CHAPTER VII

HYDROLOGY

CHAPTER VII

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7.0 HYDROLOGY

7.1.0 Scope

This section contains a general description of the ground-water hydrology for the general mine area and a detailed discussion of the ground-water hydrology of the permit area. Included are an identification and discussion of all water-bearing zones and a prediction of possible effects on them by the proposed surface-coal mining operations.

7.1.1 Methodology

Information contained in this section was obtained from published literature, private research, and Consol's current monitoring program. In addition, Consol conducted test borings to better define ground-water occurrence within the proposed surface mine area.

7.1.2 Water-Bearing Units of the General Mine Area

7.1.2.1 Quaternary Deposits

Alluvium

A minor, shallow aquifer is contained within the Quaternary alluvium which occurs along the stream channels of Christiansen Wash and Quitchupah Creek and some of its tributaries (Plate 6-1). This aquifer occurs above the Blue Gate Shale or the Ferron Member within the mine plan and adjacent areas and is unconfined. It varies in thickness from about 10 to 75 feet in the general mine area. Maximum thickness of alluvium occurs along Quitchupah Creek. Within the surface mine area, drill hole FC 703 encountered a 4 foot thick, saturated pebble gravel zone above the Blue Gate Shale. Lithologic and stratigraphic descriptions of this drill hole and others drilled in alluvium are given in Appendices 6-1 and 6-2, respectively.

No wells are known to be completed within the alluvium in the general mine area, therefore there are no known uses. For this reason, the hydrologic characteristics of the alluvium, including its water quality, are unknown. Soon, Consol intends to complete several wells in the alluvium, both upgradient and downgradient of the surface mine area to better define its physical and hydrologic characteristics. It should be noted, however, that alluvial water is believed to be derived largely from seepage of applied irrigation water. Therefore, it is anticipated to be of poor quality.

Terrace Deposits

Another minor aquifer is contained within the Quaternary terrace deposits which occur northeast of Quitchupah Creek (Plate 6-1). These deposits are located stratigraphically above the Blue Gate Shale, comprise an unconfined aquifer, and are generally less than 50 feet thick.

Recharge to the Quaternary terrace deposits is sustained by almost constant irrigation and leaching applications by farmers using water diverted primarily from Muddy Creek. Water is transmitted through these deposits and is discharged from them by springs which emanate at the contact with the underlying, relatively impervious Blue Gate Shale. Owing to the rolling topography of the Blue Gate Shale, water flowing from these springs is often trapped and creates "alkali swamps".

No wells are completed in the terrace deposits. However, water quality can be determined from data secured during spring and seep inventories conducted during October 1979 and June 1980 (Section 7.2.2.2 - Springs and Seeps). Specific conductance of spring waters which discharge to Christiansen Wash (Springs SP-1 through SP-5) within the permit area ranged from 1,295 to 2,015 umhos/cm, and averaged 1,485 umhos/cm during the October 1979 inventory. pH for these springs ranged from 7.1 to 8.1 with an arithmatic average of 7.4. Discharge at sites SP-1 through SP-4 (Plate 6-1) was unmeasurable owing to the ubiquitous nature of the spring or vegetative overgrowth. However, it can be stated that these springs all had discharges of less than 10 gpm. Site SP-5 was discharging at 1 gpm during October 1979. Water from springs SP-1 through SP-5 is unused.

7.1.2.2 Blue Gate Shale

The Blue Gate Shale separates the Quaternary deposit aquifers from the Ferron Sandstone aquifer across most of the general mine area. However, within the surface mine area where the Blue Gate pinches out beneath Quaternary alluvium, communication between these aquifers is likely where the Blue Gate is less than 20 feet thick owing to its weathering.

On the surface throughout the general mine area, weathering of the Blue Gate Shale produces void space which can contain water under unconfined conditions. No uses are known of this water owing to its brackish or saline nature, however its characteristics are important in that it has the potential to adversely impact the quality of lower ground waters by downward leakage or by intrawell transfer in improperly completed or dually completed monitor wells.

Lines and Morrissey (1981) assert that downward leakage from the Blue Gate Shale to the Ferron Sandstone has occurred within the proposed surface mine area owing to: 1) the potential for it to occur due to the lowering of the potentiometric surface of the upper section (above the base of the IJ coal zone) of the Ferron Sandstone aquifer below that of the Blue Gate water table either by underground mining or natural discharge at the head of Miller Canyon (Plate 7-1; SW¼, Section 23, T22S, R6E); and 2) alledged water-quality degradation of the upper section of the Ferron within the vicinity of the proposed surface operations due to downward leakage. Consol disputes item 1 based on water-level data available to us through our monitoring program (Section 7.1.6 and Appendix 7-2). Within the proposed surface mine area, two wells are completed next to each other exclusively in the Blue Gate, except at different depths (Plate 7-1). USGS4-1 is open in the interval of 10-30 feet below the land surface, whereas, USGS3-1 is open in the interval of 51-71 feet below the land surface. Monthly water-level data for these two wells

(Appendix 7-2) do not indicate that downward flow has occurred within the Blue Gate, even though the water level in the upper Ferron at this location (USGS1-2) has declined over this same time period. The existence of a potential for downward leakage does not, by itself, condition the occurrence of downward leakage.

Consol disputes item 2 on the basis of well completion data and water-quality data also available through our monitoring program (Section 7.1.6).

Well completion data summarized in Appendix 7-1 indicate that very few wells used to figure the distribution of total dissolved solids (TDS) concentration in the upper section of the Ferron aquifer are solely completed in the upper section. Specifically, wells Emria No's. 1, 2, and 3. Additionally, it is doubtful whether geophysical test holes used for the same means successfully isolated waters of the upper section during sampling for chemical characterization in that they were drilled in locations where Blue Gate or alluvium occurred stratigraphically above the upper Ferron.

Lastly, some TDS concentration data used by Lines and Morrissey (1981) are suspicious. TDS data compiled by Consol at USGS1-2 (Appendix 7-3) indicate a lower TDS than that reported in the USGS report, whereas, data for Emria #2 suggest a widely varying concentration of TDS. USGS1-2 is considered a reliable upper Ferron aquifer well completion while Emria #2 is suspect due to wide variation in its TDS content (Appendix 7-3). In addition, Emria #3 is completed opposite both the Blue Gate and the Ferron. While it is believed that this well registers an upper Ferron aquifer water level, contamination of its water can occur by contact with Blue Gate Shale within the well.

As previously noted, the potential for natural communication between waters of the alluvium or the Blue Gate is thought to exist near the Blue Gate-upper Ferron contact. This is a possible explanation for the varying water-quality of Emria #2.

Appendix 7-2 contains water-level data for other wells completed within the Blue Gate Shale. From these data, it is apparent that Blue Gate water levels experience seasonal variation, most likely owing to the effects of irrigation and precipitation.

7.1.2.3 Ferron Sandstone Aquifer

The primary water-bearing unit in the vicinity of the Emery Mine is contained in the permeable Ferron Sandstone Member of the Mancos Shale Formation. The Ferron Sandstone is an aquifer whose water is confined under pressure between shale and siltstones within the aquifer and between the enclosing shales in the Blue Gate and Tununk members of the Mancos Shale (Lines and Morrissey, 1981).

For the purposes of this report, the Ferron aquifer is separated into upper, middle, and lower portions. The upper portion is that part of the aquifer which includes the I-J coal zone and above and is designated Kmf(u). The portion lying stratigraphically between the base of the I-J coal zone and the base of the A Seam is called the middle Ferron aquifer and designated by the symbol Kmf(m). The remaining portion lying below the base of the A Seam is called the lower Ferron aquifer and is designated by the symbol Kmf(l).

In evaluating potential hydrologic disturbances of the surface mine, an important consideration is the degree to which water-bearing sandstones within the Ferron aquifer are interconnected.

From water-level data obtained through Consol's ground-water monitoring program (Appendix 7-2), it is apparent from head differences that ground-water within the lower and middle Ferron have the potential to move upward into the upper Ferron over much of the general mine area (Plate 7-2). Evidence for some separation of these water-bearing units exists, however, in that water has entered the floor of the underground mine on only a few occasions, and owing to a slight difference in water quality between ground water in the lower Ferron and that in the upper Ferron (see Quality portion of this section). While these examples do not preclude upward leakage, they do not suggest intimate hydraulic communication. It should be noted that the distance between the base of the I-J coal zone and the first water-bearing sandstone of the Kmf(m) is on the order of 75-85 feet (below G coal seam) and is comprised of low permeability shale and siltstone beds interbedded with hard, very fine to fine grained sandstone and coal (Appendix 6-2). Well ZZ is completed in the lower Ferron and is located at the southwest portion of the permit area. Water-production logs kept while the hole was being drilled show no production through the IJ-G coal seam interval. However, 2-3 gpm were noted below the C-D seam. For these reasons, primary emphasis will be given to ground-water characteristics of the upper Ferron in that it is the most likely to be influenced by the surface mine operations.

Aquifer Characteristics

The saturated thickness of the upper Ferron aquifer in the permit area is about 60 feet. In the southwest portion of the surface mine area northwest of Christiansen Wash, closest to the underground mine operations and where the sandstone above the I-J coal zone is the thickest, the upper Ferron has been partially dewatered. In the northeast portion of the surface mine area in the area overlain by alluvium (Plate 6-1) and further away from the underground operations, the upper Ferron is fully saturated but the thickness of sandstone above the coal zone decreases to about 60 feet. Along the outcrop area of the Ferron within the permit area the upper Ferron is for the most part unsaturated, however minor zones of saturation may exist owing to the infiltration of precipitation along fractures.

Hydraulic conductivity and porosity were determined by Lines and Morrissey (1981) on samples of upper Ferron sandstone which were obtained in close proximity to the proposed surface mine area (Emria #3; Plate 7-1). Horizontal and vertical conductivity averaged 8.9×10^{-2} feet/day and 1.0×10^{-1} feet/day respectively. Porosity averaged 18 percent. These data indicate little variation between conductivity in the horizontal and vertical directions. Lines and Morrissey (1981) also measured horizontal and vertical conductivities on siltstone strata which occur within and below the I-J coal zone in the Emery Coal Field. These values averaged 4.0×10^{-4} and 1.7×10^{-5} feet/day, respectively, in the horizontal and vertical directions, and indicate a difference of about three orders of magnitude between the upper Ferron sandstone and siltstone strata.

Aquifer tests conducted by the USGS in the vicinity of the surface mine area indicate a transmissivity range of 10-100 ft^2/day for the upper Ferron (Lines and Morrissey, 1981). Lower values of this range would agree more closely to measured hydraulic conductivity of the upper Ferron in the surface mine area. Storage coefficient for these same aquifer tests averaged about 1×10^{-3}. Specific yield of the upper Ferron aquifer is likely about 1×10^{-1}.

Recharge

Recharge to the Ferron aquifer accurs primarily as a result of subsurface inflow along the Joe's Valley - Paradise fault zone. Lines and Morrissey (1981) approximate its recharge at 2.4 cfs during 1979 or about 1,700 acre-feet/year. Based on its relative thickness, recharge to the upper Ferron would be about one-fifth of this value or about 0.5 cfs or about 360 acre-feet/year. In addition, some recharge occurs on the outcrop area of the Ferron as a result of precipitation. However, this recharge is virtually insignificant to the body of the upper Ferron aquifer in that most of it is probably discharged to lower lying alluvium and removed via the alluvial ground-water system.

Movement and Fluctuation

Plates 7-2 and 7-3 indicate that ground-water moves generally updip and in a southeast direction toward the areas of the underground mine and toward areas of outcrop. The lower Ferron potentiometric map shows more the influence of the areas of outcrop than the mine. The upper Ferron potentiometric map shows the effect of inflow to the underground mine.

Within the vicinity of the proposed surface mine area, wells known to be completed exclusively in the upper Ferron (USGS 1-2 and Muddy #2) show decline of as much as 52 feet owing to nearby underground mining (Appendix 7-2). FC346WW which is completed in the upper Ferron but also open to the middle Ferron, has shown a water-level decline of 29 feet since August, 1975. This indicates its water-level is probably that of the upper Ferron, however, all decline is probably not owing to mining. Emria #3 has declined 20 feet since September, 1978 due to nearby mining.

As indicated previously, water levels in the Blue Gate in the vicinity of the surface mine have remained constant since June, 1979 with no indications of a downward flow component.

It should be noted that the water level in well ZZ, an exclusive Kmf(1) completion, has remained essentially constant since September, 1979.

Discharge

After migrating south and southeast toward the underground mine, ground water in the upper Ferron discharges into alluvium at the head of Miller Canyon and into alluvium which overlies the upper Ferron in the northeast portion of the surface mine area (based on test borings FC 703 and FC 704; see section 6.4.5). Ground water has probably ceased to discharge along the outcrop of the upper Ferron beneath Christiansen Wash owing to dewatering by the underground mine. Using USGS estimates (Morrissey, Lines, and Bartholoma, 1980) of what discharge was to all streams in the Emery area in 1979, this would have reduced streamflow by about 0.04 cfs (29 acre-feet/year) along Christiansen Wash through the permit area, based on the thickness of the upper Ferron relative to the thickness of the entire Member and assuming that half of this discharge was previously to Chris-tiansen Wash. This would constitute a 2 percent reduction in the total flow passing the USGS gaging station on Christiansen Wash during water year 1981 (Section 7.2.2.2).

Quality

Water quality of the lower Ferron is better than that of the upper Ferron and in both portions of the aquifer, it appears to deteriorate away from the Joe's Valley - Paradise fault zone (Lines and Morrissey, 1981).

Within the vicinity of the proposed surface mine area water quality definition is complex owing to the existence of three different water-bearing strata, the effects of the underground mine on flow within the upper Ferron, and the effects of improper well completion. Withstanding these difficulties, some definite water-quality description is possible within the vicinity of the proposed strip area.

Water within the Blue Gate is usually of very poor quality. Data available for USGS 3-1 (Plate 7-1) indicate a TDS of 17,700 mg/l with sodium and sulfate contributing 16,000 mg/l of the total. Water of the upper Ferron is best indicated by samples obtained from USGS 12. The initial sample secured following well completion had a TDS of 4,039 mg/l (Appendix 7-3). Subsequent biannual sampling by Consol has shown TDS to be in the range of 9951,602 mg/l, substantially better quality water than that sampled initially. It is possible that the higher initial TDS is somehow owing to well completion/ development or it could be that water quality through the area has improved due to underground mine inflow influences.

Water of the lower Ferron within the vicinity of the surface mine area is characterized by analyses available for well ZZ and a newly completed well in the vicinity of the underground mine office/shop facilities designated WS #1 (Appendix 7-3). As shown, TDS concentration is highly variable between the two well locations. This is possibly attributed to the fact that well ZZ is partially completed in the Kmf(1) whereas WS #1 penetrates the entire thickness.

As previously noted, several wells within the permit area are thought to reflect the composite water quality of two or more water bearing zones (Emria #2 and Emria #3; Appendix 7-3).

Wells and Users

The only wells used for water supply in the Emery area are the Emery Town Well, the Bryant Well, and the Lewis Well (Plate 7-1 and Appendix 7-1). All of these wells intercept water from the recharge source upgradient of the proposed surface operations and are sufficiently removed from the area of mining that no decline in water level is expected at their specific locations due to surface mining.

Merlin H. Christiansen has appropriated water rights (Utah Application No. 2563) to 0.1 cfs of water which issues from a spring at the head of Miller Canyon (SP-15; Plate 6-1). The USGS reported this spring to issue from the upper Ferron at a rate of approximately 6 gpm on October 24, 1979. This amount of flow from this spring could be potentially impacted by the surface mine operations. As such, Consol intends to include this spring in the monitoring program (Section 7.1.6).

7.1.3 Development and Dewatering

7.1.3.1 Water Supply

Consol recently completed a water supply well in the Kmf(1) in the vicinity of the existing underground mine surface facilities under Approved Change Application No. A-8423. The supply system for this water is outlined in Section 3.2.5. Some of this water will be used to irrigate to promote reclamation.

7.1.3.2 Dewatering

Consol intends to pump pit inflow to an appropriately sized sedimentation pond. After sufficient retention time, Consol intends to discharge the produced ground-water to Christiansen Wash under an approved NPDES permit.

7.1.4 Effects of the Mining Operation

Mining will influence ground-water in the vicinity of the surface mine by removing ground-water from storage within the upper Ferron aquifer. A possible related effect is the degradation of water quality in the upper Ferron aquifer owing to the potential for downward leakage development within the Blue Gate due to lowering of potentiometric levels in the upper Ferron. Additionally, ground-water contained within alluvium which enters near the northeast corner of the surface mine area may inflow.

Water which may come in contact with displaced overburden will have the potential to leach minerals which will add to the existing TDS content of the water.

7.1.4.1 Hydrologic Balance

Of significance to the ground-water hydrologic balance is the lowering of potentiometric levels due to pit inflow derived from ground water in storage within the upper Ferron aquifer. Lines and Morrissey (1981) have predicted pit inflow to average 0.3 cfs over the life of the mine. The actual amount will probably be less than this owing to decreases in water levels which have occurred in the vicinity of the surface mine since the model was used. In addition, planned underground mining adjacent to the surface mine will serve to reduce pit inflow. As such, their prediction can be viewed as a maximum value for pit inflow from the upper Ferron aquifer.

Lines and Morrissey (1981) also predicted levels of potentiometric lowering in the upper Ferron owing to surface mining. Declines of about 60 feet were predicted close to the mine and 5 feet at a distance of about 2.5 miles. Again, these values will be reduced for the aforementioned reasons.

Consol intends to continue monitoring existing wells and install an additional well in the vicinity of the surface mine in order to verify these predicted effects.

7.1.4.2 Water Quality

Downward Leakage of Blue Gate Water

Mining of the I-J coal zone by surface methods is not expected to produce widespread changes in the existing quality of the upper Ferron aquifer by virtue of downward leakage of inferior Blue Gate water. Hydraulic communication between the Blue Gate Shale and the upper Ferron is imperfectly understood. Subsequently, the possibility of downward leakage in areas where the Blue Gate is thick and where potentiometric levels in the upper Ferron are lowered is also imperfectly understood. To this end, Consol intends to install an additional monitor well in the upper Ferron upgradient of the highwall to, among other things, monitor for any significant water quality changes.

Overburden Leaching

Water which comes in contact with displaced overburden; whose source could be either upper Ferron ground water, alluvial ground water, or precipitation; will have the potential to leach minerals which will add to the existing dissolved solids content of the contact water.

The USGS conducted leaching experiments with deionized water on overburden core obtained within the vicinity of the proposed surface coal mine (Lines and Morrissey, 1981). The TDS of the equilibrated samples ranged from 539 mg/l to 2,536 mg/l, with a mean concentration of 1,160 mg/l. Leachates contained relatively low concentrations of trace elements, however, iron concentrations were high in two samples due to pyrite occurrence. The results of this experiment indicate the concentration range of TDS that might be expected for contact waters of initial low TDS. Waters of higher initial TDS that might come in contact with disturbed overburden would have higher equilibrium TDS concentration than those of the USGS experiments.

Contact waters of the upper Ferron could potentially elevate to have a TDS concentration on the order of 4,000 mg/l based on an initial mean TDS of 1,300 mg/l. Contact water of alluvial ground water would likely be higher based on its expected higher initial TDS concentration.

Due to the anticipated influences of pit inflow and adjacent, upgradient underground mining on the potentiometric levels in the upper Ferron aquifer, it is unlikely whether significant amounts of ground water from the upper Ferron will rise to saturate, and potentially leach the emplaced spoil. Alluvial ground-water could potentially inflow to the surface mine area. Due to the expected lowering of the potentiometric levels within the upper Ferron aquifer this water could potentially leach the emplaced spoil and contribute dissolved solids to the upper Ferron aquifer. Given this possibility, control of this ground water prior to its inflow to the pit is a possibility. Consol intends to complete a pumping well in the alluvium upgradient of the surface mine area to verify the anticipated significance of this water to the mining operation.

7.1.5 Mitigation and Control Plans

As previously noted, Consol intends to pump ground-water, which is anticipated to inflow to the pit from the upper Ferron, and store it in compliance with all laws prior to discharging it to Christiansen Wash.

7.1.6 Monitoring Plans

Consol intends to drill and complete five additional monitor wells in the vicinity of the surface mine, four in alluvium and one in the upper Ferron aquifer upgradient of the highwall (Plate 7-1).

Aquifer tests will be conducted on the alluvial well to be completed upgradient of the surface mine area. Water levels in all wells will be measured bi-monthly and sampled for quality quarterly for at least a period of one year. Table 7-1 lists water-quality parameters that will be determined on collected water samples during the first year. In addition, Consol intends to document appropriate information on the Christiansen Spring and monitor it on the same frequency and for the same parameters as listed for the monitor wells.

TABLE 7-1

GROUND WATER MONITORING PARAMETERS

Field:	Water Level
	PH
	Specific Conductance
	Temperature
Lab:	Total Dissolved Solids (TDS)
	Total Hardness
	Bicarbonate
	Carbonate
	Chloride
	Sulfate
	Flouride
	Phosphate (Dissolved)
	Sodium
	Potassium
	Calcium
	Magnesium
	Iron (Total)
	Aluminum
	Arsenic
	Barium
	Boron
	Cadmium
	Chromium
	Copper
	Lead
	Manganese
	Mercury
	Molybdenum
	Nickel
	Ammonia Nitrogen
	Nitrate
	Nitrite
	Selenium
	Sulfide
	Zinc

7.2 Surface Water Hydrology

7.2.0 Scope

This section is a comprehensive, site-specific assessment of the surface-water hydrology in the vicinity of the surface mining operations at the Emery Mine. Specific data and conclusions concerning the surface water hydrologic characteristics, proposed facilities, and resultant surface water hydrologic impacts associated with the surface mine operations are discussed.

7.2.1 Methodology

This assessment combines the findings of independent hydrologic research conducted over the past seven years by various government agencies and private firms with data obtained through Consol's surface-water monitoring program. Data discussed in this report are available from the U.S. Geological Survey, U.S. Environmental Protection Agency, U.S. Soil Conservation Service, U.S. Bureau of Land Management, various Utah State agencies, and Consolidation Coal Company.

The aforementioned surface water monitoring program was iomplemented in Fall 1979 and designed specifically to meet the intent of the Office of Surface Mining permanent regulatory program together with, at that time, the proposed State of Utah regulatory program. Since that time Consol or its agents have collected data with the frequency and to the level of intensity outlined in its approved monitoring program.

7.2.2 Existing Surface Water Resources

7.2.2.1 Regional Surface Water Hydrology

The Emery Mine is situated at the confluence of Quitchupah Creek and its only major tributary Christiansen Wash. Quitchupah Creek is a tributary to Ivie Creek which in turn is a tributary to Muddy Creek (Figure 7-1). Muddy Creek empties into the Dirty Devil River above Hanksville, Utah; the Dirty Devil River then empties into the Colorado River within the Upper Basin. Information for these watersheds is provided below in Table 7-2.

TABLE 7-2
REGIONAL WATERSHED INFORMATION
(SOURCE: VTN, 1974)

Watershed	Area (mi^2)	Elevations (ft)	
		Maximum	Minimum
Dirty Devil River Basin	4400	11,600	4432
Muddy Creek Watershed	1450	11,133	4500
Quitchupah Creek Watershed	430	11,133	5760

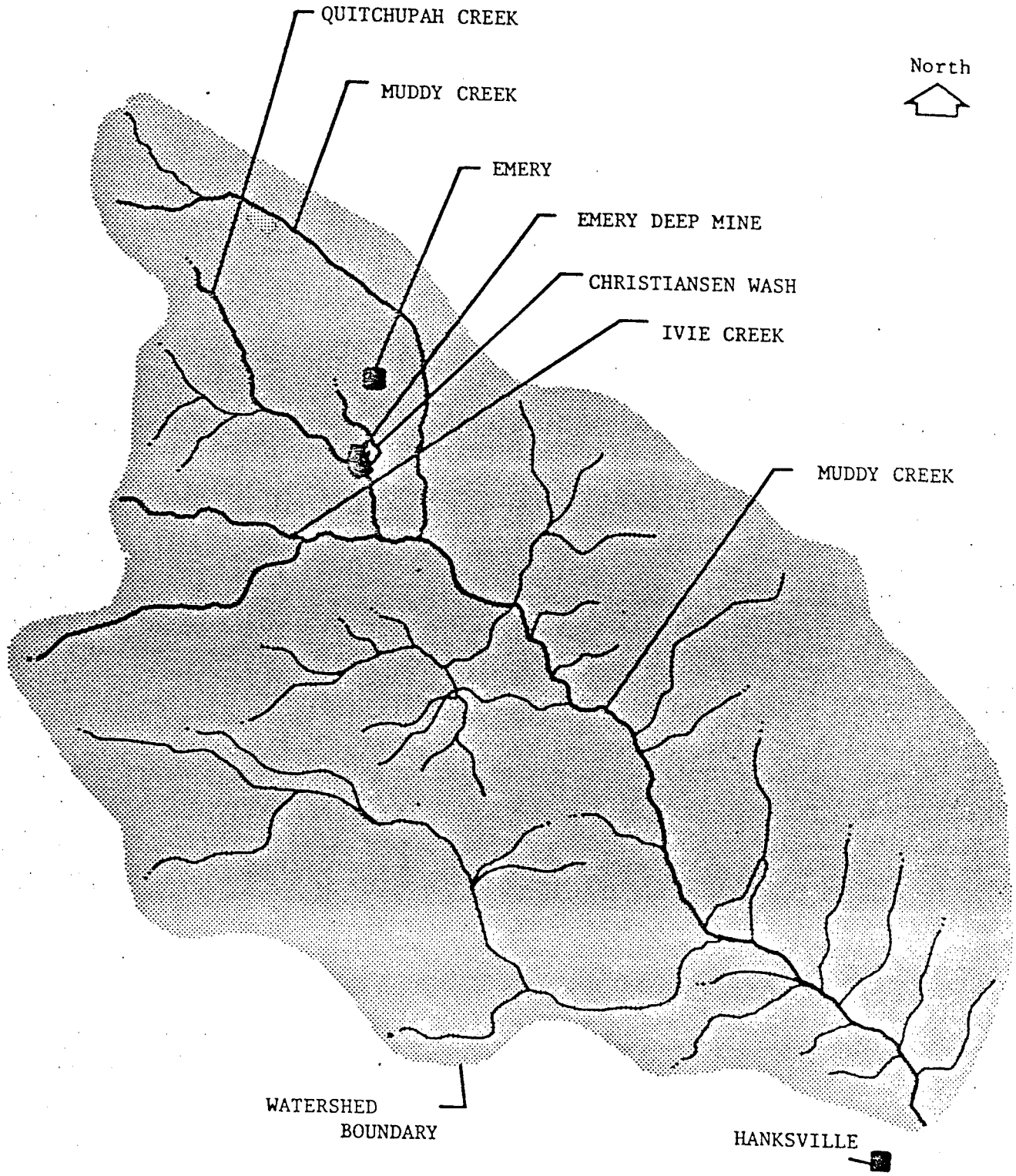

Figure 7-1. Muddy Creek Watershed

Since 1949, the USGS and Consol have gathered a great deal of water quality and streamflow data for the Emery area, by maintaining two stream gaging stations on Muddy Creek, one 4 miles north of Emery (site S-1 on Plate 7-4) and the other 13 miles south-southeast of Emery. Data for these sites and for others within the region as shown on Plate 7-4 are listed in Table 7-3. Figure 7-2 shows average monthly flows on Muddy Creek at Site-1 (Plate 7-4) for the period 1949-1970.

Three conclusions may be drawn concerning regional streamflow characteristics:

1. Most runoff occurs during March, April, and May. Peak flows occur during May, with a gradual decrease in flow occuring throughout the summer months. (Figure 7-2)

2. Irrigation diversions can cause large flow losses along various reaches of regional streams. (Table 7-3 and Plate 7-4)

3. Sizeable flows, on the order of 4,500 cfs, can occur on streams within the study area.

Tables 7-4 through 7-9 present data on the water quality of Muddy Creek for the period 1971-1979 for sampling sites S-1 through S-6 (Plate 7-4).

At S-1, calcium (Ca) and magnesium (Mg) are the dominant cations, bicarbonate (HCO_3) is the dominant anion, and mean total dissolved soilds (TDS) is 212.6 milligrams per liter (mg/l). The sodium absorption ratio (SAR) of 0.23 and a mean lab specific conductivity of 417 umhos/cm at 25°C classify this water as medium-salinity, low sodium water suitable for irrigation of plants with moderate salt tolerance (U.S. Department of Agriculture, 1954).

Below Miller Canyon at S-4, before its confluence with Ivie Creek, Muddy Creek's water is noticeably more saline, with a mean TDS of 2685 mg/l. The mean pH has lowered to 8.2, while Na has become the dominant cation and sulfate (SO_4) the dominant anion. The mean lab conductivity of 3355 umhos/cm at 25°C and a SAR of 5.5 classify the water as very high salinity, medium-sodium water which is not suitable for irrigation under ordinary conditions.

At site S-6, Ivie Creek dilutes Muddy Creek's waters slightly such that the mean pH is 8.0 and the TDS is 2306 mg/l. The dominant cation and anion, Na and SO_4, remain the same, however, water at S-7 (Table 7-10) has been diverted from Muddy Creek at S-1 and brought by canal to irrigate lands southeast of Emery within the Muddy Creek drainage. It is essentially identical to S-1 water except for a lower mean pH of 8.2 (Tables 7-4 and 7-10). The chemical characteristics of water at S-1 and S-7 are probably very representative of waters that irrigate land within the Christiansen Wash and Quitchupah Creek drainages in that they derive from the same canal system.

Table 7-3

REGIONAL INSTANTANEOUS STREAM DISCHARGE MEASUREMENTS[1]

Stream	Site No.	Period of Record	No. of Measurements	Mean Discharge (cfs)	Maximum (cfs)	Minimum (cfs)
Muddy Creek	S-1	1949 - 1978	-	38.0[2]	3340[2]	2.7
Muddy Creek	S-2	7/75 - 8/76	6	0.40	1.0	0.0
Muddy Creek	S-4	7/75 - 8/76	5	2.8	6.0	0.0
Muddy Creek	S-6	8/73 - 9/78	87	65.86	4500.0	0.01
Muddy Creek	S-41	1950 - 1961	-	15.4[2]	-	-
Miller Canyon	S-3	7/75 - 8/76	5	0.28	1.0	0.0
Ivie Creek	S-30	7/75 - 8/76	6	0.94	2.5	0.0
Ivie Creek	S-31	7/75 - 9/76	7	4.21	13.0	0.1
Quitchupah Creek	S-18	7/75 - 9/76	7	0.85	2.0	0.01
Quitchupah Creek	S-29	9/75 - 9/76	5	5.02	12.0	0.50
Christiansen Wash	S-8	7/75 - 9/76	7	0.68	3.5	0.01
Christiansen Wash	S-17	7/75 - 8/76	6	2.5	5.0	0.5

[1]Data obtained through EPA STORET Computer System, 1979.

[2]Data from VTN, 1974.

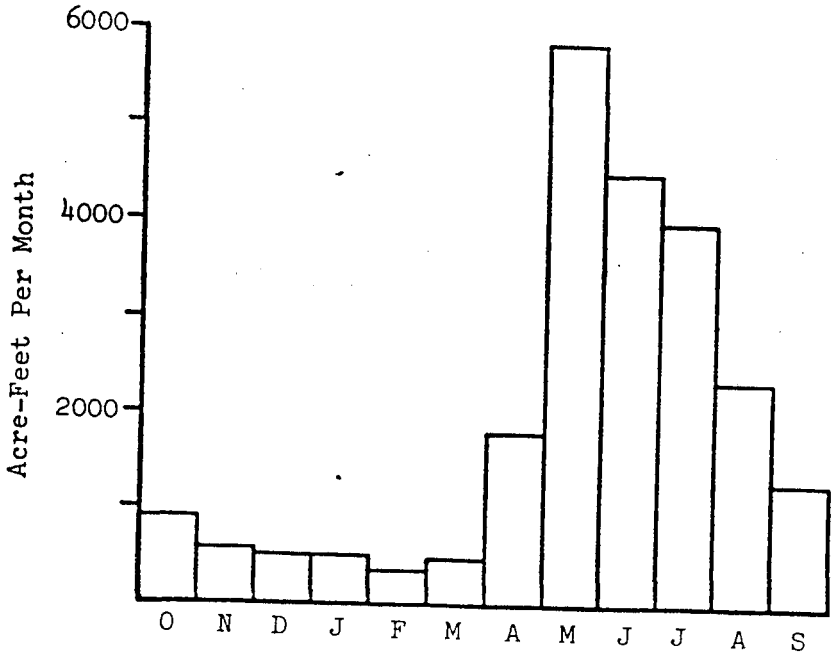

Figure 7-2. Average Monthly Flows on Muddy Creek, 1949-1970

Table 7-4

SITE S-1 CHEMICAL ANALYSIS DATA

Sample Site: S-1
Location: USGS Gaging Station: Muddy Creek No. 1 (D-21-6) 21 ABA
Dates of Collection: 8/4/71 through 9/12/78
Source of Data: USGS

	No. of Samples	Mean	Standard Deviation	Max	Min
GENERAL CHARACTERISTICS					
Alkalinity, total (as $CaCO_3$)	7	193.3	17.7	221.0	176.0
Hardness (noncarbonate)	7	13.6	5.4	21.0	4.0
Hardness, total	7	208.6	14.6	230.0	200.0
Iron, total (Fe)	18	0.28	0.32	1.0	0.02
Iron, diss. (Fe)	4	0.02	0.06	0.03	0.02
Manganese, total (Mn)	20	0.05	0.08	0.25	0.01
Oil and grease	3	1.6	.66	2.3	1.0
Oxygen, diss. (DO)	34	10.5	2.5	16.0	6.0
pH, lab (units)	33	9.2	.28	9.7	8.8
Sp. conductance, lab (µmhos/cm at 25°C)	87	416.65	53.6	620.0	286.0
Discharge (cfs)	89	33.05	42.9	201.0	2.7
Temperature (°C)	88	7.1	6.5	23.0	0.0
Total dissolved solids (TDS)	7	212.6	25.1	250.0	175.0
Total suspended solids (TSS)	18	13.8	20.9	68.0	.39
CATIONS					
Calcium (Ca)	7	42.6	3.6	48.0	39.0
Magnesium (Mg)	7	24.3	1.3	26.0	23.0
Potassium (K)	7	0.64	.08	0.8	.60
Sodium (Na)	7	6.9	2.1	10.0	5.0
Sodium adsorption ratio (SAR)	7	0.23	.05	0.3	0.2
ANIONS					
Bicarbonate (HCO_3)	7	228.8	12.7	251.0	214.0
Carbonate (CO_3)	7	3.3	5.2	14.0	0.0
Chloride (Cl)	6	2.8	0.7	3.5	1.8
Fluoride (F)	7	0.2	0.1	0.3	0.03
Sulfate (SO_4)	7	15.4	2.9	21.0	12.0
MACRONUTRIENTS					
Ammonia (NH_4)	4	0.03	.03	0.06	0.0
Nitrogen, total KJD as N	4	0.50	0.74	1.6	0.12
Nitrate + Nitrite as N	9	0.45	0.10	0.61	0.27
Phosphorus, total as P	4	0.05	0.10	0.2	0.0
TRACE AND OTHER ELEMENTS					
Aluminum (µg/ℓ, Al)	4	17.5	9.6	30.0	10.0
Arsenic (µg/ℓ,As)	4	1.25	0.5	2.0	1.0
Boron (µg/ℓ,B)	7	16.3	12.0	30.0	0.0
Carbon, diss. organic	2	2.2	0.14	2.3	2.1
Chromium (µg/ℓ,Cr)	2	2.5	3.5	5.0	0.0
Lead (µg/ℓ,Pb)	5	4.4	4.0	11.0	1.0
Lithium (µg/ℓ,Li)	5	20.0	0.01	20.0	20.0
Phenols (µg/ℓ)	3	0.67	1.15	2.0	0.0
Selenium (µg/ℓ,Se)	4	0.25	0.50	1.0	0.0
Silica, diss. (SiO_2)	7	4.9	0.52	5.5	4.2
Strontium (µg/ℓ,Sr)	4	432.5	22.2	460.0	410.0

REMARKS

1) All results are in milligrams per liter (mg/ℓ) unless otherwise noted.
2) Total Suspended Solids are given in Jackson Turbidity Units.

Table 7-5

SITE S-2 CHEMICAL ANALYSIS DATA

Sample Site: S-2
Location: Muddy Creek at Highway 10 (D-21-6) 36 BBB
Dates of Collection: 7/23/75 through 5/31/76
Source of Data: USGS

	No. of Samples	Mean	Standard Deviation	Max	Min
GENERAL CHARACTERISTICS					
Alkalinity, total (as $CaCO_3$)	5	246.0	27.1	287.0	221.0
Hardness (noncarbonate)	5	694.0	196.8	1000.0	500.0
Hardness, total	5	964.0	230.1	1300.0	750.0
Iron, diss. (Fe)	2	0.09	0.02	0.1	0.07
Manganese, total (Mn)	2	0.03	0.03	0.05	0.01
pH, lab (units)	5	7.9	0.2	8.2	7.7
Sp. conductance, lab (µmhos/cm at 25°C)	5	2132.0	465.3	2860.0	1720.0
Discharge (cfs)	6	0.4	0.4	1.0	0.0
Temperature (°C)	5	17.7	10.7	28.0	3.0
Total dissolved solids (TDS)	5	1638.0	380.7	2230.0	1230.0
CATIONS					
Calcium (Ca)	5	204.0	48.3	270.0	160.0
Magnesium (Mg)	5	105.8	21.2	140.0	85.0
Potassium (K)	5	4.5	1.2	6.2	3.5
Sodium (Na)	5	172.0	44.4	240.0	120.0
Sodium adsorption ratio (SAR)	5	2.4	0.4	3.0	1.9
ANIONS					
Bicarbonate (HCO_3)	5	300.0	32.9	350.0	270.0
Carbonate (CO_3)	5	0.0	0.0	0.0	0.0
Chloride (Cl)	5	22.0	4.6	29.0	17.0
Fluoride (F)	5	0.3	0.04	0.4	0.3
Sulfate (SO_4)	5	972.0	266.8	1400.0	690.0
MACRONUTRIENTS					
Nitrate + Nitrite as N	5	0.03	0.03	0.08	0.01
Phosphorus, total as P	5	0.02	0.02	0.03	0.0
TRACE AND OTHER ELEMENTS					
Aluminum (µg/ℓ,Al)	1	20.0			
Arsenic (µg/ℓ,As)	1	0.0			
Boron (µg/ℓ,B)	5	192.0	59.3	290.0	130.0
Lead (µg/ℓ,Pb)	1	10.0			
Lithium (µg/ℓ,Li)	1	110.0			
Selenium (µg/ℓ,Se)	2	0.0	0.0	0.0	0.0
Silica, diss. (SiO_2)	5	8.5	1.2	10.0	6.8
Strontium (µg/ℓ,Sr)	2	2450.0	495.0	2800.0	2100.0

REMARKS

1) All results are in milligrams per liter (mg/ℓ) unless otherwise noted.

