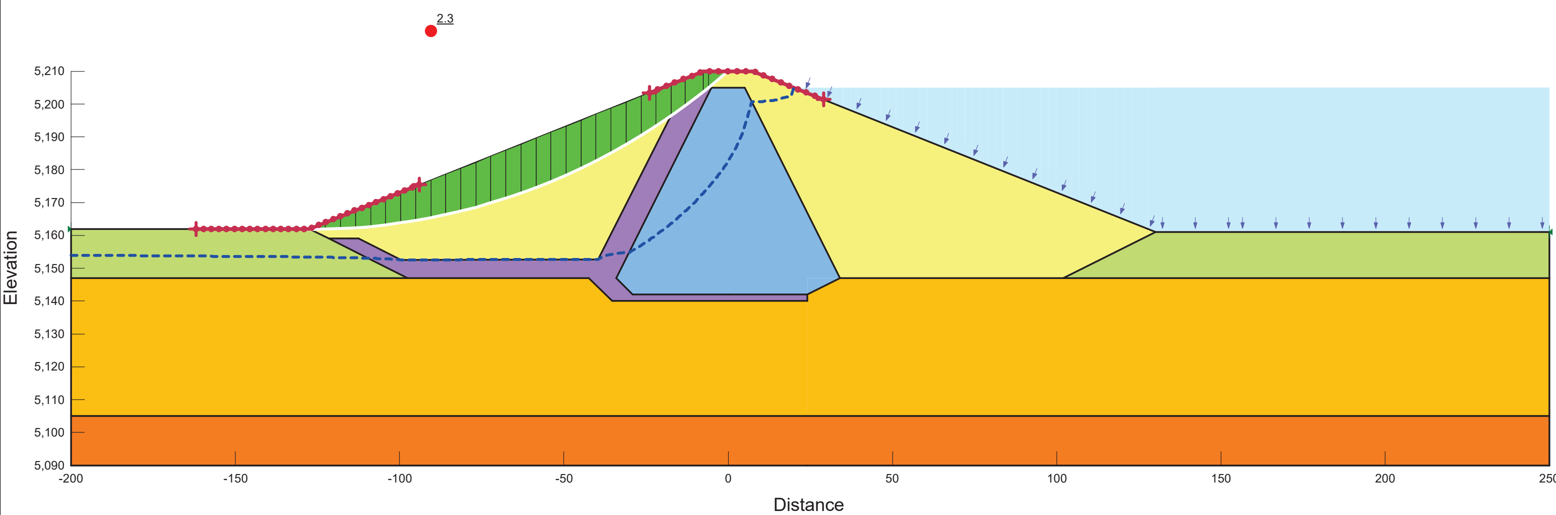
Stability Analysis- Downstream - End of Construction

Corn Creek Reservoir

Figure E-07

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (Effective Stress)	Mohr-Coulomb	115	140	29
	Zone 4	Mohr-Coulomb	135	150	36



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GERHART COLE

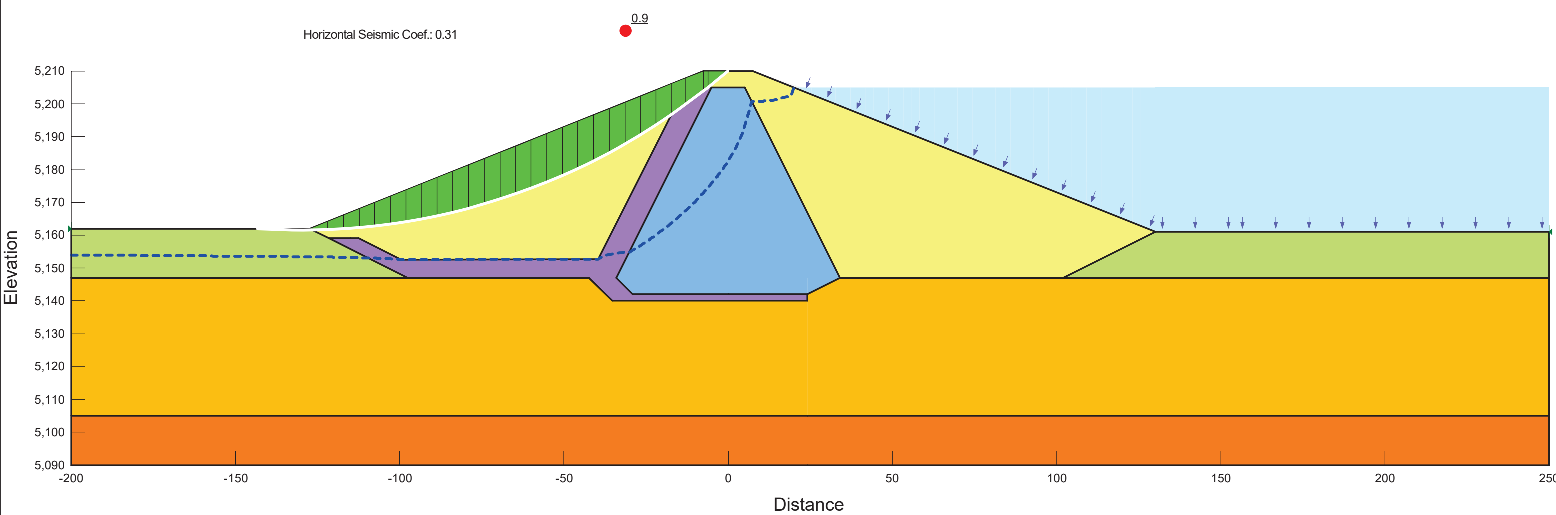
Stability Analysis - Downstream - Long Term Static

Corn Creek Reservoir

Figure E-08

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115	240	13
	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135	0	32



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GERHART COLE

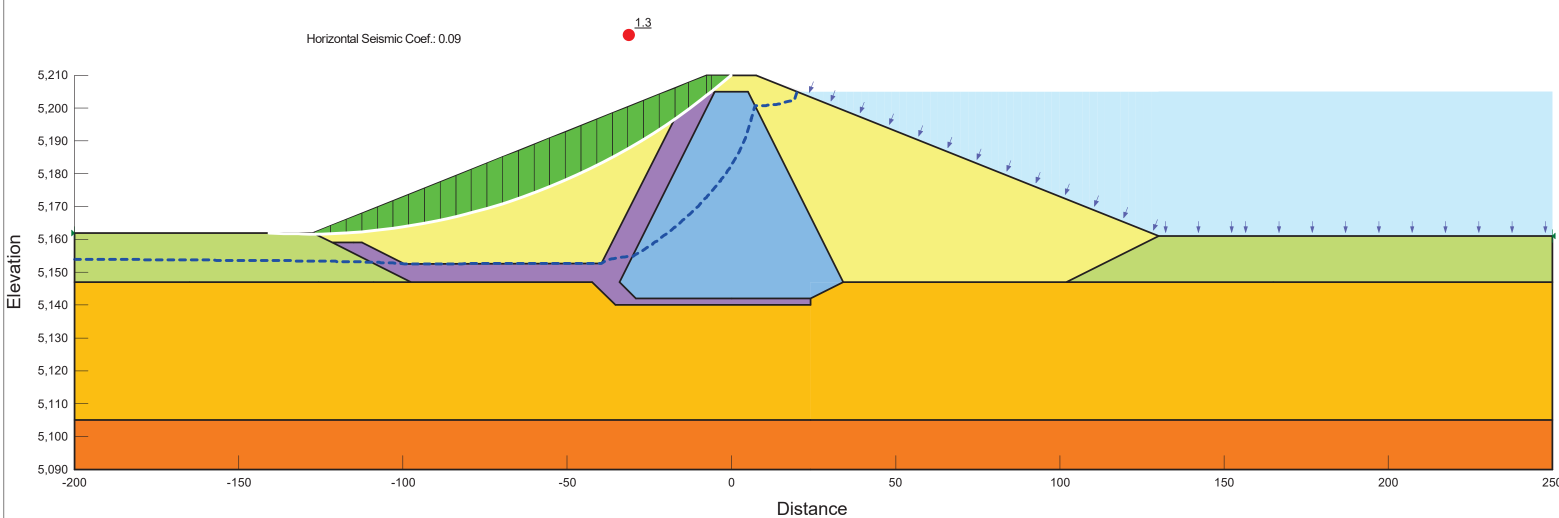
Stability Analysis - Downstream - Psuedo Static (MCE/MDE)

Corn Creek Reservoir

Figure E-09

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115	240	13
	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135	0	32



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GERHART COLE

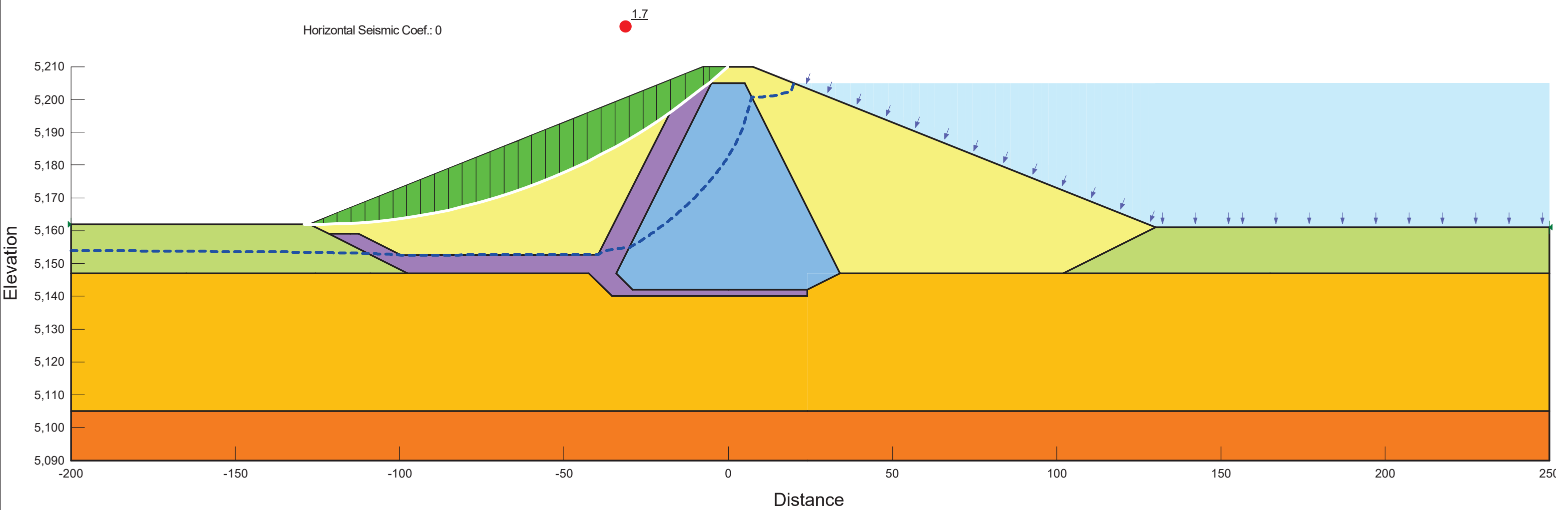
Stability Analysis - Downstream - Psuedo Static (OBE)

Corn Creek Reservoir

Figure E-10

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Total Cohesion (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150		250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120		0	34
	Lower Alluvium	Mohr-Coulomb	125		0	35
	Upper Alluvium (PL)	Undrained (Phi=0)	120	745.7		
	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115		240	13
	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135		0	32



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GERHART COLE

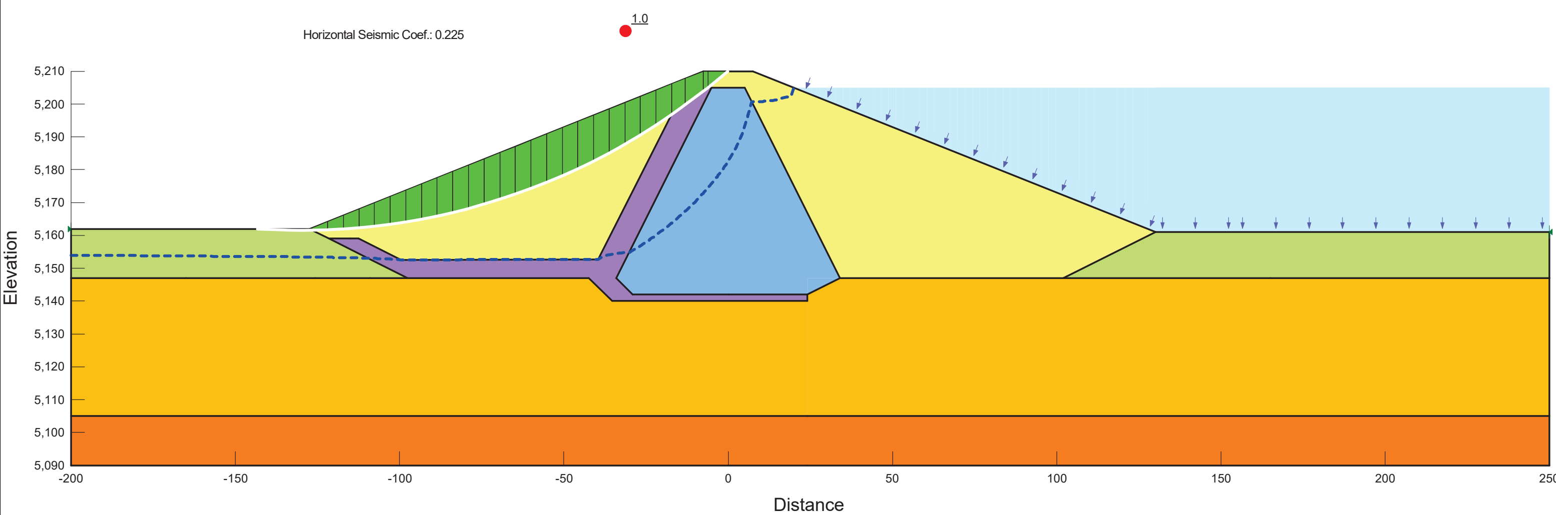
Stability Analysis - Downstream - Post Earthquake

Corn Creek Reservoir

Figure E-11

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115	240	13
	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135	0	32



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GERHART COLE

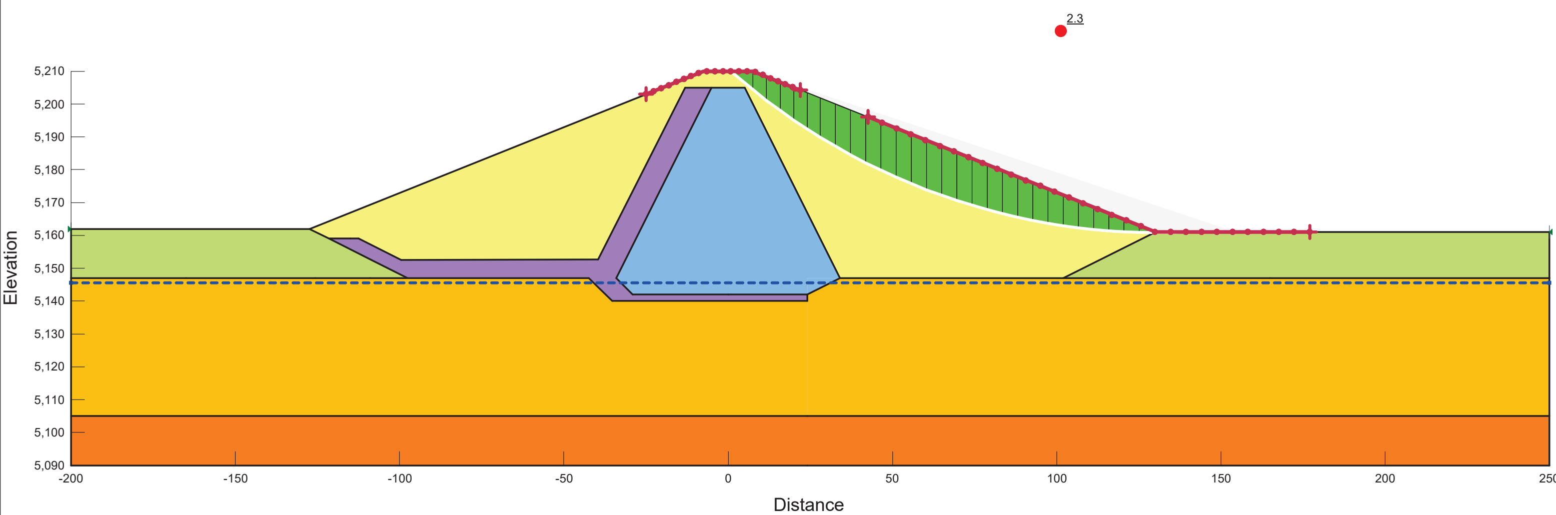
Stability Analysis - Downstream - Yield Acceleration

Corn Creek Reservoir

Figure E-12

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (Total Stress)	Mohr-Coulomb	115	300	16
	Zone 4	Mohr-Coulomb	135	150	36



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GERHART COLE

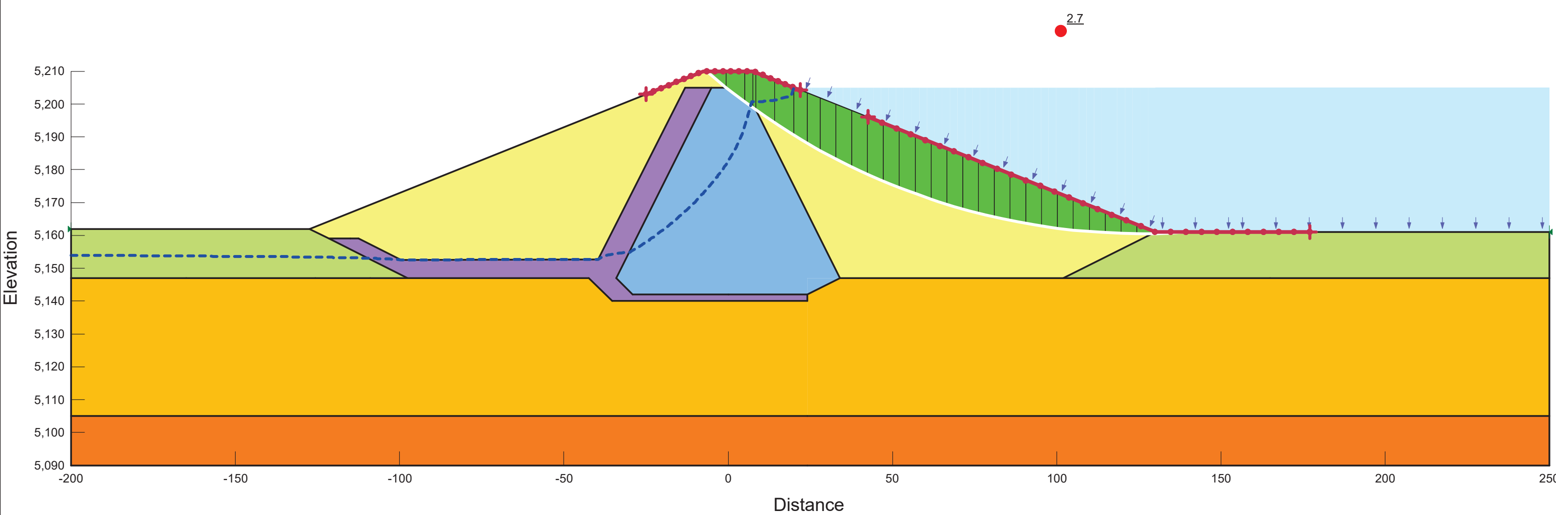
Stability Analysis - Upstream - End of Construction

Corn Creek Reservoir

Figure E-13

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
(orange)	Bedrock	Mohr-Coulomb	150	250	35
(purple)	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
(gold)	Lower Alluvium	Mohr-Coulomb	125	0	35
(light green)	Upper Alluvium	Mohr-Coulomb	120	0	33
(blue)	Zone 1 (Effective Stress)	Mohr-Coulomb	115	140	29
(yellow)	Zone 4	Mohr-Coulomb	135	150	36



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GERHART COLE

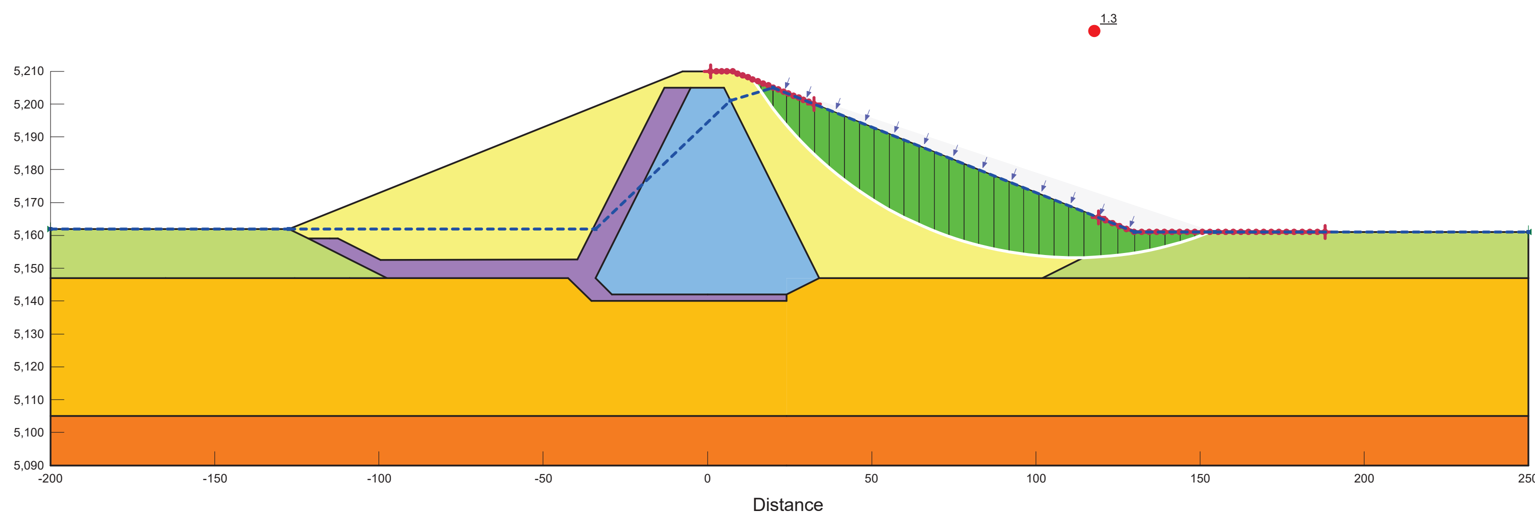
Stability Analysis - Upstream - Long Term Static

Corn Creek Reservoir

Figure E-14

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Phi 1 (°)	Phi 2 (°)	Effective Friction Angle (°)
(orange)	Bedrock	Mohr-Coulomb	150	250			35
(purple)	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0			34
(amber)	Lower Alluvium	Mohr-Coulomb	125	0			35
(light green)	Upper Alluvium	Mohr-Coulomb	120	0			33
(blue)	Zone 1 Left (Bilinear)	Bilinear	115	140	29	16	
(yellow)	Zone 4	Mohr-Coulomb	135	150			36