Table 7-6

SITE S-3 CHEMICAL ANALYSIS DATA

Sample Site: S-3
Location: Miller Canyon at Mouth (D-22-6) 26 DDD
Date of Collection: 7/23/75 through 8/11/75
Source of Data: USGS

	No. of Samples	Mean	Standard Deviation	Max	Min
GENERAL CHARACTERISTICS					
Alkalinity, total (as $CaCO_3$)	4	171.0	22.1	199.0	147.0
Hardness (noncarbonate)	4	1450.0	591.6	1900.0	600.0
Hardness, total	4	1650.0	591.6	2100.0	800.0
Iron, diss. (Fe)	2	0.03	0.04	0.06	0.0
Manganese, total (Mn)	2	0.45	0.44	0.76	0.14
pH, lab (units)	4	8.02	0.10	8.1	7.9
Sp. conductance, lab (µmhos/cm at 25°C)	4	2795.0	839.6	3470.0	1610.0
Discharge (cfs)	5	0.28	0.42	1.0	0.0
Temperature (°C)	4	15.8	10.3	21.5	0.0
Total dissolved solids (TDS)	4	2407.5	813.4	2990.0	1250.0
CATIONS					
Magnesium (Mg)	4	385.0	142.0	490.0	180.0
Potassium (K)	4	161.0	54.7	200.0	84.0
Sodium (Na)	4	129.7	37.9	170.0	79.0
Sodium adsorption ratio (SAR)	4	1.4	0.22	1.7	1.2
ANIONS					
Bicarbonate (HCO_3)	4	208.8	27.2	243.0	179.0
Carbonate (CO_3)	4	0.0	0.0	0.0	0.0
Chloride (Cl)	4	23.0	5.5	29.0	16.0
Fluoride (F)	4	0.40	0.0	0.40	0.40
Sulfate (SO_4)	4	1590.0	584.6	2000.0	760.0
MACRONUTRIENTS					
Nitrate + Nitrite as N	4	0.5	0.68	1.5	0.03
Phosphorus, total as P	3	0.0	0.0	0.0	0.0
TRACE AND OTHER ELEMENTS					
Aluminum (µg/ℓ,Al)	1	160.0			
Arsenic (µg/ℓ,As)	1	0.0			
Boron (µg/ℓ,B)	4	665.0	217.5	840.0	360.0
Lead (µg/ℓ,Pb)	1	1.0			
Lithium (µg/ℓ,Li)	1	160.0			
Selenium (µg/ℓ,Se)	3	2.0	1.0	3.0	1.0
Silica, diss. (SiO_2)	4	5.9	1.7	6.9	3.3
Strontium (µg/ℓ,Sr)	2	2850.0	212.1	3000.0	2700.0

REMARKS

1) All results are in milligrams per liter (mg/ℓ) unless otherwise noted.

Table 7-7

SITE S-4 CHEMICAL ANALYSIS DATA

Sample Site: S-4
Location: Muddy Creek Below Miller Canyon (D-22-6) 25 CCC
Dates of Collection: 7/23/75 through 8/11/76
Source of Data: USGS

	No. of Samples	Mean	Standard Deviation	Max	Min
GENERAL CHARACTERISTICS					
Alkalinity, total (as $CaCO_3$)	4	298.7	45.9	346.0	239.0
Hardness (noncarbonate)	4	857.5	570.3	1400.0	350.0
Hardness, total	4	1135.0	543.1	1700.0	670.0
Iron, diss. (Fe)	2	0.04	0.06	80.0	0.0
Manganese, total (Mn)	2	0.09	0.08	0.15	0.03
pH, lab (units)	4	8.22	0.22	8.50	8.00
Sp. conductance, lab (µmhos/cm at 25°C)	4	3355.0	1378.4	5190.0	2250.0
Discharge (cfs)	5	2.8	2.6	6.0	0.0
Temperature (°C)	4	16.3	10.9	25.0	1.0
Total dissolved solids (TDS)	4	2685.0	1280.6	4390.0	1670.0
CATIONS					
Calcium (Ca)	4	217.5	118.4	320.0	110.0
Magnesium (Mg)	4	143.5	62.9	220.0	89.0
Potassium (K)	4	8.3	0.5	8.8	7.8
Sodium (Na)	4	427.5	210.0	740.0	300.0
Sodium adsorption ratio (SAR)	4	5.5	1.6	7.8	4.0
ANIONS					
Bicarbonate (HCO_3)	4	360.0	57.6	422.0	291.0
Carbonate (CO_3)	4	1.7	3.5	7.0	0.0
Chloride (Cl)	4	42.7	16.5	67.0	30.0
Fluoride (F)	4	0.4	0.0	0.4	0.4
Sulfate (SO_4)	4	1652.5	885.3	2800.0	940.0
MACRONUTRIENTS					
Nitrate + Nitrite as N	4	0.94	1.65	3.40	0.01
Phosphorus, total as P	4	0.02	0.03	0.06	0.00
TRACE AND OTHER ELEMENTS					
Aluminum (µg/ℓ,Al)	1	170.0			
Arsenic (µg/ℓ,As)	1	1.0			
Boron (µg/ℓ,B)	4	377.5	170.0	570.0	220.0
Lead (µg/ℓ,Pb)	1	2.0			
Lithium (µg/ℓ,Li)	1	350.0			
Selenium (µg/ℓ,Se)	3	5.0	5.2	11.0	2.0
Silica, diss. (SiO_2)	4	7.1	1.9	9.2	4.7
Strontium (µg/ℓ,Sr)	2	3050.0	353.6	3300.0	2800.0

REMARKS

1) All results are in milligrams per liter (mg/ℓ) unless otherwise noted.

Table 7-8

SITE S-5 CHEMICAL ANALYSIS DATA

Sample Site: S-5
Location: Muddy Creek Above Ivie Creek (D-23-6) 13 (BAC)
Dates of Collection: 7/31/75 through 7/9/76
Source of Data: USGS

	No. of Samples	Mean	Standard Deviation	Max	Min
GENERAL CHARACTERISTICS					
Alkalinity, total (as $CaCO_3$)	21	272.6	47.5	353.0	164.0
Hardness (noncarbonate)	21	908.1	483.L	1600.0	280.0
Hardness, total	21	1190.0	508.3	2000.0	480.0
Iron, diss. (Fe)	1	0.02			
Manganese, total (Mn)	1	0.06			
Oil and grease	1	34.0			
Oxygen, diss. (DO)	3	8.6	2.1	10.8	6.6
pH, lab (units)	23	8.0	0.2	8.5	7.7
Sp. conductance, lab (µmhos/cm at 25°C)	23	3584.3	1563.4	6190.0	1330.0
Discharge (cfs)	3	7.4	6.8	14.0	0.34
Temperature (°C)	23	8.2	8.6	26.0	0.5
Total dissolved solids (TDS)	20	3065.2	1524.1	5590.0	974.0
CATIONS					
Calcium (Ca)	21	205.1	87.2	350.0	73.0
Magnesium (Mg)	21	164.4	72.0	270.0	59.0
Potassium (K)	21	7.7	3.5	12.0	2.3
Sodium (Na)	21	544.8	288.0	1100.0	140.0
Sodium adsorption ratio (SAR)	21	6.6	2.6	11.0	2.4
ANIONS					
Bicarbonate (HCO_3)	21	330.7	58.3	430.0	200.0
Carbonate (CO_3)	21	0.8	3.7	17.0	0.0
Chloride (Cl)	20	57.8	34.8	140.0	12.0
Fluoride (F)	1	0.6			
Sulfate (SO_4)	21	1975.2	1018.0	3600.0	550.0
MACRONUTRIENTS					
Ammonia (NH_4)	3	0.09	0.01	0.1	0.08
Nitrogen, total KJD as N	3	1.08	0.72	1.8	0.35
Nitrate + Nitrite as N	3	3.3	1.3	4.8	2.3
Phosphorus, total as P	3	0.6	0.88	1.6	0.0
TRACE AND OTHER ELEMENTS					
Aluminum (µg/ℓ,Al)	1	250.0			
Arsenic (µg/ℓ,As)	1	1.0			
Boron (µg/ℓ,B)	1	530.0			
Carbon, diss. organic	2	5.5	2.5	7.3	3.7
Chromium (µg/ℓ,Cr)	1	0.0			
Lead (µg/ℓ,Pb)	1	2.0			
Lithium (µg/ℓ,Li)	1	310.0			
Phenols (µg/ℓ)	3	4.0	2.0	6.0	2.0
Selenium (µg/ℓ,Se)	1	11.0			
Silica, diss. (SiO_2)	1	9.5			
Strontium (µg/ℓ,Sr)	1	3900.0			

REMARKS

1) All results are in milligrams per liter (mg/ℓ) unless otherwise noted.

Table 7-9

SITE S-6 CHEMICAL ANALYSIS DATA

Sample Site: S-6
Location: Muddy Creek Below I-70 (D-23-6) 13 DCA
Dates of Collection: 8/5/73 through 9/14/78
Source of Data: USGS

	No. of Samples	Mean	Standard Deviation	Max	Min
GENERAL CHARACTERISTICS					
Alkalinity, total (as $CaCO_3$)	122	252.2	47.4	418.0	139.0
Hardness (noncarbonate)	122	731.0	408.8	3200.0	120.0
Hardness, total	122	987.8	433.0	3700.0	270.0
Iron, diss. (Fe)	8	68.7	49.1	130.0	10.0
Manganese, total (Mn)	7	37.1	23.6	70.0	10.0
Oil and grease	2	1.5	2.1	3.0	0.0
Oxygen, diss. (DO)	4	8.0	2.2	11.2	6.1
pH, lab (units)	123	8.0	0.2	8.5	7.6
Sp. conductance, lab (µmhos/cm at 25°C)	195	2996.5	1124.3	6700.0	691.0
Discharge (cfs)	87	65.9	481.5	4500.0	0.01
Temperature (°C)	190	9.4	8.9	33.0	0.0
Total dissolved solids (TDS)	120	2305.6	926.5	6310.0	431.1
CATIONS					
Calcium (Ca)	122	157.4	53.5	440.0	62.0
Magnesium (Mg)	122	143.0	75.2	620.0	0.0
Potassium (K)	122	7.5	3.0	20.0	2.7
Sodium (Na)	122	385.3	162.2	940.0	41.0
Sodium adsorption ratio (SAR)	122	5.3	1.6	12.0	1.1
ANIONS					
Bicarbonate (HCO_3)	122	306.7	57.9	510.0	170.0
Carbonate (CO_3)	122	0.4	2.8	25.0	0.0
Chloride (Cl)	120	77.9	56.1	350.0	8.5
Fluoride (F)	14	0.5	0.09	0.6	0.3
Sulfate (SO_4)	122	1407.9	634.9	3400.0	200.0
MACRONUTRIENTS					
Ammonia (NH_4)	4	0.02	0.02	0.05	0.0
Nitrogen, total KJD as N	4	0.70	0.14	0.88	0.54
Nitrate + Nitrite as N	16	3.1	1.77	6.5	0.93
Phosphorus, total as P	4	0.52	0.93	1.9	0.0
TRACE AND OTHER ELEMENTS					
Aluminum (µg/ℓ,Al)	6	80.0	86.7	250.0	20.0
Arsenic (µg/ℓ,As)	6	1.2	0.75	2.0	0.0
Boron (µg/ℓ,B)	15	377.0	158.0	620.0	160.0
Carbon, diss. organic	3	9.0	5.5	15.0	4.3
Chromium (µg/ℓ,Cr)	3	23.3	32.1	60.0	0.0
Lead (µg/ℓ,Pb)	7	13.0	20.8	60.0	2.0
Lithium (µg/ℓ,Li)	7	282.8	95.5	440.0	180.0
Phenols (µg/ℓ)	4	1.5	1.7	4.0	0.0
Selenium (µg/ℓ,Se)	8	10.1	3.4	16.0	7.0
Silica, diss. (SiO_2)	14	9.4	1.7	12.0	6.0
Strontium (µg/ℓ,Sr)	8	2862.5	870.0	4100.0	1900.0

REMARKS

1) All results are in milligrams per liter (mg/ℓ) unless otherwise noted.

Table 7-10

SITE S-7 CHEMICAL ANALYSIS DATA

Sample Site: S-7
Location: Canal Near Emery at U-10 (D-22-6) 9 BCB
Dates of Collection: 8/26/75 through 8/12/76
Source of Data: USGS

	No. of Samples	Mean	Standard Deviation	Max	Min
GENERAL CHARACTERISTICS					
Alkalinity, total (as $CaCO_3$)	4	192.75	16.6	217.0	180.0
Hardness (noncarbonate)	4	8.2	7.9	15.0	0.0
Hardness, total	4	197.5	12.6	210.0	180.0
Iron, diss. (Fe)	1	0.02			
Manganese, total (Mn)	2	0.05	0.07	0.01	0.0
pH, lab (units)	4	8.2	0.13	8.3	8.0
Sp. conductance, lab (µmhos/cm at 25°C)	5	405.0	44.8	475.0	360.0
Discharge (cfs)	5	14.5	11.0	32.0	2.5
Temperature (°C)	5	13.5	8.1	22.0	1.0
Total dissolved solids (TDS)	4	220.25	29.8	264.0	198.0
CATIONS					
Calcium (Ca)	4	39.5	5.25	44.0	32.0
Magnesium (Mg)	4	19.6	11.6	27.0	2.2
Potassium (K)	4	0.8	0.29	1.2	0.6
Sodium (Na)	4	9.8	6.9	20.0	5.0
Sodium adsorption ratio (SAR)	4	0.3	0.2	0.6	0.2
ANIONS					
Bicarbonate (HCO_3)	4	235.25	20.4	265.0	219.0
Carbonate (CO_3)	4	0.0	0.0	0.0	0.0
Chloride (Cl)	4	3.2	1.8	5.9	2.2
Fluoride (F)	4	0.3	0.0	0.3	0.3
Sulfate (SO_4)	4	19.0	8.8	32.0	13.0
MACRONUTRIENTS					
Nitrate + Nitrite as N	4	0.44	0.08	0.56	0.38
Phosphorus, total as P	4	0.02	0.05	0.09	0.0
TRACE AND OTHER ELEMENTS					
Arsenic (µg/ℓ,As)	1	0.0			
Boron (µg/ℓ,B)	4	25.0	5.8	30.0	20.0
Lead (µg/ℓ,Pb)	1	0.0			
Lithium (µg/ℓ,Li)	1	20.0			
Selenium (µg/ℓ,Se)	1	0.0			
Silica, diss. (SiO_2)	4	5.13	0.88	6.3	4.4
Strontium (µg/ℓ,Sr)	1	420.0			

REMARKS

1) All results are in milligrams per liter (mg/ℓ) unless otherwise noted.

7.2.2.2 Mine Plan Area Surface Water Characteristics

The surface mine operation is situated along a portion of Christiansen Wash approximately one-half mile upstream of its confluence with Quitchupah Creek (Plates 7-1, 7-5, and 7-6).

Watershed Characteristics

Christiansen Wash originates in the mountains 3 miles northwest of Emery at an approximate elevation of 8,850 feet. Its upper reaches are likely intermittent, owing their flow to snowmelt and thunderstorms. Below the Muddy Creek diversion it is perennial, the majority of its flow being contributed by direct irrigation return or by springs which emanate from Quaternary terrace deposits as a result of gravity drainage of applied irrigation water. At USGS gaging station 09331950 located just a few hundred feet downstream of the surface mine, the drainage area of Christiansen Wash is 13.6 mi^2.

Quitchupah Creek is a perennial stream throughout owing to the higher elevation of its headwaters (11,333 feet) and a much larger drainage area than Christiansen Wash. The streamflow within Quitchupah Creek is primarily sustained by snowmelt, but is supplemented within the area adjacent to the proposed surface mine by : 1) direct irrigation return flow whose source is largely Muddy Creek water, 2) irrigation induced seepage from the Quaternary terrace deposits, 3) overland flow from storm events and spring snowmelt, and 4) discharge of ground water from the Emery Underground Mine. Quitchupah Creek has a drainage area of 104 mi^2 at the former location of USGS gaging station 09331900, just one-quarter mile upstream of its confluence with Christiansen Wash.

Quantity

As previously noted, the USGS has gaged Christiansen Wash just a short distance downstream of the surface mine since mid 1978. Table 7-11 shows various discharge conditions at this station for water years 1979-1981.

TABLE 7-11

Mean Daily Discharge Conditions at Christiansen Wash Gaging Station 09331950 for Water Years 1979-1981 (USGS, 1982)

Water Year	1979	1980	1981
Mean (cfs)	2.8	3.8	2.09
Maximum (cfs)	20	93	84
Minimum (cfs)	0.43	0.45	0.29

Seasonal variation of flow on Christiansen Wash is well defined. Peak flows generally occur in May as a result of spring snowmelt, in late summer owing to thunderstorms, or in late fall as a result of the melting of unseasonably heavy snowfall. Peak flows on Christiansen Wash were 155 cfs, 226 cfs, and 1560 cfs during water years 1979, 1980, and 1981, respectively, at the USGS gaging station. The former flow occured in early November, whereas the latter two happened in early September. Low flow conditions are experienced in late fall and during the winter. Late spring and the summer months are characterized by considerable flow fluctuation owing to variable snowmelt patterns and irrigation influences.

Mean daily flow conditions for Quitchupah Creek during water years 1979-1981 are summarized in Table 7-12.

TABLE 7-12

Mean Daily Discharge Conditions at Quitchupah Creek Gaging Station 09331900 for Water Years 1979-1981 (USGS, 1982)

Water Year	1979	1980	1981
Mean (cfs)	6.7	10.8	7.7
Maximum (cfs)	45	263	442
Minimum (cfs)	1.1	1.0	0.8

Seasonal variation of flow on Quitchupah Creek is very similar to that of Christiansen Wash, however, flow near the Emery Mine is supplemented by underground mine discharge which averages 0.6 cfs with a range of 0.0-2.2 cfs. Peak flows on Quitchupah Creek during water years 1979, 1980, and 1981 were 317 cfs, 1380 cfs, and 2590 cfs. These flows occurred during the same time periods as those stated for Christiansen Wash.

Consol has supplemented USGS streamflow records with systematic instantaneous and continuous flow measurements at eight sites (see Plate 7-1) in the vicinity of the Emery Mine since October 1979 as part of Consol's Surface Water Monitoring Plan (Section 7.2.6). Christiansen Wash was equipped for continuous gaging at Site No. 2 (see Plate 7-1) located just upstream of the surface mine operations in March, 1980. Quitchupah Creek was equipped for continuous gaging at Site No. 3 located below the confluence of Christiansen Wash and Quitchupah Creek (see Plate 7-1) in August, 1980. Streamflow data for these locations are discontinuous, however, owing to operational problems and damaging flood events and are therefore unamenable to statistical presentation and comparison

with the USGS gaging stations. Input to Christiansen Wash between Consol Site No. 2 and the USGS gaging station (Consol Site No. 5) would occur from: 1) a gently-sloping natural topographic low of approximately 4.5 mi^2 which primarily channels irrigation runoff from Sections 15, 16, and 22 of T22S, R6E through the surface mine area (Plate 7-6 and 7-7), 2) an area of approximately 0.75 mi^2. Southeast of the proposed surface mine area (Plate 7-6), and 3) springs SP-1 through SP-5 which runoff in Christiansen Wash at the extreme SW corner of Section 28, T22S, R6E (Plate 6-1).

Quality

Surface water on Christiansen Wash generally deteriorates in chemical quality from Utah Highway 10, where it originates as applied irrigation water, to Consol Site No. 2 located just upstream of the proposed surface mine owing to irrigation return by ground-water seepage.

Tables 7-13 shows mean concentrations of selected water-quality parameters for Consol Site No. 2 and the USGS gaging station on Christiansen Wash for water years 1980 and 1981. Between Consol Site No. 2 and the USGS gaging station, dissolved soilds concentration decreases owing to flow additions of better quality irrigation water from springs (Spring and Seep portion of this section). Reductions of sodium, sulfate, and chloride concentration account for the major differences in TDS.

Table 7-14 lists extremes of selected water-quality parameters for the USGS gaging station on Christiansen Wash for water years 1980 and 1981. Observed extremes of TDS during the 1980 water year at the USGS gaging station were 599 mg/l on July 14, 1980 and 4,100 mg/l on March 7, 1980. During the 1981 water year, extremes of TDS were 1,020 mg/l on October 21, 1980 and 4,450 mg/l on April 16, 1981. Total suspended solids (TSS) ranged from 79-7,600 mg/l during the 1980 water year and between 510 and 15,200 mg/l during the 1981 water year at the USGS station. Total iron was not monitored at the USGS gaging station during water year 1980. However, during the 1981 water year it ranged from 0.2 to 160 mg/l.

TABLE 7-13
Mean Concentrations of Selected Water-Quality Parameters
for Consol Site No. 2 and USGS Gaging Station 09331950
for Water Years 1980 and 1981

	1980 Water Year		1981 Water Year	
	Consol Site No. 2	USGS[2] No. 09331950	Consol Site No. 2	USGS[2] No. 09331950
Flow (cfs)	1.52	3.8	1.79	2.09
TDS (Sum)	4,111	2,575	4,115	3,087
pH	8.1	8.3	8.2	8.4
Bicarbonate	392	445	478	465
Carbonate	14	4	21	5
Chloride	114	56	106	53
Sulfate	2,114	1,532	2,130	1,450
Sodium	684	383	667	426
Potassium	9	7	16	7
Calcium	213	155	280	206
Magnesium	223	188	196	197
Iron (Total)	4.3	-	3.2	18
Iron (Dissolved)	0.2	0.4	1.6	.04

1 Mean flow for Consol Site No. 2 considered semi quantitative

2 USGS, personal communication, 1982

3 All concentrations in mg/l, except where otherwise noted

TABLE 7-14
Extremes of Selected Water-Quality Parameters
at USGS Gaging Station 09331950
for Water Years 1980 and 1981

Parameter	1980 Water Year		1981 Water Year	
	Minimum	Maximum	Minimum	Maximum
Total Dissolved Solids	599	4,100	1,020	4,450
Total Suspended Solids	79	7,600		
pH	8.1	8.6	8.1	8.6
Total Iron	-	-	.2	160
Total Dissolved Iron	.02	.06	.02	.05
Total Manganese	-	-	.04	2.8

1 USGS, personal communication, 1982

2 All concentrations in mg/l except pH which is in pH units.

Springs and Seeps

Spring and seep inventories were conducted in October, 1979 and June, 1980. The identified sites are shown on Plate 6-1. The results of field parameter determination on sites SP-1 through SP-14 are listed in Table 7-15. In addition, Lines and Morrissey (1981) have identified two additional springs (identified as SP-15 and SP-16 on Plate 6-1) in the area adjacent to the proposed strip operations. They reported a specific conductance of 4,500 umhos/cm for SP-15 on 102479 and a flow of 6 gpm. For SP-16, they reported a TDS of 2,870 mg/l on 4478 and a flow of 5 gpm.

Sites SP-1 through SP-14 all issue from terrace gravels overlying the Blue Gate Shale. Their source of flow is applied irrigation water. SP-1 through SP-5 are significant in that they drain to Christiansen Wash within the proposed permit area. SP-15 and SP-16 issue, respectively, from the upper and lower Ferron aquifers (Lines and Morrissey, 1981). Mining is not anticipated to have any degrading or diminutive effect on these springs, except for possibly SP-15. As such, this spring is to be included in the monitoring plan (Section 7.1.6).

7.2.3 Surface Water Development, Control and Diversions

7.2.3.1 Water Supply

Quantity and Quality

The existing underground mine does not use, nor does the proposed surface mine anticipate the use of surface water in the operation of its facilities. However, Consol intends to research the feasibility of its use to supplement ground water as an irrigation supply for reclamation.

Water Rights

Consol currently holds rights to 80 acre-feet/year of water which is diverted from Muddy Creek by the Emery Canal (Clyde Mortensen, 1982).

7.2.3.2 Sedimentation Control and Water Management Plan

A detailed surface water management plan has been prepared for the permit area in accordance with applicable regulations. The proposed plan pro-vides for the collection and control of surface water runoff from both disturbed and undisturbed areas using a system of diversions, berms, collection ditches, conveyance channels and ponds. When no longer needed during the mining process the structures will be removed as described in sections 3.5.3.2 and 3.5.3.3 of this report. The proposed permanent structures have been incorporated into the post mining land use plan as described in Chapter IV. None of the structures meet the additional requirements of MSHA.

This section describes the major components of the water management plan, identifies the design criteria based on applicable regulations, and summarizes the design information of each.

Table 7-15

RESULTS OF SPRING AND SEEP INVENTORIES: OCTOBER, 1979 AND JUNE, 1980

Spring Site:	SP-1	SP-2	SP-3	SP-4	SP-5	SP-6	SP-7
Location:							
Sample Date:	10/24/79	10/24/79	10/24/79	10/24/79	10/24/79	10/24/79	10/24/79
Developed:	No	No	No	No	No	No	No
FIELD DATA							
pH (units)	7.1	7.3	7.3	7.3	8.1	7.8	8.2
Temperature (^{o}C)	13.5	13.9	12.9	14.5	9.2	15.9	17.1
Oxygen, dissolved (mg/l)	3.0	5.0	7.6	8.1	10.9	9.2	11.1
Conductivity (umhos/cm at 25^{o}C)	1196	1613	1307	1295	2015	1086	1023
Color	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Discharge (gpm)	NM[1]	NM	NM	NM	1.0	NM	NM
Water-bearing material	Qt[2]	Qt	Qt	Qt	Qt	Qt	Qt
						Salt precipitates abundant	

Spring Site:	SP-8	SP-9	SP-10	SP-11	SP-12	SP-13	SP-14
Location:							
Sample Date:	10/24/79	10/24/79	10/24/79	10/24/79	10/24/79	10/24/79	10/24/79
Developed:	No	No	Yes	No	No	No	No
FIELD DATA							
pH (units)	8.3	7.9	7.2	7.5	7.9	7.5	7.8
Temperature (^{o}C)	16.1	13.7	12.9	13.8	15.1	14.3	13.3
Oxygen, dissolved (mg/l)	9.3	9.3	9.0	9.2	8.5	8.0	8.3
Conductivity (umhos/cm at 25^{o} C)	732	658	1043	800	1338	1046	1022
Color	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Discharge (gpm)	NM	NM	NM	NM	NM	NM	7
Water-bearing material	Qt	Qt	Qt	Qt	Qt	Qt	Qt

Table 7-15 continued

RESULTS OF SPRING AND SEEP INVENTORIES: OCTOBER, 1979 AND JUNE, 1980

Spring Site:	SP-1	SP-2	SP-3	SP-4	SP-5 &6	SP-7
Location:						
Sample Date:	6/11/80	6/11/80	6/11/80	6/11/80	6/11/80	6/11/80
FIELD DATA						
pH (units)	7.9	7.8	7.8	Stagnant	Stagnant	7.6
Temperature (^{o}C)	26.4	21.1	18.3			18.4
Oxygen, dissolved (mg/l)	8.6	6.8	9.4			8.4
Conductivity (umhos/cm at 25^{o}C)	1959	1308	1070			1012
Color	Clear	Clear	Clear			Clear
Discharge (gpm)	NM	NM	NM			NM
Water-bearing material	Qt	Qt	Qt			Qt

Spring Site:	SP-8	SP-9	SP-10	SP-11	SP-12	SP-13	SP-14
Location:							
Sample Date	6/11/80	6/11/80	6/11/80	6/11/80	6/11/80	6/11/80	6/11/80
FIELD DATA							
pH (units)	7.8	7.7	7.5	7.7	7.9	7.3	6.3
Temperature (^{o}C)	19.8	16.1	12.3	14.3	22.7	18.4	14.2
Oxygen, dissolved (mg/l)	8.8	9.6	9.9	9.2	8.1	10	8.4
Conductivity (umhos/cm at 25^{o}C)	977	830	1051	127?	1040	897	128?
Color	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Discharge	NM	NM	100	NM	1	NM	3
Water-bearing material	Qt	Qt	Qt	Qt	Qt	Qt	Qt

[1]NM = Not able to be measured because of ubiquitous nature of spring and/or vegetative overgrowth.

[2]Qt = Quaternary terrace gravels.

Plate III-2 illustrates the proposed water management system. Summary sheets and drawings that illustrate the design features specific to each component are in Chapter XII.

Applicable Regulations

The applicable regulations for the surface water control system are as follows:

Coal Mining and Reclamation Permanent Program. Chapter II. Final Rules of the Utah Board and Division of Oil, Gas and Mining. Promulgated under UCA 40-10-1 et seq.

Design Criteria

The design criteria as adopted from these regulations are as follows:

1. The sediment pond is designed to retain the total volume from a 10 year - 24 hour storm event without discharge.

2. Sediment storage capacity is provided in excess of the life of the mining process, five years, so that cleanout of the pond is not expected.

3. Sediment control structures are designed for all phases of the mining activity.

4. Temporary impoundments in the area are designed to retain the runoff from a 5 year - 24 hour storm with no discharge. The emergency spillways are designed to safely pass the peak flow from a 25 year - 24 hour storm.

5. Ditches are designed to safely pass the peak flow from the design precipitation storm event. Flow velocities were calculated based on permissible velocities for the specific soil encountered.

6. Permanent diversions and culverts are designed to safely pass the peak flow from a 100 year - 24 hour storm.

7. Slopes are designed to be stable with no fill section slopes greater than 2h: 1v.

8. Riprap will be provided where necessary on spillways and drainage channels to minimize erosion and maintenance.

Design Procedure

Peak Flow and Total Volume Runoff Determinations

The SCS hydrograph method was used to determine total runoff volume and peak flow rates for appropriate design storms. The SCS Dams 2 Structure Site Analysis Computer program was used. For very small watersheds SCS-TP-149 was used to estimate the peak discharge value.

The following parameters were determined for each drainage area:

Watershed area
Length of the longest course in the watershed
Elevation difference in the watershed
Duration and amount of rainfall
Curve Number (CN)

The rainfall values used in the design of this sediment control plan with Type II distribution are:

5 - year, 24 - hour = 1.30 inches
10 - year, 24 - hour = 1.50 inches
25 - year, 24 - hour = 1.90 inches
100 - year, 24 - hour = 2.60 inches

CN values reflect site-specific soil types and land conditions. Composite CN determinations were based on the following information:

Soil condition: Antecedent Moisture Condition II
Soil types: as illustrated on soil survey plates
Land usage: disturbed - cultivated land, no conservation treatment
undisturbed - range land, poor condition

Sediment Load Determinations

Gross Erosion: The USLE, A=RKLSCP, was used to predict the gross erosion for sediment storage design, with numerical values specific to the Emery, Utah site. These follow:

R = 20
P = 1.00

The remaining values were determined for each specific drainage area using the SCS guide Preliminary Guidance for Estimating Erosion on Areas Disturbed by Surface Mining Activities in the Interior United States. From this guide, Table 1 was used for LS factor determinations based on the topography. The K factor, or soil erodibility factor, was found in the SCS soils survey of the area. The C factor, or crop management factor, was estimated with values specific to native vegetation.

Net Erosion: The gross erosion values were not reduced by application of a delivery ratio within the mine area. The net erosion values therefore provide a conservative estimate for sediment load determinations. A delivery ratio was applied to the area outside of the mine boundary, since it will remain undisturbed.

Storage Volume Calculations: The net soil loss was converted to sediment volume using a calculated unit weight. Sediment storage capacity was determined to be the volume expected for a minimum of five years, therefore no cleanout is anticipated.

Design Plan Summary

The watershed boundaries are defined on Plate XII-23. The sediment control and water management facilities are illustrated on Plate III-2. For convenience, the structures have been numbered as follows:

Diversions

No. 1 - Surface Mine Area Northern Diversion
- Unaffected Surface Water Runoff
- Permanent Structure

No. 2 - Surface Mine Area Southern Diversion
- Unaffected Runoff
- Permanent Structure

No. 3 - Facilities Area Diversion - Northern Ditch
- Affected Runoff
- To be removed

No. 4 - Facilities Area Diversion - Southern Ditch
- Affected Runoff
- To be removed

No. 5 - Coal Dump Site Ditchline to Existing Sediment Pond
- Affected Runoff
- To be removed

Culverts

"A" - Service loop
- Unaffected Surface Water Runoff
- To be removed

"B" - Northern Diversion Flow Through Haulroad
- Unaffected Runoff
- Permanent Structure

"C" - Mine Area Flow Through Haulroad
- Affected Runoff
- Permanent Structure

"D" - Dump Site Loop
- Unaffected Runoff (In)
- To be removed

"E" - Dump Site Loop
- Unaffected Runoff (Out)
- To be removed

"F" - Coal Dump Site Area
Affected Runoff
- To be removed

Impoundments

No. 1 - Surface Mine Area Sediment Pond
- Affected Surface Water Runoff
- Permanent Structure

No. 2 - Temporary Construction Pond
- Unaffected Runoff
- To be removed

No. 3 - Temporary Construction Pond
- Unaffected Runoff
- To be removed

Proposed Structure Description

Each of the components of the water management plan will be discussed in detail. Refer to Chapter 12 for the summary sheets and design drawings.

DIVERSIONS

Northern Diversion - No. 1

The Northern diversion is a permanent structure that will control undisturbed surface water runoff from a 7,508 acre drainage area. The upper reach controls 2,848 acres while the lower reach handles the remaining 4,660 acres. The diversion intercepts water flowing south toward the mine area and effectively cuts off the flow of Christiansen Wash by intersection of the stream. The water passes through culvert B before discharging into the natural drainage channel shown on Plate III-2, ultimately returning the runoff to Christiansen Wash.

The 100 year, 24 hour design storm event resulted in a peak flow of 864 cfs for the upper reach and 2,367 cfs for the lower reach. The diversion will be constructed by excavating a 14 foot wide channel with 2:1 side slopes. The channel and side slopes will be lined with rip-rap sized in accordance with the U.S. Department of Interior Engineering Design Manual, to resist displacement during peak flows.

The rip-rap will be sized as follows:

STATION	SLOPE	MAX. VELOCITY	RIP-RAP SIZE
0 to 10+40	1.00%	14 fps	18" to 24"
10+40 - 51+00	0.25%	7 fps	9" to 24"
51+00 - 59+20	2.20%	16 fps	24" to 30"
59+20 - 129+00	0.25%	6 fps	3" to 12"

Refer to the profile of this structure, Plates XII-15 through 19.

Material from the excavation will be placed in uniform lifts of not more than 24" on the downstream side of the diversion. The material will be compacted to a density of 85% of the maximum dry density in accordance with ASTM: D-698. In areas where the embankment starts below the elevation of the maximum flow depth, the embankment will be compacted to a minimum density of 95% of the maximum density in accordance with ASTM: D-698.

Following construction of the diversion, the topsoil stripped prior to construction of the diversion will be respread on the disturbed areas. The disturbance area will then be revegetated in accordance with section 3.5.5 of the reclamation plan.

Refer to Chapter XII for typical cross sections.

Southern Diversion - No. 2

The Southern diversion is a permanent structure that will control undisturbed surface water runoff from a 473 acre drainage area. This diversion intercepts water running northward toward the mine area, and conveys the flow westward along the south side of the main haulroad. The ditch profile is as shown on plates XII-7 through 9. The stream gradient will vary from 0.17% to 1.25% as dictated by the existing topography and haulroad design. It is anticipated that this structure will be cut entirely in rock, allowing steep side slopes. If erodable materials are encountered during construction, the slope will be cut back at a 2:1, and riprapped. The channel bed will be riprapped only in erodable material. The southern diversion will discharge into a natural drainage by dropping down a series of 10' steps to gradually dissipate energy, as shown in the profile, or a more efficient method of construction to be determined in the field. This energy dissipation system will be cut in rock to negate erosion.

Refer to Chapter XII for the typical cross sections.

Facilities Area Runoff Control - Diversions 3 and 4

Surface water runoff from the facilities area will be collected in two diversion ditches and carried to the sedimentation pond. The facilities area will sit on a ridge, requiring ditches both north and south of the area. The northern ditch, No. 3, will be a V - ditch cut on the hillside with the profile shown on Plate XII-20.

The southern ditch, No. 4, will start west of the parking lot before joining the service loop haulroad ditch at approximately station 5+00. The profile of this ditch is also shown on Plate XII-20.

Both of these ditches will join together in the main haulroad ditch at haulroad station 27+00. The water will then flow along the haulroad, over the northern diversion, and be discharged into the sedimentation pond, No. 1.

The channels will be riprapped where necessary.

Refer to Chapter XII for the typical cross sections.

Coal Dump Site Ditch - No. 5

This ditch has been designed to convey runoff from the outlet point of culvert F to the plant yard area where it will flow to the existing sediment pond. The small triangular ditch will handle the peak flow of 5.5 cfs from the 6 acre drainage area. The ditch will be riprapped in erodable areas. Typical sections are shown in Chapter XII.

CULVERTS

Culvert A

Culvert A, located in the service loop area is illustrated on Plate III-2. This 18" culvert is necessary to facilitate drainage of unaffected surface water runoff within the service loop area, 4.2 acres. The water discharges into its natural drainage.

Culvert B

Culvert B has been designed to pass the peak flow from the northern diversion, No. 1, under the main haulroad. This 15 foot diameter culvert channels unaffected surface water runoff to a natural drainage and ultimately discharges into Christiansen Wash. Designed as a permanent structure, the culvert has been incorporated into the post mining land use plan.

Culvert C

Culvert C has been designed to safely pass the peak flow from the surface mine area under the main haulroad. This 10 foot culvert channels the water to its natural drainage, Christiansen Wash. Designed as a permanent structure, the culvert has been incorporated into the post mining land use plan.

Culverts D and E

Culverts D and E, located in the dump loop area, are illustrated on Plate III-2. The two culverts are necessary to channel unaffected surface water runoff through and out of the dump loop. Culvert D, an 18 inch pipe carries the peak flow of 5 cfs from its 6 acre watershed into the loop area. The water naturally flows to culvert E, a 24 inch pipe which carries the peak flow of 11 cfs from the 11.7 acre drainage area through the loop and discharges into its natural drainageway.

Culvert F

To control runoff from the surface mine dump site and the coal stockpile area inside that loop, surface water runoff will be collected against a berm, to flow to Culvert F. This 18 inch culvert has been designed to pass the peak flow of 5.5 cfs, from its 6 acre watershed, through the haulroad at a steep (30%) grade to discharge into a small ditch. This ditch, No. 5, will convey the water to the plant yard area where it will flow to the existing sedimentation pond. Typical sections for the collection berm and ditch are shown. The ditch will be riprapped in erodable areas.

PONDS

Permanent Impoundment

Sediment Pond No. 1

The sediment pond has been designed as a permanent structure to control the surface water runoff from an 815 acre watershed, 313 acres of which will be disturbed. The drainage area is defined as the area within northern and southern diversions, No.'s 1 and 2 and illustrated on Plate III-2. This totally incised pond will store the volume of runoff from a 10 year - 24 hour storm without discharge, plus sediment for the life of the mine, so that cleanout is not anticipated.

Temporary ponds No. 2 and 3 will be completed before mining begins so as to effectively control surface water runoff upstream of the site during the construction phase of the sediment pond. The incised pond will be constructed in the mined out area of Christiansen Wash. Once the overburden and coal are removed from the pond area, the pond embankments will be constructed so as to separate the pond area from the remainder of the mining area. The pond embankment will start below the existing ground surface and tie into existing unaffected ground surfaces outside of the stripping limit. The side slopes will be constructed by placing fill material at 1H: 1v with the exception of the northern area of the pond, which will have 2H: 1v slopes to enhance the postmining land use plan. Embankments which will serve to separate the pond area from the mine area, will be constructed by placing fill material in uniform lifts and compacting each lift to a minimum density of 95% of the maximum dry density in accordance with ASTM: D698.

The pond bottom is defined by the bottom of the coal seam. The average bottom of coal elevation for the eastern area is 5940 while the average for the central area is 5950. The southern berm of this structure will tie into original ground at elevation 5987. The sediment and runoff volume capacity will total 40.75 acre-feet at elevation 5955.5, which results in a minimum freeboard of 1.5 feet.

A berm will be constructed, elevation 5995, to define the northern boundary of the sediment pond. This structure is necessary to separate the active mining area from the sediment pond, so that effluent standards can be met in accordance with the NPDES discharge limitations. Runoff into the mine area will be pumped into the sediment pond where the water will be treated by allowing suspended solids to settle out of the water. The water will be tested and after acceptable quality has been established, the water will be pumped from the sediment pond into culvert C. The water will then enter Christiansen Wash at its natural elevation at the culvert outlet.

TEMPORARY IMPOUNDMENTS

In order to facilitate construction of the sedimentation pond, two temporary impoundments will be constructed upstream of the construction site. These temporary impoundments are designed to totally contain a 5-year, 24-hour precipitation event. The temporary impoundments will be constructed of compacted earth fill, placed on a 3:1 slope on the downstream face and on a 2.5:1 slope on the upstream face, with a crest width of 15'. These impoundments will be removed upon completion of the sedimentation pond.

Temporary Impoundment No. 2

This impoundment serves an undisturbed watershed of 52.3 acres. It is designed to store 2.3 acre feet of runoff with a minimum freeboard of 2 feet.

The surface area required to store the runoff is 0.73 acres. The maximum water level elevation will be 6026 at maximum storage. The impoundment will be 75' long at an elevation of 6028. The maximum height of the impoundment measured from the upstream toe is 10'. This provides for adequate freeboard under design storm conditions.

Emergency Spillway No. 2

The emergency spillway is designed to pass the entire flow of a 25 year - 24 hour storm even in the event that the impoundment is at maximum storage capacity. Runoff from the storm will peak at 55 cubic feet per second. The emergency spillway is designed to handle this peak flow with a minimum of 1.4 feet of freeboard. The spillway is a trapezoidal section and will be contoured down the slope at a 9% grade with side slopes of 2:1 and a bottom width of 10'. A minimum of 10' of virgin soil will be left between the embankment and the emergency spillway. The spillway will empty into the natural stream course.

Temporary Impoundment No. 3

This impoundment serves an undisturbed 416 acre watershed. It is designed to store 18.4 acre feet of runoff with a minimum freeboard of 3'. This runoff will be impounded to a maximum elevation of 6025 and will cover 3.25 acres in surface area. The impoundment will be 125' long at an elevation of 6028. The maximum height of the impoundment measured form the upstream toe is 19'.

Emergency Spillway No. 3

The emergency spillway is designed to pass the entire flow of a 25 year 24 hour storm, even in the event that the impoundment is at maximum storage capacity. The emergency spillway is designed to handle the peak flow of 220 cubic feet per second with a minimum of 1.74' of freeboard. This spillway is a trapezoidal section with a 12 foot bottom width, and

side slopes at 2:1. The spillway will be cut into the hillside with a minimum of 10 feet of virgin soil between it and the embankment. The elevation of the E.S. inlet is 6025 and it falls to an elevation of 6015 over a distance of 120'. This yields an 8 percent slope. The spillway will discharge into the natural stream course.

7.2.4 Effects of Mining on Surface Water

The only effect of mining on the surface water hydrology, excepting the permanent diversion of a portion of Christiansen Wash, will be the addition of flow and associated dissolved solids concentration increases to Christiansen Wash owing to discharge of mine intcepted ground-water.

7.2.4.1 Hydrologic Balance

Discharge to Christiansen Wash is expected to increase by less than .3 cfs A portion of this discharge will replace that which has ceased to flow naturally from the upper Ferron aquifer owing to underground mine inflow influences.

The primary significance of this discharge will be its potential to add dissolved solids to the water of Christiansen Wash above the concentrations that are seasonally borne by the stream, however unnatural the source of some of these concentrations may be.

The mean TDS for ground water of the upper Ferron aquifer in the period December 1979 to December 1981 was 1,300 mg/1. The TDS of the inflow water will likely increase due to some contact with overburden and coal material within the pit. TDS of underground mine inflow water, that has come in contact with rock and coal dust and has flowed to sumps within the mine for pumping, has remained constant at about 4,700 mg/1. While pit inflow will not be subject to this type of intimate contact, TDS for the inflow water to be discharged from the surface mine will probably be in a range of from 2,000 mg/1 to 5,000 mg/1. The average TDS concentration at the USGS gaging station below the proposed mining operations was 2,575 mg/1 and 3,087 during water years 1980 and 1981 respectively. The ranges of TDS at this site during the same respective water years were 599-4,100 mg/1 and 1,020-4,450 mg/1. Therefore, during some periods of the year, the TDS concentration of water in Christiansen Wash would be increased.

7.2.5 Mitigation and Control Plans

Consol intends to mitigate the effects of surface coal mining on the surface water hydrology by intercepting the streamflow of Christiansen Wash above the mine site and diverting it around the mining operation. In addition, a drainage ditch will also be constructed on the southeast of the operation to divert runoff from this area away from the mine. Erosion as a result of surface runoff from outside the mine will be precluded as a result of these two measures. Also, outside water will be prevented from coming in contact with the displaced overburden which will preclude its potential deterioration by dissolution of soluble minerals.

Within the mine site, soil erosion will be able to be kept to a minimum. A sediment pond will store all water prior to its discharge to Christiansen Wash in order to minimize downstream sediment loading.

7.2.6 Surface Water Monitoring Plans

Consol currently operates the Emery underground mine under an approved ground-water and surface-water monitoring plan. No additional monitoring sites are planned as a result of proposed surface mining. However, discharge from the sedimentation pond will be in accordance with the requirements of an NPDES permit.

7.3 Alluvial Valley Floor Determination

In 1979, the BLM concluded that according to the Soil Conservation Service (SCS) in Price, Utah, and the unsuitability criteria used for qualifying known coal resource areas, there are no alluvial valley floors in the Emery area (BLM, 1979). Consol set out to provide site-specific evidence to support this conclusion by initiating a hydrologic study. OSM guidelines for the technical identification and study of alluvial valley floors (OSM, 1978) were used (WATEC, 1980) Christiansen wash was not designated as an alluvial valley floor for the following reasons:

1. All alluvial deposits associated with Christiansen Wash have historically been irrigated with diverted Muddy Creek water.

2. Christiansen Wash has no diversion structures and has never been diverted for agricultural purposes.

3. Christiansen Wash has very severe water quality limitations. Because its water is classified as C4-S2, a very high salinity, medium sodium hazard would be imposed upon crops grown on its soil. In view of this situation, if Christiansen Wash were developed with a reservoir for irrigation purposes, it is highly unlikely that it could provide agriculturally useful water for the next twenty years, a period of usefulness suggested by the technical guidelines.

4. Christiansen Wash may provide adequate quantities of water for limited irrigation use, but the flow of water upstream of Utah Route 10 is ephemeral and seasonal. Consequently, a reservoir would need to be built. Considering water quality limitations, a prudent person would never undertake such an endeavor.

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APPENDIX 7-1

Selected Well, Test Hole, and Spring Records

Selected Well, Test Hole, and Spring Records

Well (w), Test Hole (TH), or Spring(s) Designation (Location)	Date Constructed	Surface Elevation (ft.)	Perforated or Open Interval	Completion or Source	Comments
Emery Town #1 (22-6-4 cab) W	1/66	6360	1586-1614	Kmf(1)	Not monitored regularly
Kemmerer (22-6-17 abc-1) W	2/73	6285	1368-1543	Kmf(1)	---
USGS 1-4 (22-6-17 abc-2) TH	1978	6280	1040-1100	Kmf(u)	USGS packer test site (Lines and Morrissey, 1981)
H-U (22-6-20 baa-1) W	1979	6230	835-870	Kmf(u)	---
H-L (22-6-20 baa-2) W	1979	6230	1018-1140	Kmf(1)	---
I-L (22-6-21 cdd) W	1979	6107	637-728	Kmf(1)	---
EMRIA #3 (22-6-22 cdd-1) W	1978	6090	100-275	Kmbg Kmf(u)	Probably Kmf(u) water level, but Kmbg water quality influence
EMRIA #1 (22-6-23-aac) W	10/78	6155	20-305	Kmf(u+m) + 1?	Kmf(u) unsaturated

Selected Well, Test Hole, and Spring Records

Well (w), Test Hole (TH), or Spring(s) Designation (Location)	Date Constructed	Surface Elevation (ft.)	Perforated or Open Interval	Completion or Source	Comments
FC346 (22-6-23-bcc) W	1974	6122	149-355	Kmf(u+m)	---
Upper Ferron Spring (22-6-23 cdc) S	--	6050	--	Kmf(u)	(Lines and Morrissey, 1981)
Lower Ferron Spring (22-6-23-dda) S	--	5900	--	Kmf(l)	(Lines and Morrissey, 1981) Issues at Tununk contact
EMRIA #2 (22-6-26-bbb) W	10/78	6082	40-349	Kmf (u+m+l)	Kmbg: 0-25; Probable Kmbg contamination
USGS 1-2 (22-6-27-cbb-1) W	11/78	6045	75-150	Kmf(u)	---
USGS 4-1 (22-6-27 cbb-2) W	11/78	6046	10-30	Kmbg	---
USGS 3-1 (22-6-27 cbb3) W	11/78	6046	51-71	Kmbg	---
Muddy #2 (22-6-28 ddb) W	6/79	6046	96-136	Kmf(u)	---

Well (w), Test Hole (TH), or Spring(s) Designation (Location)	Date Constructed	Surface Elevation (ft.)	Perforated or Open Interval	Completion or Source	Comments
CPW (22-6-29 dbc) W	1981	5999	--	Kmf(u)	---
R-1 (22-6-30 aad-1 W	1979	6034	830-844	Kmf(1)	---
R-2 (u) (22-6-30 aad-2) W	1979	6031	585-655	Kmf(u)	---
Bryant (22-6-31 dab) W	6/72	6023	360-402	Kmf(u)	---
AA-U (22-6-32 cdc-1) W	1979	5967	168-212	Kmf(u)	---
AA-L (22-6-32 cdc-2) W	1979	5967	415-490	Kmf(1)	---
Muddy #1 (22-6-33 abb1) W	6/79	6066	122-162	Kmf(u)	---
ZZ (22-6-33 abb2) W	1979	6066	295-390	Kmf(1)	---
WS#1 (22-6-33 bcc) W	12/81	5910	182-203 289-320	Kmf(1)	

Well (w), Test Hole (TH), or Spring(s) Designation (Location)	Date Constructed	Surface Elevation (ft.)	Perforated or Open Interval	Completion or Source	Comments
USGS 2-4 (22-6-34 bba) TH	1978	6110	? - 160	Kmf(u)	(Lines and Morrissey, 1981)
USGS 2-1 (23-6-6 acc)	1978	6040	? - 385	Kmf(u)	(Lines and Morrissey, 1981)

APPENDIX 7-2

Selected Water-Level Data

Selected Water-Level Data

Heading Explanation: Well Designation (Source of Data)
Location/Zone(s) Monitored
Land Surface Elevation (ft.-amsl)

AA-BG(Consol) 22-6-32 cdc/Kmbg 5967		H-BG(Consol) 22-6-20 baa/Kmbg 6228.8	
Date	Water Surface Elev.(ft.-amsl)	Date	Water Surface Elev.(ft.-amsl)
11-16-79	5942.2	11-15-79	6193.1
3-17-80	5936.7	3-14-80	6195.7
6-11-80	5935.2	6-10-80	6196.7
9-16-80	5932.6	9-16-80	6197.8
12-9-80	5930.5	12-10-80	-
3-16-81	5931.2	3-16-81	6196.3
6-22-81	-	6-22-81	6197.5
9-22-81	5917.3	9-19-81	6198.1
12-30-81	-	12-31-81	-
3-12-82	5917.0	3-11-82	6199.7

I-BG(Consol)
22-6-21 cdd/Kmbg
6107.3

Date	Water Surface Elev.(ft.-amsl)
11-15-79	6095.6
3-14-80	6096.8
6-10-80	6096.4
9-17-80	6097.1
12-9-80	-
3-16-81	6097.3
6-22-81	6096.8
9-19-81	6096.8
12-31-81	-
3-11-82	6095.2

R2-BG(Consol)
22-6-30 aad/Kmbg
6029.7

Date	Water Surface Elev.(ft.-amsl)
3-15-80	5981.1
6-11-80	5980.8
9-17-80	5984.2
12-9-80	5985.6
3-16-81	5980.6
6-22-81	5980.5
9-19-81	5978.9
12-30-81	-
3-11-82	5980.4
-	-

USGS 4-1(USGS/Consol)
22-6-27 cbb/Kmbg
6046.0

Date	Water Surface Elev.(ft.-amsl)
6-13-79	6027.9
10-30-79	6028.6
3-15-80	6028.3
6-11-80	6028.1
9-15-80	6028.3
12-9-80	6028.4
3-16-81	6028.6
6-22-81	6028.8
9-14-81	6028.7
12-31-81	6028.8
3-11-82	6028.9

USGS 3-1(USGS/Consol)
22-6-27 cbb3/Kmbg
6046.7

Date	Water Surface Elev.(ft.-amsl)
6-13-79	6028.8
10-30-79	6028.4
3-15-80	6028.0
6-11-80	6028.5
9-15-80	6029.0
12-9-80	6029.0
3-16-81	6028.3
6-22-81	6028.3
9-19-81	6028.7
12-31-81	6028.5
3-11-82	6028.8

AA-U (Consol)
22-6-32 cdc-1/Kmf(u)
5967.5

Date	Water Surface Elev.(ft.-amsl)
7-23-81	5929.5
3-11-82	5916.2

CPW (Consol)
22-6-29 dbc/Kmf(u)
5999

Date	Water Surface Elev.(ft.-amsl)
9-17-81	5910.9
3-29-82	5878.4

Bryant (USGS/Consol)
22-6-31 dba/Kmf(u)
6020

Date	Water Surface Elev.(ft.-amsl)
10-7-76	6023.5
6-23-77	6023.5
11-8-77	6023.8
2-9-80	6022.3
6-11-80	Flowing
9-16-80	Flowing
12-9-80	Flowing
3-16-81	Flowing
6-22-81	Flowing
9-19-81	-
12-30-81	Not Flowing
3-12-82	Not Flowing

H-U/Consol
22-6-20 baal/Kmf(u)
6228.7

Date	Water Surface Elev.(ft.-amsl)
11-15-79	6164.5
3-14-80	6177.1
6-10-80	6171.1
9-16-80	6169.0
12-10-80	-
3-16-81	6172.9
6-22-81	6175.2
9-19-81	6175.6
12-31-81	-
3-11-82	6169.4

Muddy #1/USGS/Consol
22-6-33 abb/Kmf(u)
6066.4

Date	Water Surface Elev.(ft.-amsl)
7-2-79	5925.4
9-6-79	5924.6
3-17-80	5937.1
6-11-80	5940.4
9-17-80	5939.1
12-9-80	5938.4
3-16-81	5939.8
6-22-81	5939.2
9-19-81	5939.0
12-31-81	-
3-11-82	5939.2

Muddy #2/USGS-Consol
22-6-28 ddb/Kmf(u)
6045.8

Date	Water Surface Elev.(ft.-amsl)
6-13-79	6001.6
9-6-79	6002.6
3-15-80	5981.9
6-11-80	5975.2
9-17-80	5986.9
12-9-80	5980.2
3-16-81	5965.2
6-22-81	5963.6
9-19-81	5965.6
12-31-81	-
3-11-82	5965.4

R2-U/Consol
22-6-30 aad2/Kmf(u)
6029.9

Date	Water Surface Elev.(ft.-amsl)
12-7-79	6205.3
3-14-80	6045.7
6-11-80	6041.1
9-17-80	6051.3
12-9-80	6056.1
3-16-81	6077.4
6-22-81	6066.1
9-19-81	6054.8
12-30-81	-
3-12-82	6066.3

USGS1-2/USGS-Consol
22-6-27 cbb/Kmf(u)
6045.7

Date	Water Surface Elev.(ft.-amsl)
12-6-78	6008.9
3-5-79	6005.2
7-2-79	6001.9
9-6-79	5995.4
3-15-80	5975.3
6-11-80	5968.7
9-15-80	5968.9
12-9-80	5966.3
3-16-81	5965.1
6-11-81	5958.8
9-19-81	5964.9
12-30-81	5957.6
3-12-82	5957.4

AA-L/Consol
22-6-32 cdc-2/Kmf(1)
5967.0

Date	Water Surface Elev.(ft.-amsl)
11-16-79	5894.0
3-17-80	5894.0
6-11-80	5893.9
9-16-80	5893.9
12-9-80	5893.2
3-16-81	5893.4
6-22-81	5892.4
9-22-81	5893.1
12-30-81	-
3-12-82	5892.5

H-L (Consol) 22-6-20 baa-2/Kmf(1) 6229.1	
Date	Water Surface Elev.(ft.-amsl)
10-24-79	6242.6
3-14-80	6245.1
6-10-80	6245.1
9-17-80	6239.3
12-10-80	6246.6
3-16-81	6252.9
6-22-81	6251.0
9-19-81	6242.0
12-30-81	-
3-11-82	6232.7

I-L (Consol) 22-6-21 cdd-/Kmf(1) 6107.2	
Date	Water Surface Elev.(ft.-amsl)
10-30-79	6095.9
3-14-80	6108.6
6-10-80	6108.6
9-17-80	6108.6
12-9-80	-
3-16-81	6107.7
6-22-81	6106.9
9-19-81	6106.2
12-30-81	-
3-11-82	6104.6

Kemmerer/USGS-Consol
22-6-17 abc-1/Kmf(1)
6285

Date	Water Surface Elev.(ft.-amsl)
2-73	6359
9-10-75	6333
9-2-76	6331
9-3-77	6331
9-29-78	6329.2
3-5-79	6329
6-4-79	6328
9-6-79	6328
3-14-80	6330.7
6-11-80	6329.5
9-17-80	6328.6
12-9-80	6326.7
3-16-81	6327.0
6-22-81	6325.5
9-19-81	6325.5
12-30-81	6326.0
3-11-82	6325.0

R-1 (Consol)
22-6-30 aad-1/Kmf(1)
6031.8

Date	Water Surface Elev.(ft.-amsl)
10-30-79	6117.2
3-14-80	6263.4
6-11-80	6265.6
9-16-80	6268.8
12-9-80	6267.2
3-16-81	6265.2
6-22-81	6265.2
9-19-81	6261.4
12-30-81	-
3-11-82	6257.9

ZZ (Consol)
22-6-33 abb-2/Kmf(1)
6065.7

Date	Water Surface Elev.(ft.-amsl)
9-28-79	5920.5
3-17-80	5923.0
6-11-80	5923.0
9-17-80	5923.0
12-9-80	5923.0
3-16-81	5922.4
6-22-81	5922.0
9-19-81	5922.1
12-30-81	-
3-12-82	5924.0

Upper Ferron Spring(USGS)
22-6-23 cdc/Kmf(u)
6050

Date	Water Surface Elev.(ft.-amsl)
10-24-79	6050

Lower Ferron Spring (USGS)
22-6-23 dda/Kmf(1)
5900

Date	Water Surface Elev.(ft.-amsl)
4-4-79	5900

APPENDIX 7-3

Selected Water-Quality Data

Selected Water-Quality Data

Well	USGS 3-1	USGS 1-2	USGS 1-2	USGS 1-2	USGS1-2
Date	5-31-79	11-17-78	12-7-79	5-23-80	12-12-80
Water-Bearing Unit	Kmbg	Kmf(u)	Kmf(u)	Kmf(u)	Kmf(u)
Source of Data	USGS	USGS	Consol	Consol	Consol
pH-Lab	7.9	7.4	7.7	7.8	8.4
TDS-Sum	17,700	4,039	1,585	1,115	995
Bicarbonate	300	330	727	522	450
Carbonate	-	-	-	-	10
Chloride	230	20	35	22	20
Sulfate	12,000	2,500	360	269	263
Calcium	170	140	47	32	28
Magnesium	1,100	220	28	27	17
Potassium	46	48	4	3	2
Sodium	4,000	760	370	230	200
Iron	-	-	.05	.26	.05
Silica	6.9	21	13.8	10.1	5.0
Strontium	-	-	4.8	4.3	2.7

All concentrations in mg/l, except pH which is in pH units

Selected Water-Quality Data

Well	USGS 1-2	USGS 1-2	ZZ	ZZ	ZZ
Date	6-24-81	12-30-81	12-5-79	11-9-80	12-3-81
Water-Bearing Unit	Kmf(u)	Kmf(u)	Kmf(l)	Kmf(l)	Kmf(l)
Source of Data	Consol	Consol	Consol	Consol	Consol
pH-Lab	7.6	8.3	7.0	8.0	8.1
TDS-Sum	1,602	1,228	1,048	1,078	1,317
Bicarbonate	501	684	583	594	798
Carbonate	-	-	-	-	-
Chloride	26	51	14	18	23
Sulfate	616	169	123	155	165
Calcium	204	126	8	13	138
Magnesium	36	27	4	9	9
Potassium	8	3	4	4	3
Sodium	211	168	300	270	181
Iron	24.0	-	.04	.02	-
Silica	-	-	11.8	14.0	-
Strontium	19.4	-	.2	.50	-

All concentrations in mg/l, except pH which is in pH units

Selected Water-Quality Data

Well	WS #1	Emria #2	Emria #2	Emria #2	Emria #2
Date	12-31-81	6-21-79	12-5-79	12-12-80	12-3-81
Water-Bearing Unit	Kmf(l)	Kmf(u+m+l)	Kmf(u+m+l)	Kmf(u+m+l)	Kmf(u+m+l)
Source of Data	Consol	USGS	Consol	Consol	Consol
pH-Lab	8.2	3.6	3.8	6.7	6.5
TDS-Sum	2,421	8,070	23,294	5,991	3,303
Bicarbonate	745	-	0	571	642
Carbonate	-	-	-	-	-
Chloride	109	140	250	57	59
Sulfate	955	5,900	19,500	3,920	1,729
Calcium	300	110	470	430	523
Magnesium	63	930	1,632	757	172
Potassium	22.7	10	7.2	14	14
Sodium	226	940	1,000	235	164
Iron	.09	-	344	.1	0.74
Silica	-	36	91	4	-
Strontium	-	-	0	3.1	-

All concentrations in mg/l, except pH which is in pH units

Well	Emria #3
Date	4-19-79
Water-Bearing Unit	Kmbq + Kmf(u)
Source of Data	Consol
pH-Lab	7.1
TDS-Sum	5,461
Bicarbonate	640
Carbonate	-
Chloride	120
Sulfate	3,200
Calcium	300
Magnesium	290
Potassium	12
Sodium	880
Iron	-
Silica	19
Strontium	-

All concentrations in mg/l, except pH which is in pH units

CHAPTER VIII

SOIL RESOURCES

CHAPTER VIII

TABLE OF CONTENTS

8.0 SOIL RESOURCES

8.1 Scope

The purpose of the soils investigation is to identify and describe the soil resources within the proposed Emery Surface Mine area. The on-site soils investigation was carried out in 1980 on a very large area surrounding the present Emery Underground Mine. The original investigation was needed for the repermitting of the Underground Mine. Most of the Proposed Strip Mine permit area was included in the original investigation area and the data is used herein with the exception of the overburden study. Approximately 1/4 of the surface mine area has not had on-site field investigations completed by Consol. Thus data from the USDA-SCS is used to explain the soils of this small area. Refer to Plate VIII-1 which indicates where the SCS study data is used. Consol realizes that the SCS data is basic in nature and is presently in the process of mapping and sampling this acreage more specifically. This data will be sent into the DOGM as soon as it becomes available. However, these specifically mapped acreages will probably change the SCS information only slightly.

The consultants which did the initial field sampling and prepared the original text are listed below:

James P. Walsh and Associates, Inc.
1722 Fourteenth Street
Suite 250
Boulder, Colorado 80302

The original text has been revised by Consol staff to more closely describe the Emery Surface Mine permit area in particular.

8.2 Methodology

Soil mapping was conducted according to the standards of the National Cooperative Soil Surveys (USDA, Soil Survey Staff, 1951; USDA, SCS, 1975). Mapping was conducted on foot using hand augers; approximately 100 acres per man day were mapped in the detailed area. A soil map for the permit area is shown on Plate VIII-1.

Soils of the study area are described in detail. One profile for each major series in the detailed mapping area was sampled and described. Pace transects, used in estimating vegetative cover, were done at each sample point. Eighteen soil pits were excavated to 60 inches or more; soils pedons were described and sampled according to the standards of the National Cooperative Soil Surveys.

Physical and chemical analysis of the major series were conducted by Utah State University Cooperative Soils Laboratory, Logan, Utah. All horizons were analyzed for the following: particle size distribution,

textural class, saturated paste pH, percent organic carbon, percent gypsum, electrical conductivity (EC), moisture tension at saturation and 15 atmospheres, water soluble cations (Ca, Mg and Na) SAR, and boron. The analytical techniques used are in the appendix. These parameters were used to determine availability of reconstruction material.

An extensive overburden study was also conducted to identify its characteristics. Both major and trace minerals were identified and studied. The overburden study was not a part of the original study investigation.

The soils were classified by Unified and AASHO classification Systems.

Present and potential uses of the project area soils were determined. Present uses include grazing, marginally irrigated pasture, wildlife habitat, and a small semi-woodland. Delineations were made from SCS data, aerial photo-interpretations and field inspections.

A soil use inventory was conducted to estimate present and potential soil uses in the permit area. The permit area is variable in topography and elevation. The Quitchupah Creek flows through the permit area on the flood plains, basins, and into deep walled draws. Overall, topography ranges from flood plains and basins to mesas and benches, and steep, broken, choppy, rolling topography. The location of streams, creeks and springs, type of topography and parent material, access, and soil type are important in determining land uses. Potential uses of the project area soils are described by the land capability units and range sites. Prime farmlands and farmlands of statewide importance are discussed.

Many of the interpretations made in the Soil Use section are a product of compilation of data made available through the Soil Survey of Carbon-Emery Area (USDA, SCS, 1970); U.S.D.A. Soil Conservation Service (SCS) district office, Emery, Utah; and T.B. Hutchings, State Soil Scientist, SCS, Salt Lake City, Utah.

Topics discussed in this section include soil relation to range sites, and the present and potential uses of the lands in the project area. Present and potential land uses include soil capability classification, suitability for certain crops, pasture potential yields, range sites, and suitability for wildlife habitat and forest or woodland sites.

Soil series in the area to be disturbed are evaluated as sources of reconstruction material. Soil analysis, on-site information and soil interpretation records (SCS) were used in this evaluation. Criterion used in this determination are those outlined in the National Soils Handbook (USDA, SCS, 1976). Available topsoil depth and restrictive features are given for each soil.

Water and wind erodibility in areas to be disturbed are evaluated. The wind erodibility group (WEG) is determined for each map unit within the area to be disturbed. The soil erodibility factors (K) of surface soils, and cropping factor (C) were calculated for major soils in the detailed mapping area. This information is needed for reclamation planning to control loss of salvaged material.

Soils are classified and their genesis are discussed.

8.3 Soil Resource Information of Permit Area

There are 988.7 acres within the proposed permit boundary. Approximately 837.4 acres will be disturbed during the mining process. From this acreage approximately 1,601,131 yd^3 of Suitable Plant Growth material (SPGM) will be recovered and stockpiled before mining to be used for later redistribution. Please refer to table 3.5.2 of Chapter III for recovery depth details within the disturbance site.

8.3.1 Soil Series Identification

Below are listed the identification data for the soil series found within the proposed permit area.

Abbott Series

The Abbott series consists of deep, somewhat poorly to poorly-drained soils. These soils formed in alluvium derived from shales. Annual precipitation is 6 to 11 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is mainly sedges and wiregrass with some galleta grass and clover. Greasewood is sparse, but some plants are over four feet in height. The elevations ranges from 6,000 to 6,075 feet.

The available water capacity is moderately high to high, and permeability rate is low. These soils are used for grazing and hay production.

The Abbottt series is a member of the fine, montmorillonitic, (calcareous) mesic family of Fluventic Haplaquepts. A representative profile (#15) of the Abbott clay loam, 440 feet east, and 2,450 feet north of the southwest corner of section 27, T.22S R.06E Emery County, Utah, at an elevation of 6,045 feet is:

A11	0 to 3 in. grayish brown (2.5Y 5/2) clay loam, very dark grayish brown (2.5Y 3/2) moist; strong medium angular blocky structure; hard, firm, sticky and plastic; many fine roots; common fine distinct mottles (10YR 5/6); calcareous; mildly alkaline (pH 7.8); clear smooth boundary.

A12 — 3 to 22 in. light yellowish brown (2.5Y 6/4) clay loam, light olive brown (2.5Y 5/4) moist crushed; moderate medium to coarse subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common fine roots; many fine prominent mottles (7.5YR 5/6); calcareous; mildly alkaline (pH 7.7); clear smooth boundary.

C1sa — 22 to 41 in. light yellowish brown (2.5Y 6/4) silty clay, olive brown (2.5Y 4/4) moist; moderate medium prismatic structure; slightly hard, very friable, sticky and plastic; few fine roots; abundant threads and pockets of visible salts; calcareous; mildly alkaline (pH 7.7); clear smooth boundary.

C2cs — 41 to 62 in. very dark grayish brown (2.5Y 3/2 moist) silt loam; moderate medium prismatic structure; very friable, sticky and plastic; abundant pockets of yellow gypsum crystals; many fine faint mottles; clacareous; mildly alkaline (pH 7.7).

Some profiles have salt accumulations at the surface; others have visible salts below 20 in. Standing water may be encountered below 20 in; for short periods during the year, the water is at the surface. In some places this soil receives additional water through irrigation waste water and canal seepage.

Salinity ranges from moderate to strong. The A1 has a hue of 2.5Y to 5Y. At a depth of 20 inches or less the soil may have gleyed colors, chroma of 1, or mottles. Between 10 and 40 inches is silty clay loam to clay. The color of the upper 40 inches is about the same; below this depth the hue ranges from 2.5Y to 5Y; value of 3-5 moist; the chroma changes from 1 to 3. The substratum may be strongly gleyed or mottled and have accumulations of secondary calcium carbonates and gypsum.

The pedon is classified as a fine family based on the field description. Laboratory data indicates less than 35 percent clay in the control section. This may be the result of inadequate dispersion due to high gypsum content.

Alluvial Land

Alluvial land soils consist of deep and very deep, somewhat poorly drained moderately coarse to coarse textured soils. These soils are formed in mixed alluvium derived from a variety of sedimentary rocks. Annual precipitation is 6 to 11 inches. The mean annual soil temperature is 47° to 50° F, and the frost free period is 110 to 130 days. Native vegetation is mainly tamarisk and greasewood. The elevation ranges from 5,860 to 5,980 feet.

Alluvial land is a miscellaneous land type, comprising coarse-loamy and sandy, mixed, mesic families of Typic Torrifluvents and Torripsamments and Typic Saliorthids. A representative profile (#31) of a coarse-loamy, mixed, mesic, Typic Saliorthid, about 2,140 feet west and 865 feet north of the southeast corner of section 29, T.22S R.06E, Emery County, Utah at an elevation of 5,958 feet is:

A2 — 0 to 5 in. light brownish gray (2.5Y 6/2) fine sand, grayish brown (2.5Y 5/2) moist; moderate medium to coarse angular blocky structure; slightly hard, very friable, non-sticky and non-plastic; few fine and coarse roots; calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C1 — 5 to 20 in. light brownish gray (2.5 6/2) fine sand, dark grayish brown (2.5Y 4/2) moist; weak coarse angular blocky parting to single grain; soft, very friable, non-sticky and non-plastic; few fine and medium roots, several coarse roots; calcareous; strongly alkaline (pH 8.8); clear smooth boundary.

C2sa — 20 to 30 in. light brownish gray (2.5Y 6/2) medium sand, dark grayish brown (2.5Y 4/2) moist; weak coarse angular blocky parting to single grain; soft, very friable, non-sticky and non-plastic; few fine roots; many coarse prominent mottles on ped surfaces, root channels and pores; calcareous; moderately alkaline (pH 8.1); gradual smooth boundary.

C3sa — 30 to 45 in. light brownish gray (2.5Y 6/2) sandy loam, dark grayish brown (2.5Y 4/2) moist; weak coarse angular blocky structure; firable, slightly sticky and slightly plastic; few fine roots concentrated along sandy layers; common coarse distinct mottles (5YR 4/4, n4/) on ped faces and pores; lenses of material similar to above horizon; calcareous; strongly alkaline (pH 8.6); standing water at 45 in.

There are as few salt spots on the surface and some salt crusting to a depth of 1/2 in. is visible. Salt crystals on pedon walls have a nodular habit. The texture of the stratified material ranges from fine to sandy depending on adjacent erosional surfaces and landscape position.

Beebe Series

The Beebe series consists of deep, well-drained, coarse textured soils that are strongly affected by alkali unless cultivated and irrigated. These soils formed in alluvium derived from sedimentary sandstone.

Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 125 days. The native vegetation is dominately greasewood, rabbitbrush, shadscale and in some places big sage. The elevation range is 5,930 to 5,965 feet.

The available water capacity is moderate, and permeability is rapid. These soils are used for grazing and wildlife habitat.

The Beebe series is a member of the sandy, mixed, mesic family of Typic Torrifluvents. A representative profile (#27) of Beebe very loamy fine sand, 645 feet west, 2,530 feet north of the southeast corner of section 32, T.22S R.06E. Emery County, Utah at an elevation of 5,936 feet is:

A1	0 to 9 in. pale brown (10YR 6/3) very fine sandy loam, light yellowish brown (10YR 6/4) moist; moderate very thin platy and fine granular structure; soft, very friable, non-sticky and non-plastic; common very fine, fine, and medium roots; moderately alkaline; (pH 8.4); clear wavy boundary.
AC	9 to 20 in. light yellowish brown (10YR 6/4) loamy sand, light yellowish brown (10YR 6/4) moist; weak very fine angular blocky parting to very fine granular and single grain structure; slightly hard, very friable, non-sticky and non-plastic; very few clay films bridge sand grains; common medium roots, few coarse roots; very strongly alkaline (pH 9.4); diffuse boundary.
C1	20 to 51 in. pale brown (10YR 6/3) loamy sand, light yellowish brown (10YR 6/4) moist; weak very fine granular structure parting to very fine single grain; slightly hard, very friable, non-sticky and non-plastic; few coarse, fine and very fine roots; pockets of coarse sands about 1 in. thick at 35 to 40 in. in depth; very strongly alkaline (pH 10.1); clear smooth boundary.
C2casa	51 to 65 in. very pale brown (10YR 7/3) sandy loam, light yellowish brown (10YR 6/4) moist; weak very fine granular structure parting to single grain; soft, very friable, non-sticky and slightly plastic; 15 to 20 percent calcareous gravels; strongly alkaline (pH 8.8).

Some profiles have very fine sandy loam throughout. These may have thin stratified layers of sands. The substratum may be strongly calcareous and contain stratified layers of coarse sands and cobbly sands. This profile has about 12 percent less sand than allowed for sandy families, this pedon is therefore classified as coarse-loamy family. The area was originally mapped by the SCS as the Beebe series.

The reaction is mildly to very strongly alkaline. Unless irrigated, the soils are usually dry when not frozen. In the A1 horizon, hue ranges from 10YR to 7.5YR; value is 5 to 6 when the soils are dry and 4 to 6 when they are moist; and chroma ranges from 2 to 4.