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GERHART COLE

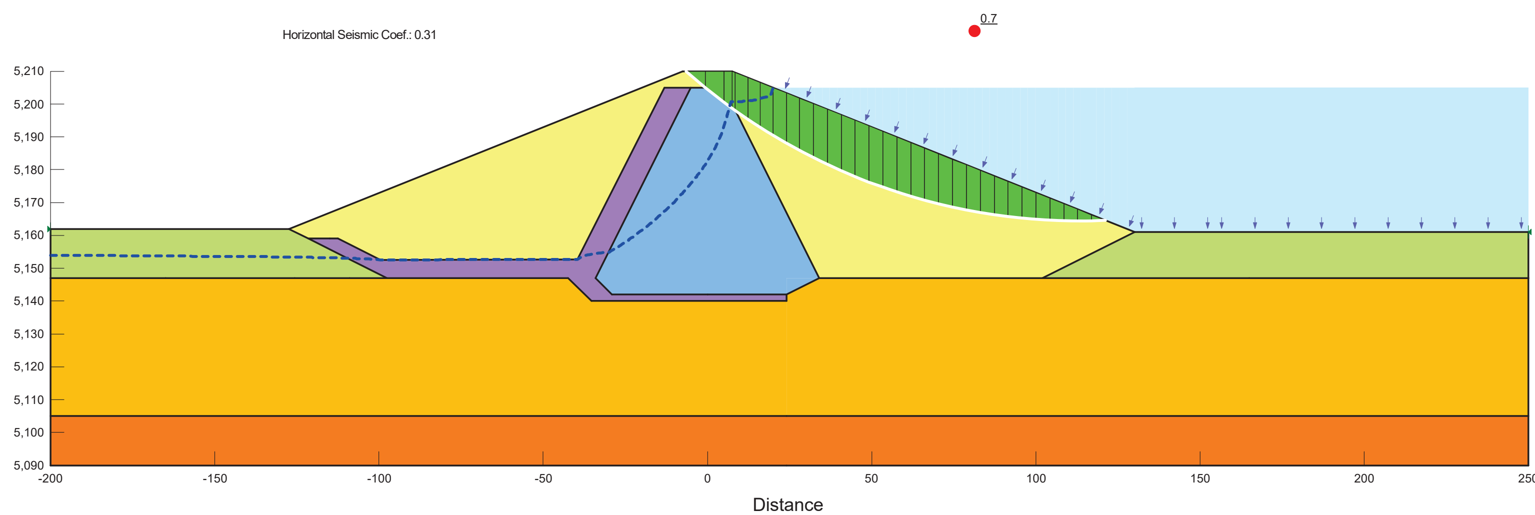
Stabiility Analysis - Upstream - Rapid Drawdown

Corn Creek Reservoir

Figure E-15

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
(orange)	Bedrock	Mohr-Coulomb	150	250	35
(purple)	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
(gold)	Lower Alluvium	Mohr-Coulomb	125	0	35
(light green)	Upper Alluvium	Mohr-Coulomb	120	0	33
(blue)	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115	240	13
(yellow)	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135	0	32



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GERHART COLE

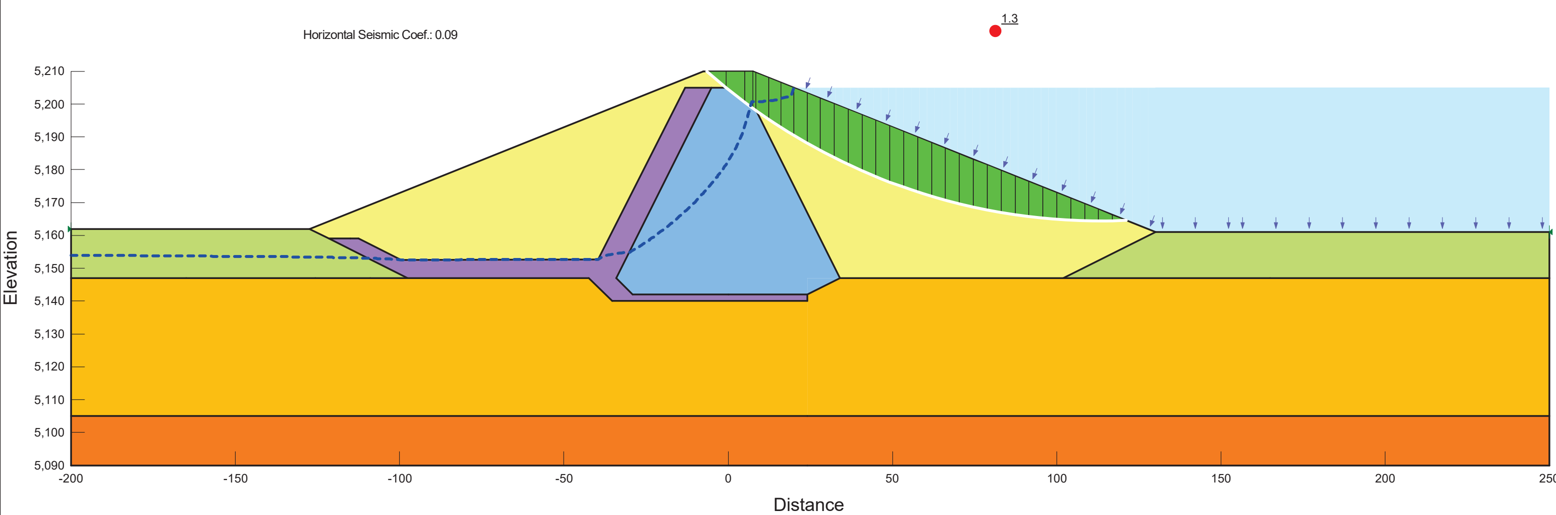
Stability Analysis - Upstream - Psuedo Static (MCE/MDE)

Corn Creek Reservoir

Figure E-16

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115	240	13
	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135	0	32



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GERHART COLE

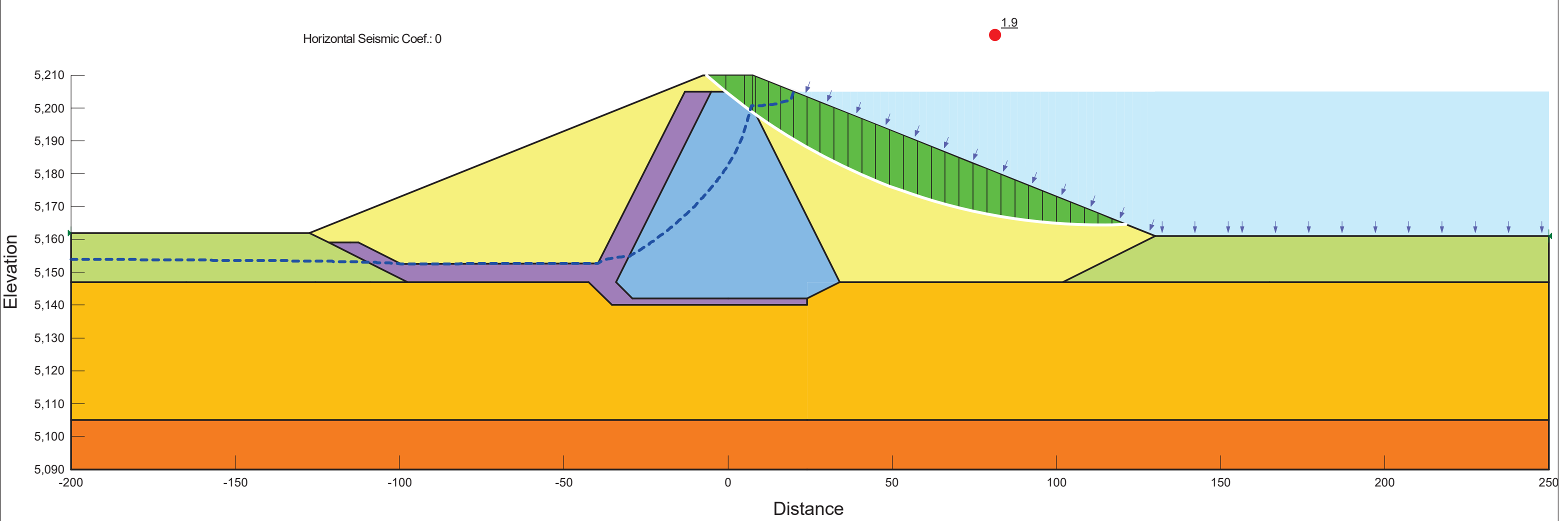
Stability Analysis - Upstream - Psuedo Static (OBE)

Corn Creek Reservoir

Figure E-17

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115	240	13
	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135	0	32



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GERHART COLE

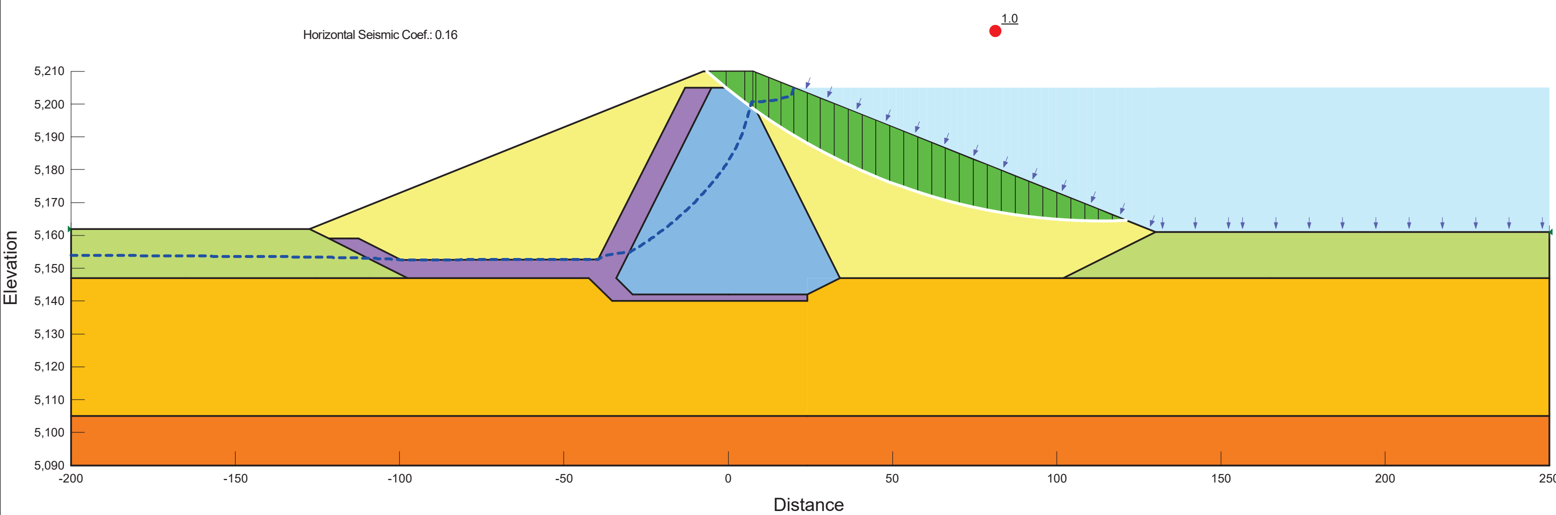
Stability Analysis - Upstream - Post Earthquake

Corn Creek Reservoir

Figure E-18

DRAFT

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	150	250	35
	Filter Sand/Drain Gravel	Mohr-Coulomb	120	0	34
	Lower Alluvium	Mohr-Coulomb	125	0	35
	Upper Alluvium	Mohr-Coulomb	120	0	33
	Zone 1 (PP Reduction 20%)	Mohr-Coulomb	115	240	13
	Zone 4 (PP Reduction 10%)	Mohr-Coulomb	135	0	32



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GERHART COLE

Stability Analysis - Upstream - Yield Acceleration

Corn Creek Reservoir

Figure E-19

Results of Regression Analyses

The regression analyses provided a mathematical relationship between the crest settlement and the two factors, PGA and M. This relationship can be expressed as:

% Settlement = e^ (5.70 PGA + 0.471 M -7.22); standard error (log e basis) = 0.9695

where: % Settlement = the amount of settlement of the crest of the dam times 100 divided by the height of the dam (DH) plus the thickness of the alluvium (AT - not to exceed two-thirds of the dam height); PGA = peak horizontal ground acceleration of the foundation rock (in g) recorded or estimated at the dam site; and M = earthquake magnitude (in Moment Magnitude scale: Mw).

The solved equations are shown graphically in Figure 2 and 3

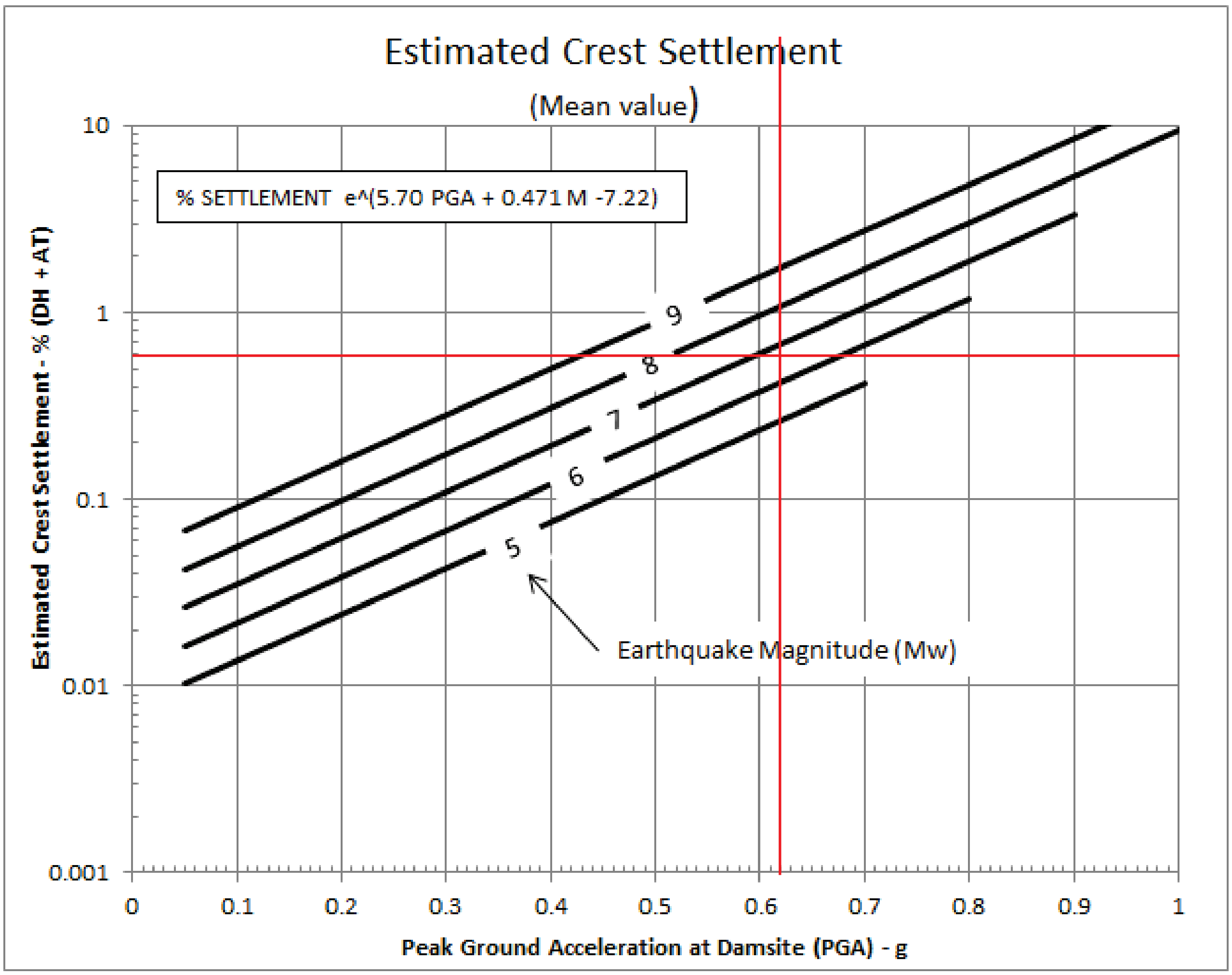


Figure 2: Mean Value of Crest Settlement

PGA = 0.62, Mw = 6.7 (highest of modal pair), estimated crest settlement = ~0.6%
0.6*(60+45 ft)/100 = 0.63 ft., = 8 inches of settlement,

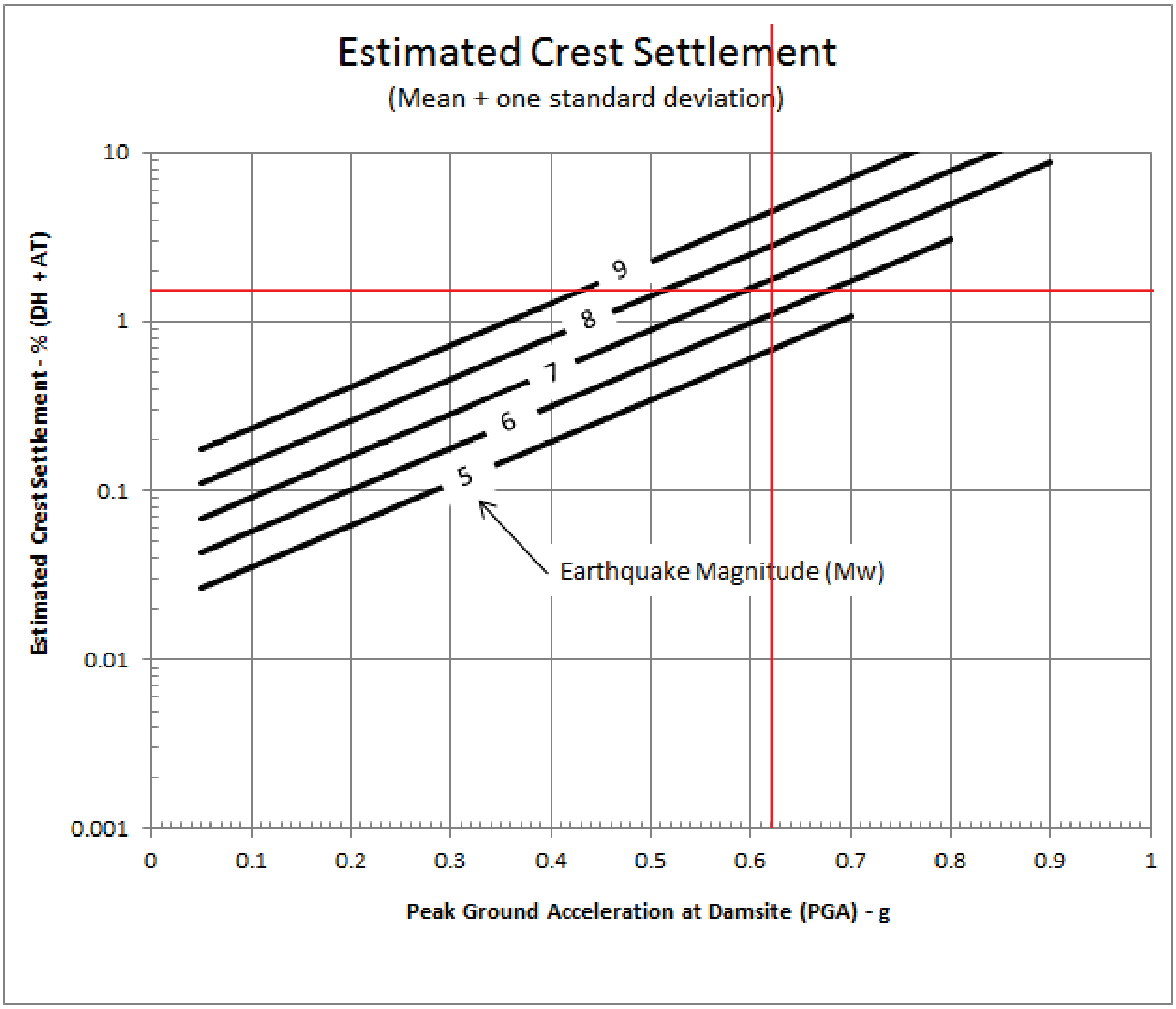


Figure 3: Mean Value plus One Standard Deviation of Crest Settlement

Calculated vs. Actual Crest Settlements

Using the regression equation, crest settlements were calculated for each of the 82 case histories included in the data base. Calculated settlement values are compared to the actual values in Figure 4. It is noteworthy that the statistical fit of actual to calculated values was found to be similar to that for acceleration attenuation data from recent well-instrumented earthquakes including the Loma Prieta earthquake (3), the Northridge earthquake (4), and the 2011 Tohoku earthquake (5). These statistical similarities suggest that prediction of crest settlements cannot be improved unless the prediction of site-specific ground accelerations can be improved.