Billings Series

The Billings series consists of deep, moderately well to well-drained soils. These soils formed in alluvium washed from alkaline, gypsum-bearing marine shale. Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 125 days. The native vegetation is greasewood, shadscale, galleta grass and Indian ricegrass. Elevation range is 6,000 to 6,150 feet.

The available water capacity is moderate to moderately high, and permeability is slow. These soils are used for rangeland.

The Billings series is a member of the fine-silty, mixed, (calcareous), mesic family of Typic Torrifluvents. Representative profile (Swenson et al, p. 70) of a Billings silty clay loam in a nearly salt-free cultivated field, 2,000 feet west and 600 feet north of the southeast corner of section 20, T.17S., R.9E., in Emery County, Utah, is:

Ap1 — 0 to 3 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak medium granular structure; hard, firm, sticky and plastic; plentiful medium roots; common fine pores; strongly calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

Ap2 — 3 to 11 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine angular and subangular block structure; hard, firm, sticky and plastic; plentiful medium roots; common fine pores; strongly calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C1 — 11 to 18 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine angular and subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine, discontinuous pores; strongly calcareous; few soft gypsum nodules; mildly alkaline (pH 7.6); diffuse boundary.

C2 — 18 to 42 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure; hard, firm sticky and plastic; few fine roots; few fine, discontinuous pores; strongly calcareous; few soft gypsum nodules; mildly alkaline (pH 7.6); diffuse boundary.

C3 42 to 58 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; massive; hard, firm, sticky and plastic; few fine roots; few fine discontinuous pores; few fine, light grayish brown (10YR 6/2) soft gypsum nodules; strongly calcareous; moderately alkaline (pH 8.0).

Salinity and alkalinity range from slight to strong, and the content of lime ranges from 5 to 25 percent. The content of gypsum in the lower C horizon ranges from 0.5 to 25 percent; gypsum nodules and crystals occur in this horizon. Clay minerals are mixed but are mainly illite and kaolinite. Unless irrigated, the soils are generally dry when not frozen. Distinct mottles occur in the moderatley well drained areas at depths below 36 inches. The A1 horizon has a hue of 2.5Y to 5Y. Value in this horizon is 6 to 7 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 2 to 4. The part of the profile between 10 and 40 inches is silty clay loam to clay loam and contains 27 to 35 percent clay and 15 percent sand that is coarser than very fine sand. The color of the upper 40 inches is similar to that of the A1 horizon. Crystals, veins or soft nodules of gypsum are visible below 20 inches. There may be up to 20 percent gravels on the surface.

Bunderson Series

The Bunderson series consists of deep, well-drained soils. These soils formed in alluvium washed from alkaline marine shale and sandstone. Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is sparse and consists mainly of scattered greasewood and halogeton. Elevation range is 5,930 to 5,960 feet.

The available water capacity is moderately low, and permeability is slow. These soils support plant species which have little range value.

The Bunderson series is a member of the fine-silty, mixed, mesic familty of Typic Torrifluvents. A representative profile (#04) of Bunderson very fine sandy loam, 1700 feet west, 530 feet south of the northeast corner of section 32, T.22S R.06E, Emery County, Utah at an elevation of 5,924 feet is:

A1 0 to 4 in. light grayish brown (2.5Y 6/2) very fine sandy loam; grayish brown (2.5Y 5/2) silty clay loam; moderate thin platy to fine granular structure; loose, very friable, slightly sticky and slightly plastic; many very fine and fine roots; strongly calcareous; moderately alkaline (pH 8.3); gradual smooth boundary.

C1ca 4 to 14 in. light brownish gray (2.5 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; moderate fine angular blocky structure parting to fine granular; soft, very friable, sticky and plastic; common coarse roots, may fine and very fine roots; strongly calcareous; secondary calcium carbonate crystals in pores and in small pockets; gypsum crystals intermixed with lime; moderately alkaline (pH 8.5); gradual smooth boundary.

C2ca 14 to 43 in. light brownish gray (2.5Y 6/2) heavy silty clay loam, grayish brown (2.5Y 5/2) moist; moderate fine angular blocky structure parting to fine granular; soft, very friable; sticky and plastic; common medium, fine, and very fine roots; white powdery lime concretations; strongly calcareous; strongly alkaline (pH 8.6); gradual smooth boundary.

C3cs 43 to 62+ in. grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; moderate fine angular blocky structure; soft, friable; sticky and plastic; few very fine roots; powdery lime concreations; common gypsum crystals; strongly calcareous; few fine distinct mottles; strongly alkaline (pH 8.6).

The depth of the surface horizon ranges from 2 to 5 in. The texture ranges from very fine sandy loam to silty clay. The surface horizon has very fine cracking. Subsurface cracking is rare but may be found as deep as 22 in. and 1/2 to 3/4 in. wide. Some horizons have a very gravelly vein and mottling below 15 in. The substratum is grayish brown silty clay loam, silt loam, clay loam or clay.

Exchangeable sodium is usually the greatest in the upper part of the profile and decreases with depth. Salinity ranges from moderate to strong. Lime ranges from 5 to 25 percent. The soils are generally dry when not frozen. The A1 horizons have a hue of 2.5Y to 5Y; value of 6 or 7 when dry and 4 or 5 when moist; the chroma ranges from 2 to 4, the control section is loam or silt loam, which contains 18 to 27 percent clay and 15 percent sand coarser than very fine sand. This pedon contains a few percent more medium and coarse sands than allowed for fine-silty family.

Castle Valley Series

The Castle Valley series consists of shallow, calcareous, well-drained soils. These soils formed in material weathered from interbedded sandstone and shale. Annual precipitation is 8 to 12 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is pinon, juniper, galleta grass and Indian ricegrass. The elevation range is 5,950 to 6,350 feet.

The available water capacity is moderately high, and permeability is moderately rapid. These soils are used for spring and fall range.

The Castle Valley series is a member of the loamy, mixed, mesic family of Lithic Zerollic Haplargids. A representative profile (#35) of Castle Valley fine sandy loam, 170 feet west, 765 feet south center of section 27, T.22S R.06E, Emery County, Utah at an elevation of 6,095 feet is:

A11	0 to 4 in. light gray (10YR 7/2) fine sandy loam, light yellowish brown (10YR 6/4) moist; moderate very fine platy structure; soft, very friable, slightly sticky and slightly plastic; calcareous; strongly alkaline (pH 8.7); clear wavy boundary.
B2t	4 to 10 in. brownish yellow (10YR 6/6) loamy coarse sand, brownish yellow (10YR 6/6) moist; strong medium and coarse angular blocky structure; hard to very hard, very friable, non-sticky and non-plastic; clay bridges across sand grains; calcareous; mildly alkaline (pH 8.1); abrupt wavy boundary.
C1ca	10 to 12 in. very pale brown to white (10YR 7/3, 8/1) sand, light yellowish brown (10YR 6/4) moist; very fine single grain; loose, very friable, non-sticky and non-plastic; calcareous; mildly alkaline (pH 8.1); abrupt wavy boundary.
Cr-R	12 to 45 in. soft rippable shale intermixed with hard fractured sandstone.

The thickness of the A1 ranges from 3 to 7 in. Depth to sandstone bedrock ranges from 9 to 20 in.; 15 to 17 in. is average. Some profiles 30 to 70 percent stones and gravels throughout. The control section in some profiles is very fine sandy loam over bedrock. The surface texture ranges from loamy sand to fine sandy loam and is usually 2 to 4 in. thick. The underlying material may be bravelly very fine sandy loam to very gravelly loam.

Chipeta Series

The Chipeta series consists of calcareous, somewhat poorly to moderately welldrained soils. These soils formed in residuum that weathered from alkaline, gypsum-bearing, marine shale. Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is very sparse (less than 30 percent plant cover) mat saltbush and shadscale.

The available water capacity is moderate, and permeability is moderately slow. These soils are not well suited for range.

The Chipeta series is a member of the clayey, mesic, shallow family of Typic Torriorthents. A representative profile (#01) of Chipeta very gravelly silty clay loam, 400 feet east, 575 feet south of the northwest corner of section 33, T.22S R.06E, Emery County, Utah at an elevation of 5,980 feet is:

A1 — 0 to 2 in. light gray (2.5Y 7/2) very gravelly heavy silty clay loam, light brownish gray (2.5Y 6/2) moist; weak thin platy parting to single grain structure; loose, friable, sticky and plastic; few fine and very fine roots; 15 percent gravels; calcareous; powdery lime accumulation in matrix; mildly alkaline (pH 7.7); clear smooth boundary.

AC — 2 to 11 in. light brownish gray (2.5Y 6/2) silty clay, grayish brown (2.5Y 5/2) moist; moderate fine angular blocky and thin platy structure; soft, very friable, sticky and very plastic; common medium roots, very few coarse roots; calcareous; some pockets of lime in matrix and lining pores; mottles in lower portion of horizon are few, fine faint (10YR 6/4); moderately alkaline (pH 8.4); clear smooth boundary.

Ccrcs — 11 to 19 in. grayish brown (2.5Y 5/2) moist clay; strong thin to coarse platy structure; slightly hard, firm, sticky and plastic; common fine and very fine roots; strongly calcareous; powdery lime filaments about ped faces; abrupt smooth boundary (not samples).

R — 19+ in. shale.

In areas below shaly colluvial land or Badland, the profile is about 4 to 11 inches deep. Surface cracking is common in some places and polyhedrons may be up to 1-1/2 in. thick and 3/4 in. wide. Up to 35 percent gravels may be present on the surface.

Disturbed Land

Disturbed Land is a miscellaneous land type comprised of various soils. A profile (#03) of a disturbed land soil, a mixed, mesic family of Ustic Torripsamments., 625 feet east and 330 feet south of the center of section 33, T.22S, R.06E Emery County, Utah is:

IIC1 — 0 to 11 in. coal waste (not sampled).

IC1 — 11 to 53 in. light brownish gray (2.5Y 6/2) loamy sand, light olive brown (2.5Y 5/4) moist; weak fine subangular blocky structure; soft, very friable, non-sticky and non-plastic; few fine roots; few fragments of wood, coal, and pockets and discontinuous lenses of very fine sandy loam; calcareous; moderately alkaline (pH 7.9); gradual smooth boundary.

IC2b 53 to 65 in. light brownish gray (2.5Y 6/2) loamy sand, olive brown (2.5Y 4/4) moist; massive structure; slightly hard, very friable, non-sticky and non-plastic; common fine and medium roots; mildly alkaline (pH 7.7).

This profile was sampled at the Emery Mine office near a coal stockpile. Other disturbed land soils will have different morphologies. Disturbed soils have either mixed surface soils and subsoils, loss of surface and/or subsoils, or have coal material at the surface.

Ferron Series

The Ferron series consists of deep, calcareous, poorly-drained soils. These soils formed in alluvium derived from marine shale and sandstone. Annual precipitation is 6 to 11 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is wiregrass, sedges, saltgrass and red topgrass. The elevation range is 5,800 to 6,075 feet.

The available water capacity is moderate to moderately high, and permeability is moderate. These soils are used for wet meadow pasture.

The Ferron series is a member of the coarse-silty, mixed, calcareous, mesic family of Fluventic Haplaquepts. A representative profile (#19) of Ferron silt loam, 430 feet west, 1530 feet north of the center of section 27, T.22S R.06E, Emery County, Utah at an elevation of 6,069 feet is:

O1 2 to 0 in. roots and grass mat.

A1 0 to 4 in. pale brown (10YR 6/3) fine sandy clay loam, dark grayish brown (10YR 4/2) moist; weak thin platy structure; slightly hard, very friable, slightly sticky and plastic; many very fine, fine and medium roots, few coarse roots; few fine faint (10YR 6/6) mottles; calcareous; moderately alkaline (pH 7.9); distinct smooth boundary.

AC 4 to 15 in. light yellowish brown (10YR 6/3) moist, silty clay loam; weak thin platy and fine subangular blocky structure; very friable, slightly sticky and plastic; many very fine, fine, and medium roots; calcareous; moderately alkaline (pH 8.0); diffuse boundary.

C1 15 to 35+ in. light yellowish brown (10YR 6/3) moist silty clay loam; very friable, slightly sticky and plastic; common very fine, fine and medium roots; moderately alkaline (pH 7.9); standing water at 35 in.

The content of lime ranges from 10 to 25 percent, salinity ranges from slight to strong and the reaction ranges from mildly to strongly alkaline. Ferron soils are mottled within 20 inches of the surface. The water table is at a depth between 6 and 36 inches below the surface, depending on the season. The described pedon may contain a few percent more clay in the control section (10 in. to 40 in.) than is allowed in coarse-silty families.

GP Series

The GP series consists of deep, well-drained, medium to moderately fine textured soils. These soils formed in alluvium and glacial outwash materials. Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is greasewood, big sage, four wing saltbush, mat sage, galleta grass and mixed forbs. The elevation range is 6,000 to 6,100 feet.

The available water capacity is moderate, and permeability is moderately rapid. These soils are used for rangeland.

The GP series is a member of the fine-loamy, mixed, mesic family of Typic Gypsiorthids. A representative profile (#06) of GP silt loam, 1,700 feet east and 1,190 feet north of the southwest corner of section 28, T.22S R.06E, Emery County, Utah at an elevation of 6,083 feet is:

A11 — 0 to 2 in. pale yellow (2.5Y 7/4) silt loam, light olive brown (2.5Y 5/4) moist; moderate medium to thin platy structure; slightly hard, very friable, slightly sticky and slightly plastic; 5 percent gravels; 1 percent cobbles; calcareous; mildly alkaline (pH 7.8); clear smooth boundary.

A12 — 2 to 6 in. pale yellow (2.5Y 7/4) silt loam, light olive brown (2.5Y 5/4) moist; moderate medium and coarse subangular blocky structure; slightly hard, very friable, slight sticky and slightly plastic; 2 percent gravels; calcareous; strongly alkaline (pH 8.7); clear smooth boundary.

C1 — 6 to 28 in. pale yellow (2.5Y 7/4) coarse silt loam, light olive brown (2.5Y 5/4) moist; weak medium angular blocky structure; soft, very friable, slightly sticky and slightly plastic; 2 percent gravels; calcareous; many fine gypsum crystals and threads of lime; moderately alkaline (pH 8.3); clear smooth boundary.

C2cs — 28 to 60 in. light brownish gray (2.5Y 6/2)) gravelly sandy clay loam, olive brown (2.5Y 4/4) moist; weak fine angular blocky structure; slightly hard, very friable, sticky and plastic; 30 percent gravels; calcareous; many large (5 mm) pockets of gypsum crystals; moderately alkaline (pH 8.3).

The gypsic horizon is between 13 and 30 in. below the surface. A gravelly horizon is at about 25 to 35 in. Weathered soft shale may be encountered below 40 in. In some landscape positions, mottling may be visible below 30 in.

Harding Variant

The Harding variant consists of deep, calcareous, moderately well or well-drained, fine or moderately fine textured soils. These soils formed in alluvium washed from sedimentary rocks. Annual precipitation is 8 to 12 inches. The mean annual soil temperature ranges from 47° to 54°F, and the frost free period is 110 to 130 days. The native vegetation is greasewood, shadscale, rabbitbrush, and galleta grass. The elevation range is 6,000 to 6,100 feet.

The available water capacity is moderately high, and permeability is slow. These soils are used for rangeland and wildlife habitat.

The Harding variant is a member of the fine-loamy, mixed, mesic family of Typic Natargids. This soil is similar to the Harding series soil mapped by the SCS in Emery County. The Harding series is a fine, mixed, mesic member of the Typic Natargids. A representative profile (#08) of Harding variant very fine sandy loam, 1,020 feet west and 170 feet south of the center of section 28, T.22S R.06E, Emery County, Utah at an elevation of 6,100 feet is:

A1	0 to 3 in. pale brown (10YR 6/3) very fine sandy loam, light yellowish brown (10YR 6/4) moist; moderate thin platy structure; slightly hard, very friable, slightly sticky and plastic; many fine, very fine and medium roots; calcareous; strongly alkaline (pH 8.6); abrupt smooth boundary.
B2t	3 to 10 in. light yellowish brown (10YR 6/4) silty clay, dark brown (10YR 4/3) moist; medium to coarse columnar separating to angular blocky structure; hard, firm, sticky and plastic; salt accumulations on top of peds; many very fine, medium, and coarse roots; calcareous; moderately alkaline (pH 8.5); clear smooth boundary.
B31tca	10 to 24 in. pale brown (10YR 6/3) very gravelly silty clay, very pale brown (10YR 7/3) moist; moderate fine subangular blocky parting to fine granular structure; soft, very friable, sticky and plastic; many very fine and medium roots, common coarse roots; lime coatings on gravels; calcareous; moderately alkaline (pH 8.4); arbitrary boundary.

B32ca — 24 to 43 in. pale brown (10YR 6/3) extremely gravelly silty clay, very pale brown (10YR 7/3) moist; moderate fine subangular blocky parting to fine granular structure; soft, very friable, sticky and plastic; many very fine and medium roots, common coarse roots; lime coatings on gravels; strongly calcareous; strongly alkaline (pH 8.7); clear smooth boundary.

IIC1 — 43 to 57 in. pale brown (10YR 6/3) loamy sand, brown (10YR 5/3) moist; moderate fine and very fine granular structure; loose, very friable, non-sticky and non-plastic; few fine and medium roots; strongly calcareous; mildly alkaline (pH 8.2); abrupt smooth boundary.

IIC2ca — 57 to 68 in. variously colored (10YR 7/3, 6/3) very gravelly and cobbly sand; single grain structure; loose dry, loose moist, non-sticky and non-plastic; many very fine, fine and medium roots; calcareous.

Some profiles have a thin (2 in.) A2 horizon as the surface horizon which is a very fine sandy loam. The A2 is absent in some places. The natric horizon may be 6 to 10 inches thick and have columnar to prismatic structure which breaks to angular blocky. Gravels are generally found below 20 inches. There are some pedons mapped with more than 35 percent gravels or cobbles in the control section. This is a fine-loamy variant of the Harding series. Salinity and alkalinity generally increase with depth. Gypsum may also be present in the substratum.

Hunting Series

The Hunting series consists of deep, somewhat poorly-drained, slightly to moderately saline, mediumn textured soils. These soils formed in alluvium washed from marine shale and sandstone. Annual precipitation is 6 to 11 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 160 days. The native vegetation is greasewood with saltgrass, red top grass or galleta grass. The elevation range is 6,000 to 6,100 feet.

The available water capacity is moderately high, and permeability is moderate. These soils are used for wet meadow pasture and irrigated pasture or cropland within the permit area.

The Hunting series is a member of the fine-silty, mixed, mesic family of Aquic Ustifluvents. A representative profile (#10) of Hunting clay loam, 1400 feet east and 800 feet south of the center of section 28, T.22S R.06E, Emery County, Utah at an elevation of 6,056 feet is:

A1g — 0 to 5 in. gray (10YR 6/1) heavy clay loam, grayish brown (10YR 5/2) moist; moderate thin platy structure; hard, slightly firm, sticky and plastic; many fine and very fine roots; calcareous; common fine prominent (7.5YR 5/6 dry) mottles; moderately alkaline (pH 7.9); diffuse boundary.

AC — 5 to 13 in. light brownish gray (10YR 6/2) clay loam, brown (10YR 5/3) moist; moderate thin platy structure; slightly hard, very friable, slightly sticky and plastic; common fine and very fine roots, very few coarse roots; calcareous; common fine and medium prominent (10YR 5/6) moist mottles; moderately alkaline (pH 8.0); diffuse boundary.

C1g — 13 to 45+ in. light yellowish brown (2.5Y 6/4 moist) silty clay loam and small pockets of coarse sands; weak fine granular structure; loose, very friable, slightly sticky and slightly plastic; common fine and very fine roots to 38 in.; calcareous; few fine distinct (10YR 6/6) moist; mottles; streaks of gleyed material (10YR 6/1) moist; moderately alkaline (pH 7.9); standing water at 45 in.

The A horizon has a texture varying from loam or silty clay loam. Horizons between 10 and 40 inches may be loam, silt loam, or silty clay loam that contains more than 18 percent clay and less than 15 percent sand coarser than very fine sand. There may be veins of gypsum in parts of these layers. The C horizon may be stratified with sandy loam or clay loam. Typically mottles are visible between 20 and 40 inches. Below a depth of 40 inches, the soil is stratified with sandy loam or clay loam. This profile has about 2 percent less clay in the control section than allowed for fine-silty families.

Ildefonso Series

The Ildefonso series consists of deep, well-drained, medium textured soils. These soils formed in alluvium and gravelly alluvial sediments. Annual precipitation is 7 to 11 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is greasewood, halogeton, shadscale, galleta grass and clumps of cacti. The elevation range is 5,985 to 6,125 feet.

The available water capacity is moderate to low, and permeability is moderate. These soils are used for rangeland and a source of gravels.

The Ildefonso series is a member of the loamy-skeletal, mixed, mesic family of Typic Calciorthids. A representative profile (#07) of Ildefonso sandy clay loam, 350 feet east and 445 feet south of the center of section 28, T.22S R.06E, Emery County, Utah at an elevation of 6,056 feet is:

A1ca — 0 to 6 in. light gray (2.5Y 7/2) sandy clay loam, yellowish brown (10YR 5/6) moist; weak very thin platy structure; soft, very friable, slightly sticky and slightly plastic; calcium carbonate accumulation on underside of surface gravels; strongly calcareous; moderately alkaline (pH 8.4); diffuse boundary.

B2 — 6 to 19 in. yellowish brown (10YR 5/4) very fine sandy clay loam, yellowish brown (10YR 5/4) moist; strong medium to coarse angular blocky and prismatic structure; very hard, firm, sticky and plastic; few thin clay films line pores; calcareous; moderately alkaline (pH 8.1); abrupt smooth boundary.

IC1ca — 19 to 33 in. white (10YR 8/1) very gravelly silty clay, white (2.5 8/2) moist; massive structure; very hard, friable, sticky and plastic, 30 percent gravels with calcium carbonate accumulation on undersides; strongly calcareous; moderately alkaline (pH 7.9); diffuse boundary.

IIC2ca — 33 to 51 in. light gray (10YR 7/2) cobbly very fine sand, very pale brown (10YR 7/4) moist; weak fine granular structure; soft, very friable, non-sticky and non-plastic; cobbly vein below 45 inches; strongly calcareous; 50 percent gravels and cobbles; strongly alkaline (pH 8.5); clear smooth boundary.

IIC3 — 51 to 60+ in. light yellowish brown (10YR 6/4) extremely gravelly very fine sand, very pale brown (10YR 7/4) moist; single grain structure; loose, loose, non-sticky and non-plastic; 60 percent pea gravels; calcareous; mildly alkaline (pH 7.8).

Gravel and cobble content ranges from 35 to 65 percent throughout. The surface soil may be stoney in places. The A1 ranges in texture from loamy fine sands, sandy loam, to sandy clay loam; it is typically 7 to 9 inches thick. The subsoil may be a gravelly to very gravelly sandy loam, fine sandy loam to very fine sand to depths greater than 60 inches.

Killpack Series

The Killpack series consists of moderately deep, slightly to moderately saline, well-drained, moderately fine textured soils. These soils formed in residuum that weathered from clayey marine shale bedrock. Annual precipitation is 7 to 10 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is shadscale, big sage and galleta grass. The elevation range is 6,000 to 6,150 feet.

The available water capacity is moderate to high, and permeability is slow. These soils are used for rangeland and wildlife habitat.

The Killpack series is a member of the fine-silty, mixed, calcareous mesic familty of Typic Torriorthents. A representative profile (Swenson et al, 1970) of Killpack clay loam in a cultiviated field about 2,450 feet north and 300 feet east of the southwest corner of section 30, T.16S. R.10E., Emery County, Utah is:

Ap	0 to 9 in. grayish brown (2.5Y 5/2) clay loam, dark grayish brow (2.5Y 4/2) moist; weak medium and fine granular structure; hard, firm, slightly sticky and slightly plastic; plentiful fine roots; comon fine pores; strongly calcareous; mildly alkaline (pH 7.8); clear smooth boundary.
C1	9 to 23 in. light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; moderate coarse angular blocky structure breaking to weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual wavy boundary.
C2cs	23 to 29 in. light brownish gray (2.5Y 6/2) shaly silty clay loam, grayish brown (2.5Y 5/2) moist; massive; hard, very firm, sticky and plastic; few fine roots; no pores; strongly calcareous; many gypsum crystals 5 to 15 mm in diameter,; mildly alkaline (pH 7.7); gradual wavy boundary.
R	29 in. + light brownish gray (2.5Y 6/2) weathered shale.

Killpack soils are generally dry when frozen, except where they are irrigated. Clay minerals are mixed, but dominately they are illite and kaolinite. In the Al horizon, hue ranges from 10YR to 5Y value is 5 or 6 when the soils are dry and 4 or 5 when moist; and chroma is 2 or 3. The control section is silty clay loam to clay loam and contains less than 35 percent clay. The hue in this section ranges from 10YR to 5Y; value is 6 or 7 when the soils are dry and ranges from 4 to 6 moist; the chroma is 2 or 3. The C2cs horizon contains 5 to 20 percent shale fragments. A weak to moderate accumulation of gypsum overlies the shale.

Libbings Series

The Libbings series consists of moderately deep, very strongly saline, poorly-drained, moderately fine textured soils. These soils formed in alluvium washed from shale parent material. Annual precipitation is 6 to 11 inches. The mean annual soil temperature ranges from 47° to 54°F, and the frost free period is 110 to 130 days. The native vegetation is mainly greasewood and saltgrass. The elevation range is 6,000 to 6,150 feet.

This soil is mainly in depressions where drainage is severely restricted. Water is removed from the soil mainly through evaporation; in this way salt accumulates.

The available water capacity is low to very low, and permeability is slow. These soils are used only for range.

The Libbings series is a member of the fine, mixed, mesic family of Ustollic Saliorthids. A representative profile (#11) of Libbings clay loam, 1,020 feet west and 1,100 feet south of the northeast corner of section 28, T.22S R.06E, Emery County, Utah at an elevation of 6,056 feet is:

A11sa	0 to 1/2 in. white salt crystals.
A12	0 to 4 in. dark brown (10YR 3/3 moist) clay loam; moderate medium granular structure; friable, sticky and plastic; common fine and medium roots; many fine faint and few fine distinct (10YR 5/6) mottles; calcareous; strongly alkaline (pH 8.6); distinct smooth boundary.
C1sa	4 to 24 in. brown (10YR 5/3 moist) silty clay; weak medium subangular blocky structure; very friable, sticky and plastic; few fine roots; common pockets (1 mm) salt crystals; calcareous; moderately alkaline (pH 8.2); distinct smooth boundary.
C2sa	24 to 39 in. grayish brown (10YR 5/2 moist) silty clay; weak medium subangular blocky structure; very friable, sticky and plastic; few fine roots; common pockets (1 mm) of salt crystals; few fine distinct mottles around roots; calcareous; moderately alkaline (pH 8.1); groundwater at 29 inches; distinct smooth boundary.
C3	39 to 50 in. grayish brown (2.5Y 5/2 moist) clay; weak medium subangular blocky structure; very friable, sticky and plastic; 5 percent gravels; common medium distinct (2.5Y 5/0) mottles; calcareous; moderately alkaline (pH 8.0).

Salt crusts from 1/2 to 1-1/2 inches on the surface are common. Water table is at a depth between 10 and 30 inches. Reaction ranges from strongly to moderately alkaline. The part of the profile between 10 inches to shale is mainly silty clay but may be heavy silty clay loam to clay. Gypsum accumulations may be seen below 8 to 10 inches.

Lab data (appendix) concludes the control section of the described pedon contains only 24 percent clay. The soil was classified on the basis of the field description which indicated 42 percent clay. High gypsum and salt contents may have prohibited adequate dispersion of fine particles in the lab.

Minchey Seeies

The Minchey series consists of deep, well-drained, moderately fine textured soils. These soils formed in glacial outwash from sandstone and quartzite. Annual precipitation is 7 to 12 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is galleta grass, big sage and bluebunch wheatgrass. The elevation range is 6,100 to 6,180 feet.

The available water capacity is moderately high, and permeability is moderate. These soils are used for spring and fall range and irrigated cropland.

The Minchey series is a member of the fine-loamy, mixed, mesic family of Typic Calciorthids. A representative profile (Swenson et al, 1970) of Minchey loam, about 1,980 feet south and 140 feet west of the northeast corner of section 9, T.16S, R.10E, Emery County, Utah is:

A1	0 to 3 inches; pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; weak thin platy structure; soft, friable, slightly sticky and slightly plastic; moderately calcareous; few fine and medium roots; vesicular pores; moderately alkaline (pH 8.2); clear smooth boundary.
C1	3 to 12 inches; brown (10YR 5/3) clay loam, dark brown (10YR 4/3) moist; moderate medium subangular blocky structure; hard, firm, slightly sticky and plastic; moderately calcareous; few medium and fine roots; many medium pores; moderately alkaline (pH 8.0); gradual wavy boundary.
C2ca	12 to 20 inches; pale brown (10YR 6/3) clay loam, dark brown (10YR 4/3) moist; moderate medium subangular blocky structure; hard, very firm, sticky and plastic; strongly calcareous; few fine and medium roots; few fine pores; lime is disseminated and in fine nodules; moderately alkaline (pH 8.3); gradual wavy boundary.
C3ca	20 to 32 inches; very pale brown (10YR 8/3) sandy clay loam, very pale brown (10YR 7/3) moist; massive structure; hard, firm slightly sticky and slightly plastic; very strongly calcareous; few find and medium roots; very few fine pores; lime is disseminated and in fine nodules; moderately alkaline (pH 8.2); diffuse wavy boundary.

C4ca 32 to 48 inches; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; massive structure; slightly hard, very friable, non-sticky and slightly plastic; strongly calcareous; few fine roots; few fine pores; moderately alkaline (pH 7.9), gradual wavy boundary.

C5 48 to 64 inches; light yellowish brown (10YR 6/4) very gravelly sandy loam, yellowish brown (10YR 5/4) moist; single grained structure; loose, very friable, non-sticky and slightly plastic; strongly calcareous; few fine roots; moderately alkaline (pH 8.4).

Depth to limy horizons ranges from 10 to 20 inches. The content of carbonates ranges from 15 to 55 percent, but a content of 25 to 40 percent is typical. The A1 horizon has a hue of 10YR, value of 5 to 7 dry and 4 or 5 moist; the chroma is 2 or 3. Texture of the A1 is loam or clay loam. The control section is clay loam or sandy clay loam with less than 35 percent clay more than 15 percent sand coarser than very fine sand, according to a weighted average.

In places the lower 1/3 of this section contains as much as 50 percent gravel and cobblestones. The control section has a hue of 7.5YR to 10YR, value of 5 to 8 dry and 4 to 7 moist; the chroma is 3 or 4. The substratum has a texture of sandy loam to loamy sand. The Minchey soils are generally dry when not frozen, unless they are irrigated.

Palisade Series

The Palisade series consists of deep, welldrained, medium textured soils. These soils formed in alluvium and glacial outwash derived from calcareous sandstone mixed with shale and limestone. Annual precipitation is 7 to 11 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is big sage, shadscale, galleta grass, and Indian ricegrass. The elevation range is 6,000 to 6,150 feet.

The available water capacity is moderately high to high, and permeability is moderate. These soils are used for spring and fall range; they are irrigated in the permit area.

The Palisade series is a member of the coarse-loamy, mixed, mesic family of Xerollic Calciorthids. A representative profile (#24) of Palisade loamy sand, 950 feet west, 855 feet south, of the northeast corner of section 24, T.22S R.06E, Emery County, Utah at an elevation of 6,056 feet is:

A11 0 to 4 in. pale brown (10YR 6/3) loamy sand, brown (10YR 5/3) moist; moderate fine granular structure; loose, loose, non-sticky and non-plastic; many medium and fine roots; many medium and fine pores; calcareous; moderately alkaline (pH 8.0); clear wavy boundary.

A12 4 to 9 in. light yellowish brown (10YR 6/4) very fine sandy loam, dark yellowish brown (10YR 4/4) moist; moderate thick platy structure; slightly hard, friable, non-sticky and slightly plastic; many medium and fine roots; many medium and fine pores; calcareous; moderately alkaline (pH 7.9); clear wavy boundary.

C1ca 9 to 19 in. very pale brown (10YR 7/4) very fine sandy loam, yellowish brown (10YR 5/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common fine and medium roots; common fine and medium pores; many cicada burrows; calcareous; moderately alkaline (pH 8.0); gradual boundary.

C2ca 19 to 32 in. very pale brown (10YR 7/4) very fine sandy loam, yellowish brown (10YR 5/4) moist; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common medium and fine roots; common medium and fine pores; numerous cicada casts impregnated with lime and very hard; calcareous; moderately alkaline (pH 8.3); gradual boundary.

C3ca 32 to 42 in. pink (7.5YR 7/4) very fine sandy loam, brown (7.4YR 5/4) moist; massive structure; slightly hard, friable, non-stick and slightly plastic; few fine and medium roots; few pores common cicada casts; calcareous; strongly alkaline (pH 8.5); gradual boundary.

C4 42 to 60 in. pink (7.5YT 7/4) very fine sandy loam, brown (7.5 5/4) moist; massive structure; slightly hard, friable; non-sticky and slightly plastic; few medium roots; few fine pores; disseminated and veined lime accumulations; burrow fillings about 8 in. diameter; calcareous; moderately alkaline (pH 8.0).

Four to 6 in. hummocks are common under shadscale; the surface texture is loamy sand.

The Palisade soils generally are dry when not frozen, unless they are irrigated. They have a mixed clay mineology. In the A horizon, hue to 10YR; value is 5 or 6 dry and 4 or 5 when they are moist; the chroma is 3 or 4. The control section is very fine sandy loam or light loam that

contains less than 18 percent clay and more than 15 percent sand coarser than very fine sand. In places gravels and cobbles make up as much as 50 percent, by volume, of the lower 1/2 portion of this section. The hue is 7.5R to 10YR; value ranges from 5 to 7 when the soils are dry and 4 to 6 when they are moist; and the chroma ranges from 2 to 4. The content of calcium carbonate in the limy horizons ranges from 15 to 40 percent. Below a depth of 40 inches, the texture ranges from very fine sandy loam to gravelly loamy sand.

Persayo Series

The Persayo series consists of shallow, well-drained, moderately fine textured soils. These soils formed in residuum that weathered from shale. Annual precipitation is 8 to 11 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is mainly galleta grass and shadscale. The elevation range is 5,900 to 6,200 feet.

The available water capacity is moderately high, and permeability is moderate. These soils are used for spring and fall range.

The Persayo series is a member of the loamy, mixed calcareous mesic family of Typic Torriorthents. A representative profile (#20) of Persayo very fine sandy clay loam, 1,060 feet east and 185 feet north of the southwest corner of section 22, T.22S R.06E, Emery County, Utah at an elevation of 4,087 feet is:

A1	0 to 4 in. light brownish gray (2.5Y 6/2) very fine sandy clay loam, pale brown (10YR 6/3) moist; moderate very thin platy structure; loose, very friable, slightly sticky and slightly plastic; few fine and very fine roots; strongly calcareous; mildly alkaline (pH 8.0); gradual smooth boundary.
AC	4 to 11 in. pale brown (10YR 6/3) heavy silty clay loam, brown (10YR 5/3) moist; weak thin platy structure; soft, very friable, sticky and plastic; common very fine and fine roots, few medium and coarse roots; calcareous; mildly alkaline (pH 8.1); abrupt smooth boundary.
Crcs	11 to 19 in. light brownish gray (10YR 6/2) very gravelly clay; light brownish gray (2.5Y 6/2) moist; strong medium platy structure; slightly hard, friable, sticky and plastic; pockets of gypsum crystals, some as streaks or threads below 15 in.; calcareous; slightly alkaline (pH 7.8); abrupt boundary.
R	19+ in. soft weathered shale.

Persayo soils are dry when not frozen, unless they are irrigated. The A1 ranges from hue to 2.5Y to 5Y; value of 6 or 7 when soils are dry and is 4 or 5 when moist; chroma is 2. The control section is silty clay loam that contains less than 35 percent clay. Soft weathered shale is encountered between 10 and 20 in. Weathered fragments of shale make up to 70 percent of the material below 10 inches; shale fragments increase with depth. Some profiles have more gypsum crystals occurring directly above the bedrock. All of the upper 20 inches is about the same color.

Rafael Series

The Rafael series consists of deep, moderately to strongly alkaline, moderately fine textured, poorly-drained soils. These soils formed in alluvium derived from marine shale. Annual precipitation is 7 to 8 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is wiregrass, sedge, redtop grass and saltgrass.

The available water capacity is moderate to moderately high, and permeability is slow. These soils are used for pasture land and some hay production.

The Rafael series is a member of the fine-silty, mixed calcareous, mesic family of Typic Haplaquepts. A representative profile (Swanson et al, 1970) of Rafael silty clay loam, 600 feet north and 1,300 feet west of the southeast corner of section 29, T.22S R.06E, Emery County, Utah is:

A11 — 0 to 3 in. light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; common medium distinct, strong brown (7.5Y 5/6) mottles; weak thin platy structure; slightly hard, firm, sticky and plastic; plentiful medium and fine roots; few fine and few medium pores; strongly calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

A12 — 3 to 11 in. light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; common medium distinct, yellowish red (5YR 5/8) mottles; weak moderately thick platy structure; hard, firm, sticky and plastic; plentiful medium and few fine roots; common medium and few fine pores; moderately calcareous; moderately alkaline (pH 8.4); clear wavy boundary.

C1g — 11 to 17 in. grayish brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; common medium distinct strong brown (7.5YT 5/6) and few fine faint gray (N6/0) mottles; weak coarse subangular blocky structure; slightly hard or hard, firm, slightly sticky and plastic; plentiful medium and fine roots; common medium and fine pores; strongly calcareous; strongly alkaline (pH 8.6); clear wavy boundary.

C2g — 17 to 33 in. grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; few fine distinct strong brown (7.5YR 5/6) mottles and common medium distinct gray (N 6/0) mottles; weak coarse prismatic structure breaking to weak, coarse subangular blocky structure; very hard, very firm, sticky and very plastic; plentiful medium and fine roots; few medium and common fine pores; numerous gypsum mycelia; strongly calcareous; strongly alkaline (pH 8.6); clear wavy boundary.

C3g — 33 to 43 in. grayish brown (2.5Y 5/2) heavy loam, dark grayish brown (2.5Y 4/2) moist; fine distinct strong brown (7.5YR 5/6) mottles and common medium distinct gray (N 6/0) mottles; massive; hard, firm, slightly sticky and plastic; few medium and fine roots; common fine and few medium pores; moderately calcareous; moderately alkaline (pH 8.3); gradual wavy boundary.

C4g — 43 to 70 in. light brownish gray (2.5Y 6/2) heavy loam, dark grayish brown (2.5Y 4/2) moist; common medium gray (N 6/0) mottles; massive; hard, firm slightly sticky and plastic; few medium and fine roots; common fine and few medium pores; strongly calcareous; moderately alkaline (pH 8.2).

The content of lime ranges from 10 to 30 percent and is greatest near the surface. In the A1 horizons, hue is 2.5Y to 5Y; value ranges from 5 to 7 when the soils are dry and is 4 or 5 when they are moist; and chroma is 2 or 3. Distinct to prominent mottles are at depths of less than 20 inches. Gley colors are common in some areas at some depth below 36 inches. Thin layers of peaty material are on the surface in some areas. The part of the profile between 10 and 40 inches is silty clay loam and heavy loam, and contains 22 to 38 percent clay and contains less than 15 percent sand that is coarser than very fine sand. All of the upper 40 inches is about the same color.

Ravola Series

The Ravola series consists of deep, well-drained, medium textured soils. These soils formed in alluvium washed from shale and sandstone. Annual precipitation is 7 to 12 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is galleta grass, shadscale and greasewood. The elevation range is 5,900 to 6,150 feet.

The available water capacity is moderately high, and permeability is moderate. These soils are used for spring and fall range.

The Ravola series is a member of the fine-silty, mixed, mesic family of Typic Torrifluvents. A representative profile (#02) of Ravola loam, 380 feet east and 820 feet south of the northwest corner of section 33, T.22S R.06E, Emery county, Utah at an elevation of 5,958 feet is:

A11 — 0 to 3 in. grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; moderate thick platy structure; soft, very friable, sticky and plastic; few fine roots; calcareous; slightly alkaline (pH 7.7); clear smooth boundary.

A12 — 3 to 15 in. grayish brown (2.5Y 5/2) silt loam, dark grayish brown (2.5Y 4/2) moist; moderate medium angular blocky structure; soft, very friable, slightly stick and plastic; common fine roots; 2 percent gravels, 1 percent cobbles; few thin lime threads; calcareous, slightly alkaline (pH 7.7); abrupt smooth boundary.

C1ca — 15 to 30 in. grayish brown (10YT 5/2) extremely gravelly clay loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky structure; loose, loose, sticky and plastic; few medium roots; few distinct mottles (10YR 5/6); many pockets of lime; very strongly calcareous; 40 percent gravels; moderately alkaline (pH 8.1); gradual smooth boundary.

C2 — 30 to 50 in. light brownish gray (10YR 6/2) sandy clay loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; few fine roots; few distinct mottles (10YR 5/6); 5 percent gravels; calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C3 — 50 to 71 in. light brownish gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) moist; weak coarse angular blocky structure; slightly hard, firm, sticky and plastic; few fine roots; many threads of lime; calcareous; moderately alkaline (pH 8.4).

This profile is found below a gravelly Typic Gypsiorthid and therefore, exhibits more gravels than the typical Ravola profile. This profile is located in an alluvial fill swale and depth of the A horizons range to 15 in. Salinity is generally slight to moderately alkaline. Gypsum occurring in veins is common below 20 to 30 inches.

In some places the surface horizon may be silty clay loam. The hue is 2.5Y to 5Y, the value is 6 or 7 dry and 4 or 5 when moist; the chroma ranges from 2 to 4. Between 10 and 40 inches, the texture is a heavy loam, silty loam, clay loam or very fine sandy loam that contains 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand. Below a depth of 40 inches, the soil may be sandy loam, to silty clay loam.

Saltair Series

The Saltair series consists of deep, poorly-drained, very strongly alkaline, moderately fine textured soils. These soils formed in alluvium derived from marine shale and sandstone. Annual precipitation is 7 to 12 inches. The mean annual soil temperature ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is greasewood and saltgrass; bare surfaces are common. Platy crusts of salt on the surface are also common. The elevation range is 5,900 to 5,975 feet.

The available water capacity is very low to moderately low, and permeability is slow. These soils are used for wet meadow range.

The Saltair series is a member of the fine-silty, mixed, mesic family of Typic Saliorthids. A representative profile (Swanson et al, 1970) of Saltair silty clay loam, 1,200 feet north, 500 feet west of the southeast corner of section 13 T.17S, R.09E, Emery County, Utah, is:

A11sa — 0 to 1/2 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak thin platy breaking to moderate fine granular structure; soft, firm, very sticky and plastic; strongly calcareous; plentiful large roots; many medium and fine vesicular pores; thin salt crust; strongly alkaline (pH 8.9); clear smooth boundary.

A12sa — 1/2 to 7 inches; light brownish gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; weak to moderate fine angular block structure; very hard, very firm, very sticky and very plastic; strongly calcareous; plentiful medium and fine roots; common medium and fine pores; many fine distinct (10YR 5/6) mottles; very strongly saline; efflorescent salt on many ped surfaces and in pores; moderately alkaline (pH 8.3); clear smooth boundary.

C1gsa — 7 to 14 inches; light brownish gray (2.5Y 6/2) heavy silt loam, grayish brown (10YR 5/2) moist; weak fine angular blocky structure; very hard, very strong, very sticky and very plastic; strongly calcareous; few fine roots; common medium pores; common fine distinct (10YR 5/4) mottles and common fine faint (N 5/0) mottles very strognly saline; efflorescent salt on many ped surfaces and in pores; strongly alkaline (pH 8.5); gradual wavy boundary.

C2gsa 14 to 32 inches; light brownish gray (2.5Y 6/2) heavy silt loam, grayish brown (2.5Y 5/2) moist; massive structure; very hard, firm, sticky and plastic; strongly calcareous; few fine roots; common medium and fine pores; many fine distinct (10YR 5/4) mottles and common fine faint (N 5/0) mottles; very strongly saline; efflorescent salt on the surfaces of many peds and in pores; strongly alkaline (pH 8.5); gradual wavy boundary.

C3g 32 to 60 inches; light gray (2.5Y 7/2) heavy silt loam, grayish brown (2.5Y 5/2) moist; massive structure; hard, firm, sticky and plastic; strongly calcareous; few fine roots; common fine pores; few fine distinct (10YR 5/4) mottles and medium faint gray (N 5/0) mottles; strongly alkaline (pH 8.5).

The content of salt is 2.0 percent or more in the upper 20 inches of the profile; the rest of the profile also contains salt. The content of exchangeable sodium ranges from 15 to 70 percent. The A1 horizons have a hue of 2.5Y or 5Y, value of 4 to 6 dry, 5 to 7 moist; the chroma is 1 or 2. The control section is heavy silt loam, silty clay loam, or clay loam that contains less than 35 percent clay. All the upper 40 inches is about the same color.

Sanpete Series

The Sanpete series consists of deep, well-drained, gravelly or cobbly soils. These soils formed in glacial outwash derived from sandstone, quartzite, and basalt. Annual precipitation is 8 to 12 inches. The mean annual soil temperatrure ranges from 47° to 50°F, and the frost free period is 110 to 130 days. The native vegetation is big sage, bluebunch wheatgrass, galleta grass, shadscale and Indian ricegrass. The elevation range is 5,900 to 6,150 feet.

The available water capacity is moderate, and permeability is rapid. These soils are used mainly for rangeland.

The Sanpete series is a member of the loamy-skeletal, mixed, mesic family of Xerollic Calciorthids. A representative profile (Swanson et at, 1970) of Sanpete fine sandy loam, 1,300 feet south and 1,000 feet west of the northeast corner of section 21, T.18S R.08E, Emery County, Utah is:

A1 0 to 1 in. pale brown (10YR 6/3) very fine sandy loam, brown (10YR 5/3) moist; weak thin platy structure breaking to weak fine granular structure; soft, friable, non-stick and non-plastic; few fine roots; vesicular pores; moderately calcareous; mildly alkaline (pH 7.8); abrupt smooth boundary.

C1 — 1 to 5 in. light yellowish brown (10YR 6/4) gravelly sandy clay loam, yellowish brown (10YR 5/4) moist; weak coarse subangular blocky structure breaking to weak fine subangular blocky structure; slightly hard, firable, slight sticky and slightly plastic; common medium-sized roots; common fine, discontinuous pores; moderately calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C2 — 5 to 9 in. brownish yellow (10YR 6/5) gravelly sandy clay loam, yellowish brown (10YR 5/5) moist; moderate coarse angular blocky structure breaking to moderate fine angular and subangular blocky structure; slightly hard, firable, slightly sticky and plastic; plentiful medium roots, few fine roots; few fine discontinuous pores; strognly calcareous, mildly alkaline (pH 7.8); clear wavy boundary.

C3ca — 9 to 14 in. very pale brown (10YR 7/4) cobbly sandy clay loam, light yellowish brown (10YR 6/4) moist; moderate coarse angular blocky structure breaking to fine angular and subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine roots; few fine discontinuous pores; very strongly calcareous; moderately alkaline (pH 8.1); gradual wavy boundary.

C4ca — 14 to 30 in. very pale brown (10YR 8/3) very cobbly sandy loam, very pale brown (10YR 7/3) moist; massive; slightly hard, firable, slightly sticky and slightly plastic; very strongly calcareous; moderately alkaline (pH 8.0); gradual wavy boundary.

C5 — 30+ in. very pale brown (10YR 7/3) very cobbly sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, non-sticky and non-plastic; no roots or pores; very strongly calcareous; strongly alkaline (pH 8.8).

Depth to the zone of lime accumulation ranges from 7 to 15 inches, and the accumulation is 8 to 24 inches thick. The soils generally are dry when not frozen, unless they are irrigated. In the A1 horizon, the hue is 7.5YR or 10YR; value ranges form 5.5 to 7 when the soils are dry and from 3.5 to 5 when they are moist; and chroma ranges from 2 to 5. The content of coarse fragments ranges from only a few percent to more than 50 percent, but 20 to 50 percent is typical. The part of the profile below 10 inches is sandy clay loam to sandy loam. The amount of coarse fragments in this part ranges from 20 to more than 70 percent, but on the basis of a weighted average the proportion is more than 50 percent. In the part of the profile below 10 inches, the hue ranges from 10YR to 5YR; value ranges from 6 to 8 when the soils are dry and from 4 to 7 when they are moist; and chroma ranges from 3 to 5.

Sh Series

The Sh series consists of moderately deep, well-drained, moderately fine textured soils. These soils formed on gently sloping upland benches in sedimentary rocks. Annual precipitation is 8 to 12 inches. The mean annual soil temperature ranges from 47° to 54°F, and the frost free period is 110 to 130 days. The native vegetation is galleta grass and shadscale.

The available water capacity is moderate to moderately low, and permeability is moderate. These soils are used for rangeland and wildlife habitat.

The Sh series is a member of the fine-loamy, mixed, mesic family of Typic Calciorthids. A representative profile (#14) of Sh cobbly very fine sandy loam, 350 feet east and 2,290 feet north of the southwest corner of section 27, T.22S R.06E, Emery County, Utah at an elevation of 6,056 feet is:

A1	0 to 3 in. light gray (10YR 7/2) heavy silty clay loam, pale brown (10YR 6/3) moist; moderate thin platy structure; soft, very friable, sticky and plastic; many fine and very fine roots, common medium roots; 40 percent gravels and cobbles; strongly calcareous; moderately alkaline (pH 8.1); gradual smooth boundary.
ACca	3 to 17 in. light brownish gray (2.5Y 6/2) silty clay loam, pale brown (10YR 6/3) moist; strong to medium platy and angular blocky structure; slightly hard, firable, sticky and plastic; common very fine, fine and medium roots; few fine prominent mottles (7.5YR 5/6) about coarser materials; strongly calcareous; moderately alkaline (pH 8.0); clear smooth boundary.
C1	17 to 29 in. light gray (2.5Y 7/2) silty clay, light brownish gray (2.5YR 6/2) moist; strong medium to coarse angular blocky structure; hard, firm, sticky and plastic; many fine and very fine roots, few medium roots; strongly calcareous; moderately alkaline (pH 8.0).
Cr	29+ in. soft, weathered, calcareous shale. Sh soil is calcareous throughout and have strongly calcareous horizons.

No range and characteristics have been established by the SCS.

Woodrow Series

The Woodrow series consists of deep, moderately fine textured, calcareous, well-drained soils. These soils formed in alluvium from mixed sedimentary rocks. Annual precipitation is 6 to 11 inches. The mean annual soil temperature ranges from 47° to 54°F, and the frost free period is 110 to 160 days. The native vegetation is mixed short grasses.

The available water capacity is moderately high, and permeability is slow. These soils are used for spring and fall range, pasture, and irrigated cropland.

The Woodrow series is a member of the fine-silty, mixed, calcareous, mesic familty of Typic Torrifluvents. A representative profile (Swanson et al, 1970) of Woodrow silty clay loam, 800 feet north and 750 feet east of the northeast corner of section 5, T.18S, R.09E, Emery County, Utah is:

Ap1 — 0 to 2 in. light brownish gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) moist; moderate fine granular structure; soft, firm, slightly sticky and slightly plastic; plentiful large and medium roots; common medium continuous pores; strongly calcareous; mildly alkaline (pH 7.6); clear smooth boundary.

Ap2 — 2 to 7 in. light brownish gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) moist; weak coarse subangular blocky structure breaking to moderate medium and fine granular structure; hard, firm, slightly sticky and plastic; plentiful roots of all sizes; common medium continuous pores; strongly calcareous; mildly alkaline (pH 7.6); clear smooth boundary.

C1 — 7 to 19 in. light brownish gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) moist; moderate medium angular blocky structure; very hard, very firm, sticky and plastic; plentiful medium and fine roots; common medium continuous pores and common fine discontinuous pores; strongly calcareous; mildly alkaline (pH 7.8); diffuse wavy boundary.

C2 — 19 to 31 in. light brownish gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) moist; weak medium subangular blocky structure; very hard, very firm, sticky and plastic; plentiful fine and few medium roots; common fine discontinuous pores; strongly calcareous; moderately alkaline (pH 7.9); diffuse wavy boundary.

C3 — 31 to 60 in. light brownish gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) moist; massive; very hard, very firm, stick and plastic; few fine roots; common fine discontinuous pores; strongly calcareous; moderately alkaline (pH 7.9).

The soils are usually dry when not frozen, unless they are irrigated. Clay minerals are mixed, but dominantly they are montmorillonitic. The content of lime ranges from 10 to 25 percent. In the A horizons, hue

ranges from 10YR to 7.5YR; value ranges from 5 to 7 when the soils are dry and from 4 to 6 when they are moist; and chroma ranges from 2 to 4. The part of the profile between depths of 10 and 40 inches is clay loam to silty clay loam that contains 27 to 35 percent clay. All of the upper 40 inches is about the same color. Below a depth of 40 inches, the texture ranges from sandy loam to silty clay loam.

8.3.2 Soil Map Unit Descriptions

Descriptions of the soil mapping units within the permit area are listed below:

Map Unit: Ab - Abbott Clay Loam, 0 to 3 Percent Slopes

This map unit is on level to gently sloping alluvial fans and flood plains of streams. The slope is 0 to 3 percent. The native vegetation is mainly wiregrass, sedges, galleta grass, clover and greasewood.

Included in this map unit is about 5 percent Ferron fine sandy clay loam and 5 percent Rafael silty clay loam, and some strongly saline soils. Included areas made up about 15 percent of the total acreage.

The Abbott soil is deep, somewhat poorly to poorly-darined, and fine textured. It is formed in alluvium derived from shale. Typically, the surface layer is a light brownish gray to grayish brown, strongly calcareous, silty clay or clay loam about 3 to 7 inches thick. The subsoil is a light yellowish brown or light brownish gray silty clay or clay to about 40 inches. The substratum to a depth of 60 inches or more is an olive gray, light gray, or highly mottled dark grayish brown silty clay loam. Mottling or gleyed material about 20 inches is typical.

Permeability of the Abbott soil is slow. Available water capacity is moderately high to high. Effective rooting depth is about 40 inches. Runoff is slow and the erosion hazard for water is slight. Wind erosion hazard is slight.

The unit is used for grazing. The potential productivity is 4,000/3,000/2,000 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIw (non-irrigated); wet meadow range site.

Map Unit: Aw - Alluvial Land, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping flood plains. The slope is 0 to 3 percent. The native vegetation is mainly salt cedar (tamarisk) and greasewood.

Included in this map unit is about 60 percent sandy families of Typic Torripsamments, and 40 percent coarse-loamy familites of Typic Saliorthids, Typic Fluvaquents and Typic Torrifluvents.

The sampled soil is deep, saline affected, medium to coarse textured, and somewhat poorly-drained. It is formed in mixed alluvium. Typically, the surface layer has about a 1/2 in. salt crust or slightly hard, medium platy structure. Below this is a light brownish gray fine sand or very fine sandy loam about 4 inches thick. The substratum to a depth of 45 inches or more is stratified and usually mottled, light grayish brown fine sandy loam, coarse or medium sand.

Permeability of this alluvial land soil is moderately rapid. Available water capacity is moderate. Effective rooting depth is greater than 30 inches. Runoff is moderate to rapid and the erosion hazard for water is high. Wind erosion hazard is severe.

The unit is mainly used for rangeland in places where gully walls are not too steep. It is also used for wildlife habitats. This map unit is in capability unit Vlw (non-irrigated); wet stream bottom range site.

Map Unit: Ba - Badland

Badland consists of nearly bare, strongly sloping to very steep, actively eroding shales and interbedded shales with sandstones; and of occasional small sandstone-capped hills. Numerous channels of intermittent streams form a branching pattern in most places. Mapped with Badland are inclusions of Chipeta and Persayo soils in the drainageways.

This map unit is in capability unit VIIIs, and is not rated for range site.

Map Unit: BeB - Beebe Fine Sandy Loam, 0 to 3 Percent Slopes

This map unit is on alluvial fans and flood plains. The slope is 0 to 3 percent. The native vegetation is mainly greasewood, rabbitbrush, shadscale, some big sage and fourwing saltbush.

Included in this map unit is about 10 percent Ravola-Bunderson complex and areas where Beebe has a surface layer of loam or light sandy clay loam. Included areas make up about 12 percent of the total acreage.

The Beebe soils is deep, coarse textured, and well-drained. It is formed in alluvium derived from sedimentary sandstone. Typically, the surface layer is a pale brown, slightly calcareous, very fine sandy loam about 7 inches thick. The underlying material is a light yellowish brown loamy fine sand that is weakly stratified with layers of loam, fine sand or sandy loam.

Permeability of the Beebe soil is rapid. Available water capacity is moderate. Effective rooting depth is 60 inches or more. Runoff is slow and the erosion hazard for water is high. Gullying is active below rock outcrops and rock land units. It is highly susceptible to wind erosion.

The unit is mainly used for rangeland. It is also used for wildlife habitat. The potential productivity is 900/625/500 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIe (non-irrigated) IV (irrigated); desert sand range site.

Map Unit: BlB - Billings Silty Clay Loam, 1 to 3 Percent Slopes

This map unit is on level to nearly level slopes of alluvial fans, flood plains and narrow alluvial valleys. The slope is 1 to 3 percent. The native vegetation is mainly greasewood, shadscale, galleta grass and Indian ricegrass.

Included in this map unit is about 10 percent Bunderson fine sandy loam and 5 percent Hunting, strongly alkaline phase. Included areas make up about 15 percent of the total acreage.

The Billings soil is deep, well-drained, and moderately fine textured. It is formed in alluvium washed from alkaline gypsum-bearing marine shale. Typically, the surface layer is a light brownish gray, strongly calcareous, hard stilty loam about 11 inches thick. The underlying material is a light brownish gray, gypsiferous, stratified silty clay loam, loam, or clay loam. Gypsum as veins, crystals or soft nodules is visible below 20 inches.

Permeability of the Billings soil is slow. Available water capacity is moderate to moderately high. Effective rooting depth is 40 inches or more. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is moderate.

The unit is mainly used for rangeland. The potential productivity is 725 and 325 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIIs (non-irrigated), IIIe (irrigated), desert loam range site.

Map Unit: CeE2 - Castle Valley Extremely Stony Very Fine Sandy Loam, 0 to 20 Percent Slopes, Eroded

This map unit is on steep to gently sloping soils on upland benches, mesas and piedmont surfaces. The slope range is 0 to 20 percent. The native vegetation is mainly pinon, juniper, galleta grass, and Indian ricegrass.

Included in this map unit is about 15 percent rock outcrop, rockland and areas with less than 4 inches of soil overlying bedrock, and some soils deeper than 20 inches.

The Castle Valley soils is shallow, well-drained, and medium to coarse textured. It is formed in weathered material derived from interbedded shale and sandstone. The surface layer is an extremely stony very fine sand loam about 4 inches thick. The subsoil is a brown to brownish yellow very fine sandy loam or gravelly very fine sandy loam about 8 inches thick. Sandstone bedrock is at a depth of 8 to 18 inches. In places wind erosion has removed as much as half the surface layer.

Permeability of the Castle Valley soil is moderately rapid. Available water capacity is moderately high. Effective rooting depth is about 8 to 18 inches; some roots spread horizontally above hard bedrock. Runoff is slow to moderate; in rock areas it is high. The erosion hazard for water is slight to high. Wind erosion hazard is slight to severe.

This unit is mainly used for spring and fall range. It is also used for wildlife habitat. Fenceposts are cut from juniper in favorable sites. The potential prodictivity is 725/500/325 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIs (non-irrigated), semi-desert shallow loam range site.

Map Unit: CeC-Sh - Castle Valley-Sh Series Complex, 5 to 25 Percent Slopes

This map unit is on complex, gently sloping to steep slopes of upland benches, mesas, and piedmont surfaces. The slope range is 5 to 25 percent. The native vegetation is mainly pinon, juniper and mixed grasses including galleta grass and Indian ricegrass.

This unit is 55 percent Castle Valley fine sandy loam, and 40 percent Sh Series. The Castle Valley soil is found on the broad flat fans and ridges, and the Sh Series soil is found in the narrow draws and valleys between the fans. Included in this map unit is about 5 percent Castle Valley extremely stony fine sandy loam.

The Castle Valley soil is shallow, well-drained, and medium to coarse textured. It is formed in weathered material derived from interbedded sandstone and shale. The surface layer is a loam to loamy very fine sand about 4 inches thick. The subsoil is a brown to brownish yellow very fine sandy loam or gravelly very fine sandy loam about 8 inches thick. Sandstone bedrock is at a depth of 8 to 18 inches. In places wind erosion has removed as much as half the surface layer.

Permeability of the Castle Valley soil is moderately rapid. Available water capacity is moderately high. Effective rooting depth is about 8 to 18 inches. Runoff is slow to moderate; in rocky areas it is high, and the erosion hazard for water is sight to high. Wind erosion hazard is slight to severe.

The Sh Series soil is moderately deep, well-drained, and moderately fine textured. It is formed in weathered material derived from interbedded sandstone and shale. Typically, the surface layer is a light brown, cobbly very fine sandy loam about 6 inches thick. The subsoil is light yellowish brown, clay loam about 14 inches thick. The substratum to a depth of 20 to 40 inches is limy, cobbly clay loam overlying sandstone bedrock.

Permeability of the Sh Series soil is moderate. Available water holding capacity is moderate. Effective rooting depth is 20 to 40 inches. Runoff is moderate and the erosion hazard for water is slight to high. Wind erosion hazard is slight to severe.

This unit is mainly used for spring and fall range. It is also used for wildlife habitat. The capability unit for the Castle Valley soil is VIIs (non-irrigated), semi-desert shallow loam range site. The Sh series is not rated.

Map Unit: CBE2 - Chipeta-Badland Association, 13 to 30 Percent Slopes, Eroded

This map unit is on steep to strongly sloping broad fans, ridges and sandstone and shale hills. The slope range is 13 to 30 percent. The native vegetation consist of scattered shadscale and mat saltbush.

This unit is 50 percent Chipeta very gravelly silty clay loam, and about 40 percent Badland.

Included in this map unit is about 5 percent Shale outcrop-colluvial land and 5 percent Persayo loam. Included areas make up about 10 percent of the total acreage.

The Chipeta soil is shallow, somewhat poorly to moderately well-drained, and moderately fine textured. It is formed in residuum derived from marine shale. Typically, the surface horizons are highly eroded and severely cracked; the surface soil is thin, about 2 inches thick. Light gray and light grayish brown heavy silty clay loams and silty clays overlie soft weathered shale. A paralithic contact is encountered at about 17 to 19 inches.

Permeability of the Chipeta soil is moderately slow. Available water capacity is moderate. Effective rooting depth is about 12 to 16 inches. Runoff is rapid and the erosion hazard for water is high. Wind erosion hazard is moderate to high.

The Badland, a miscellaneous land type, consists of nearly bare, strongly sloping to very steep, actively eroding shale, interbedded sandstones and shales and small sandstone capped-hills. Badland is in the Blue Gate shale member of the Mancos shale.

This unit is not well suited to range. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years. The Chipeta is in capability unit VIIe (non-irrigated) and VIIIs (non-irrigated), desert shale range site. The Badland is in capability unit VIIIs, and is not rated for range site.

Map Unit: CPB2 - Chipeta-Persayo Complex, 1 to 8 Percent Slopes, Eroded

This map unit is on gently sloping to moderately steep slopes on broad fans and ridges. The slope range is 1 to 8 percent. The native vegetation is mainly shadscale, mat saltbush, and galleta grass.

This unit is 60 percent Chipeta very gravelly silty clay loam, and 25 percent Persayo very fine sandy clay loam. The two soils are intermingled and do not occur in any identifiable pattern on the landscape.

Included in the mapping are some areas of very shallow unnamed soils. Also included are other soils that are 20 to 40 inches thick over shale and small areas, generally less than 1 acre in extent, of strongly saline/alkalai soils.

The Chipeta soil is shallow, somewhat poorly to moderately well-drained, and moderately fine textured. It is formed in residuum derived from marine shale. Typically, the surface horizons are highly eroded and severely cracked; the surface soil is a very gravelly silty clay loam about 2 inches thick. Light gray and light grayish brown heavy silty clay loams and silty clays overlie soft weathered shale. A paralithic contact is encountered at about 17 to 19 inches.

Permeability of the Chipeta soil is moderately slow. Available water capacity is moderate. Effective rooting depth is about 12 to 16 inches. Runoff is rapid and the erosion hazard for water is high and active. Wind erosion hazard is moderate to high.

The Persayo soil is shallow, well-drained and moderately fine textured. It is formed in residuum weathered from shale. Typically, the surface layer is a very fine sandy clay loam about 12 to 20 inches thick. The Persayo soils has paralithic contact between 10 and 20 inches. Surface horizons may be eroded on the gently to moderately sloping landscapes.

Permeability of the Persayo soil is moderate. Available water holding capacity is moderate. Effective rooting depth is about 12 inches or to paralithic contact. Runoff is medium, and the erosion hazard for water is moderate. Wind erosion hazard is moderate.

This unit is mainly used for spring and fall range. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. The Chipeta is in capability unit VIIe and VIIIs (non-irrigated); desert shale range site. The Persayo is in capability unit VIIe (non-irrigated); desert shallow shale range site.

Map Unit: DL - Disturbed Land, 0 to 15 Percent Slopes

This map unit is on level to strongly sloping areas previously disturbed by mining activities. Surface facilities, gravel pits, haul roads, stockpiles, and surfaces disturbed by burning coal beds are included in this map unit.

Surface soils are either removed, buried under coal dust, or heavily mixed with subsoils.

This map unit occurs at the Emery Mine portal and facilities area, proposed tailings area, and in scattered areas above burned coal beds.

Map Unit: Fe - Ferron Silt Loam, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, floodplains and bottoms of narrow valleys. The slope range is 0 to 3 percent. The native vegetation is mainly wiregrass, sedges, redtop grass and saltgrass.

Included in this map unit is about 10 percent Abbott fine sandy clay loam and small areas of very strongly saline/alkali soils and soils in which the water table is at a moderate depth.

The Ferron soil is deep, calcareous, poorly-drained, and medium textured. It is formed in alluvium washed from marine shale and sandstone.

Typically, the surface layer is light brownish gray, moderately calcareous, slightly hard silt loam about 3 inches thick. The underlying material is a light brownish gray loam or very fine sandy loam that in places contains thin layers of clay loam or sandy loam. Veins of gypsum are common. The Ferron soils are mottled or gleyed at a depth of less than 20 inches. The water table is near the surface most of the year.

Permeability of the Ferron soil is moderate. Available water capacity is moderate to moderately high. Effective rooting depth is 30 inches. Runoff is slow and the erosion hazard for water is slight.

This unit is mainly used for wet meadow pasture and rangeland. The potential productivity is 6,500 and 3,500 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit Vw (non-irrigated), wet meadow range site.

Map Unit: GP - Silt Loams, 0 to 12 Percent Slopes

This map unit is on level to moderately sloping alluvial fans and mesa surfaces. The slope range is 0 to 12 percent. The native vegetation is mainly greasewood, big sage, four wing saltbush, mat sage and mixed forbs.

Included in this map unit is aobut 10 percent Sanpete sandy clay loam, and 10 percent Ildefonso soils. Included areas make up about 20 percent of the total acreage.

The GP soil is deep, well-drained, and medium to moderately fine textured. It is formed in alluvium and glacial outwash material. Typically, the surface layer is a pale yellow to light gray silt loam about 6 inches thick. The underlying material is a light yellowish brown, pale yellow, or light brownish gray typsiferous silt loam, coarse silt loam, silty clay, or gravelly sandy clay loam. Weathered, soft shale may be encountered below 40 inches.

Permeability of the GP soil is moderate rapid. Available water capacity is moderate. Effective rooting depth is about 30 to 35 inches. Runoff is moderately slow and the erosion hazard for water is slight to moderate.

The unit is mainly used for spring and fall range. It is also used for wildlife habitat. The soil is not rated for capability unit or range site.

Map Unit: GU - Gullied Land, Variable Slopes

Gullied Land is widely distributed on a range of slopes and land forms. The vegetation is mainly greasewood.

Gullied Land is adjacent to Quitchupah Creek, below rock outcrops/rockland, and areas adjacent to (AW) Alluvial Lands. The unit is mapped where gullying is severe or where gullies occur at closer than 100 feet.

Gullied Land has little or no value for farming. It is used by wildlife and, in places, for limited grazing. It also provides drainage outlets for adjacent soils. This soils is in the capability unit is VIII (non-irrigated); wet meadow range site.

Map Unit: HA - Harding Variant-Haplargid Complex, 3 to 8 Percent Slopes

This map unit is on gently sloping benches and mesa tops. The slope is 3 to 8 percent. The native vegetation is mainly greasewood, shadscale, rabbitbrush and galleta grass.

This unit is 60 percent Harding variant very fine sandy loam and 25 percent fine and fine-loamy, montmorillonitic, calcareous, mesic Typic Haplargids.

Included in this map unit is about 15 percent clayey-skeletal Typic Natrargids. Gravels and cobbles are below 30 inches and are mainly glacial outwash material.

The Harding variant soil is deep, calcareous, moderately well or well-drained, and fine to moderately fine textured. It is formed in alluvium washed from sedimentary rocks. Typically, the surface layer is a pale brown to light brownish gray very fine sandy loam aobut 2 inches thick. The subsoil is a pale brown heavy clay loam to silty clay about 10 inches thick that is strongly affected by alkali. The substratum to a depth of 60 inches or more is a pale brown to white silty clay loam or clay over sand or sandy loam.

Permeability of the Harding variant is slow. Available water capacity is moderately high. Effective rooting depth is 45 to 60 inches. Runoff is medium and the erosion hazard for water is moderate to high.

The Typic Haplargids are deep, moderately well-drained, and moderately fine to fine textured. The argillic horizon is not well developed. This soil is moderately affected by alkali.

The unit is mainly used for rangeland. It is also used for wildlife habitat. The potential productivity is 1,500 and 500 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIs, VIIe (non-irrigated); semi-desert limy loam range site.

Map Unit: Hn - Hunting Clay Loam, 0 to 5 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, flood plains and narrow alluvial valleys. The slope range is 0 to 5 percent. The native vegetation is mainly saltgrass, galleta grass, and redtop. Greasewood is dominant on the edges of the map unit.

Included in this map unit are areas of Billings and Rafael soils and small spots of strongly saline/alkali soils. Included areas make up about 15 percent of the total acreage.

The Hunting soil is deep, somewhat poorly-drained, and medium textured. It is formed in alluvium washed from marine shale and sandstone. Typically, the surface layer is a light brownish gray to light gray, strongly calcareous, loam or clay loam about 10 inches thick. The underlying material is a light brownish gray loam, clay loam or silty clay loam about 40 to 50 inches thick. Mottles may be visible to the surface, but are typically distinct below 20 to 40 inches. The water table is below 20 to 45 inches.

Permeability of the Hunting soil is moderate. Available water capacity is moderately high. Effective rooting depth is about 40 to 50 inches. Runoff is medium and the erosion hazard for water is moderate.

The unit is mainly used for wet meadow pasture. This map unit is in capability unit VIIw (irrigated); not rated for range site.

Map Unit: Hs - Hunting Clay Loam, Moderately Saline, 1 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans, floodplains and narrow alluvial valleys. The slope range is 1 to 8 percnet. The native vegetation is mainly saltgrass, redtop grass, galleta grass and greasewood.

Included in this map unit are areas generally smaller than one acre which are strongly saline. Included areas make up about 5 percent of the total acreage.

The Hunting soil is deep, somewhat poorly-drained, and medium textured. It is formed in alluvium washed from marine shale and sandstone. Typically, the surface layer is a light brownish gray to light gray, moderately saline, strongly calcareous, loam or clay loam about 10 inches thick. The underlying material is a light brownish gray loam, clay loam or silty clay loam aobut 40 to 50 inches thick. Mottles may be visible to the surface, but are typically distinct below 20 to 40 inches. The water table is below 20 to 45 inches. This map unit receives additional water through irrgation seepage and irrigation runoff. Wetness, depth to water table and salinity are the major limitations of this soil.

Permeability of the Hunting soil is moderate. Available water capacity is moderately high. Effective rooting depth is about 40 to 50 inches. Runoff is medium and the erosion hazard for water is moderate.

The unit is mainly used for marginally irrigated pasture. The potential productivity is 2,000 and 1,000 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit IVs (irrigated); note rated for range site.

Map Unit: IlB - Ildefonso Loam, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping fans. The slope range is 0 to 3 percent. The native vegetation is mainly greasewood, halogeton, shadscale, galleta grass and clumps of cacti.

Included in this map unit is about 5 percent GP silt loams, 5 percent Haverson loam, and 5 percent Sanpete sandy clay loam. Included areas make up about 15 percent of the total acreage.

The Ildefonso soil is deep, well-drained, and medium textured. It is formed in alluvium and glacial outwash material. Typically, the surface layer is a light gray to light grayish brown loam or sandy clay loam about 9 inches thick. The subsoil is a light brown to yellowish brown very fine sandy clay loam about 12 inches thick. The substratum to a depth of 60 inches or more is light gray to white, calcareous, gravelly very fine sand.

Permeability of the Ildefonso soil is moderate. Available water capacity is moderate to low. Effective rooting depth is about 20 to 30 inches; they are impeded by gravel layers. Runoff is slow and the erosion hazard for water is moderate. Wind erosion hazard is moderate.

The unit is mainly used for rangeland. It is also used for a source of gravels.

The potential productivity is 1,000/650/200 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIe (non-irrigated).

Map Unit: IlD2 - Ildefonso Loam, 3 to 10 Percent Slopes, Eroded

This map unit is on nearly level to moderate sloping fans. The slope range is 3 to 10 percent. The native vegetation is mainly greasewood, halogeton, shadscale, galleta grass and clumps of cacti.

Included in this map unit is about 5 percent Hunting clay loam, 5 percent HA series sandy clay loam, and 5 percent Sanpete sandy clay loam. Included ares make up about 15 percent of the total acreage.

The Ildefonso soil is deep, well-drained, and medium textured. It is formed in alluvium and glacial outwash material. Typically, the surface layer is a light gray to light grayish brown loam or sandy clay loam about 6 inches thick. The subsoil is a light brown to yellowish brown very fine sandy clay loam aoubt 3 inches thick. The substratum to a depth of 60 inches or more is light gray or white, calcareous, gravelly very fine sand.

Permeability of the Ildefonso soil is moderate. Available water capacity is moderate to low. Effective rooting depth is about 20 to 30 inches; they are impeded by gravel layers. Runoff is slow and the erosion hazard for water is medium to high; gullying is active. Wind erosion hazard is moderate.

The unit is mainly used for rangeland. It is also used for a source of gravels. The potential productivity is 1,000/650/200 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIs (non-irrigated), IVe (irrigated).

Map Unit: KlB - Killpack Silty Clay Loam, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping fans and shale hills generally below the Chipeta and/or Persayo soils. The slope range is 0 to 3 percent. The native vegetation is mainly shadscale, big sage and galleta grass. Included in this map unit are small units of strongly and very strongly saline soils, and 5 percent Billings silty clay loam. Included areas make up about 10 percent of the total acreage.

The Killpack soil is moderately deep, well-drained. It is formed in residuum that weathered from clayey marine shale bedrock. Typically, the material overlying soft, calcareous shale is light gray to light grayish brown silty loam or silty clay loam. There is a paralithic contact at 20 to 40 inches.

Permeability of the Killpack soil is slow. Available water capacity is moderate to high. Effective rooting depth is about 40 inches. Runoff is medium and the erosion hazard for water is moderate to high. Wind erosion hazard is slight to moderate.