PGA = 0.62, Mw = 6.7 (highest of modal pair), estimated crest settlement = ~1.1%
1.1*(60+45 ft)/100 = 1.16 ft., = 14 inches of settlement,

DRAFT

Simplified Seismic Slope Displacement

after Bray & Travasarou (2007)

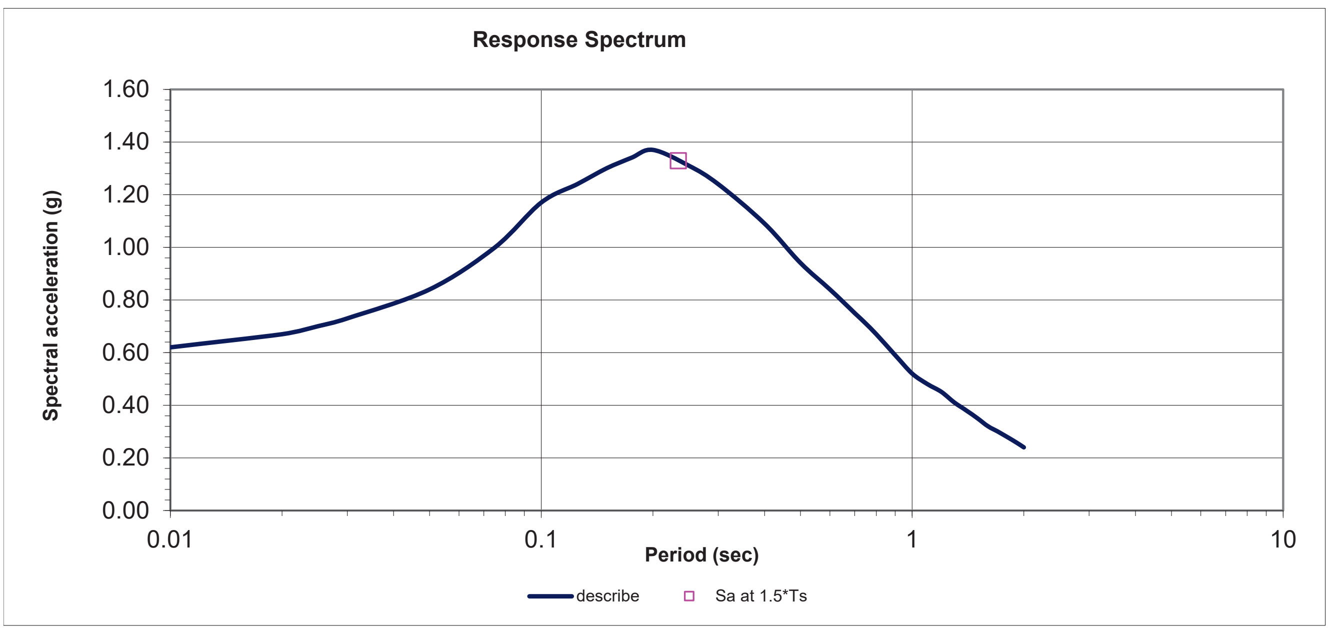
Project:	**Corn Creek Reservoir**	By RRB
STA:	Downstream	Date 3/4/2022
Model:		
Mw =	6.71	
Yield acceleration, ky (g) =	0.225	
Shear wave velocity, Vs (ft/sec) =	1000	
Maximum vertical slip surface distance, H (ft) =	60	
Response largely 1D (1) or 2D (2) =	2	
Period of sliding mass, Ts (sec) =	0.156	
1.5* Ts (sec) =	0.234	
Spectral acc.at degraded T, Sa(1.5Ts) (sec) =	1.329	
Probability assessment		
Prob. of zero displacement, P(D=0) =	0.00	
Prob. of non-zero displacements, P(D>1cm) =	1.00	
Displacement threshold, Dmax (cm) =	10	
Prob. of displacement > Dmax, P(D>Dmax) =	0.90	
Slope deformation		
ln (D) =	3.136	
ln (D) + sig =	3.796	
ln (D) - sig =	2.476	
Davg (cm) =	23	
Davg+sig (cm) =	45	
Davg-sig (cm) =	12	
Estimated range (cm) =	12-45	
Davg (in) =	**9.1**	
Estimated range (in) =	4.7-17.5	

Assumptions:

Ky - 0.02-0.4; Ts = 0-2.0 sec; Sa(1.5Ts) = 0.002-2.7g

Reference:

Bray and Travasarou (2007). "Simplified procedure for estimating earthquake-induced deviatoric slope displacements" JGGE 133(4)



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Simplified Seismic Slope Displacement

after Bray & Travasarou (2007)

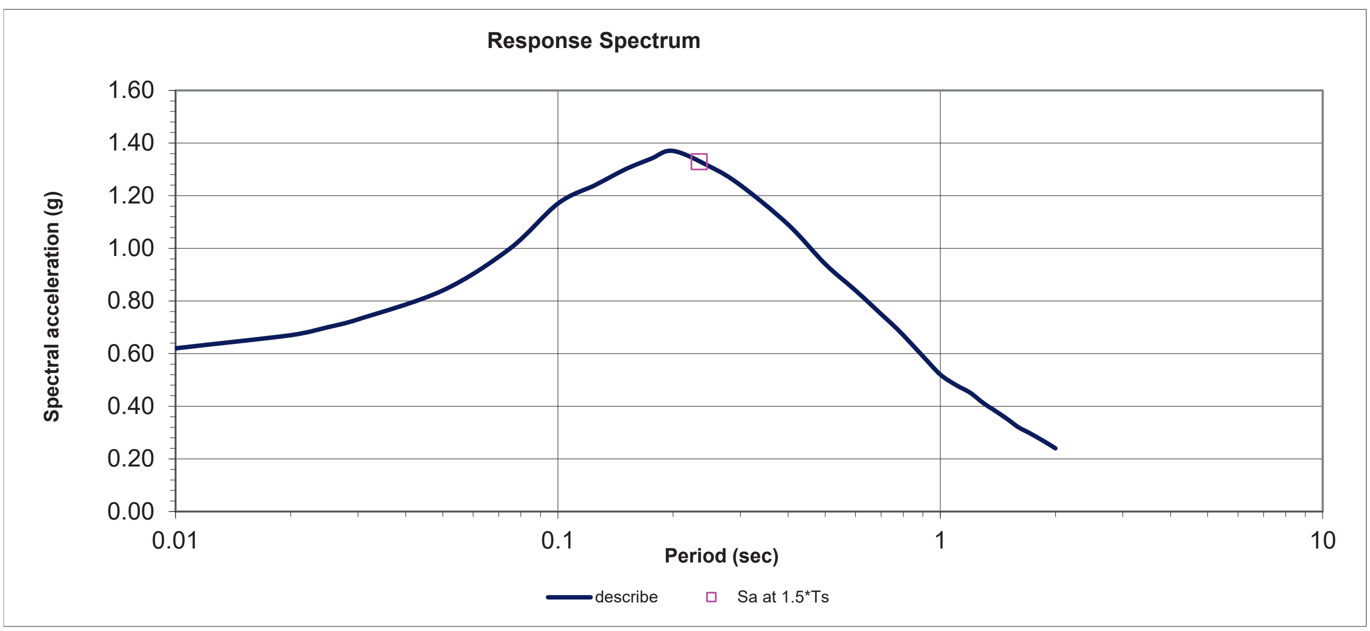
Project:	**Corn Creek Reservoir**	By RRB
STA:	Upstream	Date 3/4/2022
Model:		
Mw =	6.71	
Yield acceleration, ky (g) =	0.16	
Shear wave velocity, Vs (ft/sec) =	1000	
Maximum vertical slip surface distance, H (ft) =	60	
Response largely 1D (1) or 2D (2) =	2	
Period of sliding mass, Ts (sec) =	0.156	
1.5* Ts (sec) =	0.234	
Spectral acc.at degraded T, Sa(1.5Ts) (sec) =	1.329	
Probability assessment		
Prob. of zero displacement, P(D=0) =	0.00	
Prob. of non-zero displacements, P(D>1cm) =	1.00	
Displacement threshold, Dmax (cm) =	10	
Prob. of displacement > Dmax, P(D>Dmax) =	0.98	
Slope deformation		
ln (D) =	3.669	
ln (D) + sig =	4.329	
ln (D) - sig =	3.009	
Davg (cm) =	39	
Davg+sig (cm) =	76	
Davg-sig (cm) =	20	
Estimated range (cm) =	20-76	
Davg (in) =	**15.4**	
Estimated range (in) =	8-29.9	

Assumptions:

Ky - 0.02-0.4; Ts = 0-2.0 sec; Sa(1.5Ts) = 0.002-2.7g

Reference:

Bray and Travasarou (2007). "Simplified procedure for estimating earthquake-induced deviatoric slope displacements" JGGE 133(4)



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Appendix F

GERHART COLE

Background Information
Corn Creek Reservoir

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Northern
Engineering and Testing, Inc.

REPORT OF GEOTECHNICAL INVESTIGATION (CORN CREEK)
KANOSH DAM
KANOSH, UTAH

DRAFT

Northern
Engineering
and Testing, Inc.

400 West 900 North
Building #8
P.O. Box 281
North Salt Lake City, Utah 84054
(801) 298-9314

June 14, 1985

Sunrise Engineering
60 East Center Street
Fillmore, UT 84631

Attention: Mr. Alden C. Robinson, P.E.

Subject: Geotechnical Investigations
Kanosh Dam

Gentlemen:

At your request, and in accordance with our agreement dated July 6, 1984, we have completed an investigation of foundation soil conditions at the Kanosh Dam, near Kanosh, Utah. The original earth dam structure washed away during the spring of 1984. The purpose of this study was to develop stable sections for reconstruction of the dam.

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

A zoned earth structure, utilizing a relatively impermeable core of compacted silt and sand, and granular gravel outer shells, is recommended. Impermeable core material is available from the existing embankment structure, and in the stockpile immediately downstream of the dam. Gravel for shell material is available in the ridge above the south abutment, and in the upper reservoir area. Slope inclinations were adjusted to achieve acceptable factors of safety for each of the different reservoir loading conditions.

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 an information sheet for geotechnical engineering reports in the Appendix. If you have any questions regarding this report, or if we can be of further service, please contact us.

Respectfully submitted,

Walter V. Jones

Walter V. Jones, P.E.

Alan Stilley

Al Stilley, P.E.

REGISTERED PROFESSIONAL ENGINEER
No. 7287
ALAN N. STILLEY
STATE OF UTAH

WVJ/AS/hlk
Enclosure
In quadruplicate

REPORT
OF
GEOTECHNICAL INVESTIGATION

KANOSH DAM
KANOSH, UTAH

TO
SUNRISE ENGINEERING
FILLMORE, UTAH

PREPARED
BY
NORTHERN ENGINEERING AND TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Salt Lake City, Utah

JUNE 1985

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INTRODUCTION

The Kanosh Dam was constructed in the early 1900's to control flooding and provide a source of irrigation water from Corn Creek. The earth fill structure was about 25 feet high, and originally had a metal culvert outlet works, a concrete spillway, and an emergency spillway excavated into the north abutment. During May 1984, precipitation and excessive snowmelt runoff caused the dam to fail. It is unclear whether the failure was due to overtopping, or due to piping of the embankment soil, but a portion of the embankment, approximately 200 feet long near the center of the dam, was washed away. After the washout, Corn Creek was rerouted into an excavated channel along the south abutment of the dam. The purpose of our investigation was to develop a geotechnical design for reconstruction of the dam.

SCOPE OF SERVICES

Specifically, the scope of services for our investigation was as follows:

1. Perform sufficient field and laboratory investigations to determine the subsurface profile and engineering properties of foundation and potential borrow materials.

2. Develop a geotechnical design for an earth embankment, utilizing on-site materials, and satisfying established factors of safety for stability.

FIELD INVESTIGATIONS

Field investigations were conducted in two phases. Initially, the surface geology in the embankment and reservoir area was mapped by our field engineer. Potential sources of borrow for different types of material were identified at this time. Ten test pits in potential areas were then excavated with a backhoe to depths of about 6 to 10 feet. The test pits were logged by our engineer, and bulk samples of the different materials were obtained.

During the next phase of the field investigation, seven test borings were made with a truck-mounted drill. Six of these test borings were located along the dam centerline, or in the embankment, and one was made in a borrow area. The borings extended to depths of from 4 to 50 feet, and were logged by our engineer. Standard penetration tests were made and disturbed and undisturbed samples were obtained during the field drilling program. Test pits and test borings were located, and elevations were obtained, by your surveyors, and are shown on Drawing No. 85-2315-1.

LABORATORY INVESTIGATIONS

Samples obtained during the field exploration were taken to the laboratory where they were carefully inspected and visually classified in accordance with the Unified Soils Classification System. 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.
Natural moisture..................	moisture content representative of field conditions at time sample was taken.
Natural density...................	dry unit weight of sample representative of in situ undisturbed condition.
Consolidation.....................	the amount and rate at which a soil sample compresses when loaded, and the influence of saturation on its behavior. For use in settlement analysis and footing design.
Direct shear......................	soil shearing strength under varying load and/or moisture conditions. For use in foundation design and slope stability evaluation.
Permeability......................	the rate at which fluid (water) will flow through soil or rock.
Moisture-density relationship.....	the optimum moisture content for compacting soil and the maximum dry unit weight for a given compactive effort.
Pin Hole Dispersion Test..........	a test conducted to determine the erodability of fine grained soils.

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

AREA GEOLOGY, SITE DESCRIPTION AND SUBSOIL CONDITIONS

The dam site is located on the west side of the Pavant Range, near the mouth of Corn Creek Canyon. The entire area is covered with alluvial, colluvial or outwash deposits, originating from the mountains to the east.

There is a large plateau, approximately 60 feet high, along the south abutment and south side of the reservoir. Terrace gravels are exposed in a cut at the south abutment, and apparently are present along the top of the plateau. Another gravel deposit is exposed in the upper portion of the reservoir. There is a stockpile, consisting mostly of silt or sand, excavated from the lower part of the reservoir, just downstream of the dam. Approximately 150 feet of the old embankment along the south abutment, and 700 feet of embankment on the north abutment, still remain. Concrete debris from the previous outlet works is still present. The locations of the gravel areas and the stockpile are shown on the Drawing.

The site is located in Seismic Zone U-3(1). This corresponds to a Zone 3 seismic risk area, as defined by the Uniform Building Code. This is characterized as an area where major damage due to earthquake shaking could occur.(2)

The subsurface profile along the existing dam embankment generally consists of embankment soil, underlain by a layer of silty clay, and then gravel. The depth of the embankment fill ranges from about 17 to 23 feet, while the depth to the top of the gravel ranges from about 23 to 46 feet, and it extends beyond the depth of the borings. The in-place soils and material in the borrow sources are described in detail on the boring and test pit logs on the Drawing, and are discussed below:

Dam Embankment: The dam embankment consists of a sandy silt, or a silty sand. It is generally stiff with occasional soft zones. Standard penetration resistance (N) values ranged from about 4 to 30 blows per foot.

In-place Clay or Sand: This material is generally stiff, with N values in the range of 10 to 15, although some lenses of softer material were encountered. Data from a direct shear test on a sample of clay was as follows:

In-place dry unit weight, pcf..................	99
In-place moisture content, percent............	19
Angle of internal friction, degrees...........	29
Cohesion intercept, psf.......................	300

In-place Gravel: The in-place gravel is generally very dense with N values normally in excess of 50. It apparently contains numerous cobbles and boulders, as auger refusal was generally experienced within several feet of penetration into the gravel.

(1)"Rules and Regulations Governing Dam Safety in Utah", State of Utah, Division of Water Rights, January, 1982.

(2)Uniform Building Code, International Conference of Building Officials, 1982.

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Silt-Sand Borrow: The material present in the stockpile downstream of the dam is similar to the embankment material, and it consists of sandy silt or silty sand. Samples of the stockpile material were obtained, and laboratory tests were run on remolded samples. The results of those tests were as follows:

Maximum dry density, ASTM D698, pcf...............	106
Optimum moisture content, ASTM D698, percent......	17
Angle of internal friction, degrees*...............	29
Cohesion intercept, psf...........................	150
Coefficient of permeability, cm/sec*..............	7×10^{-6}

* Samples remolded to 95 percent of maximum dry density by ASTM D698 of optimum moisture content - all samples were saturated.

Gravel Borrow: Samples of gravel were obtained from both the upper reservoir and south abutment area. The gravel material from the upper reservoir location is somewhat cleaner than the gravel on the south abutment. Laboratory tests conducted on these samples are summarized below:

Maximum dry density, ASTM D698, pcf..............	126 to 131
Optimum moisture content, ASTM D698, percent.....	8 to 10
Angle of internal friction, degrees*.............	35 to 40
Cohesion intercept, psf*.........................	0 to 400
Coefficient of permeability, cm/sec*.............	2×10^{-5} to 3×10^{-5}

* Minus No. 4 portion of sample remolded at 120 pcf dry density at 10 percent moisture content.

The stratification lines shown on the logs and idealized geologic cross section represent the approximate boundary between soil types; the actual in situ transition may be gradual.

Groundwater was only encountered in Drill Hole 11, at a depth of 18 feet at the time of drilling (4-25-85). Numerous factors contribute to fluctuations, and evaluation of such factors is beyond the scope of this report.

ENGINEERING ANALYSIS

Introduction

Initially, different embankment sections, utilizing locally available materials were considered. In order to limit seepage through an embankment, a relatively impermeable core is normally required. To provide strength, free draining granular shells are used. An embankment section, utilizing the silt-sand material as a core, and gravel shells on the upstream and downstream slopes, appears to be the most economical section. A ten foot thick clean gravel drain should be provided on the downstream toe to drain water from within the section. Silt-sand material is available in the existing embankment, or in the stockpile downstream of the dam. Gravel for the shells is available above the right abutment, or in the upper reservoir area. Gravel for the toe drain will probably have to come from the upper reservoir area. Items to consider in geotechnical design include stability of the embankment section, seismic considerations, embankment settlement, seepage considerations, and requirements for preventing erosion. These items are discussed separately below.

Stability Considerations

In order to evaluate the stability, it is necessary to establish the critical subsurface profile, the maximum embankment height, and the high water level. Design criteria provided by you for the dam, were as follows:

Embankment crest elevation..............	5195
Maximum high water elevation............	5190
Minimum crest width, feet...............	12

The subsurface profile encountered in Drill Hole No. 15 appears to be the most critical for stability (maximum depth of clay above gravel) and was used for the foundation profile in our analysis. The specific section, subsurface profile, and strength parameters, are shown in a following section.

In our analysis, a Modified Bishop method of slices analysis was used to determine stability. With this method, a circular failure arc was assumed. The forces tending to cause a failure (gravity and seepage) and the forces resisting a failure (friction and cohesion) are then calculated. By checking many surfaces, the circular arc with the lowest factor of safety is determined. A computerized method of analysis was used.

Three reservoir conditions were evaluated for stability. These included the maximum reservoir, steady state seepage, with and without earthquake loading, and the sudden reservoir draw down condition. In evaluating the adequacy of stability, guidelines for minimum factors of safety for the different reservoir conditions, as published by the State of Utah and listed below, were followed.(1)

Loading Condition	Minimum Factor of Safety
Full reservoir, steady state seepage, without earthquake......................	1.5
Full reservoir, steady state seepage, with earthquake........................	1.0
Sudden draw down from full reservoir.......	1.5

(1)"Rules and Regulations Governing Dam Safety in Utah", State of Utah, Division of Water Rights, January, 1982.

In our analysis, the following strength parameters, and unit weights were used:

Material	Moist Unit Weight, pcf	Saturated Unit Weight, pcf	Angle of Internal Friction, degrees	Cohesion Intercept, pounds per square foot
Compacted sand, silt, or clay core	118	125	29	0
Compacted gravel, outer shell or toe drain	133	145	37	0
In-place clay, silt, or sand	116	120	29	0
In-place gravel	135	145	40	0

An embankment section with a 12 foot wide crest, and upstream and downstream slopes of 2 (horizontal) to 1 (vertical) was used in our analysis. A core crest width of 12 feet with upstream and downstream slopes of 1 (horizontal) to 1 (vertical) was used. This section is shown on the following page.

In evaluating the stability of the dam section under seismic loading, two conditions were analyzed. First, the possibility of liquefaction of foundation soils was considered. Liquefaction occurs in loose, fine grained, clean sands when earthquake shaking causes pore water pressures to build up to the effective overburden pressure, resulting in a loss of strength. Past studies have identified the physical properties of soils which are susceptible to liquefaction.(3) Analysis indicates that the soils at this site will not be subject to liquefaction, due to the high clay and silt content.

Second, the stability of the dam section under the forces created by earthquake acceleration were examined. A conventional psudeo-static method of analysis was used. The site is located in a Zone 3 seismic risk area. The corresponding seismic coefficient recommended by the U.S. Army Corps of Engineers is 0.1.(4) The results of the seismic, as well as the static stability analysis are as follows.

(3)Seed, H.B., Idriss, I.M., and Arargo, I., "Evaluation of Liquefaction Potential Using Field Performance Data", Journal of Geotechnical Engineering, American Society of Civil Engineers, March 1983, pp 458-482.

(4)"Recommended Guidelines for Safety Inspection of Dams", Department of the Army, Corps of Engineers, 1972.

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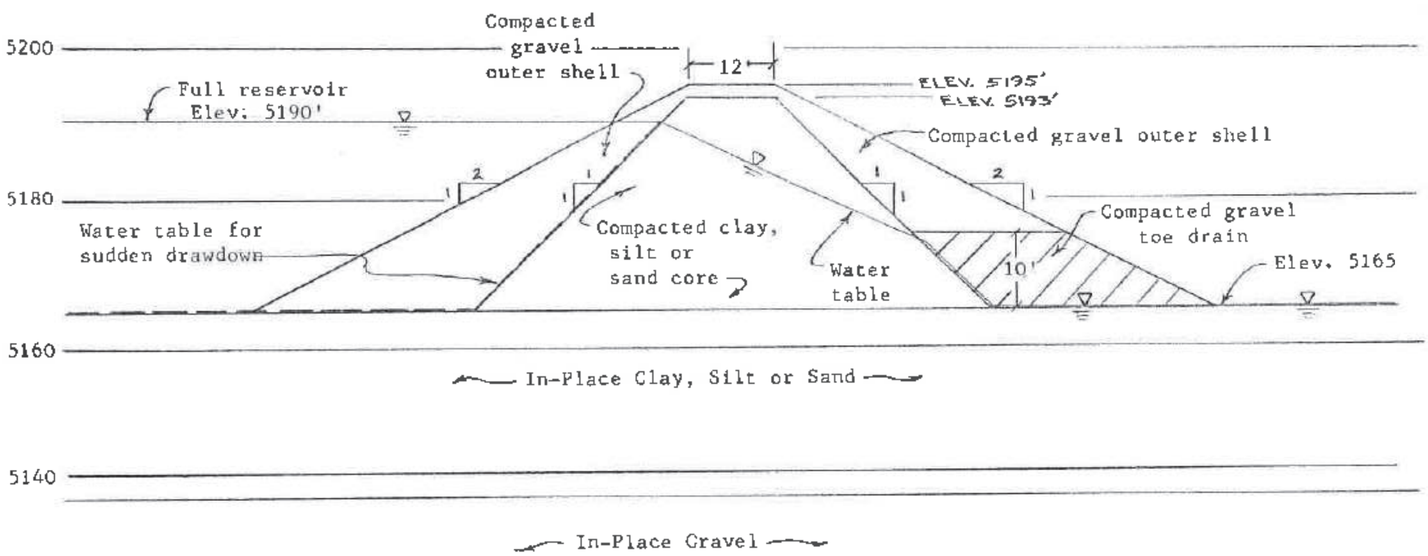
Scale: 1"=20'



KANOSH DAM - PROPOSED TYPICAL SECTION

FOR STABILITY ANALYSIS

Loading Condition	Minimum Apparent Factor of Safety
Full reservoir, steady state seepage without earthquake..........................	1.6
Full reservoir, steady state seepage with earthquake.............................	1.2
Sudden draw down from full reservoir...........	1.6

Examination of the factors of safety shown above indicate they satisfy the required minimums.

Miscellaneous

The necessity of providing a filter between the compacted core material and the gravel toe drain or granular shell was evaluated. The silt-sand material is erodable, and if the grain size distribution of the clay and the gravel differed by a large amount, piping could occur. According to published criteria, it does not appear that graded aggregate filters will be required.(5)

A granular drain at the toe of the dam is essential to collect seepage through the dam and to carry it away from the fine embankment materials. Grading requirements for the drain material are provided in the Recommendations. The drain material should be relatively clean. It will probably be necessary to obtain the drain material from the gravel deposit in the upper reservoir area, since it is relatively free of silt and clay fines.

Seepage losses out of the reservoir may be a concern. It appears that as long as the underlying in-place gravel is not exposed in the reservoir or abutment areas, seepage losses should not be excessive. We understand the previous reservoir performed satisfactorily. The gravel layer at the higher elevations on the south abutment apparently does not extend downward into the reservoir. If gravel is exposed during construction activity in the reservoir, it should be covered with compacted silt or sand.