This unit is mainly used for spring and fall range. It is also used for wildlife habitat. The potential producivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit in capability unit VIIe (non-irrigated), IVe (irrigated); desert loamy shale range site.

Map Unit: KlC2 - Killpack Silty Clay Loam, 3 to 8 Percent Slopes, Eroded

This map unit is on gently to moderately sloping fans and shale hills below shale outcrop-colluvial land and Chipeta-Persayo soils. The slope range is 3 to 8 percent. The native vegetation is mainly shadscale, big sage and galleta grass.

Included in this map unit are shallow, clayey soils over shale, soils with gravelly surface horizons deeper than 40 inches and soils similar to Sh series. Included areas make up about 15 percent of the total acreage.

This soil is steeper and more eroded than as described in the series description. It is closer to nearly barren shale hills which contribute to increased runoff. The Killpack soil is moderately deep, well-drained. It is formed in redisuum that weathered from clayey, weak to moderately gypsiferous, marine shale bedrock. Typically, the material overlying soft, calcareous shale is light gray to light grayish brown silty loam or silty clay. There is a paralithic contact at 20 to 40 inches.

Permeability of the Killpack soil is slow. Available water capacity is moderate to high. Effective rooting depth is about 40 inches. Runoff is rapid and the erosion hazard for water is high. Gullies 3 to 6 feet deep and 100 to 300 feet apart are common. In some places most of the surface layer has been lost to sheet erosion. Wind erosion hazard is slight to moderate.

This unit is mainly used for spring and fall range. It is also used for wildlife habitat. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIe (non-irrigated), IVe (irrigated), desert loamy shale range site, and 7 to 10 inch precipitation zone.

Map Unit: KpB - Killpack Loam, 1 to 3 Percent Slopes

This map unit is on alluvial fans and below shale hills. The slope range is 1 to 3 percent. The native vegetation is mainly galleta grass, shadscale and big sage.

Included in this map unit are small areas in which the surface layer is clay loam or the water table is high. Included areas make up about 5 percent of the total acreage. Typically, the surface layer of the Killpack soil is a light gray to light grayish brown heavy loam about 20 to 40 inches overlying soft, calcareous shale. Gypsum is less prominent in this soils than as described for Killpack clay loam.

Permeability of the Killpack soil is slow. Available water capacity is moderate to high. Effective rooting depth is about 40 inches. Runoff is medium and the erosion hazard for water is moderate to high. Wind erosion hazard is slight to moderate.

The unit is mainly used for irrigated pasture. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIc (non-irrigated), IVe (irrigated), desert loam bottom range site.

Map Unit: KpC2 - Killpack Loam, 3 to 6 Percent Slopes, Eroded

This map unit is on side slopes of shale hills. The slope range is 3 to 6 percent. The native vegetation is mainly grass - shrub community.

Included in this map unit are areas of deep loam and silty clay loam. Included areas make up about 15 percent of the total acreage.

Typically, the surface layer of the Killpack soil is a light gray to light grayish brown heavy loam about 15 to 24 inches thick. The underlying material is silty clay loam or light silty clay overlying soft, calcareous shale is at 20 to 40 inches.

Permeability of the Killpack soils is slow. Available water capacity is moderate to high. Effective rooting depth is about 40 inches. Runoff is rapid and the erosion hazard for water is active and severe near shale hills; gullies are 3 to 6 feet deep and 100 to 300 feet apart. Wind erosion hazard is slight to moderate.

The unit is used for native range. The potential productivity is 400 and 150 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIe (non-irrigated), VIe (irrigated), desert loam bottom range site.

Map Unit: Lb - Libbings Clay Loam, 0 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans and flats. It is usually found downslope from the Chipeta-Persayo soils. The slope range is 0 to 3 percent. The native vegetation is mainly greasewood and saltgrass.

Included in this map unit are areas of deep and shallow clayey soils over shale which are less affected by salt. Included areas make up about 5 percent of the total acreage.

The Libbings soil is moderately deep, poorly-drained, and moderately fine textured. It is formed in alluvium derived from shale parent material. Typcially, the surface layer is a thin, white, platy, strongly salt affected layer about 1/4 to 1/2 inch thick. The material above the shale is a light grayish brown, gray or light brown silty clay or clay which may be salic, typsic, or both. Shale is encountered 40 to 60 inches. Water table depth is at 10 to 30 inches below the surface; it is closer to the surface in early summer.

Permeability of the Libbings soil is slow. Available water capacity is low to very low. Effective rooting depth is about 10 to 30 inches. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is slight.

The unit is mainly used for rangeland. It is not rated for any other uses due to the effects of salt content and water table. The potential productivity is 2,500 and 1,000 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIw (non-irrigated), salt meadow range site.

Map Unit: MlB - Minchey Loam, 1 to 3 Percent Slopes

This map unit is on nearly level benches and mesas. The slope range is 1 to 3 percent. The native vegetation is mainly galleta grass, big sage and big blue bunch grass.

Included in this map unit are areas of Sanpete gravelly sandy clay loam and a medium texture phase of the Minchey loam. Included ares make up about 15 percent of the total acreage.

The Minchey soil is deep, well-drained, and moderately fine textured. It is formed in glacial outwash derived from sandstone and quartzite. Typically, the surface layer is pale brown loam about 3 inches thick. The underlying material is mainly brown or pale brown clay loam or sandy clay loam, and a very pale brown, thick, limy layer is below it. Pale brown and light yellowish brown gravelly sandy loam is below a depth of 32 inches. Gravel and cobblestones are typical at a depth between 2 and 5 ft.

Permeability of the soil is moderate. Available water capacity is moderately high. Effective rooting depth is about 30 to 60 inches; gravels below 30 inches may restrict roots. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is moderate.

The unit is mainly used for spring and fall range. It is also used for irrigated cropland. The potential productivity is 900 and 550 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIe (non-irrigated), IIe (irrigated) semi-desert loam range site.

Map Unit: PaB - Palisade Loam, High Water Table Variant, 1 to 3 Percent Slopes

This map unit is on nearly level to gently sloping benches and depression areas. The slope is 1 to 3 percent. The native vegetation is mainly wiregrass, saltgrass and sedge.

Included in this map unit is some areas having a clay loam surface layer, and some Minchey cobbly loam. Included areas make up about 15 percent of the total acreage.

The Palisade soil is deep and somewhat poorly-drained. It is formed in glacial outwash material derived from sandstone, limestone and shale. Typically, the surface layer is light brownish gray loam or clay loam about 6 inches thick. The subsoil is a light brownish gray very fine sandy loam about 10 to 12 inches thick. The substratum to a depth of 60 inches or more is very pale brown fine sandy loam, and gravelly sandy clay loam and loamy sand.

Permeability of the Palisade soil is moderately high to high. Available water capacity is high. Effective rooting depth is 60 inches or more, but is dependent on depth of gravel layer and water table. Runoff is slow and the erosion hazard for water is low. Wind erosion hazard is low.

The unit is used for native pasture. This map unit is in capability unit Vw (non-irrigated), wet meadow range site.

Map Unit: PdB - Palisade Loamy Sand, 1 to 8 Percent Slopes

This map unit is on nearly level to moderately sloping upland benches and piedmont surfaces. The slope is 1 to 8 percent. The native vegetation is mainly galleta grass and shadscale, with scattered clumps of cactus and big sage.

Included in this map unit is about 10 percent moderately deep, Palisade-like soil, and 10 percent Castle Valley very fine sandy loam. Included areas make up about 20 percent of the total acreage.

The Palisade soil is deep, well-drained, and medium textured. It is formed in alluvium and glacial outwash derived from calcareous sandstone mixed with shale and limestone. Typically, the surface layer is a pale brown to light yellowish brown loamy sand to very fine sandy loam about 9 inches thick. The underlying material is calcareous, very pale brown to pink or light brown very sandy loam 9 inches thick extending to a depth of 60 inches or more.

Permeabiility of the Palisade soil is moderate. Available water capacity is moderately high to high. Effective rooting depth is about 60 inches or more. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is moderate to severe.

The unit is mainly used for rangeland. It is also used for wildlife habitat. The potential productivity is 900 and 375 pounds of air-dry vegetation in favorable and unfavorable years, respectively. This map unit is in capability unit VIIc or VIIe (non-irrigated); IIe or IIIe (irrigated), semi-desert loam bench range site.

Map Unit: Pd-LT - Palisade-Lithic Torriorthents, 8 to 15 Percent Slopes

This map unit is on moderately sloping to moderately steep upland benches, and piedmont surfaces. The slope range is 8 to 15 percent. The native vegetation is mainly galleta grass, shadscale and scattered pinon and juniper.

This unit is 70 percent Palisade sandy loam, and 20 percent loamy-skeletal and loamy mixed, mesic Lithic Torriorthents. The Palisade soil is found on the broad fans and narrow valley, and the lithic soils is usually found on the sideslopes.

Included in this map unit is some Castle Valley fine sandy loam, and small areas of rock outcrop. Included areas make up about 10 percent of the total acreage.

The Palisade soil is deep, well-drained, and medium textured. It is formed in alluvium and glacial outwash derived from calcareous sandstone mixed with shale and limestone. Typically, the surface layer is a pale brown to light yellowish brown loamy sand to very fine sandy loam about 9 inches thick. The underlying material is calcareous, very pale brown to pink or light brown very sandy loam extending to a depth of 60 inches or more.

Permeability of the Palisade soil is moderate. Available water capacity is moderately high to high. Effective rooting depth is about 60 inches or more. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is moderate to severe.

The Lithic Torriorthents are shallow, well-drained, and medium to coarse textured. They are formed in material weathered from interbedded sandstone and shale. Typically, the surface layer is a light gray to light grayish brown sandy clay loam, fine sandy loam or loamy sand about 4 inches thick. The substratum to a depth of 10 to 12 inches or more is light grayish brown very fine sandy loam. Bedrock is encountered from 8 to 16 inches.

Permeability of this soil is moderately rapid. Available water holding capacity is moderately low. Effective rooting depth is to bedrock and thin roots radiate horizontally. Runoff is moderate, high in rock outcrop areas. The erosion hazard for water is moderately high. Wind erosion hazard is severe.

The unit is mainly used for rangeland. It is also used for wildlife habitat. The Palisade soil is in capability unit VIIe (non-irrigated), IIIe (irrigated), semi-desert loam range site, and 8 to 12 inch precipitation zone.

Map Unit: PCE2 - Persayo-Chipeta Complex, 1 to 20 Percent Slopes, Eroded

This map unit is on nearly level to steep fans, terraces, uplands, and shale knolls. The slope range is 1 to 20 percent. The native vegetation is mat saltbush, shadscale, Indian ricegrass and galleta grass.

This unit is 40 percent Persayo eroded and non-eroded very fine sandy clay loam, and sandy clay loam and 40 percent Chipeta silty clay loam. The two soils are intermingled and occur in an unidentifiable pattern on the landscape. Persayo is usually in the depression areas and draws, but also occurs on the broad fans with the Chipeta soil. Included in this map unit is about 20 percent Badland.

The Persayo soil is shallow and well-drained, and moderately fine textured. It is formed in residuum that weatherd from shale. Typically, the surface layer is a light brownish gray loam to very fine sandy clay loam about 1 to 4 inches thick. The underlying material is a light brownish gray or pale brown silty clay loam, loam or clay overlying soft, weathered shale at a depth of 10 to 20 inches. This is a weak to moderately strong gypsic horizon.

Permeability of the Persayo soil is moderate. Available water holding capacity is moderately high. Effective rooting depth is dependent on depth to bedrock. Runoff is medium to rapid, and the erosion hazard for water is moderate to high. Wind erosion hazard is moderate.

The Chipeta soil is shallow, somewhat poorly to moderately well-drained, and moderately fine textured. It is formed in residuum derived from marine shale. Typically, a paralithic contact is encountered at about 17 to 19 inches. The surface horizons are highly eroded and severely cracked when dry; the surface soil is thin, about 2 inches thick. Light gray and light grayish brown heavy silty clay loams and silty clays overlie soft weathered shale.

Permeability of the Chipeta soil is moderately slow. Available water capacity is moderate. Effective rooting depth is about 12 to 16 inches. Runoff is rapid and the erosion hazard for water is high and active. Wind erosion hazard is moderate to high.

The unit is mainly used for spring and fall range. The Chipeta soil is in the VIIe (non-irrigated) capability unit; the Persayo soil is in the VIIe (non-irrigated) capability unit. The Chipeta is in the desert shallow shale range site. The Persayo is in the desert loamy shale range site.

Map Unit: R1B - Ravola Loam, 1 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans. The slope range is 1 to 3 percent. The native vegetation is mainly galleta grass, shadscale and greasewood.

Included in this map unit is about 10 percent Billings silty clay loam, 5 percent Bunderson fine sandy loam, about 10 percent Ravola silty clay - gravelly phase - and small areazs of highly saline-alkali soils. Included ares make up about 15 percent of the total acreage.

The Ravola soil is deep, well-drianed, and medium textured. It is formed in alluvium washed from shale and sandstone. Typically, the surface layer is a light brownish gray to dark grayish brown loam about 3 to 5 inches thick. The subsoil is a light yellowish brown, light brownish gray to grayish brown silty loam, silty clay loam or loam about 12 inches thick. The substratum to a depth of 60 inches or more is light brownish gray startified clay loam, silty clay loam or sandy loam. It may be gravelly in a few places.

Permeability of the Ravola soils is moderate. Available water capacity is moderately high. Effective rooting depth is about 60 inches or more. Runoff is medium and the erosion hazard for water is moderate to severe. Some gullying is active. Wind erosion hazard is moderate.

The unit is mainly used for rangeland and wildlife habitat. It is also used for irrigated cropland. The potential productivity is 900/575/375 pounds of air-dry vegetaion in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIc (non-irrigated), IIe (irrigated), semi-desert loam range site.

Map Unit: RlB2 - Ravola Loam, 1 to 3 Percent Slopes, Eroded

This map unit is on nearly level to gently sloping, actively eroding, alluvial fans. Erosion has caused V-shaped gullies 4 to 5 ft. deep and 100 to 400 ft. apart. The slope range is 1 to 3 percent. The native vegetation is mainly galleta grass, shadscale, and greasewood.

Included in this map unit is about 10 percent Bunderson fine sandy loam, and 10 percent Billings silty clay loam and some Ravola soils with silty clay surfaces. Included areas make up about 20 percent of the total acreage. The Ravola soil is deep, well-drained, and medium textured. It is formed in alluvium washed from shale and sandstone.

Typically, the surface layer is a light brownish gray to dark grayish brown very fine sandy loam, loam, or silty clay about 3 to 5 inches thick. The subsoil is a light yellowish brown, light brownish gray to grayish brown silty loam, silty clay loam or loam about 12 inches thick. The substratum to a depth of 60 inches or more is light brownish gray stratified clay loam, silty clay loam or sandy loam. It may be gravelly in a few places.

Permeability of the Ravola soil is moderate. Available water capacity is moderately high. Effective rooting depth is about 60 inches or more. Runoff is medium and the erosion hazard for water is severe. Gullying is active. Wind erosion hazard is moderate.

The unit is mainly used for spring and fall range. It is also used for wildlife habitat. The potential productivity is 900/575/375 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIc (non-irrigated), IIe (irrigated), desert loam range site.

Map Unit: RuB2 - Ravola-Bunderson Complex, 1 to 3 Percent Slopes

This map unit is on nearly level to level alluvial fans, floodplains and bottomlands. The landscape is hummocky in some ares in this complex. The slope range is 1 to 3 percent. The native vegetation is mainly scattered greasewood, halogeton, galleta grass and shadscale.

This unit is 60 percent Ravola silty clay, and 35 percent Bunderson fine sandy loam. Included in this map unit is about 5 percent strongly saline soils and Ravola with loam or silty clay loam surface textures.

The Ravola soil is deep, well-drained, and medium textured. It is formed in alluvium washed from shale and sandstone. Typically, the surface layer is a light brownish gray to dark grayish brown very fine sandy loam, loam, or silty clay about 3 to 5 inches thick. The subsoil is a light yellowish brown, light brownish gray to grayish brown silty loam, silty clay loam or loam about 12 inches thick. The substratum to a depth of 60 inches or more is light brownish gray stratified clay loam, silty clay loam or sandy loam. It may be gravelly in a few places.

Permeability of the Ravola soil is moderate. Available water capacity is moderately high. Effective rooting depth is about 50 inches or more. Runoff is medium and the erosion hazard for water is moderate to severe. Some gullying is active. Wind erosion hazard is moderate.

The Bunderson soil is deep, well-drained, calcareous, and medium textured. It is formed in alluvium washed from alkaline, sedimentary marine shale and sandstone. Typically, the surface layer is a nearly impermeable, light grayish brown very fine sandy loam or silty clay abour 4 inches thick. The subsoil is light grayish brown or brown silty clay loam, silt loam or fine sandy loam about 10 to 12 inches thick. The substratum to a depth of 60 inches or more may be a strongly calcareous clay or silty clay. In some profiles gypsum is visible below 40 inches.

Permeability of the Bunderson soil is slow. Available water holding capacity is moderate. Effective rooting depth is about 60 inches or more. Runoff is moderately rapid to rapid, and the erosion hazard for water is severe. Wind erosion hazard is moderate.

The unit is mainly used for rangeland; the dominant species have little range quality. It is also used for wildlife habitat. The Bunderson soil is not rated for range, the capability unit is VIIe (non-irrigated). The Ravola soil is in capability unit VIIc (non-irrigated), IIc (irrigated), semi-desert loam range site.

Map Unit: Ry - Rockland

This map unit is on nearly level to steep slopes and cliffs. The native vegetation is mainly a sparse cover of pinon, juniper and sagebrush. Elevation range is 5,900 to 6,400 feet.

This unit is a miscellaneous land type in which most of the surface (about 55 percent) is covered by stones, boulders, and outcrops of sandstone. Some shale outcrops are found. About 20 percent of the land has 4 inches or less of soil overlying bedrock. Much of this material is wind deposited. Most of this land is moderately to severely eroded.

Included in mapping unit are gently sloping, moderately deep to deep, fine sandy loams. Intermingled with the sandstone outcrops are inclusions of Castle Valley fine sandy loam. Included areas make up about 25 percent of the total acreage.

The unit is mainly used for wildlife habitat. It is also used for rangeland when the area is not too steep or rocky. This map unit is in capability unit VIIIs; it is not rated for range.

Map Unit: Sa - Saltair Silty Clay Loam, 0 to 3 Percent Slopes

This map unit is on level to nearly level alluvial fans, floodplains, and narrow alluvial valleys. The slope range is 0 to 3 percent. The native vegetation is mainly grasewood, saltgrass and kochia. Barren spots and surface salt crusting is common.

The Saltair soil is deep, very strongly saline, moderately fine textured, and poorly-drained. It is formed in alluvium derived from marine shale and sandstone. Typically, the surface layer is light brownish gray, strongly calcareous, very strongly saline, hard, silty clay loam about 7 inches thick. The underlying material is a light brownish gray to light gray, very strongly saline, heavy silt loam. Platy salt crusting on the surface is common.

Permeability of the Saltair soil is slow. Available water capacity is low to moderate. Roots generally concentrate near the surface, but do penetrate to a depth of 60 inches. Runoff is slow and the erosion hazard for water is slight to moderate. Some shrubs have a pedestal-like appearance. Wind erosion hazard is slight.

The unit is mainly used for rangeland; the quality of forage is poor (Swenson et al, 1970). The potential productivity is 2,500/1,750,1,000 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIw (non-irrigated), salt meadow range site.

Map Unit: ShC - Sh Cobbly Very Fine Sandy Loam, 3 to 8 Percent Slopes

This map unit is on gently to moderately sloping upland benches. The slope range is 3 to 8 percent. The native vegetation is mainly galleta grass and shadscale.

Included in this map unit is about 15 percent Palisade loamy sand on the more gently slopes and draws.

The Sh soil is moderately deep, strongly calcareous, moderately fine textured, and well-drained. It is formed in weathered sandstone material.

Typically, the surface layer is light brown to light brownish gray, cobbly very fine sandy loam about 6 inches thick. The subsoil is a light yellowish brown clay loam about 14 inches thick. The substratum to a depth of 20 inches or more is limy, very hard, cobbly clay loam. Sandstone bedrock is encountered at 20 to 40 inches; a depth of about 28 inches is typcial.

Permeability of the Sh soil is moderate. Available water capacity is moderate to moderately low. Effective rooting depth is about 20 inches or to bedrock. Runoff is slow and the erosion hazard for water is moderate; high when near rockland. Wind erosion hazard is severe.

The unit is mainly used for spring and fall range. This map unit is in capability unit VIIe (non-irrigated), semi-desert loam range site.

Map Unit: Sh-PdC - Sh Series-Palisade Complex, 5 to 15 Percent Slopes

This map unit is on gently sloping to moderately steep slopes of upland benches and piedmont surfaces. The slope range is 5 to 15 percent. The native vegetation is mainly galleta grass and shadscale.

This unit is 50 percent Sh series and 35 percent Palisade loamy sand. The Palisade soil is found on the more gently sloping areas and in draws.

Included in this map unit is about 10 percent Castle Valley fine sandy loam, and 5 percent rock outcrop. Included areas make up about 15 percent of the total acreage.

The Sh soil is moderately deep, strongly calcareous, moderately fine textured, and well-drained. It is formed in weathered sandstone material. Typically, the surface layer is light brown to light brownish gray, cobbly very fine sandy loam about 6 inches thick. The subsoil is a light yellowish brown clay loam about 14 inches thick. The substratum to a depth of 20 inches or more is limy, very hard, cobbly clay loam. Sandstone bedrock is encountered at 20 to 40 inches; a depth of about 28 inches is typical.

Permeability of the Sh soil is moderate. Available water capacity is moderate to moderately low. Effective rooting depth is about 20 inches or to bedrock. Runoff is slow and the erosion hazard for water is moderate; high when near rockland. Wind erosion hazard is severe.

The Palisade soil is deep, well-drained, and medium textured. It is formed in alluvium and glacial outwash derived from calcareous sandstone mixed with shale and limestone. Typically, the surface layer is a pale brown to light yellowish brown loamy sand to very fine sandy loam about 9 inches thick. The underlying material is calcareous, very pale brown to pink or light brown very sandy loam extending to a depth of 60 inches or more.

Permeability of the Palisade soil is moderate. Available water capacity is moderately high to high. Effective rooting depth is about 60 inches or more. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is moderate to severe.

The unit is mainly used for rangeland. It is also used for wildlife habitat.

The Sh series is in capability unit VIIe (non-irrigated), semi-desert loam range site. The Palisade is in the capability unit VIIc (non-irrigated), IIe (irrigated), and semi-desert loam range site. Range site is not established for the Sh series.

Map Unit: Wo - Woodrow Silty Clay Loam, 1 to 3 Percent Slopes

This map unit is on nearly level to gently sloping alluvial fans and floodplains. The slope range is 1 to 3 percent. The native vegetation is mainly mixed short grasses.

Included in this map unit is about 5 percent Penoyer loam, 5 percent Billings silty clay loam, and small areas of strongly saline soil. Included ares make up about 15 percent of the total acreage.

The Woodrow soil is deep, moderately fine textured, and well-drained. It is formed in alluvium derived from mixed sedimentary rocks. Typically, the surface layer is light brownish gray, strongly calcareous, silty clay loam about 7 inches thick. The underlying material is a light brownish gray, silty clay loam with thin layers of sandy loam or loam.

Permeability of the Woodrow soil is slow. Available water capacity is moderately high. Effective rooting depth is about 60 inches or more. Runoff is medium and the erosion hazard for water is moderate. Wind erosion hazard is moderate.

The unit is used for pasture and rangeland. The potential producitivity is 750/650/500 pounds of air-dry vegetation in favorable/normal/ and unfavorable years, respectively. This map unit is in capability unit VIIs (non-irrigated), IIe (irrigated), desert loam bottom range site, and 6 to 11 inch precipitation zone.

8.3.3 Pre-mine Soil Uses and Capabilities

The present soil uses of the permit area include primarily native rangeland, with minor uses being marginal pastureland, previously disturbed land, and a native open woodland type. These types are utilized by both livestock and wildlife. Refer to land use sections for details.

Pasturelands

Table 8-1 outlines the expected pasture potentials and land capability units (irrigated and non-irrigated) for the major soils mapped in the permit area. This data is compiled from SCS form 5's, Soil Interpretation Records and the Carbon-Emery Area Soil Survey (USDA, SCS, 1970).

The potential productivity of irrigated pasture for each major soil is estimated by the unit cow-acre days. Soils such as Ferron, Libbings, Minchey, Persayo, Rafael, and Saltair are not rated since they are either too clayey, have excess salts, or occur on steep slopes.

Table 8-1 lists land capability classes and subclasses, used in the Land Capability classification of soils. Capability classes indicated suitability for most kinds of farming. The capability class is numerical based on the limitations of the soils, risk of damage through use, and their response to treatment. Capability units show, in a general way, the ability of soils to support cultivated crops. The capability subclass classifies the soils as to their limitations. Most soils in the study area have limitations which include shallowness, droughtiness, erosion hazard, wetness or climatic features. In light of these limitations, most soils are, therefore, severely limited to crop choice and would require careful management practices.

Capablity subclasses for the rangeland soils are II, IV, V, and VII. The principal limitations are erosion (e), wetness (w), climate (c) and shallowness (s). Soils in capability class II have few limitations to restrict crop choice or cultivation. Soils in capability class IV have very severe restrictions. Soils in capability class V have limitations that are impractical to remove, and soils in class VII are unsuited for cultivation.

Irrigated pasture and meadows occur in the study area. Table 8-2 lists the predicted yields of meadow hay for the principal soils under irrigation and other improved management practices in the project area. Predicted yields are based on information from SCS Soil Interpretation Records for established series, when available.

TABLE 8-1

SOIL POTENTIALS: PASTURELANDS

Major Soils	Irrigated Pasture Cow Acre Days[1]	Capability Unit	
		Non-Irr	Irr
Abbott	--	VIIw	--
Badland	--	VIIIs	--
Beebe	180-280	VIIe	IVs,IIIe
Billings	210-280	VIIs,VIIe	IIIe
Chipeta	100	VIIe	--
Ferron	--	Vw	--
Gullied Land	--	VIIe	--
Harding Variant	--	VIIs,VIIe	--
Hunting	180-240	--	IIIw
Killpack	150-240	VIIe,VIw,VIIc	VIe,IVe
Ildefonso	--	VIe	IVe
Libbings	--	VIIe,VIIw	--
Minchey	250	VIIIw,VIIe	IIe
Palisade	200-250	VIW,VIIe	IIe,IIIe
Penoyer	150-280	VIIc,VIIe	IIe,IIIe
Persayo	--	VIIe	--
Rafael	--	VIIw	--
Ravola	150-2880	VIIe,VIIc	IIe,IIe
Rock Land	--	VIIs	--
Saltair	--	VIIs,VIIIw,IVs	--
Sanpete	70-100	VIIs	IVs
Shale Outcrop-Colluvial Land	--	VIIs	--
Woodrow	160	VIIs	IIe

[1] Cow acre days: carrying capacity of a pasture

-- No data available.

Table 8-2

Predicted Average Yields

Principal Irrigated Soils[2]

Soil Series[1]	Class Determining Phase	Meadow Hay (tons/acre)
Hunting	all	6.0
Killpack	1-12% slopes	4.0
Ravola	1-3% slopes	6.0
	3-6% slopes	5.0
Woodrow	all	4.0

[1] Series or Component; information given when data available (SCS, Soil Interpretation Records).

Rangelands

The soils of the project area are used extensively as rangeland.

A range site is a distinctive kind of rangeland which differs from other rangelands in its ability to produce a characteristic plant community. It also differs from others in kind or proportion of species or in total production (USDA, SCS, 1976). The range sites occurring in the study area are: desert shale, desert shallow shale, desert loam, semi-desert shallow loam, semi-desert loam bench, semi-desert loam bottom, salt meadows, and wet meadows.

Range sites are used to determine the vegetation which can be grown on the soil, the potential productivity, and the carrying capacity of the site. Range site condition can be determined by the percent vegetation of decreasers, increasers, or invaders. From the determination of the range site conditions, appropriate measures to maintain range condition can be taken.

Desert shale range sites are on hill slopes up to 30 percent. The native vegetation is mat saltbush, Indian ricegrass, galleta grass and shadscale. The Chipeta and Badlands areas are included in this range site.

Desert shallow shale range sites are on nearly level to steeply sloping shale hills with broken, choppy, and rolling topography. The native vegetation consists mainly of Indian ricegrass, mat saltbush, shadscale and fourwing saltbush. The potential climax vegetation is about 45 percent shrubs, 40 percent grasses and 15 percent forbs. The soils which occur in this range site include Billings, Penoyer, Ravola and Woodrow. The climax vegetation consists of 70 percent shrubs, 25 percent grasses and 5 percent forbs. The Chipeta and shallow shale outcrops are in this range site.

Desert loam range sites are on gently sloping desert masas, benches, flood plains, low lake terraces and alluvial fans. The native vegetation consists mainly of Indian ricegrass, galleta grass, western wheatgrass, and shadscale. The Ravola soils are in this range site.

Semi-desert shallow loam range sites are on shallow, well-drained soils on foothills and benchlands. The native vegetation is bluebunch wheatgrass, Indian ricegrass, needle and thread, pinon and juniper. The climax vegetation is approximately 15 percent Utah juniper, 40 percent grasses, 10 percent forbs and 35 percent shrubs. The Castle Valley soils occur in this range site.

Semi-desert loam bench range sites are on level to very gently sloping benches. The native vegetation is Indian ricegrass, blue gramma, big sage and winter fat. The climax vegetation is approximately 45 percent grasses, 45 percent shrubs and 10 percent forbs. The Minchey and Palisade soils are included in this range site.

Semi-desert loam bottom range sites occur on gently rolling alluvial bottoms. The native vegetation includes shadscale, galleta grass and Indian ricegrass. The Palisade and Sh series are in this range site.

The salt meadow range site always occur at lower elevations where there is additional moisture either by seepage or irrigation waste water. The Libbings and Saltair soils occur in this range site. These deep and moderately deep silty clays and silty clay loams are strongly alkaline. Greasewood and other salt-tolerant plants such as alkali sacaton, alkali blue grass, and alkali weed survive in this range site. Under poor management, saltgrass will predominate (USDA, SCS, 1970).

The wet meadow range sites are located on alluvial bottomlands and floodplains. These soils are usually wet during the growing season. The native vegetation includes tufted hairgrass, redtop, clover, cinquefoil, wiregrass, sedge, goldenrod, plaintain and arrowgrass. The Ferron, Killpack variant, and the Rafael are in this range site.

Wildlife Suitability and Forest Land

Three wildlife suitability groups (1, 2, and 3) appear in the project area. Wildlife suitability groups are similar in land use, physiographic position, plant cover, or a combination of the three.

The wildlife that live in a given area and the populations and kind are closely related to land use and the resulting patterns of vegetation. These, in turn, are generally related to soil types. Table 8-3 lists wildlife suitability groups, general soil type, series, and wildlife adapted to the area (USDA, SCS, 1970).

Small areas in the permit area are delineated as woodland. The physical and climatic conditions (i.e., low rainfall, shallow soils, steep slopes and boundery soils) limit the area's potential as a use for forest or timber production. Most soils are therefore better suited as rangeland.

TABLE 8-3

WILDLIFE SUITABILITY GROUPS

Wildlife suitability group 1

Soils: Irrigated soils, wet soils, stream channel soils

Series:
- Billings
- Chipeta
- Killpack
- Libbings
- Minchey
- Penoyer
- Ravola
- Saltair
- Sanpete

Wildlife: Chinese pheasant, mourning dove, cottontail rabbit, ducks, geese, muskrat, and beaver.

Wildlife suitability group 2

Soils: Non-irrigated soils

Series:
- Chipeta
- Persayo
- Chipeta-Badlands

Wildlife: Chinese pheasant, mourning dove, chukar partridge, cottontail rabbit, and mule deer.

Wildlife suitability group 3

Soils: Soils of shubby foothills

Series:
- Castle Valley
- Rockland

Wildlife: Chukar partridge, cottontail rabbit, and mule deer.

8.4 Prime Farmland Investigation and Determination

It has been determined that within Consol's detailed, on-site mapping area (refer to Plate VIII-1 for boundary line,), there are no prime farmlands present. However, the acreages mapped with SCS data in the NE end of the permit area indicate that there may be some prime farmland soil present. The SCS maps show approximately 12.4 acres of Ravola loam and 3 acres of Woodrow silty clay loam present within the disturbance boundary. The soils were apparently marginally cropped in the past, but presently are poorly taken care of having only grasses and weeds present. A small amount of irrigation water is applied to these acreages on seldom events.

After observing the above described soils in the field, it is very questionable as to whether these soils are actually Ravola and Woodrow Series. They do not appear to be. However, Consol is in the process of mapping these acreages more specifically to insure an inventory of what is actually there. This data will be presented to the DOGM for review at the earliest time possible. If these soils do turn out to be prime farmland soils in the final analysis, Consol will treat them as such according to the corresponding regulations.

8.5 Soil Reconstruction Material

8.5.1 Method of Evaluation

The criteria for evaluating soil as a plant growth media are given in Table 8-4. The criteria include sodium absorption ratio (SAR), electrical conditivity or salinity (EC), toxic materials, soil reaction (pH), available water capacity, erosion factor, wind erosion group, texture, and percent coarse fragments.

Limits of each parameter are those of SCS, National Soils Handbook (NSH) or Wyoming Dept. of Environmental Quality (DEQ), Guideline No. 3 (revised March, 1980). Criteria are given for good, fair or poor sources of reconstruction material. A good rating means vegetation is relatively easy to establish and maintain, the surface is stable and resists erosion, and the reconstructed soil has good potential productivity. Material rated fair can be vegetated and stabilized by modifying one or more properties. Top dressing with better material or application of soil amendments may be necessary for satisfactory performance. Material rated poor/unsuitable has such severe problems that revegetation and stabilization is very difficult and costly.

8.5.2 Soil Chemistry and Physical Properties

Chemical and physical data for project area soils were collected to evaluate the soils as reconstruction material for disturbed lands. Sources of information include analysis by Utah State University Soils Laboratory, Carbon-Emery Area Soil Survey (USDA, SCS, 1970), and SCS Soil Interpretation Records. Soil chemical and physical data for major soils are reported in the appendix.

To evaluate the soils for reclamation, soils were sampled mainly from the detailed mapping area. Soils were sampled by horizon and analyzed by Utah State University Soils Laboratory. The parameters determined were particle size distribution, texture class, paste pH, organic carbon, gypsum, boron, electrical conductivity, sturation percent, atmosphere moisture tensions, cation exchange capacity, SAR, engineering analysis and classification. The techniques used were those of USDA Handbook 60, with the exception of organic carbon, which was determined using the University of Colorado, Agronomy Series No. 13, Method 90.3. Particle size analysis was determined using a sieve and hydrometer technique (see TECHNIQUES USED IN SOIL ANALYSIS, Appendix).

Data was obtained from published soil survey (USDA, SCS, 1970) and SCS Soil Survey Interpretation Records for soils for which no site specific data was collected.

Vegetation is difficult to establish on soils with high SAR which indicates potential instability and water transmission problems. SAR was determined for all samples. A number of soils are rated poor/unsuitable in some of the horizons. Some are rated marginally suitable. Others are good or fair. The horizons rated marginally suitable (Table 8-5) could be utilized if other factors are not more limiting. Adequate mixing of this material may decrease the sodicity of this material. A judicious selection of sodic tolerant species may also aid in reclamation success.

Salinity [electrical conductivity (ED)] tests were run on most soils in the detailed mapping area. The Beebe, Bunderson, Chipeta, GP, Harding variant, Ravola, and Alluvial Lands soils are rated poor/unsuitable or marginally suitable in one or more horizons. Other soils are rated good or fair throughout.

Some elements such as boron and selenium can be deleterious to plants or the animals that feed on them. Boron was tested in all samples and most soils are rated good for boron (less than 5 ppm, Wyo. DEQ, Guideline No. 3). Boron does not seem to be a major problem in the soils. Boron exceeded 5 ppm in the substratum of the GP series; is rated poor for toxic material. No selenium indicators were found at the site. Therefore, selenium was not tested.

Paste pH was determined for all samples tested. For soil for which no site specific data were available, pH values from Carbon-Emery Area Soil Survey (USDA, SCS, 1970) as used. Excessively high or low pH causes problems in establishing vegetatiion and as a result influence erosion and stability of the surface. pH values ranged from mildly alkaline to very strongly alkaline (7.7 to 10.1). The Beebe, Bunderson, Chipeta, GP Series, Harding variant, Rafael, Ravola, Saltair, Sh Series and Alluvial Land soils are rated poor in portions or all of the substratum. High pH values can be made more neutral by the addition of a soil amendment. Plant species selection may be made according to degree of alkalinity.

The available water capacity (AWHC) also is important in establishing vegetation. Soils with low available water capacity map require irrigation for establishment of vegetation. AWHC was estimated by using saturation percentage, textural analysis and coarse fragments from site specific data (USDA, USFS, 1974). All soils are rated good or fair throughout. AWHC is not a limiting factor in any of the soils recommended.

The stability of the soil depends upon its erodibility by water and wind and its strength. Water erodibility is indicated by the K factor; wind erodibility is rated according to the wind erodibility group. For soils at the Emery Mine erodibility factors (K) were calculated based on the soil erodibility nomograph (Wischmeier, 1979). K factors were corrected to include the effects of coarse fragments. K values for other soils of the project area are from the best data available in the SCS Soil Survey Interpretation Records. Most soils are rated good or fair throughout. The alluvial land and the Chipeta soils are rated poor since field observations include active erosion. The surface layer of the Libbings soil is rated fair to poor. This is about a 1/2 inch horizon which is heavily salt crusted.

Wind erodibility is based on textural data and wind erodibility group (WEG) (USDA, USFS, 1979). The ratings for WEG ranged from good to poor; most soils are rated good or fair in most horizons. The surface horizon of the Beebe soil is rated poor; it is a loamy sand. The substratum of the alluvial soils is rated poor; these horizons are also in the textural class loamy sand. Some soils are rated one class lower from field observations.

USDA texture influences available water capacity and erodibility by wind or water. Texture also influences soil structure, consistence, water intake rate, runoff, fertility, workability, and trafficability. Potential lippage hazard is related to soil texture, and although other factors also contribute, the ratings of soil texture represent one important factor. Soil texture is rated fair or good in most soils. No soils tested are too sandy. The subsoil of the Chipeta is too clayey.

Coarse fragments influence the ease of excavation, stockpiling and respreading, and suitability for the final use of the land. A certain amount of coarse fragments can be tolerated depending upon the size and the intended use of the reclaimed area. If the size of rock fragments exceed 10 inches the problems are more severe. Coarse fragments do not present a limiting factor in the use of most soils. Shallow, skeletal soils such as the Castle Valley have increasing coarse fragments with depth. Some soils are gravelly or very gravelly in the subsoils; fragments greater than 3 inches (stones) tend to increase limitations of use.

8.5.3 Suitability as a Source Material for Reclamation of Disturbed Lands

Table 8-5 is an evaluation of soil reconstruction material for each horizon of each project area soil type. The evaluation is based on the soil chemical and physical data described in Section 8.5.2 based on the criteria of Table 8-4.

The soils are rated good, fair, marginally suitable or poor/unsuitable sources of reconstruction material. The soils are variable in nature but overall the recovered and stockpiled SPGM should be of acceptable quality. The biggest problem will not likely be chemical but physical, the soils are fairly erodible. The recovered SPGM will be loamy in texture and should work well with the reconstructed overburden materials in providing a suitable growth medium.

Table 8-4

Soil Reconstruction Material for Disturbed Areas

Property	Limits				Restrictive Feature
	Good	Fair	Marginally Unsuitable	Poor/ Unsuitable	
1. Sodium Adsorption Ratio (SAR)	<6[c]	6-10[c]	10-15[cd]	>15[c]	Excess Sodium
2. Salinity (MMHOS/CM)	<4[c]	4-8[c]	8-16[c]	>16[c]	Excess Salt
3. Toxic Materials (boron)	<5[c]	<5[c]	>5[c]	>5[c]	Toxicity
4. Soil Reaction (pH)[a]	5.6-7.8	4.5-5.5	<4.5	<4.5	Too Acid
5. Soil Reaction (pH)	<7.9	7.9-8.4	8.4-9.0[c]	>9.0[c]	Excess Lime
6. Available Water Capacity (IN/IN)[2/]	>.10	.05-.10	---	<.05	Droughty
7. Erosion Factor (K)	<.37	>.37	---	---	Erodes Easily
8. Wind Erod. Group	>3	>3	---	1, 2	Soil Blowing
9. USDA Texture	---	SCL, CL SICL	---	C[b] SIC[b] SC	Too Clayey
10. USDA Texture	---	LCOS, LS LFS, LVFS	---	COS, S, FS, VFS	Too Sandy
11. Coarse Frag. (WT PCT)					
3-10 in.	<15	15-35	---	>35	Large Stones
> 10 in.	<3	3-10		>10	Large Stones

Adapted from National Soils Handbook, NSH - Part II [403.6(a)]

[a]Layers with high potential acidity should be rated poor.

[b]If in kaolinitic family, rate one class better if experience confirms.

[c]Wyoming Dept. of Environmental Quality, Guideline No. 3 (revised March 1980)

[d]10-12 for heavy textured soils (WDEQ, 1980)

Table 8-5
Evaluation of Soil Reconstruction Material
for Areas to be Disturbed

Series and Phase	Sample No.	Horizon	Depth (in)	SAR	Salinity	Toxic Materials (Boron)	Soil Reaction	Available Water Cap[3]	Erosion Factor(K)[4]	Wind Erodibility Group[5]	USDA Texture	Coarse Frags[6]	Overall Rating
Abbott	15	A11	0-3	good	good	good	good	good	good	good	fair	good	FAIR
fine		A12	3-22	good	good	good	good	fair	good	good	good	good	FAIR
sandy		C1sa	22-41	good	good	good	good	good	good	good	good	good	GOOD
clay		C2Cs	41-62	good	good	good	good	good	fair	good	good	good	FAIR
loam													
Beebe,	27	A1	0-9	marg.	good	good	fair	good	fair	poor	fair	good	POOR
fine		AC	9-20	unsuit.	good	good	unsuit.	fair	fair	fair	good	good	UNSUIT.
sandy		C1	20-51	unsuit.	unsuit.	good	unsuit.	fair	fair	fair	good	good	UNSUIT.
loam		C2cacs	51-65+	unsuit.	unsuit.	good	marg.	fair	fair	fair	good	good	UNSUIT.
Billings[1]		Ap1	0-3	--	good	--	good	good	fair	good	fair	good	FAIR
silty	--	Ap2	3-11	--	good	--	fair	good	fair	good	fair	good	FAIR
clay		C1	11-18	--	good	--	good	good	fair	good	fair	good	FAIR
loam		C2	18-42	--	good	--	good	good	fair	good	fair	good	FAIR
		C3	42-58	--	good	--	fair	good	fair	good	fair	good	FAIR
Bunderson		A1	0-4	unsuit.	unsuit.	good	fair	good	good	good	good	good	UNSUIT.
very	04	C1ca	4-14	unsuit.	unsuit.	good	marg.	good	good	good	good	good	UNSUIT.
fine		C2ca	14-43	unsuit.	unsuit.	good	marg.	good	good	good	fair	good	UNSUIT.
sandy		C3cs	43-63+	unsuit.	unsuit.	good	marg.	good	good	good	good	good	UNSUIT.
loam													
Castle Valley		A11	0-4	marg.	good	good	marg.	fair	fair	fair	good	fair	MARG.
very	35	A12	4-10	fair	good	good	fair	fair	fair	fair	good	fair	FAIR
fine		ACca	10-12	fair	good	good	fair	fair	fair	fair	good	poor	POOR
sandy													
loam													

Table 8-5(continued)
Evaluation of Soil Reconstruction Material
for Areas to be Disturbed

Series and Phase	Sample No.	Horizon	Depth (In)	SAR	Salinity	Toxic Materials (Boron)	Soil Reaction	Available Water Cap[3]	Erosion Factor(K)[4]	Wind Erodibility Group[5]	USDA Texture	Coarse Frags[6]	Overall Rating
Chipeta eroded very gravelly silty clay loam	01	A1	0-2	fair	fair	good	good	fair	poor[9]	fair[9]	good	good	POOR
		AC	2-11	unsuit.	unsuit.	good	fair	good	poor[9]	fair[9]	poor	good	UNSUIT.
Ferron silt loam	19	A1	0-4	good	good	good	fair	good	fair	good	fair	good	FAIR
		AC	4-15	good	good	good	fair	good	fair	fair	good	good	FAIR
		C1	15-35	good	good	good	fair	good	fair	good	good	good	FAIR
GP Silt loam	06	A11,A12	0-6	good	good	good	fair	good	fair	good	good	good	FAIR
		C1	6-28	unsuit.	unsuit.	fair	marg.	good	--	good	good	good	UNSUIT.
		C2Cs	28-60	unsuit.	unsuit.	poor	marg.	good	—	good	fair	good	POOR
Harding variant very fine sandy loam	08	A1	0-3	unsuit.	good	good	marg.	fair	good	fair[9]	good	good	UNSUIT.
		B2t	3-10	unsuit.	marg.	good	marg.	good	good	fair[9]	fair	good	UNSUIT.
		B31tca	10-24	unsuit.	unsuit.	good	fair	good	fair	fair[9]	fair	good	POOR
		B32tca	24-43	unsuit.	unsuit.	good	marg.	poor	good	fair	good	good	UNSUIT.
		IIC1	43-57	marg.	unsuit.	good	fair	fair	good	poor	fair	good	UNSUIT.
Hunting clay loam, non-saline phase	10	A1g	0-5	good	good	good	fair	good	fair	good	good	good	FAIR
		AC	5-13	good	good	good	fair	good	fair	good	good	good	FAIR
		C1g	13-45+	good	good	good	fair	good	fair	fair	good	good	FAIR

Table 8-5 (continued)
Evaluation of Soil Reconstruction Material
for Areas to be Disturbed

Series and Phase	Sample No.	Horizon	Depth (in)	SAR	Salinity	Toxic Materials (Boron)	Soil Reaction	Available Water Cap[3]	Erosion Factor(K)[4]	Wind Erodibility Group[5]	USDA Texture	Coarse Frags[6]	Overall Rating
Ildefonso		A1	0-6	unsuit.	good	good	fair	good	good	fair	good	good	UNSUIT.
sandy	07	B2	6-19	marg.	good	good	good	good	good	good	fair	good	MARG.
clay		IC1ca	19-33	marg.	good	good	good	fair	good	fair	good	good	MARG.
loam,		IIC2ca	33-51	marg.	good	good	marg.	poor	good	fair	good	good	POOR
non-		IIC3	51-60+	good	good	good	fair	fair	good	fair	good	good	FAIR
eroded phase													
Kill-pack[1]		Ap	0-9	--	good	--	good	good	fair	fair[9]	fair	good	FAIR
clay		C1	9-23	--	good	--	good	good	fair	fair[9]	fair	good	FAIR
loam		C2cs	23-29	--	good	--	good	good	fair	fair[9]	fair	good	FAIR
Libbings													
clay	11	A1	0-4	unsuit.	unsuit.	poor	marg.	good	fair	good	good	good	UNSUIT.
loam		C1sa	4-24	fair	marg.	good	fair	good	fair	good	good	good	MARG.
		C2sa	24-39	marg.	marg.	good	fair	good	fair	good	good	good	MARG.
		C3	39-50	marg.	marg.	good	fair	good	fair	good	good	good	MARG.
Pallsade													
sandy	24	A11	0-4	good	good	good	fair	fair	fair	fair	good	good	FAIR
loam		A12	4-9	good	good	good	fair	good	fair	fair	good	good	FAIR
		C1ca	9-19	good	good	good	fair	good	fair	good	good	good	FAIR
		C2ca	19-32	good	good	good	fair	good	fair	fair	good	good	FAIR
		C3ca	32-42	fair	good	good	marg.	good	fair	fair	good	good	MARG.
		C4	42-60	good	marg.	good	fair	good	fair	fair	good	good	MARG.

Table 8-5(continued)
Evaluation of Soil Reconstruction Material
for Areas to be Disturbed

Series and Phase	Sample No.	Horizon	Depth (In)	SAR	Salinity	Toxic Materials (Boron)	Soil Reaction	Available Water Cap[3]	Erosion Factor(K)[4]	Wind Erodibility Group[5]	USDA Texture	Coarse Frags[6]	Overall Rating
Persayo fine sandy clay loam, eroded	20	A1	0-4	good	good	good	fair	fair	fair	fair	good	good	FAIR
		AC	4-11	good	good	good	fair	good	fair	good	good	good	FAIR
		Crcs	11-19	good	good	good	good	good	fair	good	fair	good	FAIR
Rafael[1] silty clay loam	--	A11	0-3	--	good-fair	--	fair	good	good	good	fair	good	FAIR
		A12	3-11	--	good-fair	--	fair	good	fair	good	good	good	FAIR
		C1g	11-17	--	good-fair	--	marg.	good	fair	good	good	good	MARG.
		C2g	17-33	--	good-fair	--	marg.	good	fair	good	fair	good	MARG.
		C3g	33-43	--	good-fair	--	fair	good	fair	good	good	good	FAIR
		C4g	43-70	--	good-fair	--	fair	good	fair	food	good	good	FAIR
Ravola loam, eroded	02	A11	0-3	good	good	good	good	good	fair	good	good	good	FAIR
		A12	3-15	good	good	good	good	good	fair	good	good	good	FAIR
		C1	15-30	fair	fair	good	fair	fair	fair	good	fair	good	FAIR
		C2	30-50	marg.	fair	good	fair	good	fair	good	good	good	MARG.
		C3	50-71	unsuit.	unsuit.	good	fair	good	fair	good	good	good	UNSUIT.
Saltair[1] silty clay loam	--	A11sa	0-.5	unsuit.	good	--	marg.	good	fair-poor	good	fair	good	UNSUIT.
		A12sa	.5-7	unsuit.	good	--	marg.	good	fair	good	fair	good	UNSUIT.
		C1gsa	7-14	unsuit.	good	--	marg.	good	fair	good	fair	good	UNSUIT.
		C2gsa	14-32	unsuit.	good	--	marg.	good	fair	good	fair	good	UNSUIT.
		C3g	32-60	unsuit.	good	--	marg.	good	fair	good	fair	good	UNSUIT.

Table (concluded)
Evaluation of Soil Reconstruction Material
for Areas to be Disturbed

Series and Phase	Sample No.	Horizon	Depth (in)	SAR	Salinity	Toxic Materials (Boron)	Soil Reaction	Available Water Cap[3]	Erosion Factor(K)[4]	Wind Erodibility Group[5]	USDA Texture	Coarse Frags[6]	Overall Rating
Sh Series cobble very fine sandy loam	14	A1	0-3	good	good	good	fair	good	fair[9]	fair	good	good	FAIR
		AC	3-17	unsuit.	fair	good	fair	good	fair[9]	good	fair	good	UNSUIT.
		C1	17-29	marg.	good	good	fair	good	fair[9]	good	fair	good	MARG.
Alluvial land	31	A2	0-5	marg.	good	fair	good	poor[9]	poor[9]	good	good	poor[7]	POOR
		C1	5-20	unsuit.	unsuit.	good	marg.	fair	poor[9]	poor	good	good	POOR
		C2sa	20-30	unsuit.	unsuit.	good	fair	fair	poor[9]	poor	good	good	POOR
		C3sa	30-45	unsuit.	unsuit.	good	marg.	fair	poor[9]	poor	good	good	POOR
Disturbed land	03	IIC1	0-11[7]										
		IC1	11-53	fair	good	good	fair	good	good	fair	good	good	FAIR
		IC2b	53-65	good	good	good	good	good	good	fair	good	good	FAIR

[1]pedon information taken from: SCS soil interpretation records, established series descriptions, Carbon-Emery Area Soil Survey (USDA, SCS, 1971), and Coal Creek portion of Carbon Area Survey (SCS, 1978).
[3]calculated from textural analysis, saturation percentage, and laboratory determination of fragments >2.0mm (USDA, USFS, 1974).
[4]calculated from Wischmeier's soil erodibility nomograph and particle size determination (Wischmeier, 1978).
[5]calculated from SCS wind erodibility group (WEG) and textural analysis (USDA, SCS, 1978).
[6]coarse fragments determined from laboratory analysis.
[7]not sampled; waste coal layer
[9]rating from field observations
marg. = marginally suitable
unsuit. = poor/unsuitable

8.5.4 Depths Of Suitable Topsoil Available For Reclamation

The depths of material available for reclamation are listed on Table 8-6 by map unit. The table includes the map unit, soil type, depth of horizon, rating (from Table 8-5), and percent of map unit, as well as the recommended depth of stripping and restrictive features. Some map units are not rated because of insufficient data. Others are not rated due to the variability of the map unit.

Soils rated good or fair are suitable for use in reclamation. Some soils considered marginally suitable may be used. Soils rated poor/unsuitable are not suitable for use in reclamation.

Recommendations for use have been rounded to 3 in. intervals. Those soils rated fair or good to 3 inches or less are considered too thin for salvage.

Table 8-6
Depths of Suitable Topsoil Material
for Areas to be Disturbed[1]
(by map unit)

Map Unit	Components	Depth (in)	Rating	Percent of Map Unit	Recommended Depth Suitable Material (restrictive feature)
Ab	Abbott	0-62	FAIR-GOOD	85	60 in. (erosion, SAR, AWHC)
	Ferron	0-35	FAIR	0-15	36 in. (erosion, pH, wetness)
	Rafael	0-11	FAIR	0-15	12 in. (salinity, pH, texture)
AW	Alluvial land	0-45	POOR	100	0 in. (erodible)
Ba	Badland	*		95	N/R
BeB	Beebe	0-65+	POOR	88	0 in. (SAR, wind erodible,salinity)
	Various Inclusions	variable	POOR	12	0 in. (too variable)
BlB	Billings[3]	0-58	FAIR	85	60 in. (erodible, texture)
	Bunderson	0-63	UNSUIT.	0-15	0 in. (SAR, salinity, pH)
	Hunting	0-45+	FAIR	0-15	42 in. (erodible, texture)
CeE2	Castle Valley	0-10	MARG.-FAIR	85	9 in. (SAR, pH)
	Rock outcrop		*	0-15	N/R
	Rockland		*	0-15	N/R

Table 8-6 (continued)

Map Unit	Components	Depth (in)	Rating	Percent of Map Unit	Recommended Depth Suitable Material (restrictive feature)
CaC-Sh	Castle Valley-Sh Complex				
	Castle Valley	0-10	MARG.-FAIR	55	9 in. (SAR, pH)
	Sh Series	0-29	FAIR-UNSUIT.	40	0 in. (too thin)
	(Castle Valley, extremely rocky phase	0-10	POOR	5	N/R
CB2	Chipeta-Badland Association				
	Chipeta	0-11	POOR/UNSUIT.	50	0 in. (erosion, SAR, salinity)
	Badland		*	40	
	Persayo	0-19	FAIR	0-10	0 in.
					18 in. (erosion, pH)
	Shale Outcrop colluvial land		*	0-10	N/R
CPB2	Chipeta-Persayo Complex				
	Chipeta	0-11	POOR/UNSUIT.	60	0 in. (erosion, SAR, salinity)
	Persayo	0-19	FAIR	25	18 in. (erosion, pH)
	Shallow soils		*	15	N/R
DL	Disturbed Land[2]	0-11 11-65	N/R FAIR	100	40 in.[2] (wind erodible, pH)
Fe	Ferron	0-35	FAIR	90	30 in. (wetness, pH, erosion)
	Abbott	0-62	FAIR-GOOD	10	60 in. (erosion, SAR, AWHC)
Gu	Gullied land	*			N/R
GP	GP Series	0-6	FAIR	80	6 in. (pH, erosion)
	Sanpete	0-30	GOOD-FAIR	0-20	30 in. (pH, texture)
	Ildefonso	0-33	MARG.-UNSUIT.	0-20	24 in.[2] (SAR, pH, AWHC)

Table 8-6 (continued)

Map Unit	Components	Depth (in)	Rating	Percent of Map Unit	Recommended Depth Suitable Material (restrictive feature)
HA	Harding variant-Haplargid Association				
	Harding variant	0-57	UNSUIT.	60	0 in. (SAR, salinity, pH)
	Typic Haplargid		N/T	25	0 in. (SAR, salinity, pH, cobbly)
	Harding		N/T	15	0 in.
HB	Hunting	0-45+	FAIR	85	40 in. (wetness, erosion, pH)
	Billings	0-58	FAIR	0-15	60 in. (erodible, texture)
	Rafael	0-11	FAIR	0-15	12 in. (salinity, pH, texture)
	saline/alkaline soils		N/T	0-15	N/R
HS	Hunting, moderately saline phase	0-45+	FAIR-MARG.	95	40 in. (wetness, pH, erosion, salinity)
	Strongly saline soils		*	5	N/R
IIB	Ildefonso[2]	0-6 6-60+	UNSUIT. MARG.-FAIR	85	54 in.[2] (SAR, pH, AWHC)
	Gypsiorthids	0-6	FAIR	0-15	6 in. (pH, erosion)
	Sanpete	0-30	GOOD-FAIR	0-15	30 in (pH, texture)
	Haverson		N/T	0-15	N/R
IID2	Ildefonso[2]	0-6 6-60+	UNSUI. MARG.-FAIR	85	54 in.[2] (SAR, pH, AWHC)
	Hunting	0-45	FAIR-MARG.	0-15	40 in. (wetness, pH, erosin)
	Sanpete	0-30	GOOD-FAIR	0-15	30 in. (pH, texture)
	Harding	0-57	UNSUIT.	0-15	0 in. (SAR, salinity, pH)

Table 8-6 (continued)

Map Unit	Components	Depth (in)	Rating	Percent of Map Unit	Recommended Depth Suitable Material (restrictive feature)
IB	Killpack[3]	0-29	FAIR	90	28 in. (texture, erosion)
	Billings	0-58	FAIR	0-10	60 in. (erodible, texture)
	Saline soils		*	0-10	N/R
IC2	Killpack[3]	0-29	FAIR	85	28 in. (texture, erosion)
	shallow, clayey soils		*	15	N/R
KpB	Killpack[3]	0-29	FAIR	95	28 in. (texture, erosion)
	Killpack clay loam	0-29	FAIR	5	28 in. (texture, erosion)
KpC2	Killpack[3]	0-29	FAIR	85	28 in. (texture, erosion)
	Killpack clay loam	0-29	FAIR	15	28 in. (texture, erosion)
Lb	Libbings[2]	0-50	UNSUIT.-MARG.	95	36 in.[2] (SAR, salinity)
	deep and shallow clayey soils		*	5	N/R
MlB	Minchey[3]	0-64	FAIR	85	60 in. (pH, erosion, wind erodible)
	Sanpete	0-30	GOOD-FAIR	0-15	30 in. (pH, texture)
	Minchey loam	0-64	FAIR	0-15	60 in. (pH, erosion, wind erodible)
PaB	Palisade	0-32	FAIR	85	30 in. (pH, erosion, wind erodible)
	Palisade clay loam	0-32	FAIR	0-15	30 in. (pH, erosion, wind erodible)
	Minchey loam	0-64	FAIR	0-15	60 in. (pH, erosion, wind erodible)

Table 8-6 (continued)

Map Unit	Components	Depth (in)	Rating	Percent of Map Unit	Recommended Depth Suitable Material (restrictive feature)
PdB	Palisade	0-32	FAIR	80	30 in. (pH, erosion, wind erodible)
	Palisade-like	0-32	FAIR	0-20	30 in. (pH, erosion, wind erodible)
	Minchey cobbly loam	0-64	FAIR	0-20	60 in. (pH, erosion, wind erodible)
Pd-LT	Palisade-Lithic Torriorthents Association				
	Palisade	0-32	FAIR	70	30 in. (pH, erosion, wind erodible)
	Lithic Torriorthents	0-20	N/T	20	N/R
	Castle Valley,	0-10	MARG.-FAIR	0-10	9 in. (SAR, pH)
	rock outcrop		*	0-10	N/R
PCE2	Persayo-Chipeta Association				
	Persayo	0-19	FAIR	40	18 in. (erosion, pH)
	Chipeta	0-11	POOR/UNSUIT.	40	0 in. (erosion, SAR, salinity)
	Badland		*	20	N/R
RlB	Ravola	0-30	FAIR	80	30 in. (SAR, salinity, erosion)
		30-71	MARG.-UNSUIT.		
	Billings	0-58	FAIR	0-20	60 in. (erodible, texture)
	Bunderson	0-63	UNSUIT.	0-20	0 in. (SAR, salinity, pH)
	saline/alkali soils		*		N/R
RlB2	Ravola	0-30	FAIR	80	30 in. (SAR, salinity, erosion)
		30-71	MARG.-UNSUIT.		
	Bunderson	0-63	UNSUIT.	0-20	0 in. (SAR, salinity, pH)
	Billings	0-58	FAIR	0-20	60 in. (erodible, texture)

Table 8-6 (concluded)

Map Unit	Components	Depth (in)	Rating	Percent of Map Unit	Recommended Depth Suitable Material (restrictive feature)
RuB2	Ravola-Bunderson Complex				
	Ravola	0-30	FAIR	60	30 in. (SAR, salinity, erosion)
		30-71	MARG.-UNSUIT.		
	Bunderson	0-63	UNSUIT.	35	0 in. (SAR, salinity, pH)
	(strongly saline soils)		N/T	5	N/R
Ry	Rockland	*			N/R
Sa	Saltair[3]	0-60	UNSUIT.	100	0 in. (SAR, pH, erosion)
ShC	Sh Series	0-29	FAIR-UNSUIT.	95	0 in. (too thin) 30 in. (pH, erosion, wind erodible)
	Palisade	0-32	FAIR	5	
Sh-PdC	Sh Series-Palisade Complex				
	Sh series	0-3	FAIR	50	0 in. (too thin) 30 in. (pH, erosion, wind erodible)
	Palisade	0-32	FAIR	35	
	Castle Valley	0-10	MARG.-FAIR	0-15	9 in. (SAR, pH)
	rock outcrop		*	0-15	N/R
WO	Woodrow Series	30	Good	100	30 in.

[1]Detailed mapping area only.

[2]excluding surface soil

[3]evaluations and recommendations made from SCS information.

N/R - not recommended

* - too variable

8.6 Overburden Characteristics and Descriptions

During early January of 1982 a study was undertaken by Consol to document the physical and chemical nature of the overburden in the Emery Surface Mine site. Seven study holes were drilled, two of which were cores. Laboratory analysis was conducted on the materials at interval depths. Of particular interest was the characteristics of the materials above the J coal seam because this is the material which will end up directly below the respread SPGM during the reclamation process. Since there are only approximately 14 inches of SPGM to respread, the characteristics of the upper overburden is of obvious importance. The layer of significance runs from the surface to the J coal seam and averages about 71 feet in depth.

Data indicates that this layer of material actually is made up of several strata of shales and sandstones. After being blasted and worked with heavy machinery these materials become soil-like in nature and will closely resemble a "slightly saline sandy loam" soil.

After analyzing 28 different parameters it becomes evident that these overburden materials should be suitable for use as subsoil material during the reclamation of the site. The pH, saturation percentage, sodium absorption ratio, lime percentage, calcium content, potassium, and trace mineral contents are all at acceptable levels. The electical conductivity is a little high but is at a level that will usually only affect the yields of salt sensitive plants "if it were used as the topsoil materials". Of course the overburden will not be the surface soil but will be subsoil instead.

The sodium content is slightly excessive for crop plants but will have little to no affect on rangeland species. The magnesium content averages about 747 ppm, this appears to be higher than optimum levels, however toxic levels are not known. This figure is considerably lower than what the USDI-BLM found in a nearby overburden study (EMRIA Report No. 16, 1979).

Refer to tables 8-7 and 8-8 for data details on overburden study.

The overburden will end up as a sandy, loamy material after mining and will be highly capable of leaching undesirable minerals downward and away from the SPGM and plant rooting zones. It is doubtful that undesirable mineral contents at present levels would cause any revegetation problems, but because of leaching there is even a smaller likelihood of this becoming a problem.

TABLE 8-7

EMERY STRIP MINE AREA
OVERBURDEN CHEMISTRY DATA
MAJOR PARAMETERS

Parameter	Sample Hole Numbers 700 Aver.	700 Range	701 Aver.	701 Range	702 Aver.	702 Range	703 Aver.	703 Range	704 Aver.	704 Range	705 Aver.	705 Range	706 Aver.	706 Range	Overall Average
pH	7.3	7.8 - 6.8	6.9	7.3 - 6.3	6.4	7.2 - 5.2	7.0	7.4 - 6.9	7.0	7.3 - 6.9	6.1	7.6 - 6.1	7.2	7.7 - 7.2	6.8
Electrical Conductivity (mmhos/cm)	5.1	11.5 - 2.4	9.7	12.6 - 6.0	7.3	13.9 - 2.4	9.8	16.6 - 7.0	6.7	11.1 - 4.5	1.5	1.9 - 1.2	7.9	10.4 - 5.8	6.8
Saturation %	39.3	74.0 - 27.2	32.3	35.3 - 29.6	30.8	36.1 - 27.5	51.2	75.0 - 32.0	55.1	75.3 - 34.4	35.7	38.1 - 34.2	46.0	73.8 - 28.7	41.4
Sodium (meg/l)	7.9	26.2 - 4.6	11.3	21.5 - 4.2	11.2	36.6 - 4.5	26.3	69.5 - 11.9	15.8	42.9 - 1.4	4.0	4.8 - 3.5	14.3	24.8 - 1.8	12.9
Calcium (meg/l)	15.8	26.0 - 7.4	35.0	39.4 - 26.1	33.6	43.5 - 14.6	28.6	37.1 - 18.5	22.7	33.5 - 14.6	6.6	10.4 - 4.7	28.2	38.6 - 16.3	24.3
Magnesium (meg/l)	22.5	57.2 - 6.4	41.3	63.7 - 13.2	24.6	62.8 - 3.5	34.6	50.7 - 22.7	24.4	30.8 - 14.2	2.6	3.5 - 1.5	30.6	40.5 - 21.2	25.8
Sodium Absorption Ratio	1.9	4.1 - 0.9	1.9	3.4 - 0.6	1.9	5.5 - 0.9	4.6	11.8 - 2.3	3.2	8.3 - 0.3	1.9	2.1 - 1.8	2.6	4.6 - 0.3	2.5
Sand %	65.0	85.0 - 3.0	68.0	77.0 - 63.0	79.0	90.0 - 47.0	45.0	68.0 - 13.0	49.0	76.0 - 18.0	55.0	58.0 - 52.0	50.0	82.0 - 14.0	59.0

TABLE 8-7 (continued)

EMERY [redacted]P MINE AREA
OVERBURDEN CHEMISTRY DATA
MAJOR PARAMETERS

Parameter	Sample Hole Numbers 700 Aver.	700 Range	701 Aver.	701 Range	702 Aver.	702 Range	703 Aver.	703 Range	704 Aver.	704 Range	705 Aver.	705 Range	706 Aver.	706 Range	Overall Average
Silt %	20.0	49.0 - 8.0	24.0	31.0 - 16.0	16.0	47.0 - 4.0	28.9	49.0 - 16.0	20.0	33.0 - 10.0	36.0	43.0 - 30.0	26.0	40.0 - 12.0	24.0
Clay %	15.0	48.0 - 3.0	8.0	18.0 - 3.0	6.0	12.0 - 3.0	27.0	51.0 - 3.0	31.0	49.0 - 5.0	10.0	18.0 - 3.0	24.0	54.0 - 4.0	17.0
Organic Matter %	0.6	3.6 - 0.2	0.1	0.2 - 0.1	1.1	6.6 - 0.1	0.2	0.4 - 0.1	0.3	0.6 - 0.1	2.4	6.2 - 0.1	0.2	0.7 - 0.1	0.7
Lime %	6.1	20.3 - 2.1	2.8	4.7 - 1.5	1.5	3.5 - 0.0	8.4	17.1 - 0.0	11.6	21.8 - 1.1	0.1	0.1 - 0.0	7.9	15.5 - 2.7	5.4
Nitrogen (PPM)	2.4	8.0 - 0.0	1.6	3.0 - 1.0	0.6	2.0 - 0.0	5.6	12.0 - 2.0	6.1	13.0 - 1.0	2.0	None	4.3	11.0 - 1.0	3.2
Phosphorus (PPM)	1.0	None	1.0	None	1.3	4.0 - 1.0	1.7	4.0 - 1.0	1.0	None	1.0	None	1.8	4.0 - 1.0	1.2
Available Potassium (PPM)	328.0	840.0 - 140.0	210.0	260.0 - 190.0	168.0	230.0 - 120.0	553.0	960.0 - 250.0	607.0	910.0 - 200.0	288.0	320.0 - 220.0	437.0	940.0 - 140.0	370.0

TABLE 8-7 (continued)

EMERY STRIP MINE AREA
OVERBURDEN CHEMISTRY DATA
MAJOR PARAMETERS

Parameter	Sample Hole Numbers 700	701	702	703	704	705	706	Overall Average
Total Depth to J Seam	93.6 ft.	67.0 ft.	56.1 ft.	84.0 ft.	90.0 ft.	42.0 ft.	66.0 ft.	72.1 ft.
Number of Samples	10	5	12	8	7	4	6	

NOTE: The overall average data will be basically the characteristics to be expected in the overburden to be replaced after mining and will be the materials located directly below the replaced SPGM.

TABLE 8-8

EMERY STRIP MINE AREA
OVERBURDEN CHEMISTRY DATA
TRACE MINERALS

Parameter	Sample Hole Numbers 700 Aver.	700 Range	701 Aver.	701 Range	702 Aver.	702 Range	703 Aver.	703 Range	704 Aver.	704 Range	705 Aver.	705 Range	706 Aver.	706 Range	Overall Average
Arsenic (PPM)	0.1	0.0 - 1.7	0.2	0.0 - 0.5	0.1	0.0 - 0.8	0.3	0.0 - 1.6	0.1	0.0 - 1.2	0.0	None	0.0	0.0 - 0.4	0.1
Cadmium (PPM)	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0
Mercury (PPM)	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0
Lead (PPM)	2.0	0.7 - 5.0	1.8	1.4 - 3.0	1.0	0.5 - 1.9	1.3	0.9 - 1.9	1.4	0.7 - 2.4	0.9	0.6 - 1.3	1.6	1.3 - 2.3	1.4
Molybdenum (PPM)	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0
Boron (PPM) (Soluble)	0.9	0.2 - 1.9	0.5	0.3 - 1.1	0.7	0.4 - 1.3	1.2	0.1 - 3.4	0.8	0.2 - 1.9	0.1	0.1 - 0.2	0.4	0.0 - 1.6	0.65
Selenium (PPM) (Soluble)	0.03	0.01 - 0.03	0.01	0.01 - 0.03	0.02	0.01 - 0.03	0.01	0.01 - 0.02	0.01	0.01 - 0.02	0.02	0.01 - 0.03	0.02	0.01 - 0.03	0.01
Zinc (PPM)	5.0	0.5 - 13.3	7.5	3.8 - 11.4	4.0	1.1 - 14.0	2.0	0.4 - 6.2	4.0	0.7 - 9.6	5.6	1.9 - 8.9	5.2	0.9 - 9.2	4.7
Nickel (PPM)	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0	None	0.0
Copper (PPM)	0.4	0.0 - 1.2	0.2	0.2 - 0.4	0.7	0.0 - 4.0	0.5	0.0 - 1.0	0.4	0.1 - 0.8	0.1	0.1 - 0.4	0.4	0.1 - 1.3	0.3

TABLE 8-8 (continued)

EMERY STRIP MINE AREA
OVERBURDEN CHEMISTRY DATA
TRACE MINERALS

Parameter	Sample Hole Numbers 700 Aver.	700 Range	701 Aver.	701 Range	702 Aver.	702 Range	703 Aver.	703 Range	704 Aver.	704 Range	705 Aver.	705 Range	706 Aver.	706 Range	Overall Average
Fluoride (PPM)	0.32	0.05 - 1.05	0.15	0.07 - 0.22	0.19	0.06 - 0.73	1.15	0.05 - 4.80	1.60	0.05 - 5.02	0.08	0.08 - 0.09	0.12	0.05 - 0.44	0.51
Manganese (PPM)	11.1	3.3 - 18.0	3.8	0.9 - 6.1	19.3	3.9 - 39.0	0.1	2.8 - 16.0	5.7	1.9 - 20.0	0.6	0.2 - 1.4	6.0	2.3 - 14.0	7.9
Iron (PPM)	782.0	0.0 - 1221.0	111.0	0.0 - 555.0	499.0	145.0 - 926.0	99.0	0.0 - 699.0	0.0	None	31.0	0.0 - 127.0	0.0	None	217.0
Total Depth to J Seam	93.6 ft.		67.0 ft.		56.1 ft.		86.0 ft.		90.0 ft.		42.0 ft.		66.0 ft.		71.2 ft.
Number of Samples	10		5		12		9		7		4		6		

NOTE: The overall average data will be basically the characteristics to be expected in the overburden to be replaced after mining and will be the materials located directly below the replaced SPGM.

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8.8 APPENDIX

TECHNIQUES USED IN SOIL ANALYSIS

Parameter	Reported as	Recommended Procedure
pH	Hydrogen ion activity at saturation (paste)	U.S.D.A. Handbook 60, method (21a), p. 102.
Conductivity	mmhos/cm @ 25°C	U.S.D.A. Handbook 60, method (31), p. 84 and method (4b), p. 89-90, or A.S.A. Mono. No. 9, Part 2, pp. 937-940.
Soluble Ca, Mg & Na	meg/l	Extraction of Ca, Mg, and Na by U.S.D.A. Handbook 60, Method (3a) p. 84, Analysis by atomic absorption spectrophotometry.
Sodium-absorption-ratio	SAR calculated from soluble Ca, Mg & Na concentrations	U.S.D.A. Handbook 60, p. 26.
Texture	U.S.D.A. textural class	U.S.D.A. Handbook 18, p. 205-233.
Organic matter	Percent	A.S.A. Mono. No. 9, Part 2, method 90-3, pp. 1372-1376.