Settlement of the embankment, due to consolidation of foundation soils, was evaluated. It appears that the in-place clay layer has been preloaded by the previous embankment structure. Placement of the embankment in these areas should result in a minimal amount of settlement. After the limits of the new embankment have been established, the settlement potential should again be reviewed.

It may be necessary to provide riprap on the upstream embankment slope. The gravel shell material will be somewhat resistant to wave action. After the prevailing wind direction, wind velocity, and fetch length have been determined, the necessity for riprap should be further studied. Cobbles and boulders present in the gravel on the south abutment and in the reservoir could be used as riprap.

(5)Cedergren, H.R. "Seepage, Drainage and Flow Nets", John Wiley & Sons, Inc., New York, NY, 1967, p 175.

RECOMMENDATIONS

General

1. All topsoil, organic material, and debris from the previous structure should be removed from the embankment areas.

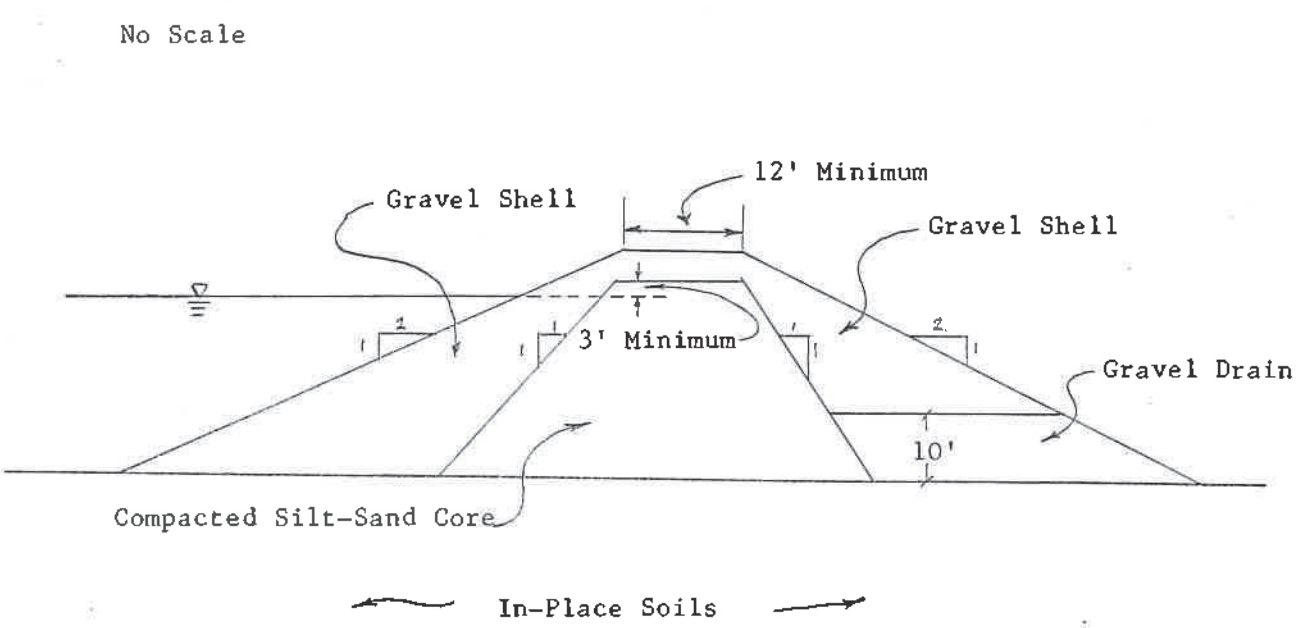
2. All fill and backfill should be approved by a soils engineer, placed in uniform lifts, and compacted. All fill should be compacted to a minimum of 95 percent of maximum dry density determined by ASTM D698, or to a minimum relative density of 65 percent, as determined by ASTM D4253 and D4254.

3. The reservoir and embankment area should be carefully inspected to determine if in-place gravel, which might extend under the embankment, is exposed. If so, a minimum of 2 feet of compacted silt should be placed over the gravel to limit seepage.

4. After the design parameters discussed in the Engineering Analysis have been determined, the necessity for riprap should be evaluated.

Embankment and Borrow Materials

5. An embankment section, as shown below, should be used:



6. The preferred materials for construction of the dam are as follows:

Material	Borrow Location
Compacted Silt-Sand Core	Existing Embankment or Stockpile Downstream of Dam
Gravel Shell	Gravel on South Abutment or in Upper Reservoir
Gravel Drain	Gravel in Upper Reservoir

7. Gravel for shell and drain construction should conform to the following grading requirements:

Sieve or Screen Size	Percent Passing Gravel Shell	Percent Passing Gravel Drain
8-Inch	100	100
3-Inch	60 to 100	60 to 100
No. 4	10 to 60	10 to 60
No. 200	0 to 15	0 to 5

8. Qualified personnel should observe borrow source excavation and embankment construction for material types, and perform density tests of the embankment fill.

Recommendations given in this report are based on results of field and laboratory investigations, combined with interpolation of subsurface conditions between boring locations. The nature and extent of variations between the borings may not become evident until construction. If variations are then exposed, it will be necessary to reevaluate the recommendations of this report.

If changes in the nature, design, or location of the structure are planned, the recommendations contained in this report shall not be considered valid unless the changes are reviewed and the recommendations of this report modified or verified in writing.

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IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

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 turn-about 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-overruns 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 report's 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

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).

APPENDIX

EXPLORATION AND LABORATORY TESTING

Exploration

Test pits are excavated using a tractor-mounted backhoe. Field logs are prepared by classifying the materials in accordance with the Unified Soils Classification System. Disturbed samples are obtained from the excavations and placed in moisture-tight sacks. Undisturbed samples are obtained by pushing a thin-walled shelby tube into the soil.

Laboratory Testing Classification

The field classification is verified in the laboratory, also in accordance with the Unified Soils Classification System. Laboratory classification normally includes estimating the percent of gravel or rock fragments, sand and silt, or clay, as well as performance of ASTM test methods. Tests could include mechanical analysis, Atterberg limits, and hydrometer analysis. The final classification is shown on the "Summary of Field and Laboratory Test Results."

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.

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.

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.

Permeability Test

Constant and falling head permeability tests are performed on undisturbed and remolded samples. Where applicable (most granular soils), ASTM Designation D2434 is followed. Tests are also made in special equipment such as the compaction permeameter, triaxial chamber, or other permeameter cylinders. Remolded samples are compacted to the specified density and water content. Undisturbed samples are carefully trimmed to the desired size. Following a saturation process, the appropriate gradient is applied and measurements of flow through the sample are taken, from which the coefficient of permeability is calculated.

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NORTHERN ENGINEERING & TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS

TABLE I

SUMMARY OF FIELD AND LABORATORY TEST RESULTS

Project: Kanosh Dam

Job No. 85-2315

Boring Number	Depth in Feet	Classification	Penetration Test Blows Per Foot	Moisture Content Percent	Atterberg Limits			Gradation Percent Retained			
					Liquid Limit,%	Plastic Limit,%	Plasticity Index,%	Gravel	Sand	Silt	Clay
TP 1	3.5 - 4.0	FILL; SILT, Sandy	--	18							
	8.5 - 9.0	FILL; SILT, Sandy	--	22							
TP 2	3.5 - 4.0	FILL; SAND, Silty	--	16	GRANULAR NON - PLASTIC			2	51	- 47 -	
		See Plate Nos. 1 & 2 and Table II for additional test data.									
	8.5 - 9.0	FILL; SAND, Silty	--	18							
TP 3	5.0 - 6.0	FILL; SILT, Sandy	--	17	GRANULAR NON - PLASTIC			6	37	- 57 -	
	9.5 - 10.0	FILL; SILT, Sandy	--	18							
TP 4	2.0 - 2.5	GRAVEL, Well Graded	--	9	GRANULAR NON - PLASTIC			87	11	- 2 -	
TP 5	3.0 - 3.5	SAND, Gravelly	--	13							
TP 6	12.0 - 12.5	GRAVEL, Silty	--	5				47	40	- 13 -	
		See Plate Nos. 3 & 4 and Table II for additional test data.									
TP 7	3.5 - 4.0	GRAVEL, Sandy	--	5	GRANULAR NON - PLASTIC			68	24	- 8 -	
TP 8	2.5 - 3.0	GRAVEL, Well Graded	--	--				72	25	- 3 -	
	3.2 - 3.5	GRAVEL, Well Graded	--	14							
TP 9	2.0 - 2.5	GRAVEL, Well Graded	--	--	GRANULAR NON - PLASTIC			64	32	- 4 -	
		See Plate Nos. 5 & 6 and Table II for additional test data.									
TP 10	3.0 - 3.5	GRAVEL, Well Graded	--	--				77	21	- 1 -	
	3.5 - 4.0	SILT, Sandy	--	17							

NORTHERN ENGINEERING & TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS

SUMMARY OF FIELD AND LABORATORY TEST RESULTS

Project: Kanosh Dam

Job No. 85-2315

Boring Number	Depth in Feet	Classification	Penetration Test Blows Per Foot	Moisture Content Percent	Atterberg Limits: Liquid Limit,%	Atterberg Limits: Plastic Limit,%	Atterberg Limits: Plasticity Index,%	Gradation Percent Retained: Gravel	Sand	Silt	Clay
DH 11	0.0 - 1.5	FILL; GRAVEL, Clayey	59	--							
	5.0 - 6.5	FILL; SAND, Silty	14	--							
	6.5 - 8.0	FILL; SAND, Silty	19	--							
	10.0 - 11.0	FILL; SAND, Silty	17	--							
	11.0 - 12.5	FILL; SAND, Silty	14	--	GRANULAR	NON - PLASTIC		11	45	- 44 -	
	15.0 - 16.5	FILL; SAND, Silty	18	--							
	17.0 - 18.0	CLAY, Silty	8	--							
	20.0 - 21.5	CLAY, Silty	22	--							
	21.5 - 22.0	CLAY, Silty	10/0.5	--							
	24.0 - 24.3	GRAVEL, Sandy	100/0.3	--							
DH 12	0.0 - 1.5	FILL; SAND, Silty	14	--							
	1.5 - 3.0	FILL; SILT, Sandy	11	17							
	4.0 - 5.5	FILL; SILT, Sandy	11	--							
	5.5 - 7.0	FILL; SILT, Sandy	4	16							
	9.0 - 10.5	FILL; SILT, Sandy	17	--							
	10.5 - 12.0	FILL; SILT, Sandy	10	--							
	14.0 - 16.0	FILL; SILT, Sandy	--	--							
	16.0 - 17.5	FILL; SILT, Sandy	6	35							
	19.0 - 20.0	FILL; SILT, Sandy	5	--							
	20.5 - 22.0	CLAY, Silty	7	--							
	24.0 - 26.0	SAND, Silty	--	19							
		In-place Dry Density = 99 pcf; See Plate No. 7 for additional test data.									
	26.0 - 27.5	SAND, Silty	9	13	20	17	3	0	54	- 46 -	
	29.0 - 30.5	CLAY, Silty	15	--							
	30.5 - 31.7	CLAY, Silty	27	--							
	34.0 - 35.5	GRAVEL, Sandy	107	--							

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NORTHERN ENGINEERING & TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS

SUMMARY OF FIELD AND LABORATORY TEST RESULTS

Project: Kanosh Dam

Job No. 85-2315

Boring Number	Depth in Feet	Classification	Penetration Test Blows Per Foot	Moisture Content Percent	Atterberg Limits Liquid Limit,%	Atterberg Limits Plastic Limit,%	Atterberg Limits Plasticity Index,%	Gradation Percent Retained Gravel	Sand	Silt	Clay
DH 13	0.0 - 1.5	FILL; SILT, Sandy	8	15							
	1.5 - 3.0	FILL; SILT, Sandy	15	--							
	3.0 - 4.5	FILL; SILT, Sandy	6	--							
	5.0 - 7.0	FILL; SILT, Sandy	--	--							
	7.0 - 8.5	FILL; SAND, Silty	5	12	GRANULAR	NON - PLASTIC		0	56	- 44 -	
	10.0 - 11.5	FILL; SILT, Sandy	6	--							
	11.5 - 12.5	FILL; SILT, Sandy	9	--							
	13.0 - 14.5	FILL; CLAY, Silty	5	--							
	15.0 - 16.5	FILL; CLAY, Silty	6	--							
	16.5 - 18.0	FILL; CLAY, Silty	8	15							
	18.0 - 19.5	FILL; CLAY, Silty	17	--							
	20.0 - 21.2	FILL; CLAY, Silty	12	--							
	21.5 - 23.0	CLAY, Silty	13	--							
	23.0 - 24.5	CLAY, Silty	16	15							
	25.0 - 26.5	CLAY, Silty	5	17							
	26.5 - 27.5	CLAY, Silty	12	--							
	28.0 - 29.5	GRAVEL, Sandy	32	--							
	30.0 - 31.5	CLAY, Silty	8	--							
	31.5 - 33.0	GRAVEL, Sandy	32	--							
	33.0 - 33.1	GRAVEL, Sandy	50/0.1	--							
DH 14	0.5 - 1.5	GRAVEL, Sandy	36	--							
	1.5 - 3.0	GRAVEL, Sandy	59	--							
DH 15	0.0 - 1.5	FILL; GRAVEL, Silty	28	10							
	1.5 - 3.0	FILL; GRAVEL, Silty	26	--							
	5.0 - 6.5	FILL; SILT, Sandy	14	--							
	6.5 - 8.0	FILL; SILT, Sandy	14	17							
	10.0 - 10.1	FILL; SILT, Sandy	--	--							
	10.0 - 15.0	FILL; SILT, Sandy	--	12							
	10.1 - 11.6	FILL; SILT, Sandy	17	--							

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NORTHERN ENGINEERING & TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS

SUMMARY OF FIELD AND LABORATORY TEST RESULTS

Project: Kanosh Dam

Job No. 85-2315

Boring Number	Depth in Feet	Classification	Penetration Test Blows Per Foot	Moisture Content Percent	Atterberg Limits			Gradation Percent Retained			
					Liquid Limit,%	Plastic Limit,%	Plasticity Index,%	Gravel	Sand	Silt	Clay
DH 15	11.6 - 13.1	FILL; SILT, Sandy	18	--							
	15.0 - 15.3	FILL; SILT, Sandy	--	--							
	15.3 - 16.8	FILL; SILT, Sandy	8	--							
	16.8 - 18.3	FILL; SILT, Sandy	22	--							
	20.0 - 21.5	FILL; SILT, Sandy	7	20							
	21.5 - 22.8	FILL; SILT, Sandy	7	--							
	25.0 - 26.7	CLAY, Silty	--	34							
		In-place Dry Density = 86 pcf; See Plate No. 8 for additional test data.									
	26.7 - 28.2	SILT, Sandy	9	31	GRANULAR NON - PLASTIC			1	45	- 54 -	
	30.0 - 31.5	CLAY, Silty	7/0.7	--							
	31.5 - 33.0	CLAY, Silty	4	--							
	35.0 - 36.5	CLAY, Silty	8	--							
	36.5 - 38.0	CLAY, Silty	7	--							
	40.0 - 41.5	CLAY, Silty	15	--							
	46.2 - 46.5	GRAVEL, Sandy	41	--							
DH 16	0.0 - 1.5	FILL; SILT, Sandy	4	--							
	5.0 - 6.5	FILL; SILT, Sandy	9	17							
	10.0 - 11.5	FILL; SILT, Sandy	8	23							
	10.0 - 15.0	FILL; SILT, Sandy	--	--							
	15.0 - 16.5	FILL; SILT, Sandy	21	15							
	15.0 - 20.0	FILL; CLAY, Sandy	--	--	26	17	9	0	35	- 65 -	
	20.0 - 21.5	FILL; SILT, Sandy	11	17							
DH 17	0.0 - 1.5	FILL; CLAY, Gravelly	12	--							
	4.0 - 5.5	GRAVEL, Sandy	36	--							
	10.0 - 11.5	GRAVEL, Sandy	33	--							
	11.5 - 13.0	GRAVEL, Sandy	30	--							
	15.0 - 15.8	GRAVEL, Sandy	50/0.3	--							

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Northern Engineering and Testing, Inc.

MOISTURE - DENSITY RELATIONSHIP DATA

Client: Kanosh Dam

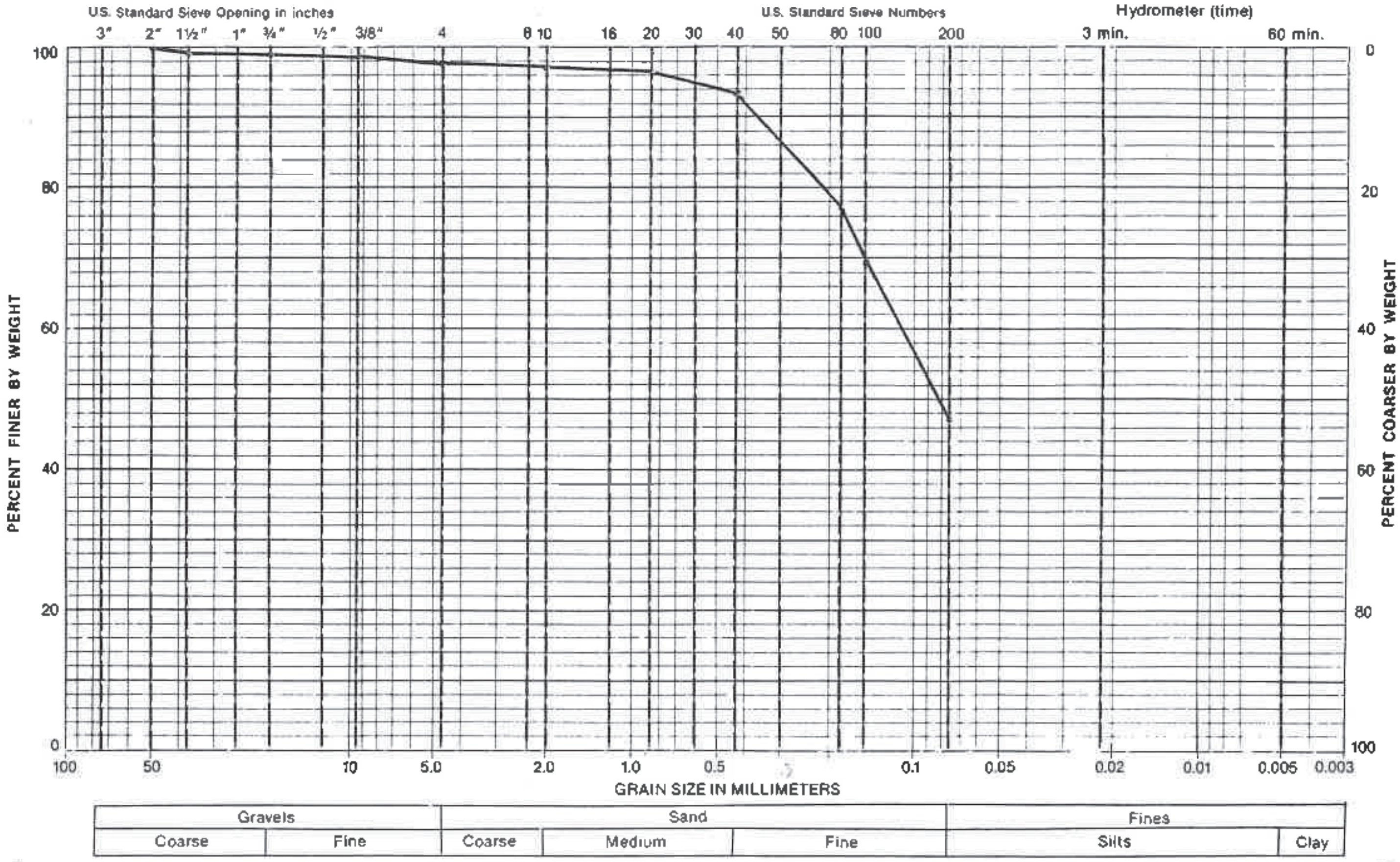
Location Sampled: TP-2; 3.5' - 4.0'

Sampled By: ______ Date: ______

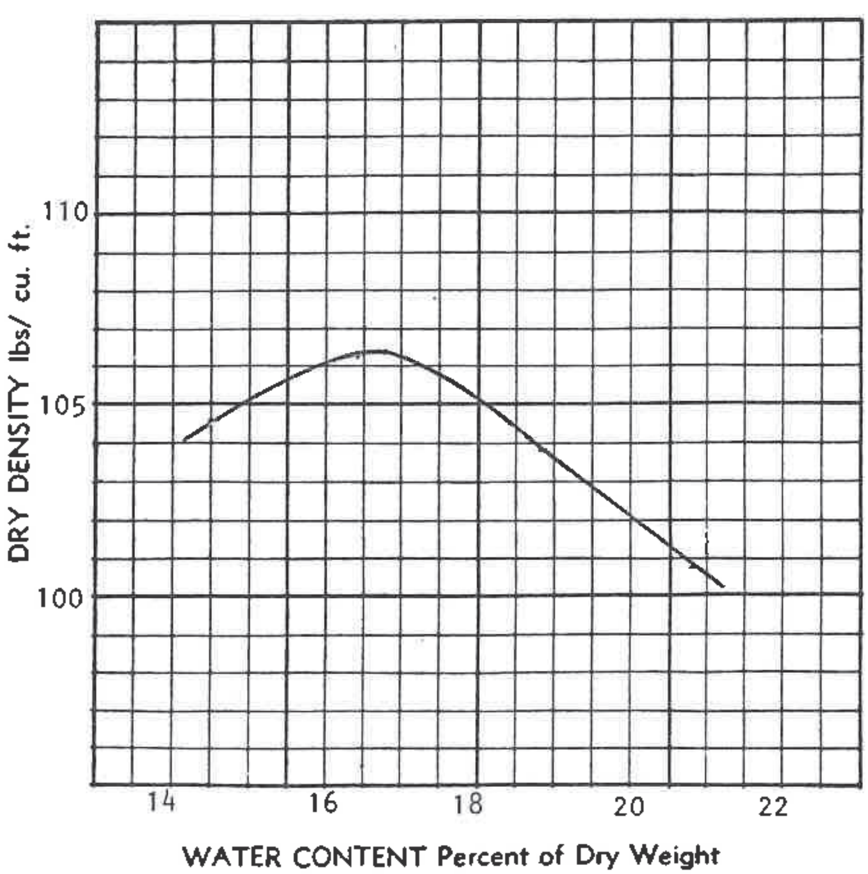
Sample No. 3343

Job No. 85-2315

Date: ______



MOISTURE-DENSITY RELATIONSHIP



TEST METHODS

ASTM D698

Method A

.0333 cu. ft. mold

5 lb. hammer

12 in. drop

3 layers

25 blows/layer

SOIL CONSTANTS

Classification: FILL; SAND, Silty

Liquid Limit: Granular

Plasticity Index: Non-Plastic

Max. Density: 106.4 pcf

Optimum Moisture: 16.7 %

SOIL USE

Borrow Stockpile

Kanosh Dam

Project

TP - 2; 3.5' - 4.0'

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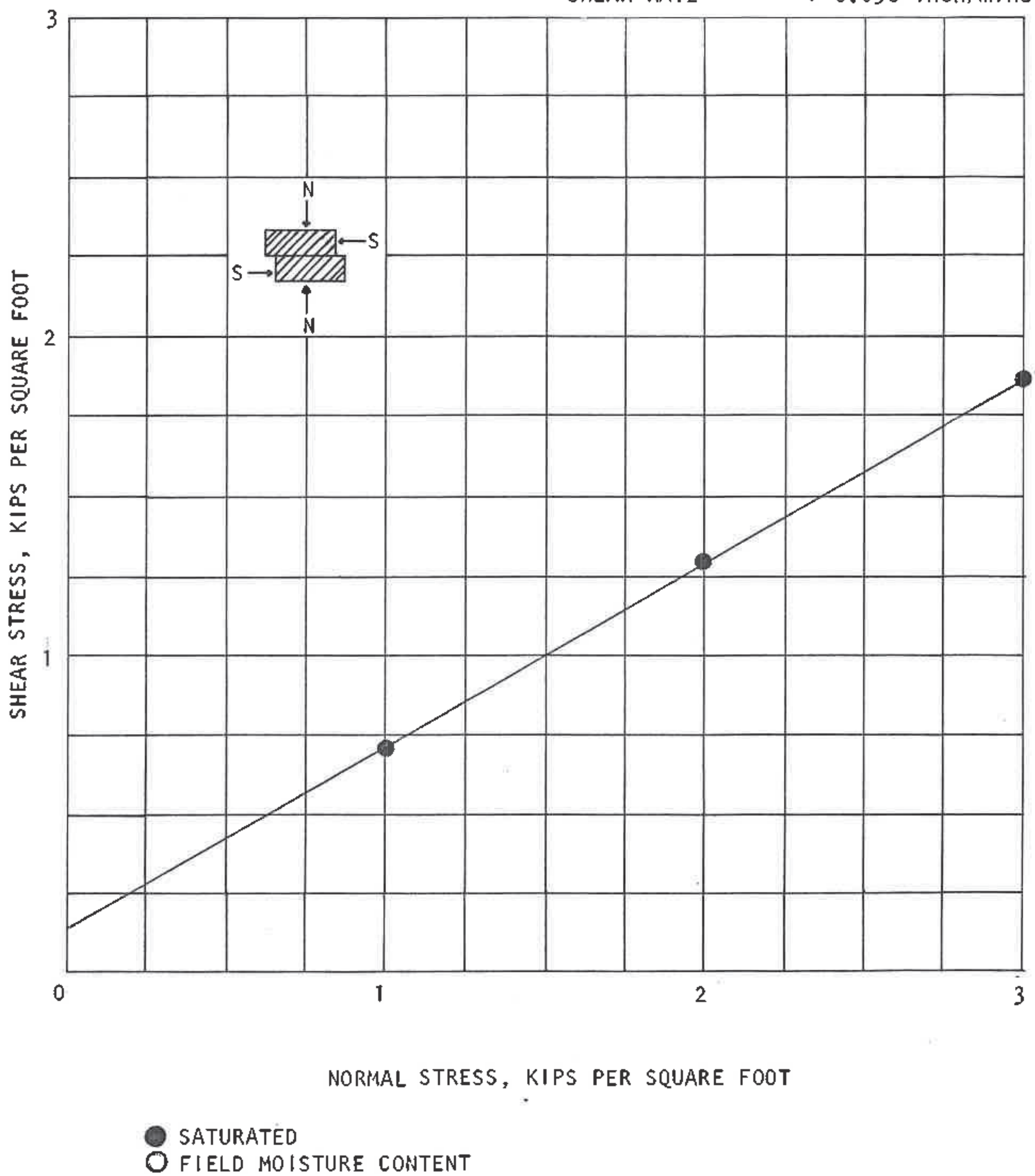
REMOLDED

DIRECT SHEAR TEST

DRILL HOLE: TP - 2
DEPTH: 3.5' - 4.0'
SAMPLE NO.: 3343

MOIST UNIT WEIGHT: 118 pcf
DRY UNIT WEIGHT : 110 pcf
MOISTURE CONTENT : 17%
CLASSIFICATION : FILL; SAND, Silty
FRICTION ANGLE : 29 degrees
COHESION INTERCEPT: 0.15 ksf
SHEAR RATE : 0.036 inch/minute



Kanosh Dam
Kanosh, Utah

Sunrise Engineering
Fillmore, Utah

Northern Engineering and Testing, Inc.
Salt Lake City, Utah

JOB NO. 85-2315 PLATE NO. 2

NET 159

Northern Engineering and Testing, Inc.

MOISTURE - DENSITY RELATIONSHIP DATA DRAFT

Client Kanosh Dam

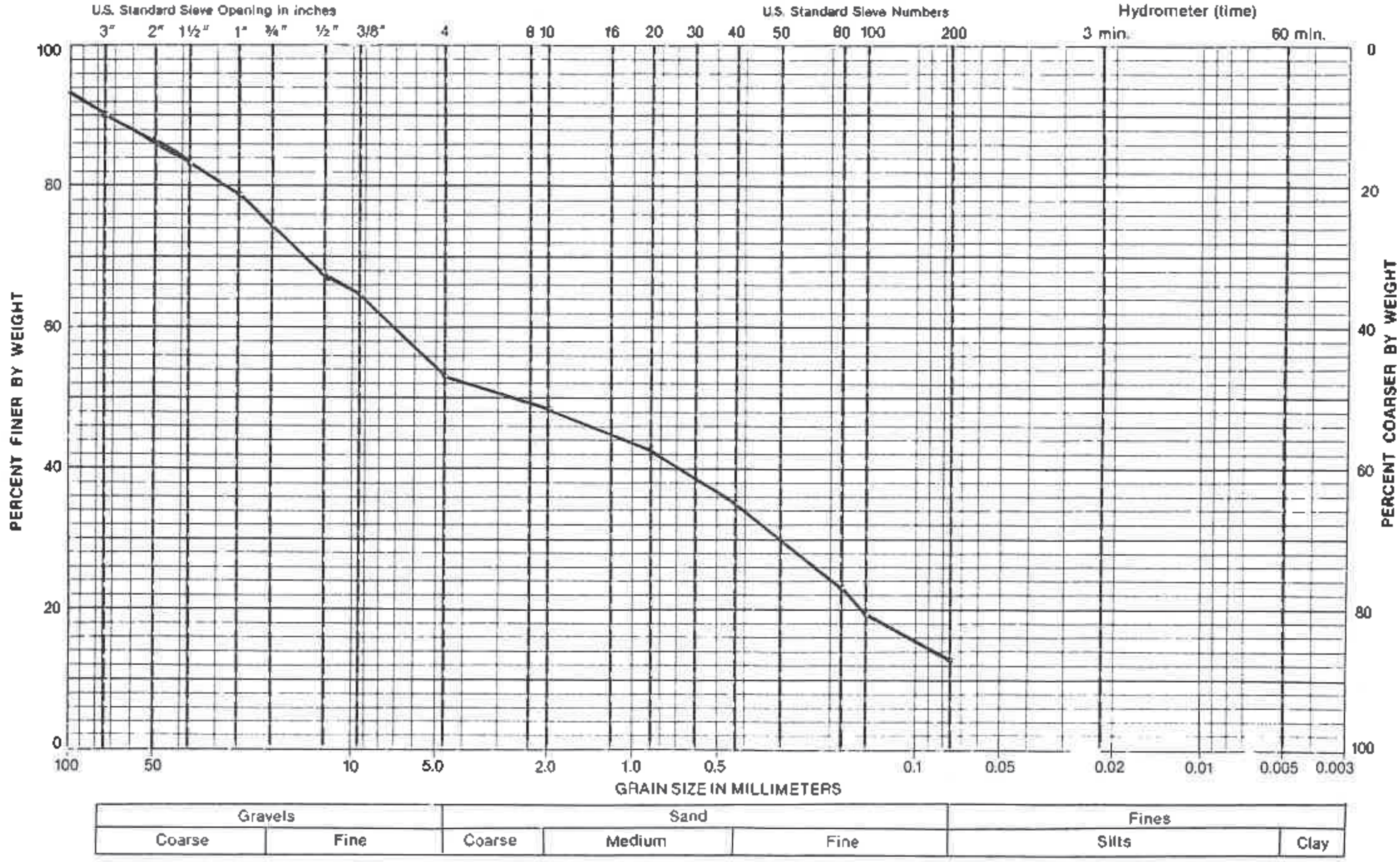
Location Sampled TP-6; 12.0' - 12.5'

Sampled By ____ Date ____

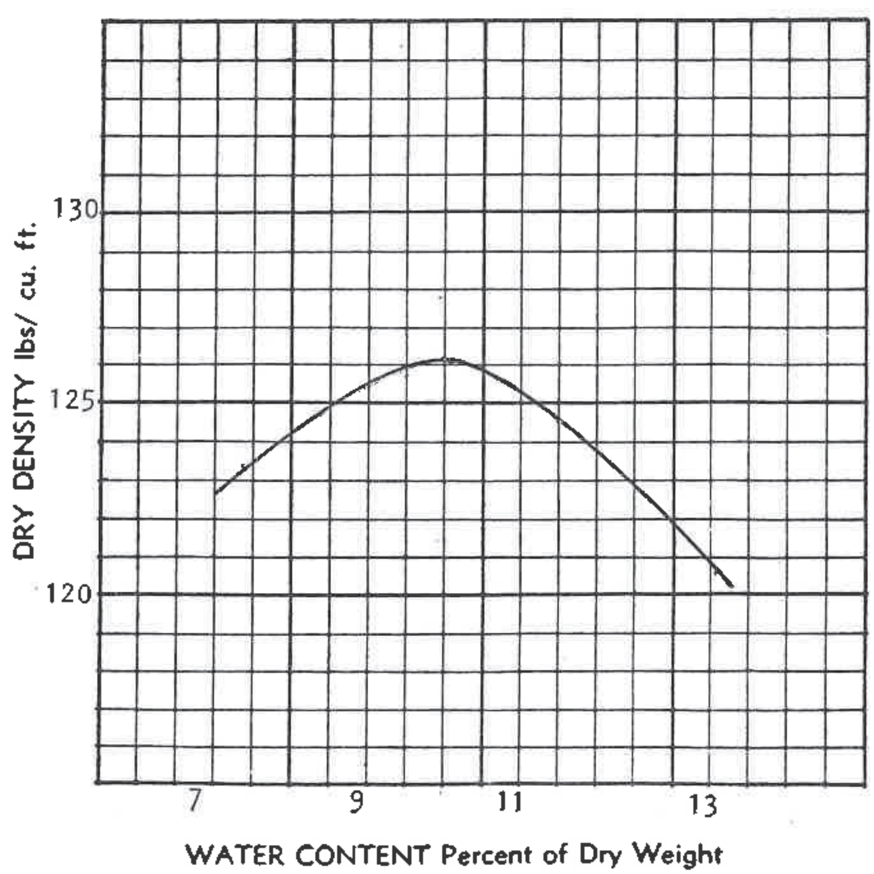
Sample No. 3349

Job No. 85-2315

Date ____



MOISTURE-DENSITY RELATIONSHIP



TEST METHODS

ASTM D698

Method D

0.075 cu. ft. mold

5 lb. hammer

12 in. drop

3 layers

56 blows/layer

SOIL CONSTANTS

Classification GRAVEL, Silty

Liquid Limit ____

Plasticity Index ____

Max. Density 126.1 pcf

Optimum Moisture 10.0 %

SOIL USE

Gravel Borrow Area

Kanosh Dam

Project

TP-6; 12.0' - 12.5'

NET 116

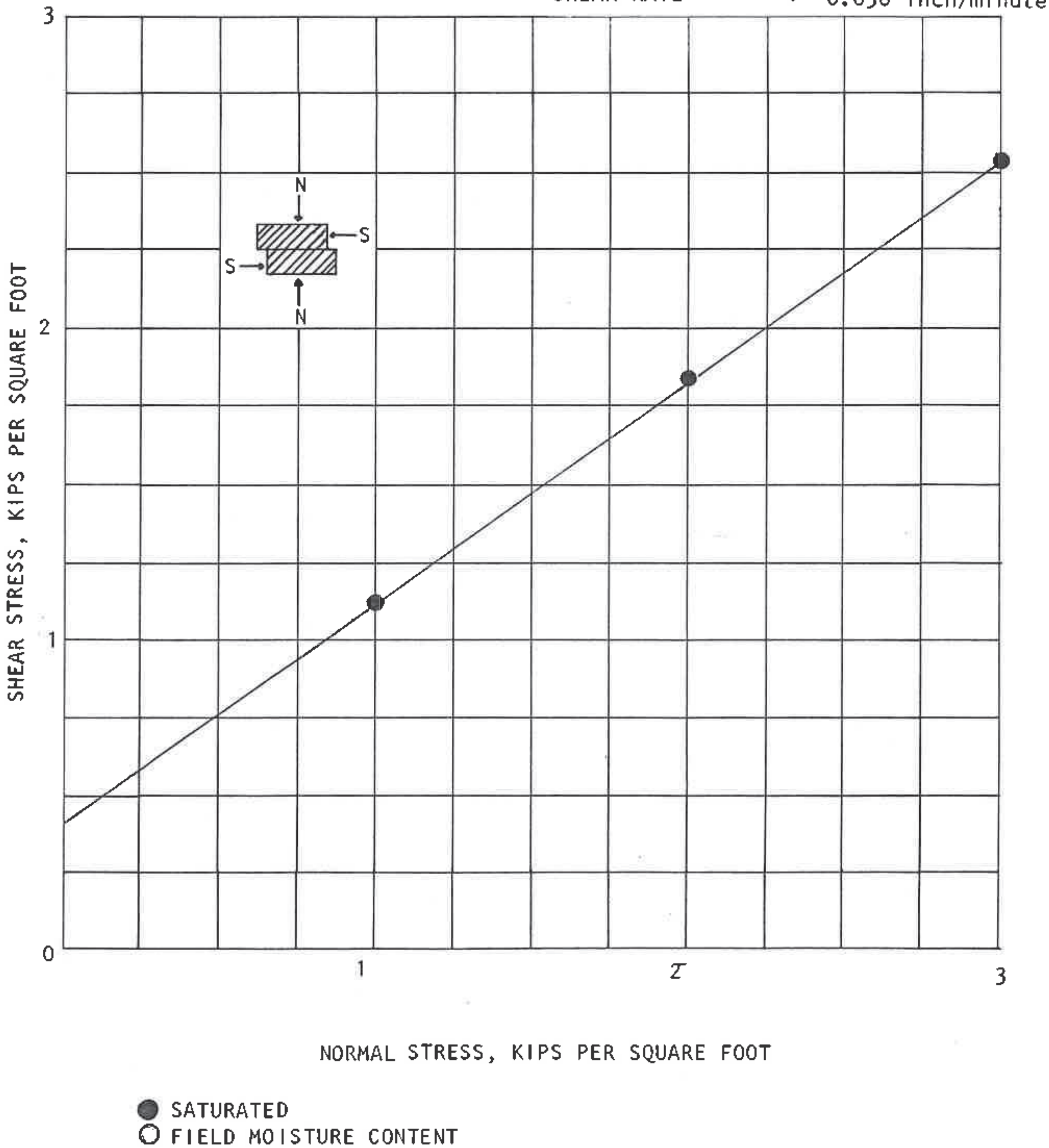
DRAFT

REMOLDED

DIRECT SHEAR TEST

DRILL HOLE: TP-6
DEPTH: 12.0' - 12.5'
SAMPLE NO.: 3349

MOIST UNIT WEIGHT: 132 pcf
DRY UNIT WEIGHT : 120 pcf
MOISTURE CONTENT : 10%
CLASSIFICATION : GRAVEL, Silty
FRICTION ANGLE : 35 degrees
COHESION INTERCEPT: 0.4 ksf
SHEAR RATE : 0.036 inch/minute



Kanosh Dam
Kanosh, Utah

Sunrise Engineering
Fillmore, Utah

Northern Engineering and Testing, Inc.
Salt Lake City, Utah

JOB NO. 85-2315 PLATE NO. 4

NET 159

Northern Engineering and Testing, Inc.

MOISTURE - DENSITY RELATIONSHIP DATA

DRAFT

Client: Kanosh Dam

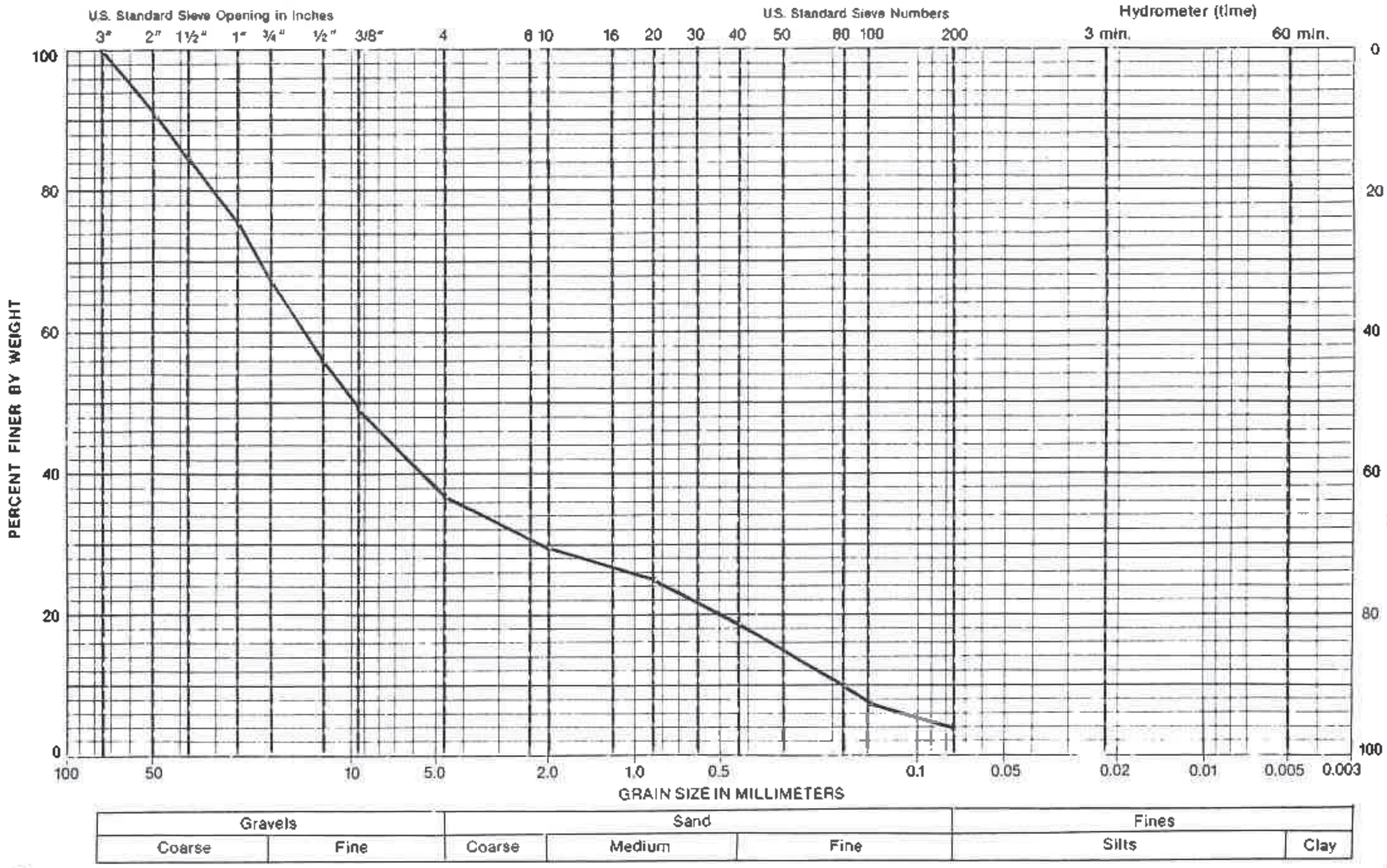
Location Sampled: TP-9; 2.0' - 2.5'

Sampled By: ______ Date: ______

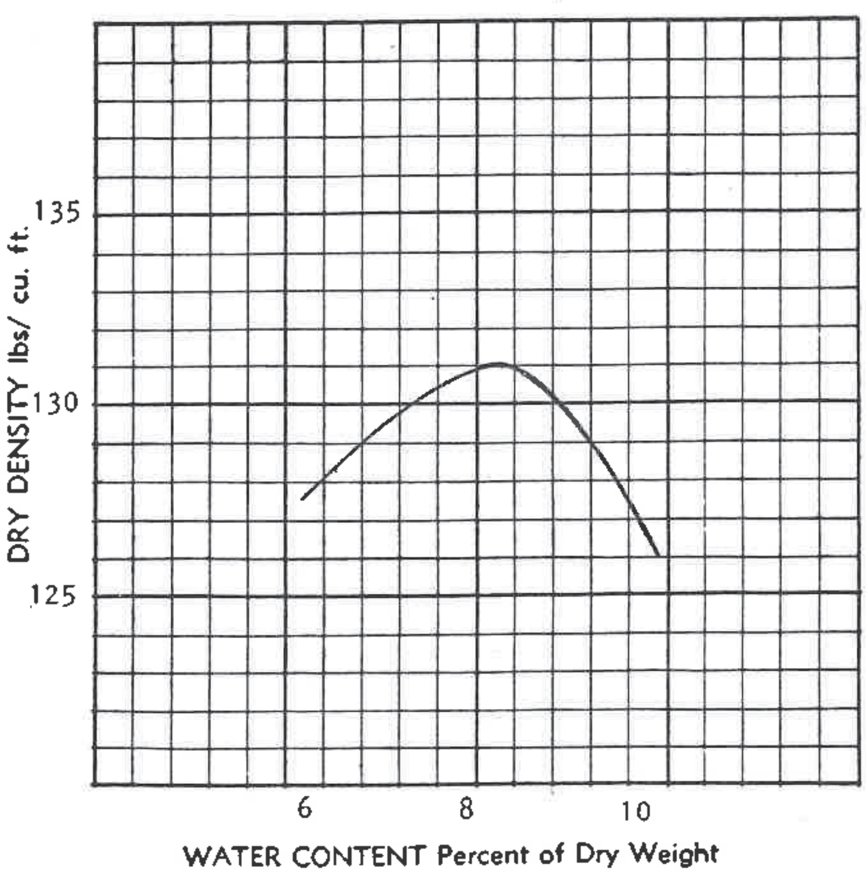
Sample No.: 3353

Job No.: 85-2315

Date: ______



MOISTURE-DENSITY RELATIONSHIP



TEST METHODS

ASTM D698

Method D

0.075 cu. ft. mold

5 lb. hammer

12 in. drop

3 layers

56 blows/layer

SOIL CONSTANTS

Classification: GRAVEL, Well Graded

Liquid Limit: Granular

Plasticity Index: Non-Plastic

Max. Density: 131.0 pcf

Optimum Moisture: 8.3 %

SOIL USE

Gravel Borrow Area

Kanosh Dam

Project

TP-9; 2.0' - 2.5'

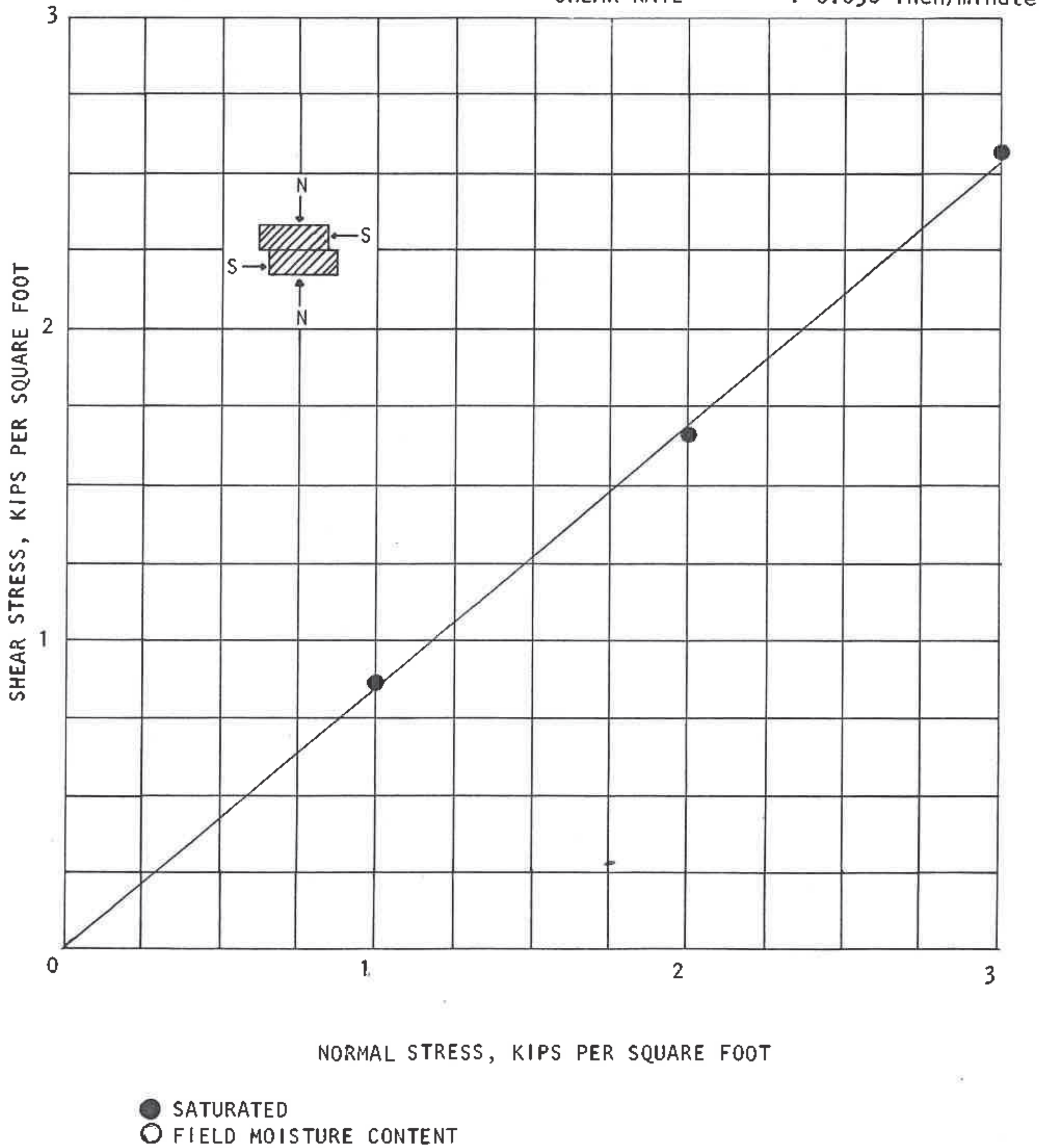
REMOLDED

DRAFT

DIRECT SHEAR TEST

DRILL HOLE: TP-9
DEPTH: 2.0' - 2.5'
SAMPLE NO.: 3353

MOIST UNIT WEIGHT: 130 pcf
DRY UNIT WEIGHT : 120 pcf
MOISTURE CONTENT : 8%
CLASSIFICATION : GRAVEL, Well Graded
FRICTION ANGLE : 40 degrees
COHESION INTERCEPT: 0
SHEAR RATE : 0.036 inch/minute



Kanosh Dam
Kanosh, Utah

Sunrise Engineering
Fillmore, Utah

Northern Engineering and Testing, Inc.
Salt Lake City, Utah

JOB NO. 85-2315 PLATE NO. 6

NET 159

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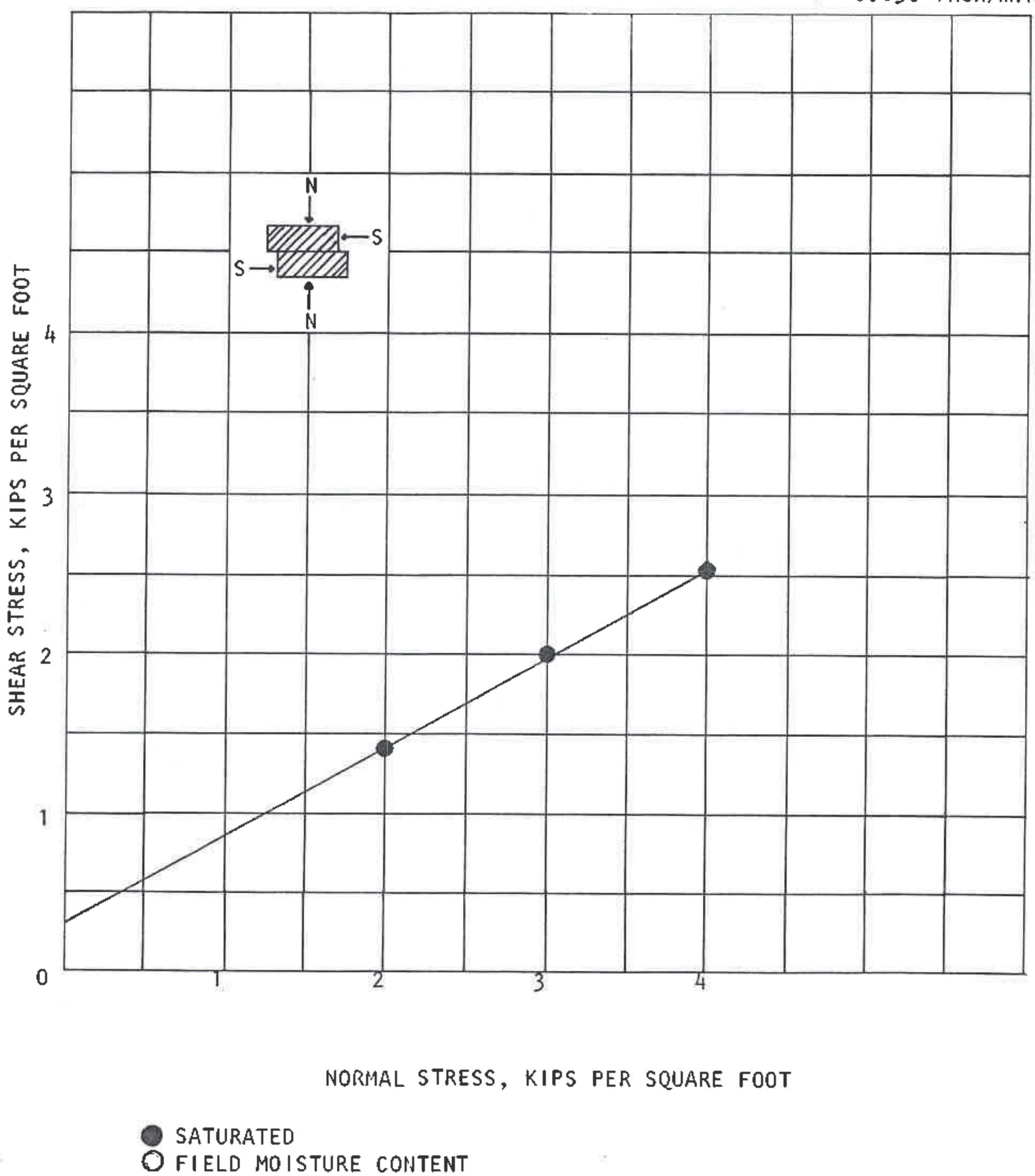
DIRECT SHEAR TEST

DRILL HOLE: DH - 12
DEPTH: 24.0' - 26.0'
SAMPLE NO.: 3675

MOIST UNIT WEIGHT:	118 pcf
DRY UNIT WEIGHT :	99 pcf
MOISTURE CONTENT :	19%
CLASSIFICATION :	SAND, Silty
FRICTION ANGLE :	29 degrees
COHESION INTERCEPT:	0.30 ksf
SHEAR RATE :	0.036 inch/minute



Kanosh Dam
Kanosh, Utah

Sunrise Engineering
Fillmore, Utah

Northern Engineering and Testing, Inc.
Salt Lake City, Utah

JOB NO. 85-2315 PLATE NO. 7

NET 159

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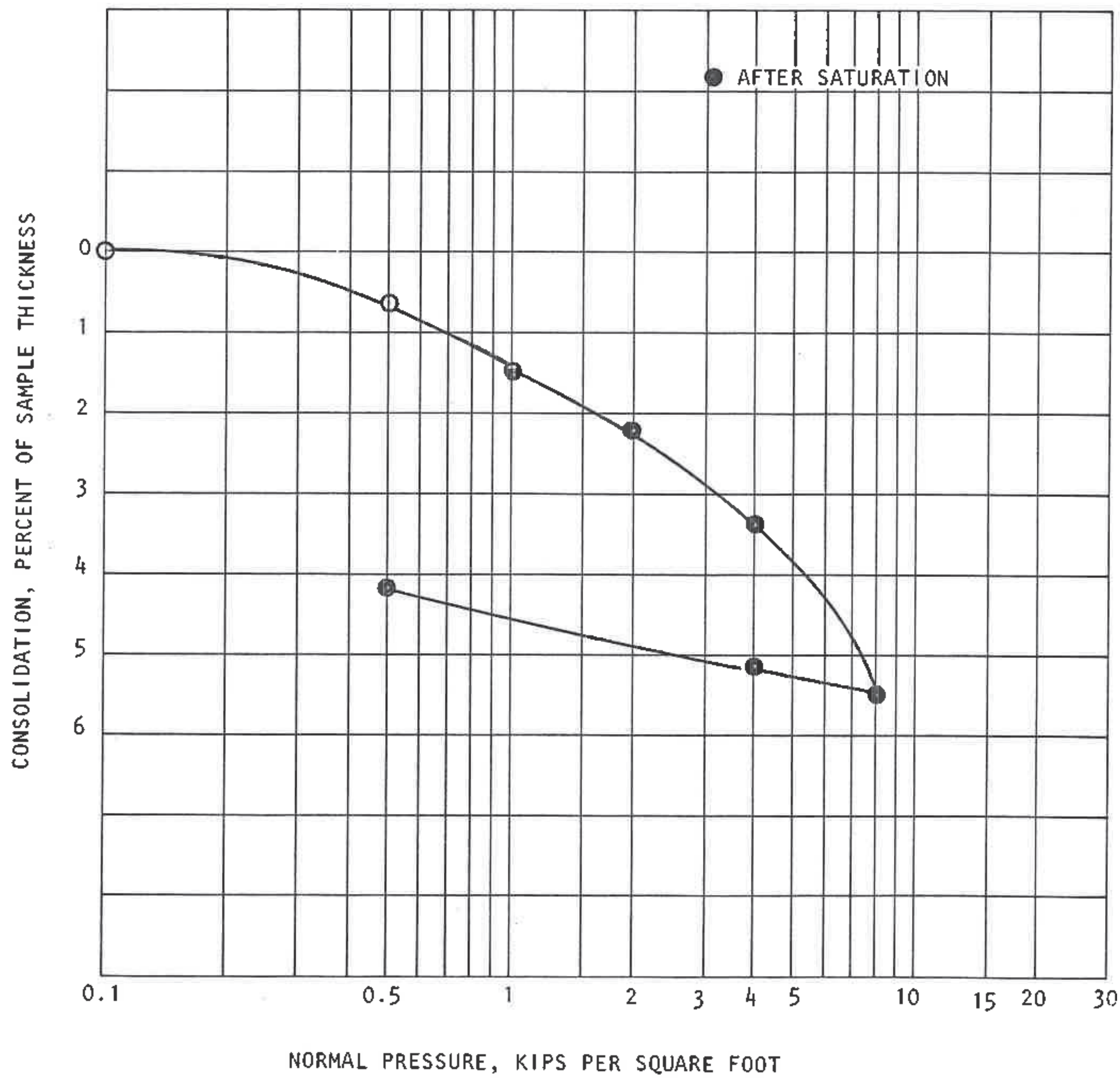
CONSOLIDATION TEST

DRILL HOLE DH - 15
DEPTH 25.0' - 26.7'
SAMPLE NO. 3715

MOIST UNIT WEIGHT : 115 pcf
DRY UNIT WEIGHT : 86 pcf
INITIAL MOISTURE CONTENT: 34%
FINAL MOISTURE CONTENT : 33%
CLASSIFICATION : CLAY, Silty



Kanosh Dam Kanosh, Utah	Northern Engineering and Testing, Inc.
Sunrise Engineering Fillmore, Utah	Salt Lake City, Utah JOB NO. 85-2315 PLATE NO. 8

NET 156

NORTHERN ENGINEERING AND TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS

TABLE II

SUMMARY OF REMOLD PERMEABILITY TESTS

Sample No.	Test Pit No.	Depth, ft.	Material Type	Remold Dry Density, pcf	Remold Moisture Content, %	Coefficient of Permeability cm/sec
3343	2	3.5- 4.0	FILL; SAND Silty	101	17	7×10^{-6}
3349	6	12.0-12.5	GRAVEL, Silty*	120	10	3×10^{-5}
3353	9	2.0- 2.5	Gravel, Well Graded*	120	10	2×10^{-5}

* Minus No. 4 portion remolded.

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NORTHERN ENGINEERING & TESTING, INC.
CONSULTING GEOTECHNICAL ENGINEERS

RESULTS OF PINHOLE DISPERSION TESTS (1) - TABLE III

KANOSH DAM - KANOSH, UTAH

Sheet 1 of 1
Job No. 85-2315

Test Pit Number	Depth, feet	Material Type	Flow Through Pinhole in ml/sec for Indicated Head in Inches of Water 2	7	15	24	Pinhole Enlargement After Test	Remarks	Classification
TP									
TP 2	3.5 - 4.0	SILT	0.43	2.20	3.00	*	2.5 to 4.0 cm	Flow through sample cloudy during all phases of test. Specimen remolded at a dry density of 101.1 pcf at 16.7% moisture.	DI

* Complete washout around nipple.

(1) Tests run in accordance with procedure recommended by Sherard, et al in Vol. 102 No. GT1, January 1976, Journal of the Geotechnical Engineering Division, American Society of Civil Engineers.

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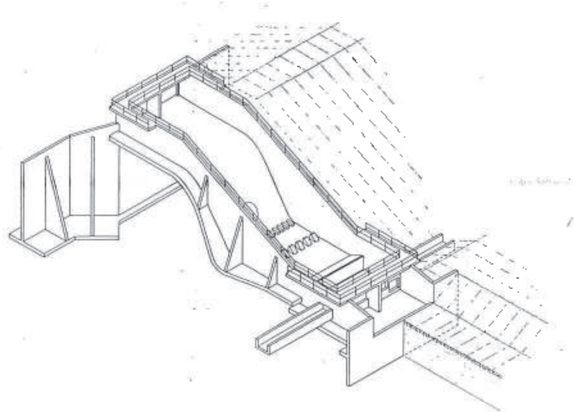
TOWN OF KANOSH

CORN CREEK DAM PROJECT



KANOSH TOWN COUNCIL

FRANK HARDING .... MAYOR
VIRGE CHRISTENSEN ..... COUNCILMAN
BRUCE WHATCOTT ..... COUNCILMAN
TERRY HIGGS .... COUNCILMAN
ROBERT NAFUS .... COUNCILMAN
CINDY TURNER .... CLERK
KAREN CROOK .... TREASURER

CERTIFICATE OF ACCEPTANCE

THE COUNCIL NAMED ABOVE CERTIFIES THAT THEY EMPLOYED ALDEN C. ROBINSON, OF SUNRISE ENGINEERING, INC., TO PREPARE THE ACCOMPANYING DRAWINGS AND SPECIFICATIONS FOR THE CONSTRUCTION OF THE CORN CREEK DAM AND SPILLWAY AND THAT THEY HEREBY ACCEPT THESE DRAWINGS AND SPECIFICATIONS.

APPROVED AND ACCEPTED THIS ________ DAY OF ____________ 1985

SIGNED ______________
MAYOR

CERTIFICATE OF ENGINEER

I DO HEREBY CERTIFY THAT THESE PLANS FOR THE CONSTRUCTION OF THE CORN CREEK DAM WERE PREPARED BY ME FOR THE OWNERS THEREOF.

Alden C. Robinson   Aug. 20, 1986
ENGINEER   DATE

PROFESSIONAL LICENSE NO. 5422

STATE ENGINEERS APPROVAL

IN ACCORDANCE WITH SECTION 73-5-5 UTAH CODE ANNOTATED 1953, AS AMENDED, APPROVAL IS HEREBY GIVEN FOR THE CONSTRUCTION OF CORN CREEK DAM.

Robert L. Morgan
STATE ENGINEER

prepared by

SUNRISE ENGINEERING, INC.

FILLMORE, UTAH

CONTRACT RECORD DRAWING

SEP 5 1985

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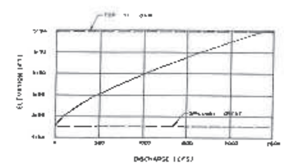
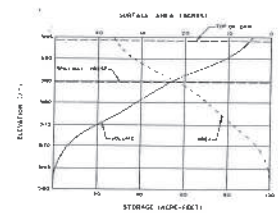
AREA MAP

LOCATION MAP



SPILLWAY DISCHARGE CURVE



RESERVOIR AREA-CAPACITY CURVE

ABBREVIATIONS

LEGEND

- STOCK FENCE
- SOIL BORING LOCATION
- SLOPE (PLAN VIEW) — TOP OF SLOPE / TOE OF SLOPE
- BENCH MARK
- EXIST. CONTOURS — 7645
- NEW CONTOURS — 7645
- CROSS REFERENCING — DETAIL DESIGNATION / DWG. NUMBER
- REMOVAL DESIGNATION
- CENTER LINE
- IRRIGATION DITCH
- EXISTING FEATURES
- NEW IMPROVEMENTS
- SECTION CORNER
- PERFORATED DRAIN

NOTES

1. All locations where embankment is to be placed over existing terrain, the existing ground must first be stripped, scarified and compacted prior to being covered.
2. All concrete construction, including bending of bars, bar supports, spacers, laps at splices, etc., shall comply with A.C.I. Building Code Requirements for Reinforced Concrete. All splices and bent bar hogs shall be 24" minimum length.
3. Membrane curing compound or water curing is required on all concrete work.
4. Exposed edges shall be finished with a 3/4" chamfer. Exposed surfaces shall be finished as per specifications.
5. Rebar shall be placed 3" minimum below exposed surfaces, unless otherwise specified.
6. Soil beneath slabs shall be undisturbed wherever possible. Otherwise, compacted as per specifications.
7. Concrete design requirements:

   Reinforcement ASTM A 615 gr. [illegible]

   Concrete

   - Strength test average of any 3 consecutive tests ... 3500 psi
   - Average Compression Strength (28 days) ... 3000 psi
   - Min. Cement per Cubic Yard of Concrete ... 6 bags
   - Slump Range ... 2½" to 3"

INDEX

REVISIONS

SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah

TOWN OF KANOSH CORN CREEK DAM PROJECT

MAPS, LEGEND, & SHEET INDEX

DRAWN	CHECKED		
E.J.S	?C.R	B.H.	
APPROVED		DATE	8-20-85
SCALE	NONE	SHEET NO.	2 OF 13

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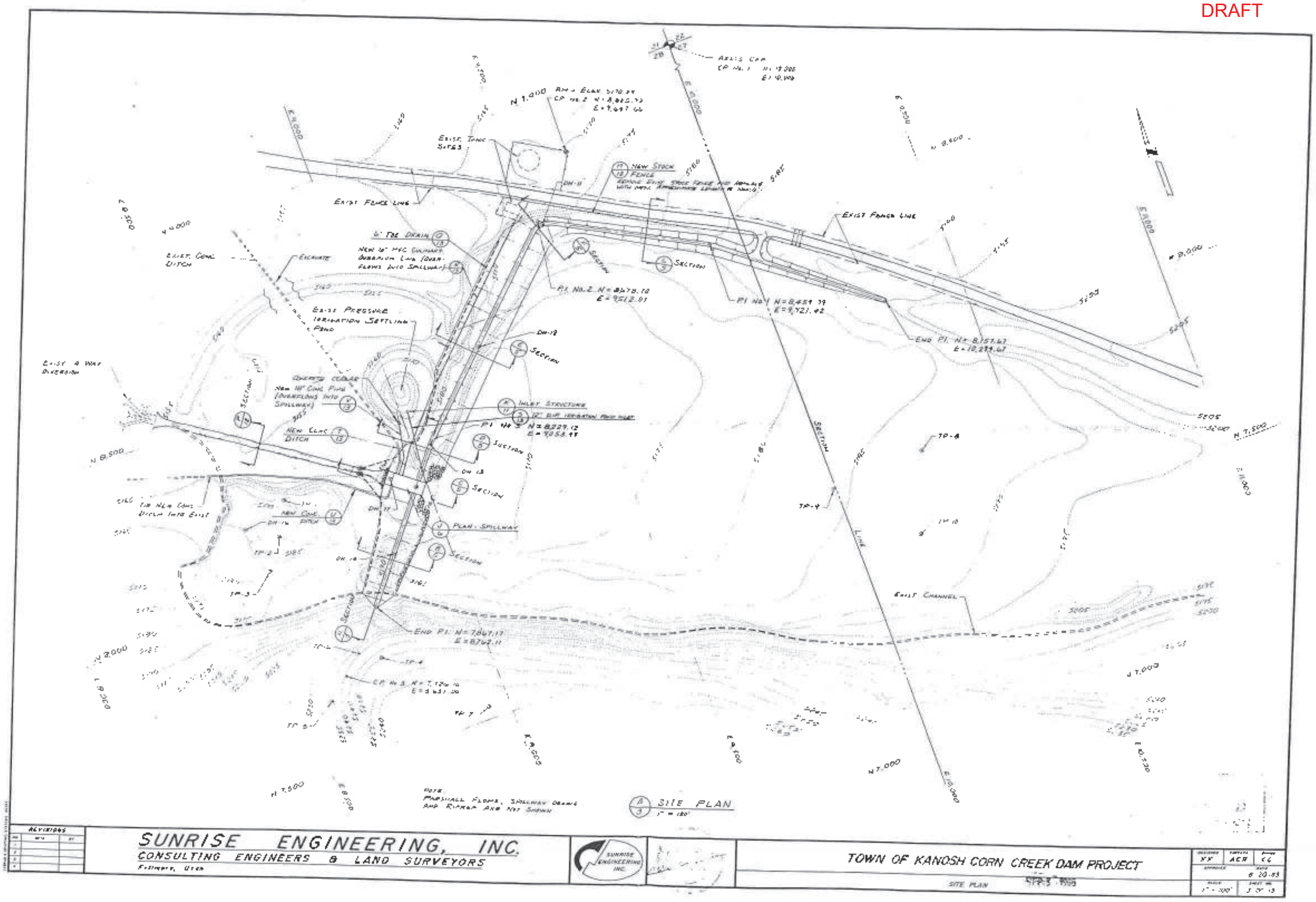
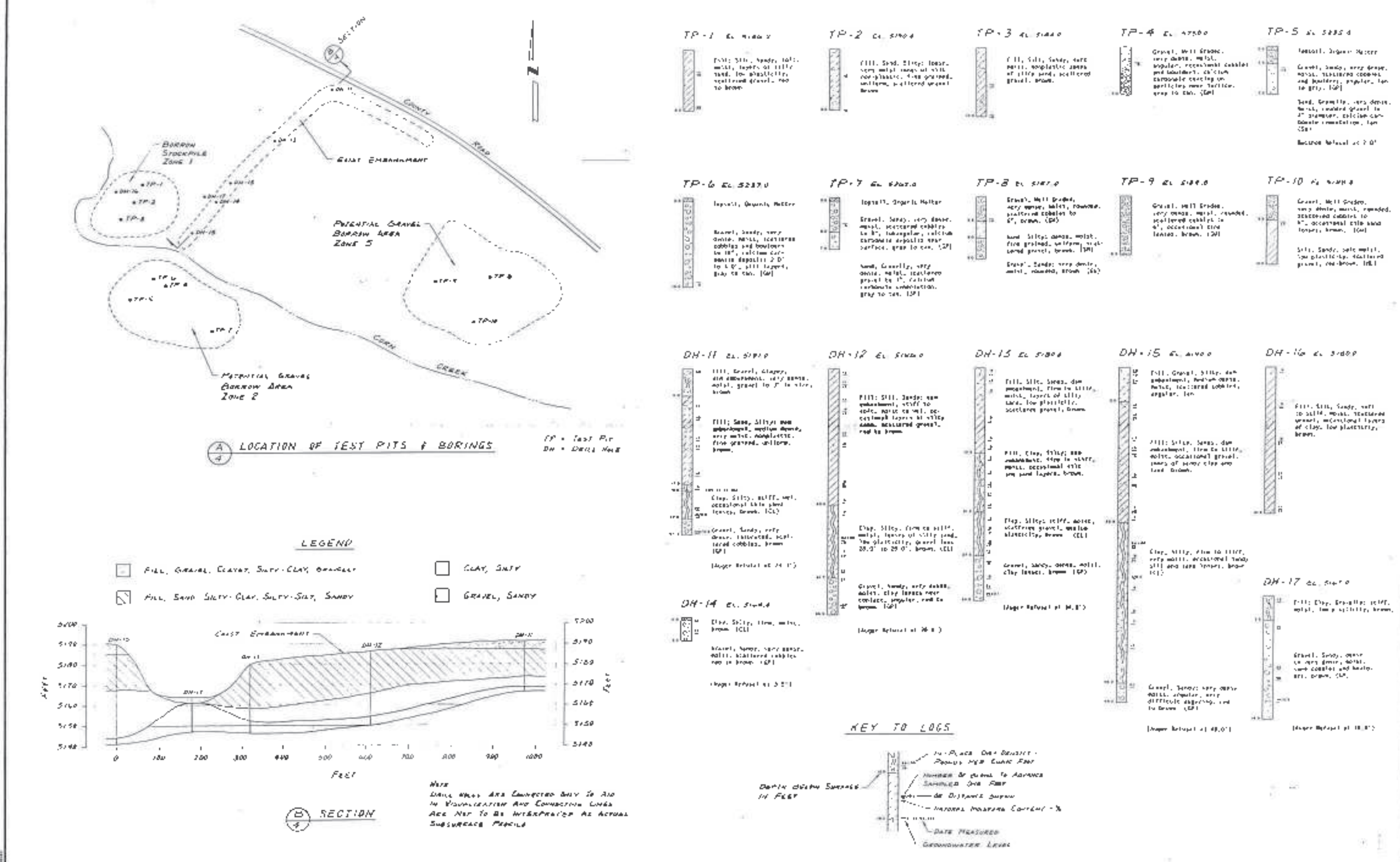


SITE PLAN
1" = 100'
NOTE
PARSHALL FLUME, SPILLWAY DRAINS AND RIPRAP ARE NOT SHOWN
EXIST FENCE LINE
EXIST CHANNEL
INLET STRUCTURE
PLAN - SPILLWAY
SECTION
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah
TOWN OF KANOSH CORN CREEK DAM PROJECT
SITE PLAN
REVISIONS

DRAFT



REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		

SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah

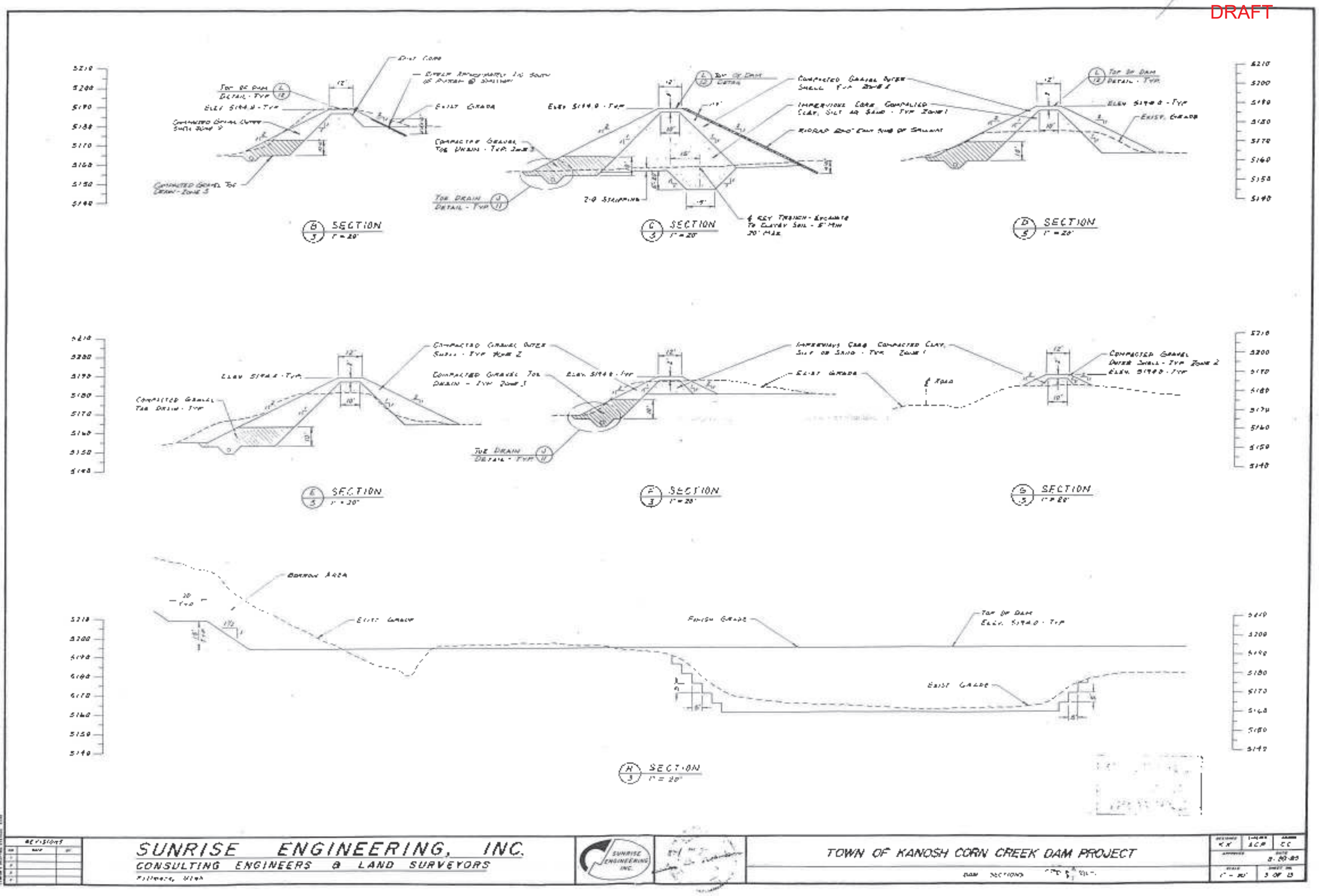
SUNRISE ENGINEERING INC.

TOWN OF KANOSH CORN CREEK DAM PROJECT

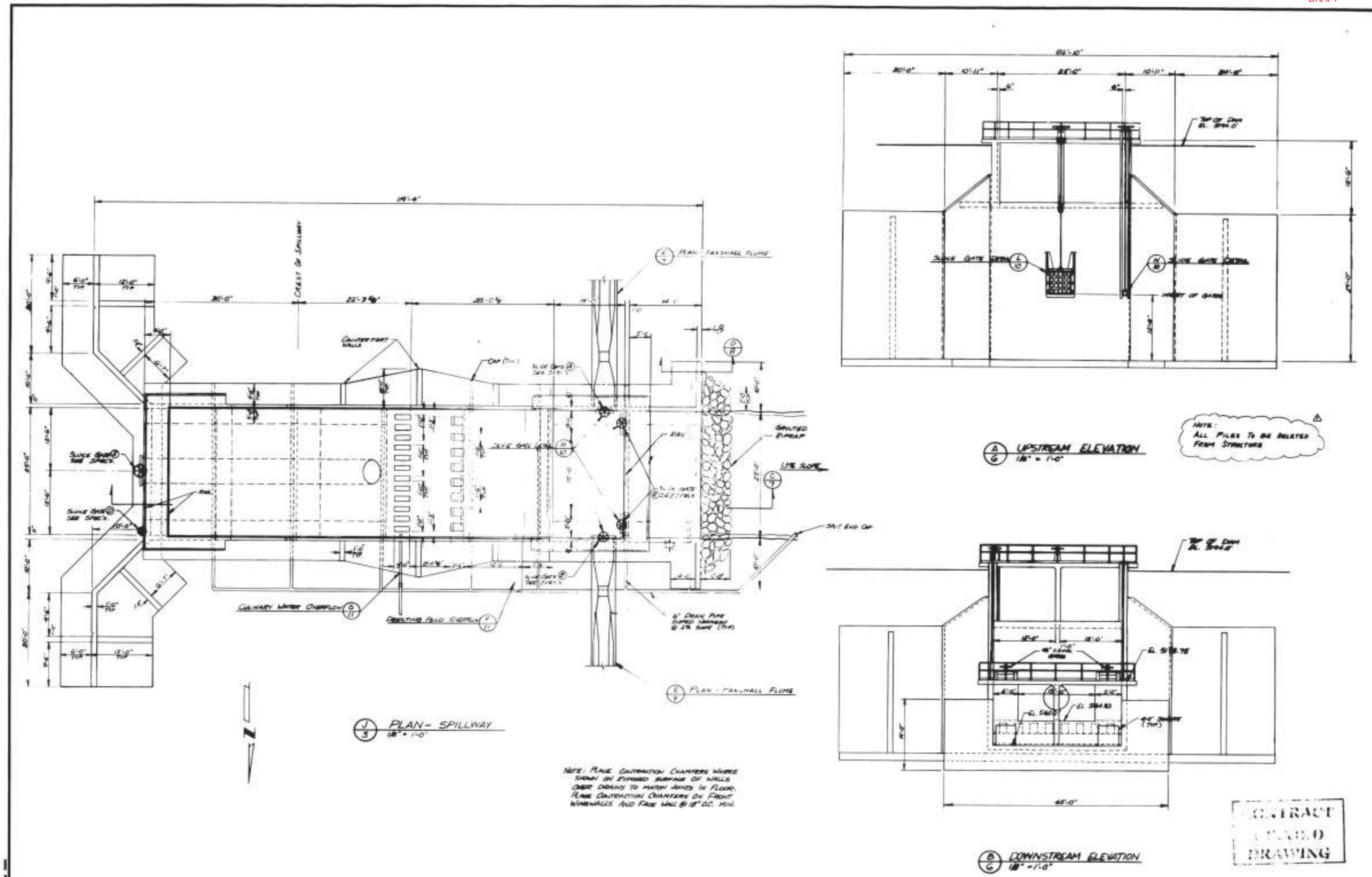
GEOTECHNICAL INVESTIGATION

K K	A C R	E C
		8-20-85
NONE		4 OF 13

DRAFT



SECTION 1" = 20'
SECTION 1" = 20'
SECTION 1" = 20'
SECTION 1" = 20'
SECTION 1" = 20'
SECTION 1" = 20'
SECTION 1" = 20'
Borrow Area
Exist Grade
Finish Grade
Top of Dam Elev. 5194.0 - Typ
Compacted Gravel Outer Shell - Typ Zone 2
Impervious Core Compacted Clay, Silt or Sand - Typ Zone 1
Compacted Gravel Toe Drain - Typ Zone 3
Toe Drain Detail - Typ
2.0 Stripping
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
TOWN OF KANOSH CORN CREEK DAM PROJECT
DAM SECTIONS



REVISIONS		
NO.	DATE	BY
1	11-13-86	CJC

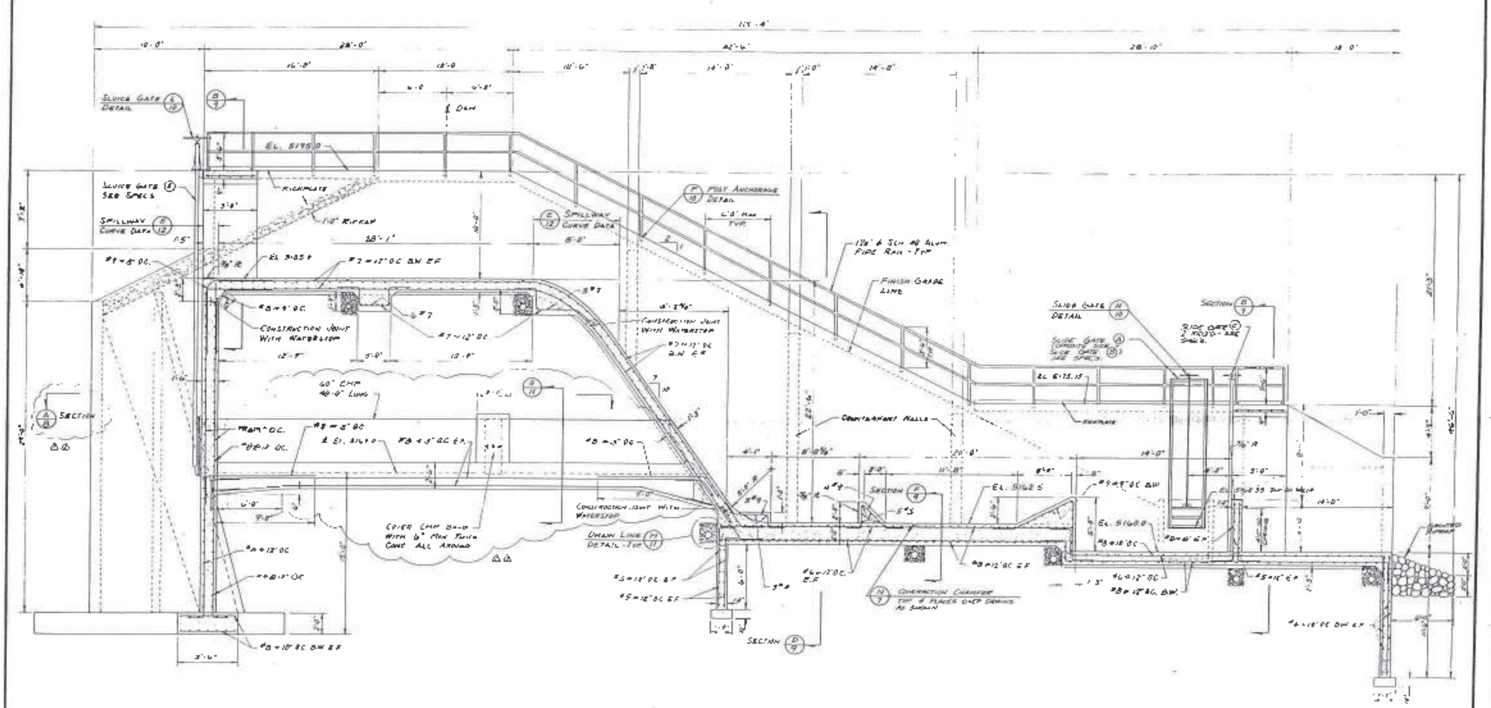
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah

TOWN OF KANOSH CORN CREEK DAM PROJECT

SPILLWAY PLAN & ELEVATIONS SEP 5 1986

Scale 1/8" = 1'-0" — Sheet 6 of 13

DRAFT



Note:
All Piles To Be Deleted From Structure

CONTRACTION CHAMFER
No Scale

SECTION
1/4" = 1'-0"

SLUICE AND SLIDE GATE SCHEDULE

Mark	Total	Type	Opening Size	Seat Type	Frame Height	Seating Head	Operating Head	Gear Model Hydro	Gear Model Waterman
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	Flat Back	[illegible]	[illegible]	[illegible]	10-00	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Flat Back w/ Flush Bottom	[illegible]	10	[illegible]	[illegible]	[illegible]
D	1	[illegible]	[illegible]	Flat Back	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L	1	[illegible]	[illegible]	Flat Back	—	[illegible]	[illegible]	[illegible]	[illegible]

REVISIONS

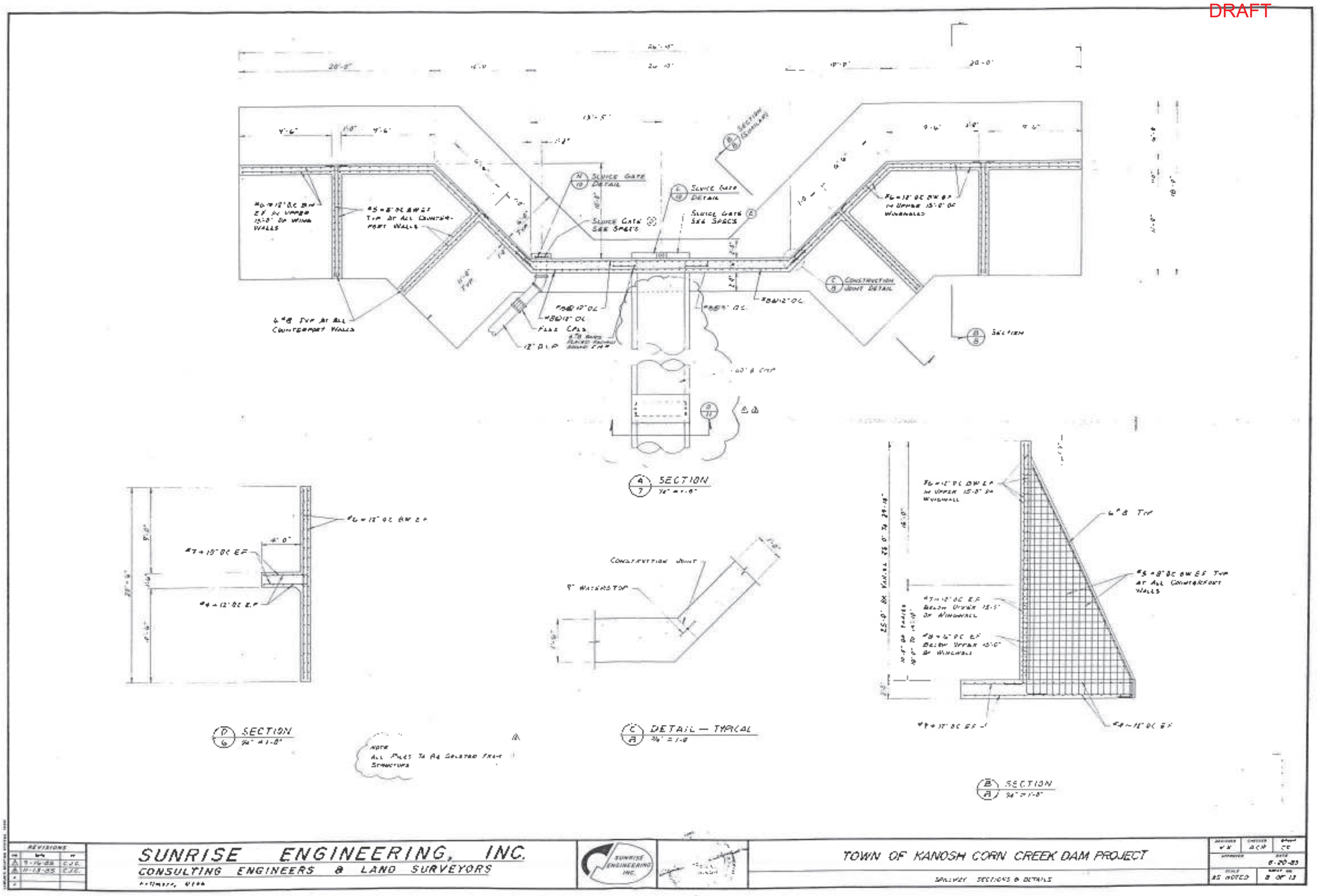
No.	Date	By
1	7-16-85	CJC
2	11-13-85	CJC

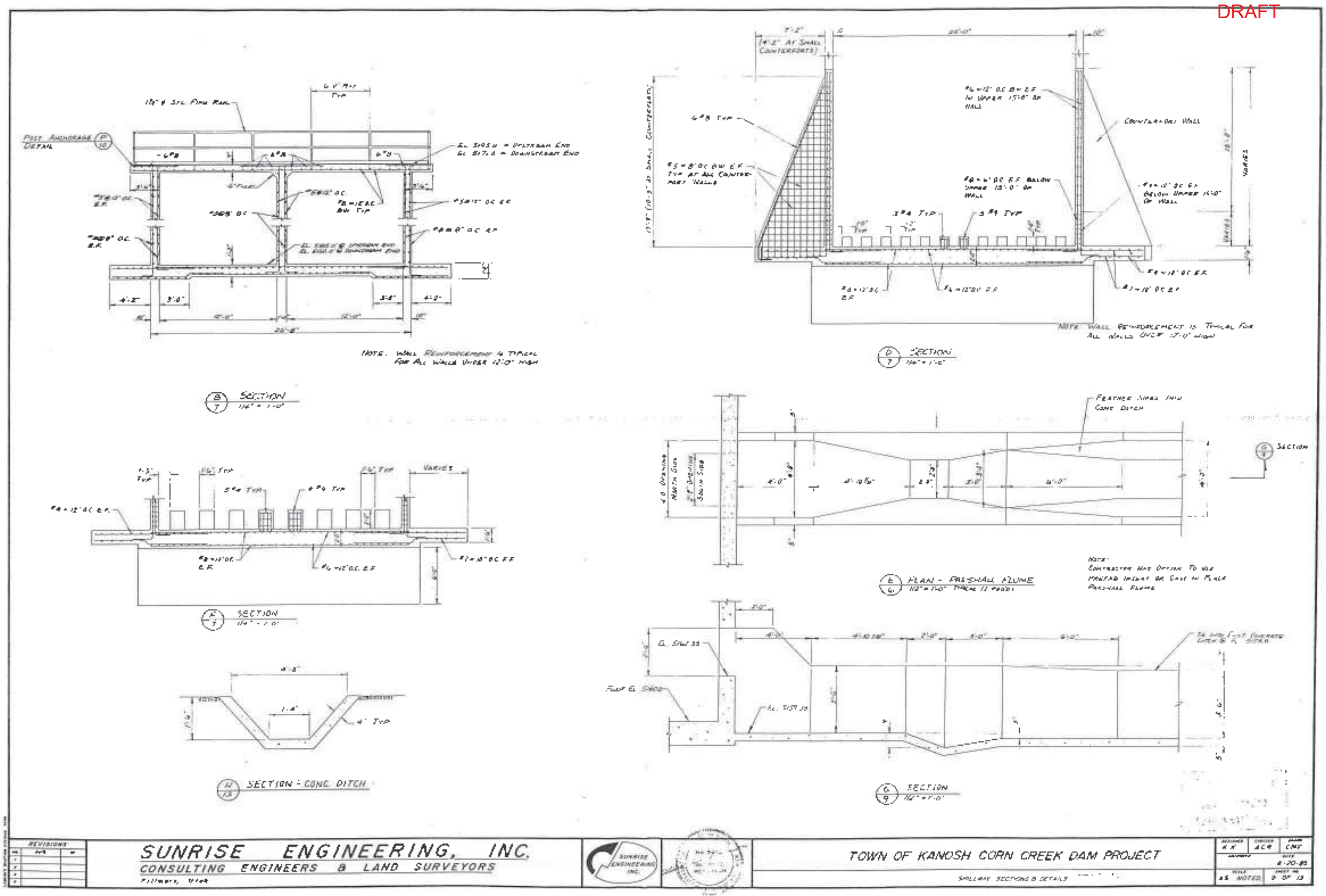
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah

TOWN OF KANOSH CORN CREEK DAM PROJECT
SPILLWAY SECTION

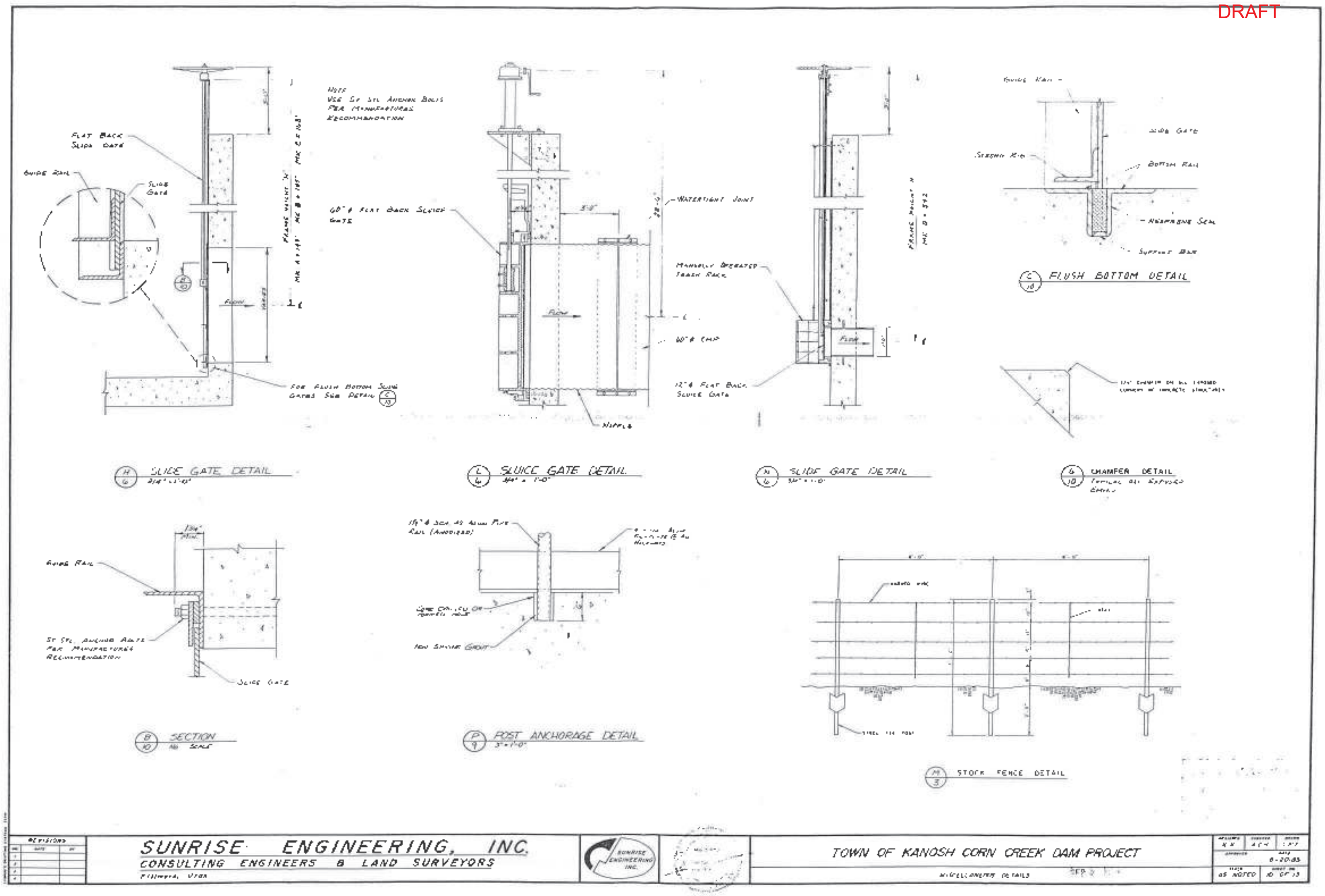
KR | ACF | CC
A-80-85
1/4" = 1'-0" | 7 OF 13

DRAFT

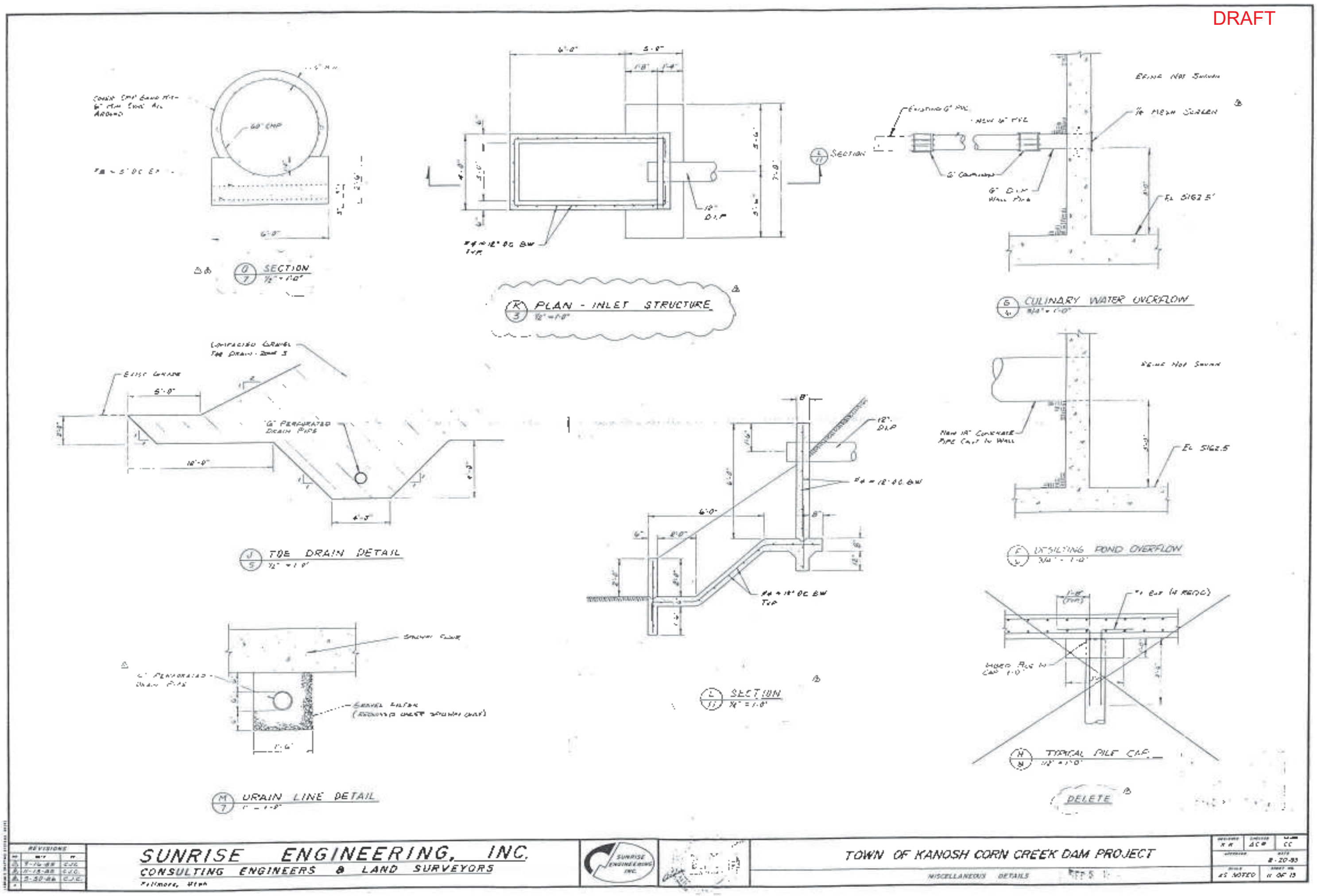

SECTION A
SECTION D
DETAIL — TYPICAL C
SECTION B
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
TOWN OF KANOSH CORN CREEK DAM PROJECT
SPILLWAY SECTIONS & DETAILS
AS NOTED
8 OF 13


DRAFT
SECTION
SECTION
SECTION
SECTION - CONC. DITCH
PLAN - PARSHALL FLUME
SECTION
SECTION
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah
TOWN OF KANOSH CORN CREEK DAM PROJECT
SPILLWAY SECTIONS & DETAILS
AS NOTED
9 OF 13

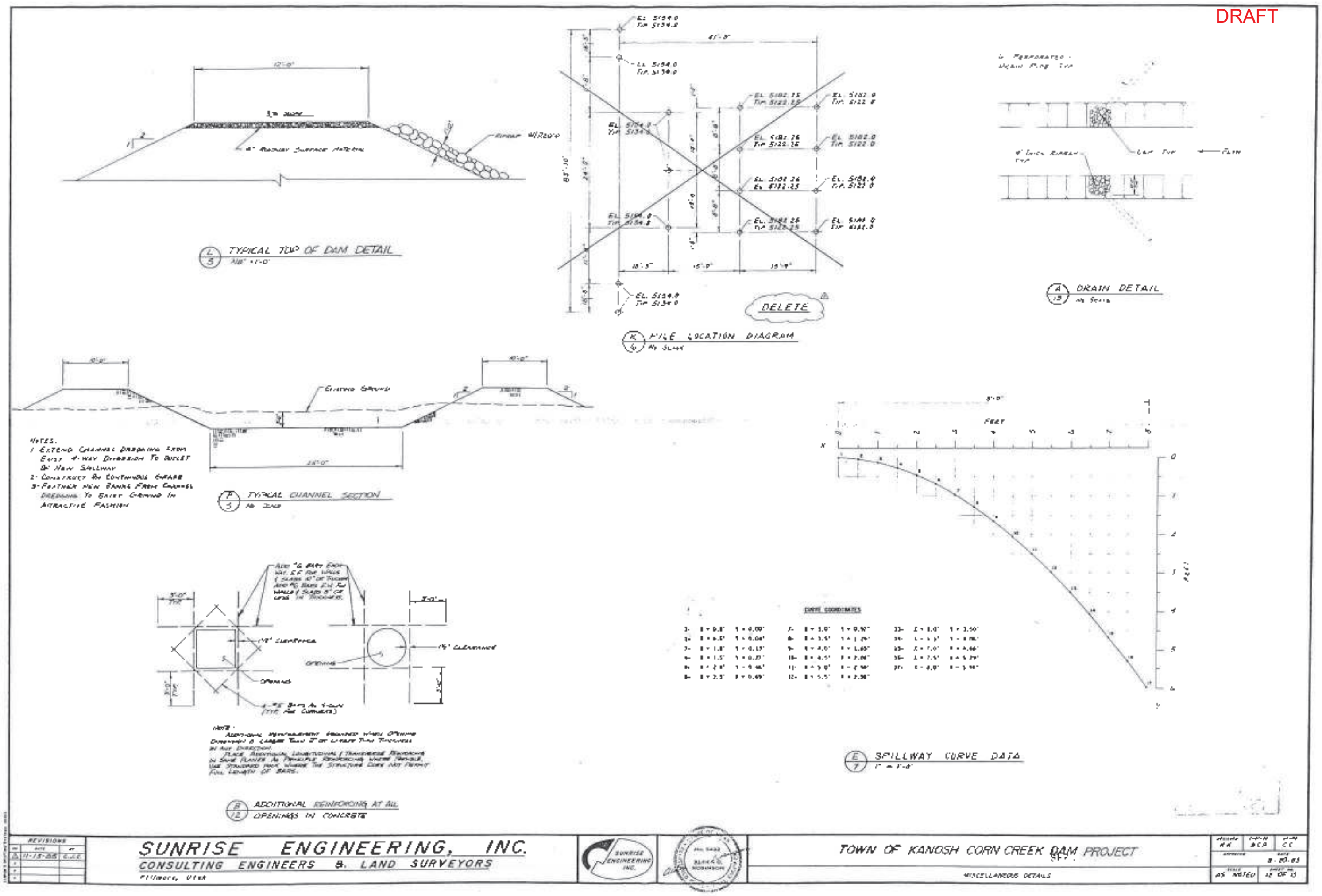
DRAFT


SLIDE GATE DETAIL
SLUICE GATE DETAIL
SLIDE GATE DETAIL
FLUSH BOTTOM DETAIL
CHAMFER DETAIL
SECTION
POST ANCHORAGE DETAIL
STOCK FENCE DETAIL
FLOW
WATERTIGHT JOINT
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
TOWN OF KANOSH CORN CREEK DAM PROJECT
MISCELLANEOUS DETAILS
6-20-83
AS NOTED

DRAFT


SECTION
PLAN - INLET STRUCTURE
CULINARY WATER OVERFLOW
TOE DRAIN DETAIL
EXISTING POND OVERFLOW
SECTION
TYPICAL PILE CAP
DRAIN LINE DETAIL
DELETE
EL 5162.5'
EL 5162.5
12" D.I.P.
60" CMP
6" Perforated Drain Pipe
5'-0"
10'-0"
6'-0"
8'-0"
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah
TOWN OF KANOSH CORN CREEK DAM PROJECT
MISCELLANEOUS DETAILS
AS NOTED
11 OF 13

DRAFT



TYPICAL TOP OF DAM DETAIL
4" ROADWAY SURFACE MATERIAL
RIPRAP W/ REG'D
PILE LOCATION DIAGRAM
No SCALE
DELETE
DRAIN DETAIL
No Scale
4" PERFORATED DRAIN PIPE TYP
4' THICK RIPRAP TYP
FLOW
EXISTING GROUND
NOTES.
1 EXTEND CHANNEL DREDGING FROM EXIST 4-WAY DIVERSION TO OUTLET OF NEW SPILLWAY
2 CONSTRUCT ON CONTINUOUS GRADE
3 FEATHER NEW BANKS FROM CHANNEL DREDGING TO EXIST GROUND IN ATTRACTIVE FASHION
TYPICAL CHANNEL SECTION
No SCALE
CURVE COORDINATES
FEET
SPILLWAY CURVE DATA
1" = 1'-0"
1/2" CLEARANCE
1 1/2" CLEARANCE
OPENING
ADDITIONAL REINFORCING AT ALL OPENINGS IN CONCRETE
SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah
TOWN OF KANOSH CORN CREEK DAM PROJECT
MISCELLANEOUS DETAILS
REVISIONS
11-15-85
8-20-85
AS NOTED
12 OF 13

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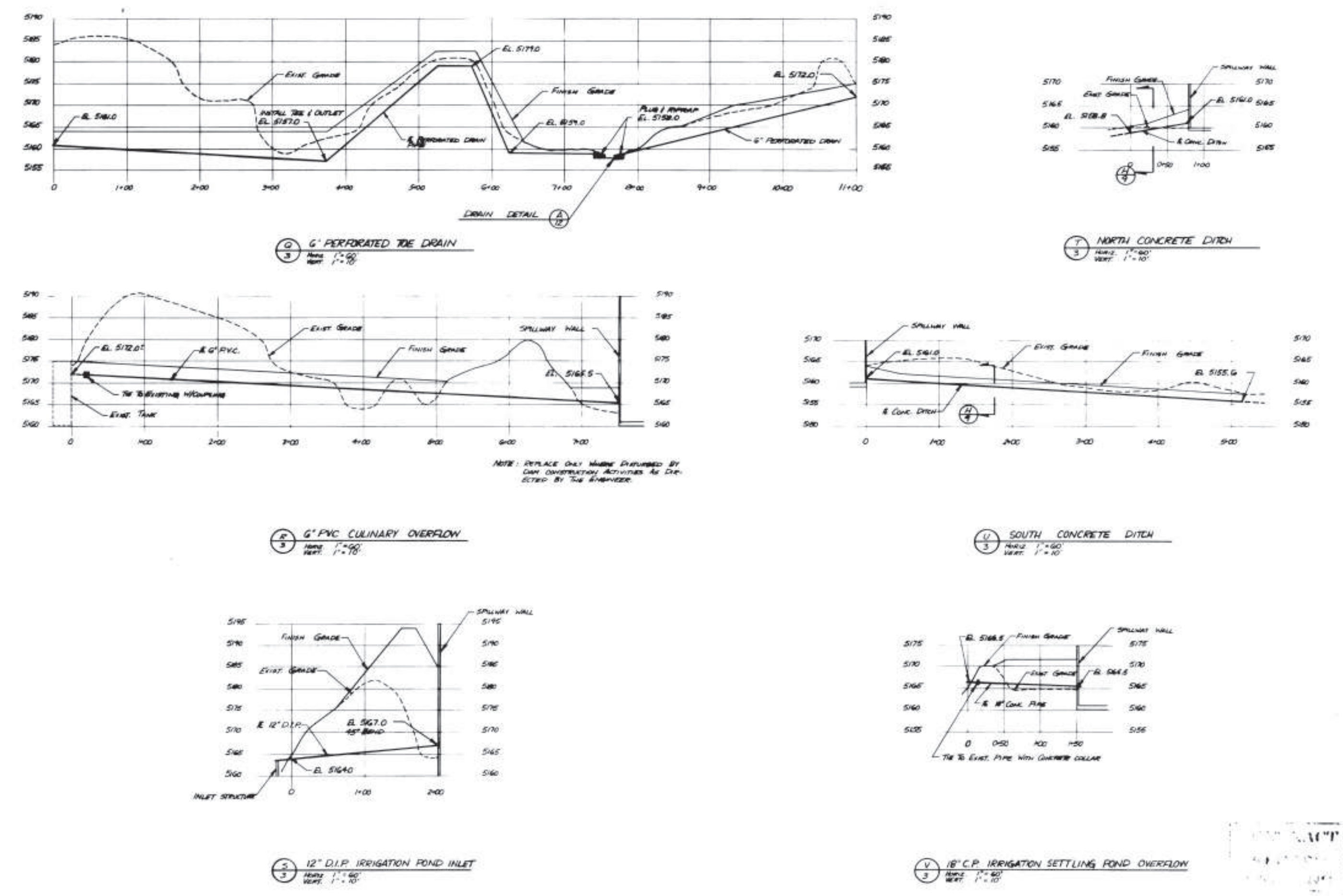

REVISIONS

SUNRISE ENGINEERING, INC.
CONSULTING ENGINEERS & LAND SURVEYORS
Fillmore, Utah

TOWN OF KANOSH CORN CREEK DAM PROJECT

PROFILES

DESIGNED	CHECKED	DRAWN
K K	A C R	C M Y
APPROVED		DATE 8-20-85
SCALE AS NOTED		SHEET NO. 13 OF 13

DRAFT

State of Utah

DEPARTMENT OF NATURAL RESOURCES

BRIAN C. STEED
Executive Director

Division of Water Rights

TERESA WILHELMSEN
State Engineer/Division Director

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

March 27, 2020

Emily Fife
State Conservationist
Natural Resources Conservation Service
Wallace F. Bennett Federal Building
125 South State Street Room 4010
Salt Lake City, UT 84138-1100

Re: Corn Creek Debris Basin / UT00322

Congress has provided $150 million in funding to the NRCS through the PL83-566 Watershed Protection and Flood Prevention Program (Watershed Act). It is our understanding that Millard County and Corn Creek Irrigation Company are requesting Federal assistance under the provisions of this act in order to remediate the existing debris basin and provide increased flood control protection to the town of Kanosh and agricultural lands.

The debris basin is on Utah Dam Safety's list of dams that needs rehabilitation. Utah Dam Safety is concerned about significant seepage through the dam foundation when the reservoir fills during high water events. Project remediation is needed to provide defensive design measures that control seepage and protects from internal erosion of the foundation and embankment. Utah Dam Safety supports this application to remediate the debris basin and bring the dam into compliance with current Dam Safety Standards, while providing increased flood control protections to Kanosh and the surrounding area.

Thank you for the time taken to consider this project for funding. Please feel free to contact me at 801-538-7376 or davemarble@utah.gov concerning additional information or questions you may have regarding Utah Dam Safety's support of this request.

Sincerely,

David K. Marble, P.E.
Assistant Utah State Engineer / Dam Safety

DKM/tg

pc: Bronson Smart - NRCS, bronson.smart@ut.usda.gov
Norm Evenstad - NRCS, norm.evenstad@ut.usda.gov
Lance Smith - NRCS, lance.smith@ut.usda.gov