Compiled from Table I-1: WDEQ, Guideline No. 1, revised Feb. 1980

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OIL ANALYSIS REPORT ABBOTT 15 Date: September 5, 1980

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
80-1227	15	0-3						26.5	36	30	34	0	CL
1228		3-22						26.8	40	21	39	0	L
1229		22-41						28.5	31	26	43	0	L
1230		41-62						4.0	41	43	16	0	SiC

LABORATORY NUMBER	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %		TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 equivalent %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1227	7.8		1.22		0			1.9	14.0	71			13.5	
1228	7.7		.57		.5			4.7	13.5	35			6.6	
1229	7.7		.45		4.2			4.5	7.5	39			10.3	
1230	7.7		.62		4.2			4.3	15.5	60			15.0	

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg			WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →												
80-1227		14.2			8.5		3.2						.48
1228		45.7			19.1		4.0						.21
1229		39.6			22.6		5.1						.32
1230		46.2			14.3		3.0						.50

LABORATORY NUMBER	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1227	-		-		-		-		-		-		-		-		-	-
1228						100	97	94	78					23	17	6	A-4 (8)	CL - ML
1229						100	99	96	78					26	17	9	A-4 (8)	CL
1230	-		-		-		-		-		-		-		-		-	-

(1) Calculated on basis of <2mm material
(2) 5.5-lb Rem 12 inch drop
(3) Fractions calculated on basis of original sample

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Date: September 5, 1980

IL ANALYSIS REPORT ALLUVIAL LAND 31

BORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	31												
80-1282		0-5						52.1	32	9	59	0	SL
1283		5-20						46.0	16	6	78	0	LS
1284		20-30						40.0	8	6	86	0	LS
1285		30-45						38.0	16	6	78	0	LS

	pH		ORGANIC MATTER				ELECTRICAL CONDUCTIVITY		MOISTURE TENSIONS				
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	MILLIMHOS PER CM @25°C	CaCO3 equivalent %	SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1282	8.0		.46		.9		8.9	12.0	33			2.8	
1283	8.8		.31		.5		22.6	12.0	29			2.1	
1284	8.1		.24		.6		39.0	10.0	25			1.7	
1285	8.6		.24		.8		34.4	11.5	27			2.5	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg			WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS (2) MAX. DRY DENS. pcf	MOIST-DENS (2) OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →												
80-1282		55.1			62.6		12						2.30
1283		103			163		23						1.80
1284		166			278		31						1.80
1285		157			226		26						1.50

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1282	-		-		-		-		-		-		-		-		-	-
1283						100	98	89	36					NP	NP	NP	A-4 (0)	ML
1284	-		-		-		-		-		-		-		-		-	-
1285						100	98	89	39					20	NP	NP	A-4 (1)	ML

(1) Calculated on basis of -2mm material
(2) 5 6 lb Ham, 12 inch drop
(3) Fractions calculated on basis of original sample

umhos/cm

1.5

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Date: September 5, 1980

OIL ANALYSIS REPORT BEEBE 27

ABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	27												
80-1237		0-9						47.1	16	6	78	0	LS
1238		9-20						36.8	25	13	62	0	SL
1239		20-51						33.9	18	11	71	0	SL
1240		51-65						36.2	23	11	66	0	SL

	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %		TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1237	8.4		.50		0			1.3	9.0	33			2.3	
1238	9.4		.36		0			2.6	8.5	28			4.4	
1239	10.1		.27		0			18.0	9.0	23			2.9	
1240	8.8		.41		0			21.2	10.0	25			3.6	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg			WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →					→							
80-1237		1.7			12.2		13						.50
1238		1.4			22.6		27						1.40
1239		1.6			156		175						2.78
1240		18.5			174		57						.51

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No 4 (4.7 mm.)	No. 10 (2.0 mm.)	No 40 (0.42 mm.)	No 60 (0.25 mm.)	No 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	UNIFIED
80-1237						100	94	85	39					21	NP	0	A-4 (1)	ML
1238	-		-		-	-	-	-	-		-		-				-	-
1239						100	81	65	40					NP	NP	NP	A-4 (0)	ML
1240	-		-		-	-	-	-	-		-		-				-	-

(1) Calculated on basis of 2mm material
(2) 5-inch (6cm. 12 inch mold)
(3) Fractions calculated on basis of [illegible]

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SOIL ANALYSIS REPORT BUNDERSON 04

Date: September 5, 1980

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	04												
80-1260		0-4						37.3	39	17	44	0	L
1261		4-14						31.1	33	22	45	0	L
1262		14-43						23.2	27	23	50	0	SCL
1263		43-62						23.1	42	22	36	0	L

LABORATORY NUMBER	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1260	8.3		.74		0		19.2	14.0	36			6.5	
1261	8.5		.48		2.4		36.0	14.5	38			7.9	
1262	8.6		.49		2.8		61.6	16.0	46			9.7	
1263	8.6		.43		1.3		68.0	16.5	41			8.6	

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg	WATER SOLUBLE Na	SAR	BASE SATURATION %	DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	MOIST-DENS. (2) OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →								
80-1260		15.6	161	58					1.36
1261		56.6	343	64					.58
1262		180	435	46					.43
1263		214	543	53					.39

LABORATORY NUMBER	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1260						100	99	99	80					19	NP	0	A-4 (8)	ML
1261							100	99	80					21	17	4	A-4 (8)	CL-ML
1262						100	99	98	89					23	16	7	A-4 (8)	CL-ML
1263								100	91					22	17	5	A-4 (8)	CL-ML

(1) Calculated on basis of 2mm material
(2) 5.6 lb item, 12 inch drop
(3) Fractions calculated on basis of original sample

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Date: September 5, 1980

_ ANALYSIS REPORT CASTLE VALLEY 35

ORATORY UMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	35												
80-1277		0-4						30.0	17	7	76	0	SL
1278		4-10						13.5	18	17	65	0	SL
1279		10-12						9.0	19	10	71	0	SL

	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %		TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1277	8.7		.51		0			1.8	4.5	25			2.6	
1278	8.1		.80		0			1.3	3.5	25			5.4	
1279	8.1		.63		.3			5.0	5.0	28			2.9	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg				WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →													
80-1277		2.6				13.9		12						.43
1278		3.8				9.1		6.6						.17
1279		36.2				33.0		7.8						.84

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1277						100	89	73	63					NP	NP	0	A-4 (6)	ML
1278						100	83	56	32					18	NP	NP	A-2-4(0)	ML
1279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -	- -

(1) Calculated on basis of <2mm material
(2) 5.6 lb. Ham. 12 inch drop
(3) Fractions calculated on basis of original sample

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SOIL ANALYSIS REPORT CHIPETA 01

Date: September 5, 1980

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
80-1254	01	0-3						9.2	49	30	21	50	CL
1255		3-11						4.0	45	44	11	0	SiC
1256		11-19		-	-	-	missing	-	-	-	-	-	-

LABORATORY NUMBER	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %		TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1254	7.7		.63		2.5			4.3	4.5	44			12.5	
1255	8.4		.61		2.4			17.0	12.0	107			16.4	
1256	-	-	-		-	-		-	-	-		-	-	-

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca / Mg				WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →													
80-1254		30.8				24.8		6.3						
1255		26.0				178		49						.78
1256		-	-	-		-	-		-	-			-	.74 -

LABORATORY NUMBER	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	UNIFIED
80-1254	-		-		-		-		-		-		-				-	-
1255						100	98	97	95					43	21	22	A-7-6 (14)	CL
1256	-		-		-		-		missing		-		-				-	-

(1) Calculated on basis of <2mm. material
(2) 5 lb. Hamm 12 inch drop
(3) Fractions calculated on basis of original sample

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Date: September 5, 1980

L ANALYSIS REPORT DISTURBED LAND 03

ORATORY UMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
80-1280	03	11-53						59.0	23	8	69	0	SL
1281		53-65						65.0	26	7	67	0	SL

	pH		ORGANIC MATTER				ELECTRICAL CONDUCTIVITY		MOISTURE TENSIONS				
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	MILLIMHOS PER CM @25°C	CaCO3 equivalent %	SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1280	7.9		.34		.4		4.5	11.5	34			2.8	
1281	7.7		.36		.5		4.4	11.0	36			2.6	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg				WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	MOIST-DENS. (2) OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →													
80-1280		22.3				30.4		9.1						.33
1281		46.8				9.1		1.9						.28

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1280	-		-		-		100	99	52		-		-	NP	NP	NP	A-4 (3)	ML
1281							-		-						-		-	-

(1) Calculated on basis of 2mm material
(2) 6.6 lb Item, 12 Inch drop
(3) Fractions calculated on basis of original sample

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SOIL ANALYSIS REPORT FERRON 19

Date: September 15, 1980

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
80-1231	19	0-4						37.2	26	21	53	0	SCL
1232		4-15						37.0	23	18	59	0	SL
1233		15-35						17.7	38	24	38	0	L

	pH		ORGANIC MATTER				ELECTRICAL CONDUCTIVITY		MOISTURE TENSIONS				
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	MILLIMHOS PER CM @25°C	$CaCO_3$ equivalent %	SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1231	7.9		.92		.3		3.0	12.5	44			7.8	
1232	8.0		.62		.3		2.6	13.0	34			6.7	
1233	7.9		.47		.3		4.2	15.5	38			8.9	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg				WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →						→							
80-1231		26.9				8.7		2.4						.38
1232		21.2				10.4		3.2						.32
1233		33.0				21.7		5.3						.36

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN												LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
	1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.					
80-1231						100	98	96	64					23	19	4	A-4 (6)	CL - ML
1232						100	98	95	58					19	NP	NP	A-4 (5)	ML
1233	-		-		-	-	-	-	-		-		-	-	-	-	-	-

(1) Calculated on basis of 2mm material
(2) S.D. to pass 3/4 inch sieve
(3) Fractions calculated on basis of original sample

TAH STATE UNIVERSITY

ils Laboratory

ian, Utah

Project: Walsh/Southard

Agency:

L ANALYSIS REPORT G P SERIES 06

Date: September 5, 1980

ORATORY UMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS	
	06													
80-1286		0-6						24.0	Gypsum			0		
1287		6-28						28.1	Gypsum			0		
1288		28-60						21.0	Gypsum			0		

	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %		TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1286	7.8		.53		14.1			3.2	13.0	37			11.7	
1287	8.7		.39		17.2			19.4	12.0	49			15.1	
1288	8.3		.18		10.9			19.0	12.5	38			12.7	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca / Mg			WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →												
80-1286		36.6			8.3		1.9						.52
1287		86.0			135		21						4.9
1288		82.0			113		18						5.3

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	UNIFIED
80-1286						100	98	93	65					28	NP	NP	A-4 (6)	ML
1287						100	95	88	47					35	32	3	A-4 (2)	ML
1288						100	82	69	44					27	NP	NP	A-4 (2)	ML

(1) Calculated on basis of 2mm material
(2) S.S.B. Item, 12 inch sieve
(3) Fractions calculated on basis of original sample

ITAH STATE UNIVERSITY

oils Laboratory

ogan, Utah

Project: Walsh/Southard

Agency:

Date: September 5, 1980

OIL ANALYSIS REPORT HARDING VARIANT 08

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	08												
80-1241		0-3						41.3	27	11	62	0	SL
1242		3-10						29.8	26	28	46	0	SCL
1243		10-24						16.8	25	27	48	39	SCL
1244		24-43						28.1	25	13	62	68	SL
1245		43-57						44.3	14	7	79	0	LS

	pH		ORGANIC MATTER				TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %									
80-1241	8.6	.52			0			3.0	10.5	27			3.5	
1242	8.5	.67			0			11.6	9.5	56			12.1	
1243	8.4	-			1.2			96.0	40.5	35			8.0	
1244	8.7	.40			1.9			122.0	26.5	29			4.0	
1245	8.2	.13			.2			16.2	12.0	28			1.6	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg			WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →												
80-1241		2.5			28.6		26						.52
1242		6.8			113		61						1.62
1243		180			700		74						2.12
1244		288			848		71						4.50
1245		84.2			84.8		13						2.41

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	UNIFIED
80-1241						100	95	90	57					NP	NP	NP	A-4 (4)	ML
1242						100	97	94	72					36	17	11	A-4 (7)	CL
1243	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1244	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-
1245	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-

(1) Calculated on basis of -2mm material
(2) 5.6 lb. rammer, 12 inch drop
(3) Fractions calculated on basis of original sample

UTAH STATE UNIVERSITY

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Project: Walsh/Southard

Agency:

HUNTING (non-saline phase)

SOIL ANALYSIS REPORT 10

Date: September 5, 1980

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
80-1234	10	0-5						24.0	39	23	38	0	L
1235		5-13						31.7	41	22	37	0	L
1236		13-45						52.7	25	15	60	0	SL

LABORATORY NUMBER	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1234	7.9		1.17		0		1.0	12.5	46			9.6	
1235	8.0		.77		0		1.0	14.0	40			8.4	
1236	7.9		.43		.3		2.8	10.0	32			5.4	

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Water-soluble Cations MILLIEQUIVALENTS PER liter Ca + Mg	WATER SOLUBLE Na	SAR	BASE SATURATION %	DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	MOIST-DENS. (2) OPT. MOIST. %	Boron ppm
80-1234		7.0	3.1	1.7					.32
1235		7.3	3.7	1.9					.47
1236		21.0	13.0	4.0					.36

LABORATORY NUMBER	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1234	-		-		-		-		-		-		-		-		-	-
1235						100	99	99	81					25	18	7	A-4 (8)	CL - ML
1236						100	99	98	63					20	NP	NP	A-4 (5)	ML

(1) Calculated on basis of <2mm material
(2) Soil to form 12 inch strip
(3) Fractions calculated on basis of original sample

UTAH STATE UNIVERSITY

Soils Laboratory

Logan, Utah

Project: Walsh/Southard

Agency:

Date: September 5, 1980

SOIL ANALYSIS REPORT ILDEFONSO 07

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	07												
80-1246		0-6						39.7	23	16	61	0	SL
1247		6-19						29.4	25	26	49	0	SCL
1248		19-33						25.7	21	19	60	43	SL
1249		33-51						26.4	23	16	61	56	SL
1250		51-60						25.8	19	13	68	60	SL

	pH		ORGANIC MATTER				ELECTRICAL CONDUCTIVITY		MOISTURE TENSIONS				
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1246	8.4		.70		0		3.8	8.0	30			5.6	
1247	8.1		.70		0		3.6	5.0	42			9.4	
1248	7.9		.61		1.8		7.6	46.0	37			8.5	
1249	8.5		.41		0		2.6	37.0	25			4.2	
1250	7.8		.36		.4		3.2	29.5	30			3.7	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg			WATER SOLUBLE Na		SAR	BASE SATURATION %		DRY BULK DENS. g/cc	MOIST-DENS (2) MAX. DRY DENS. pcf	MOIST-DENS (2) OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →												
80-1246		7.3			30.4		16						.62
1247		10.0			26.1		12						.83
1248		46.0			56.1		12						4.70
1249		4.1			15.2		11						1.03
1250		41.5			4.5		1.0						2.37

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN													LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
	1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.					
80-1246						100	95	89	53					NP	NP	NP	A-4 (4)	ML
1247						100	97	92	64					25	17	8	A-4 (6)	CL
1248	87	77	71	68	65	57	48	42	22					NP	NP	NP	A-1-b (0)	SM
1249	-		-		-		-		-		-		-		-		- -	- -
1250	-		-		-		-		-		-		-		-		- -	- -

(1) Calculated on basis of <2mm material
(2) 6.6 lb. from 12 inch drop
(3) Fractions calculated on basis of original sample

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Project: Walsh/Southard

Agency:

OIL ANALYSIS REPORT 11 LIBBINGS Date: September 5, 1980

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	11											
80-1269		0-4					32.9	32	22	46	0	L
1270		4-24					26.4	41	24	35	0	L
1271		24-39					24.0	42	24	34	0	L
1272		39-50			Insufficient Sample			41	26	33	0	L

LABORATORY NUMBER	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 equivalent %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1269	8.6		.80		2.3		55.0	13.5	42			5.4	
1270	8.2		.41		1.0		10.0	18.0	42			9.1	
1271	8.1		.40		4.4		14.4	18.0	41			9.6	
1272	8.0		.50		1.7		11.0	15.5	43			7.1	

LABORATORY NUMBER	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca + Mg	WATER SOLUBLE Na	SAR	BASE SATURATION %	DRY-BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	MILLIEQUIVALENTS PER liter								
80-1269		264	409	36					11.1
1270		82.9	62.6	9.7					1.43
1271		84.9	81.7	13					.93
1272		70.1	69.6	12					.50

LABORATORY NUMBER	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1269	-		-		-	-	-	-	-					-	-	-	-	-
1270						100	99	99	89					25	24	1	A-4 (8)	ML
1271	-		-		-	-	-	-	-					-	-	-	-	-
1272						100	99	98	85					29	17	12	A-4 (8)	CL

(1) Calculated on basis of <2mm material
(2) S.G. in from 1/2 inch sieve
(3) Fractions calculated on basis of original sample

TAH STATE UNIVERSITY

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Project: Walsh/Southard

Agency:

Date: September 5, 1980

IL ANALYSIS REPORT 24 PALISADE

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES	PARTICLE SIZE DISTRIBUTION (In mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	24											
80-1289		0-4					49.1	17	9	74	0	SL
1290		4-9					47.0	22	15	63	0	SL
1291		9-19					40.3	44	18	38	0	L
1292		19-32					42.2	26	16	58	0	SL
1293		32-42					47.1	21	19	60	0	SL
1294		42-60					44.1	56	17	56	0	SL

	pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC CARBON %	ORGANIC MATTER NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	MOISTURE TENSIONS SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1289	8.0		.50		0		.8	3.5	27			3.1	
1290	7.9		.45		0		.3	7.0	32			5.5	
1291	8.0		.67		0		.6	7.0	37			7.3	
1292	8.3		.52		0		.9	9.0	34			6.7	
1293	8.5		.27		0		3.3	11.0	34			6.2	
1294	8.0		.47		.8		9.9	5.0	34			6.6	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca / Mg	WATER SOLUBLE Na	SAR	BASE SATURATION %	DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	MOIST-DENS. (2) OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →								
80-1289		6.4	2.3	1.3					< .1
1290		2.8	.6	.5					< .1
1291		5.0	1.1	.7					< .1
1292		3.7	5.2	3.8					< .1
1293		13.0	20.9	8.2					1.60
1294		97.5	35.2	5.0					2.05

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	CLASSIFICATION UNIFIED
80-1289	-		-		-		-		-		-		-		-		-	-
1290						100	98	95	54					19	NP	NP	A-4 (4)	ML
1291	-		-		-		-		-		-		-		-		-	-
1292						100	99	97	67					22	NP	NP	A-4 (6)	ML
1293	-		-		-		-		-		-		-		-		-	-
1294	-		-		-		-		-		-		-		-		-	-

(1) Calculated on basis of <2mm material
(2) 5.6 lb. ram, 12 inch drop
(3) Fractions calculated on basis of original sample

TAH STATE UNIVERSITY

ɔils Laboratory

ɔgan, Utah

Project: Walsh/Southard

Agency:

Date: September 5, 1980

OIL ANALYSIS REPORT PERSAYO 20

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	20												
80-1251		0-4						26.4	30	16	54	0	SL
1252		4-11					Insufficient Sample		38	27	35	0	L
1253		11+						3.4	53	34	13	47	SiCL

	pH		ORGANIC MATTER				TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY MILLIMHOS PER CM @25°C	CaCO3 equivalent %	MOISTURE TENSIONS				
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %					SATU-RATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1251	8.0		.49		0			.6	14.0	27			4.9	
1252	8.1		.51		0			.5	16.5	33			8.6	
1253	7.8		.86		3.7			2.8	16.5	44			10.6	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca	Mg	WATER SOLUBLE Na	SAR	BASE SATU-RATION %	DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →									
80-1251		4.9		1.5	1.0					.44
1252		3.0		1.8	1.5					.42
1253		33.6		4.1	1.0					.62

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 4 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	UNIFIED
80-1251						100	99	97	63					17	NP	NP	A-4 (6)	ML
1252						100	99	98	80					22	15	7	A-4 (8)	CL-ML
1253				100	93	53	52	51	50					35	22	13	A-6 (4)	SC

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Project: Walsh/Southard

Agency:

OIL ANALYSIS REPORT 02 RAVOLA

Date: September 5, 1980

LABORATORY NUMBER	COLLECTORS NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	02												
80-1264		0-3						38.0	38*	17	45	0	L
1265		3-15						36.4	36	20	44	0	L
1266		15-30						20.0	27	27	46	55	SCL
1267		30-50						27.0	33	24	43	0	L
1268		50-71						27.6	39	22	39	0	L

	pH		ORGANIC MATTER				ELECTRICAL CONDUCTIVITY		MOISTURE TENSIONS				
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	MILLIMHOS PER CM @25°C	$CaCO_3$ EQUIVALENT %	SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1264	7.7		.32		0		1.6	16.0	30			5.0	
1265	7.7		.51		.7		3.5	16.5	35			6.6	
1266	8.1		.51		6.5		8.7	14.0	39			9.5	
1267	8.0		.42		4.6		14.4	15.5	36			7.5	
1268	8.4		.36		3.3		19.5	16.0	36			7.9	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca++ Mg				WATER SOLUBLE Na		SAR	BASE SATURATION %		MOIST. DENS. (2) DRY BULK DENS. g/cc	MAX. DRY DENS. pcf	OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →													
80-1264		16.4				2.1		.7						.46
1265		45.5				4.8		1.0						1.11
1266		66.0				54.3		9.5						1.27
1267		76.3				73.0		12						.90
1268		88.5				124		19						.89

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN 1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION AASHO	UNIFIED
80-1264								100	87					NP	NP	NP	A-4 (8)	ML
1265							100	98	82					21	19	2	A-4 (8)	ML
1266	100	98	93	83	68	45	39	36	28					28	14	14	A-2-6 (0)	SC
1267						100	94	93	78					23	19	4	A-4 (8)	CL-ML
1268	-		-		-	-	-	-	-		-		-	-	-	-	-	-

(1) Calculated on basis of 2mm material
(2) 5.5 lb. Hamm. 12 inch drop
(3) Fractions calculated on basis of original sample

TAH STATE UNIVERSITY

oils Laboratory

ogan, Utah

Project: Walsh/Southard

Agency:

OIL ANALYSIS REPORT Sh SERIES 14

Date: September 5, 1980

LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN INCHES		PARTICLE SIZE DISTRIBUTION (in mm.) (percent) (1) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY <0.002	SAND <2 mm %	% >2 mm.	TEXTURAL CLASS
	14												
80-1257		0-3						35.7	30	18	52	0	SL
1258		3-17						6.0	32	30	38	0	CL
1259		17-29						11.7	42	37	21	0	CL

	pH		ORGANIC MATTER				ELECTRICAL CONDUCTIVITY		MOISTURE TENSIONS				
	SATURATED PASTE	1:5	ORGANIC CARBON %	NITROGEN %	GYPSUM %	TOTAL SOLUBLE SALTS %	MILLIMHOS PER CM @25°C	CaCO3 EQUIVALENT %	SATURATION %	1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %	AIR DRY %
80-1257	8.1		.66		0		1.2	13.0	31			5.8	
1258	8.0		.52		.5		8.3	29.5	49			8.9	
1259	8.0		.49		.2		6.7	17.5	75			12.0	

	CATION EXCHANGE CAPACITY	Water-soluble Cations Ca / Mg	WATER SOLUBLE Na	SAR	BASE SATURATION %	DRY BULK DENS. g/cc	MOIST-DENS. (2) MAX. DRY DENS. pcf	MOIST-DENS. (2) OPT. MOIST. %	Boron ppm
	← MILLIEQUIVALENTS PER liter →								
80-1257		3.8	7.8	5.7					.60
1258		31.9	61.7	16					.95
1259		26.2	50.4	11					1.02

	MECHANICAL ANALYSIS (ENGINEERING)[3] PERCENTAGE SMALLER THAN												LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	CLASSIFICATION	
	1 1/2 in.	1 in.	3/4 in.	3/8 in.	No. 4 (4.9 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				AASHO	UNIFIED
80-1257	-		-		-	-	-	-	-		-		-		-	-	- -	-
1258						100	72	68	63					27	15	12	A-6 (7)	CL
1259						-	100	99	90					34	17	17	A-6 (11)	CL

(1) Calculated on basis of -2mm material
(2) Soils Lab. 1.2 inch mold
(3) Fractions calculated on basis of original sample

BOTANICAL LIST

alkali sacaton	*Sporobolus airoides*
alkali bluegrass	*Poa juncifolia*
basin wildrye	*Elymus spp.*
big blue bunchgrass	*Poa spp.*
big sage	*Artemesia tridentata*
cactus	*Cactaceae*
four wing saltbush	*Atriplex canescens*
galleta grass	*Hilaria jamesii*
greasewood	*Sarcobatus spp.*
halogeton	*Halogeton spp.*
Indian ricegrass	*Oryzopis hymenoides*
juniper	*Juniperus osteosperma*
mat saltbush	*Atriplex spp.*
pinon pine	*Pinus edulis*
rabbit brush	*Chrysothamnus spp.*
redtop grass	*Agrostis alba*
rushes	*Juncus spp.*
saltgrass	*Distichlis spp.*
Salina wildrye	*Elymus salinus*
sedge	*Carex spp.*
shadscale	*Atriplex confertifolia*
tamarisk (salt cedar)	*Tamarix spp.*
tufted hairgrass	*Deschampsia caepitosa*
wiregass	*Juncus spp.*

GLOSSARY OF TERMS

alkali soil--Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is severely restricted.

Alluvial fans--Alluvium deposited in fan- or cone-shaped deposits at the base of mountains.

Alluvium--Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

amendment, soil--Any substance added to the soil which alters soil properties. Examples are gypsum, lime, fertilizers, sawdust, etc.

Aquents--Entisols that are saturated with water for periods long enough to limit their use for most crops other than pasture unless they are artificially drained. Aquents have low chromas or distinct mottles within 50 cm of the surface, or are saturated with water at all times. (A suborder in the USDA soil taxonomy.)

Aquepts--Inceptisol that are saturated with water for periods long enough to limit their use for most crops other than pasture or woodland unless they are artificially drained. Aquepts have either a histic or umbric epipedon and gray colors within 50 cm, or an ochric epipedon underlain by a cambic horizon with gray colors, or have sodium saturation of 15% or more. (A suborder in the USDA soil taxonomy.)

aquic--A mostly reducing soil moisture regime nearly free of dissolved oxygen due to saturation by ground water or its capillary fringe and occurring at periods when the soil temperature at 50 cm is above 5 C.

Argids--Aridisols that have an argillic or natric horizon. (A suborder in the USDA soil taxonomy.)

argillic horizon--A mineral soil horizon that is characterized by the illuvial accumulation of layer-lattice silicate clays. The argillic horizon has a certain minimum thickness depending on the thickness of the solum, a minimum quantity of clay in comparison with an overlying eluvial horizon depending on the clay content of the eluvial horizon, and usually has coatings of oriented clay on the surface pores or peds or bridging sand grains.

aridic--A soil moisture regime that has no moisture available for plants for more than half the cumulative time that the soil temperature at 50 cm is above 5 C and has no period as long as 90 consecutive days when there is moisture for plants while the soil temperature at 50 cm is continuously above 8 C.

Aridisols--Mineral soils that have an ardic moisture regime, an ochric epipedon, and other pedogenic horizons but no oxic horizon. (A suborder in the USDA soil taxonomy.)

association, soil--(i) A group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region, comparable to plant associations in many ways. (ii) A mapping unit used on general soil maps, in which two or more defined taxonomic units occurring together in a characteristic pattern are combined because the scale of the map or the purpose for which it is being made does not require delineation of the individual soils.

available water--The portion of water in a soil that can be absorbed by plant roots. The amount of water released by the soil when the equilibrium soil water matrix potential is decreased from field capacity to -15 bar.

bedrock--The solid rock underlying soils and the regolith in depths ranging from zero (where exposed by erosion) to several hundred feet.

calcareous soil--Soil containing sufficient free calcium carbonate or calcium-magnesium carbonate to effervesce visibly when treated with cold 0.1N hydrochloric acid.

calcic horizon--A mineral soil horizon of secondary carbonate enrichment that is more than 15 cm thick, has a calcium carbonate equivalent of more than 15%, and has at least 15% more calcium carbonate equivalent than the underlying C horizon.

caliche--A layer near the surface, more or less cemented by secondary carbonates of calcium or magnesium precipitated from the soil solution.

cation--exchange capacity (CEC) --The sum total or exchangable cations that a soil can absorb. Express in milliequivalents per 100 grams.

chroma--The relative purity, strength, or saturation of a color; directly related to the dominance of the determining wavelength of the light and inversely related to grayness; on of the thrree variables of color. See Munsell color system, hue, and value color.

classification, soil--The systematic arrangement of soils into groups or categories on the basis of their characteristics. USDA soil classification system (soil taxonomy) was adopted for use in publications by the National Cooperative Soil Survey.

clay--(i) A soil separate consisting of particles < 0.002 mm in equivalent diameter. (ii) A textural class; 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

clayey--Containing large amounts of clay or having properties similar to those of clay.

clay films--Coatings of clay on the surfaces of soil peds and mineral grains and in soil pores. (Also called clay skins, clay flows, illuviation cutans, argillans or tonhautchen.)

coarse fragments--Rock or mineral particles > 2.0 mm in diameter.

cobble--Rounded or partially rounded rock or mineral fragments between 8 and 25 cm in diameter. See coarse fragments.

compaction--Increasing soil bulk density and decreasing porosity due to the application of mechanical forces to the soil. Firming is a process of achieving a desirable degree of compaction.

consistency--(i) The resistance of a material to deformation or rupture. (ii) The degree of cohesion or adhesion of the soil mass. Terms used for describing consistency at various soil moisture contents are:

WET SOIL - nonsticky, slightly sticky, sticky, very sticky, nonplastic, slightly plastic, plastic, and very plastic.

MOIST SOIL - loose, very friable, friable, firm, very firm, and extremely firm.

DRY SOIL - loose, soft, slightly hard, hard, very hard, and extremely hard.

CEMENTATION - weakly cemented, strongly cemented, and indurated.

Depth, soil--The terms and their meanings used to describe depth of the soil over bedrock or over a restricting layer are: deep, more than 36 inches; moderately deep, 20 to 36 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Drainage, natural--The relative rapidity and extent of the removal of water from on and within the soil under natural conditions. Terms commonly used to describe drainage are:

Excessively drained - Water is removed from the soil rapidly. The soils are typically sandy and porous.

Well drained - Water is removed from the soil readily but no rapidly. There is no evidence of wetness above a depth of 40 inches.

Moderately well drained - Water is removed from the soil somewhat slowly so that the soil is wet for a short, but significant, periods of time.

Somewhat poorly drained - Water is removed from the soil slowly enough to keep it wet for significant periods but not all the time. Wetness is apparent between a depth of 20 and 40 inches.

Poorly drained - Water is removed from the soil so slowly that the water table is at or on the surface most of the time. Wetness is apparent within 20 inches of the surface.

Very poorly drained - Water is removed from the soil so slowly that the water table is at or on the surface most of the time. These soils are generally in low areas or depressions.

EC--The electrical conductivity of an extract from saturated soil, normally expressed in units of millimhos per centimeter at 25C.

Entisols--Mineral soils that have no distinct pedogenic horizons within 1 m or the soil surface. (An order in the USDA soil taxonomy.)

erodible--Susceptible to erosion. (Expressed by terms such as highly erodible, slightly erodible, etc.)

gully erosion - The erosion process whereby water accumulates in narrow channels and over short periods removes the soil from this narrow area to considerable depths, ranging from 0.56 meter to as much as 25 to 30 meters.

rill erosion - An erosion process in which numerous small channels of only several centimeters in depth are formed; occurs mainly on recently cultivated soils. See rill.

sheet erosion - The removal of soil from the land surface by rainfall and surface runoff. Often interpreted to include rill and interrill erosion.

family soil--The status of a soil with respect to its ability to supply the nutrients essential to plant growth.

fine texture--Consisting of or containing large quantities of the fine fractions, particularly of silt and clay. (Includes all clay loams and clays; that is, clay loam, sandy clay loam, silty clay loam, sandy clay, sitly clay, and clay textural classes.)

firm--A term describing the consistency of a moist soil that offers distinctly noticeable resistance to crushing but can be crushed with moderate pressure between thumb and fore-finger. See consistency.

Flood plain--Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Fluvents--Entisols that form in recent loam or clayey alluvial deposits, are usually stratified, and have an organic carbon content that decreases irregularly with depth. Fluvents are not saturated with water for periods long enough to limit their use for most crops. (A Suborder in the USDA soil taxonomy.)

friable--A consistency term pertaining to the ease of crumbling of soils. See consistency.

frigid--A soil temperature regime that has mean annual soil temperatures of more that 0 C but less than 8 C, more than 5 C difference between mean summer and mean winter soil temperatures at 50 cm, and warm summer temperatures. Insofrigid is the same except the summer and winter temperatures differ by less than 5 C.

Gravelly soil--A soil in which 20 to 50 percent of material by volume, consists of fragments between 2mm (1/8 in) and 3 inches in diameter. A very gravelly soil is one in which 50 to 90 percent material by volume is coarse fragmens the size of gravel.

ground water--That portion of the water below the surface of the ground whose pressure is greated than atmospheric.

gully--A channel resulting from erosion and caused by the cencentrated but intermittent flow of water usually during and immediately following heavy rains. Deep enough to interfere with and not to be obliterated by, normal tillage operations.

gypic horizon--A mineral soil horizon of secondary calcium sulfate enrichment that is more than 15 cm thick, has at least 5% more gypsum than the C horizon, and in which the product of the thickness in centimeters and the percent calcium sulfate is equal to or greater than 150% cm.

halophytic vegetation--Vegetation requiring or tolerating a saline environment.

Horizon, soil--A layer of soil, approximately parallel to the surface, that has distinct characterisitics produces by soil-forming processes.

Hydrologic Soil Groups--The hydrologic soil groups are used to estimate runoff from rainfall. Soil properties which are considered are those that influence the rate of infiltration obtained from a bare soil after prolonged wetting. Soil properties considered are: (1) depth of seasonally high water table, (2) intake rate and permeability after prolonged wetting, (3) depth to very slowly permeable layer. The soils have been classified into four groups, A through D. Group A soils have low runoff potential; group B soils have moderately low runoff potential; group C soils have moderately high runoff potential; and group D soils have high runoff potential.

hue--One of the three variables of color. It is caused by light of certain wavelengths and changes with wavelength.

illuvial horizon--A soil layer or horizon in which material carried from an overlying layer has been precipitated from solution or deposited from suspension. The layer of accumulation.

Inceptisols--Mineral soils that have one or more pedgenic horizons in which mineral materials other than carbonates or amorphous silica have been altered or removed but not accumulated to a significant degree. Under certain conditions, Inceptisols may have an ochric, umbric, histic, plaggen or molic epipedon. Water is availabel to plants more than half of the year or more than 3 consecutive months during a warm season. (An order in the USDA soil taxonomy.)

irrigation--The artificial application of water to the soil for the benefit of growing crops.

land classification--The arrangement of land units into various categories based upon the properties of the land or its suitability for some particular purpose.

liquid limit--The minimum percentage (by weight) of moisture at which a small sample of soil will barely flow under a standard treatment. Synonymous with "upper plastic limit".

lithic contact--A boundary between soil and continuous coherent, underlying material. The underlying material must be sufficiently coherent to make hand digging with a spade impractical. If mineral, it must have a hardness of 3 or more (Mohs scale), and gravel size chunks that can be broken out do not disperse with 15 hours shaking in water or sodium hexametphosphate solution.

loamy--Intermediate in texture and properties between fine-textured and coarse-textured soail. Includes all textural classes with the words "loam" or "loamy" as part of the class name, such as clay loam or loamy sand. See loam and soil texture.

medium texture--Intermediate between fine-textured and coarse-textured (soils). (It includes the following textural classes: very fine sandy loam, loam, silt loam, and silt.)

mesic--A soil temperature regime that has mean annual soil temperatures of 8 C or more but less than 15 C, and more than 5 C difference between mean summer and mean winter soil temperatures at 50 cm. Isomesic is the same except the summer and winter temperatures differ by less than 5 C.

miscellaneous land type--A mapping unit for areas of land that have little or no natural soil, that are too nearly inaccessible for orderly examination, or that for any reason is is not feasible to classify the soil. Also badland, mine land, river wash, rough broken land, rubble land, scoria land, slickens, stony land, swamp, urban land, and disturbed land.

moderately-coarse texture--Consisting predominantly of coarse particles (in soil textural classification, in includes all the sandy loams except the very fine sandy loam.) See coarse texture.

moderately-fine texture--Consisting predominantly of intermediate-size (soil) particles or with relatively small amounts of fine or coarse particles. (In soil textural classification, it includes clay loam, sandy clay loam, and silty clay loam.)

moisture tension (or pressure)--The equivalent negative pressure in the soil water. It is equal to the equivalent pressure that must be applied to the soil water to bring it the hydraulic equilibrium, through a porous permeable wall or membrane, with a pool of water of the same composition.

montmorillonite--An aluminosilicate clay mineral with a 2:1 expansible layer structure; that is, with two silicon tetrahedral sheets enclosing an aluminum octahedral sheet. Considerable expansion may be caused along the C-axis by water moving between silical layers of contiguous units.

mottling, soil--Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage.

Munsell color system--A color designation system that specifies the relative degress of the three simple variable of color: hue, value, and chroma. For example: 10YR 6/4 is a color (of soil) with a hue = 10YR, value = 6, and chroma = 4. These notations can be translated into several different systems of color names as desired. See chroma, hue, and value, color.

natric horizon--A mineral soil horizon that satisfied the requirements of an argillic horizon, but that also has prismatic, columnar, or block structure and a subhorizon having more than 15% saturation with exchaneable sodium.

Orthents--Entisols that have either textures of very fine sand or finer in the earth fraction, or textures of loamy fine sand or coarser and a coarse fragment content of 35% or more and that have an organic carbon content that decreases regularly with depths. Orthents are not saturated with water for periods long enough to limit their use for most crops. (A suborder in the USDA soil taxonomy.)

paralithic contact--Similar to a lithic contact except that the minerat material below the contact has a hardness of less than 3 (Mohs scale), and gravel size chunks that can be broken out will partially disperse within 15 hours shaking in water or sodium hexametaphosphate solution.

parent material--The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of soils is developed by pedogenic processes.

particle size--The effective diameter of a particle measured by sedimentation, sieving or micrometric methods.

particle size analysis--Determination of the various amounts of the different separates in a soil sample, usually by sedimentation, sieving, micrometry, or combintions of these methods.

particle size distribution--The amounts of the various soil separates in a soil sample, usually expressed as weight percentages.

pedon--A three dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations. Its area ranges from 1 to 10 square meters. When horizons are intermittent or cyclic, and recur at linear intervals of 2 to 7 m, the pedon includes one-half of the cycle. Where the cycle is less than 2 m, or all horizons are continuous and of uniform thickness, the pedon has an area of approximately 1 square meter. If the horizons are cyclic, but recur at intervals greater than 7 m, the pedon reverts to the 1 square meter size, and more than one soil will usually be represented in each cycle.

reaction, soil--The degree of acidity or alkalinity of a soil, usually expressed as a pH value. Descriptive terms commonly associated with certain ranges in pH are: extremely acid, < 4.5; very strongly acid, 4.5-5.0; strongly acid, 5.1-5.5; moderately acid, 5.6-6.0; slightly acid, 6.1-6.5; neutral, 6.6-7.3; slightly alkaline, 7.4-7.8; moderately alkaline, 7.9-8.4; strongly alkaline, 8.5-9.0; and very strongly alkaline, > 9.1.

rill--A small intermittent water course with steep sides; usually only a few inches deep and, hence, no obstacle to tillage operations.

rock land--Areas containing frequent rock outcrops and shallow soils. Rock outcrops usually occupy from 25 to 90% of the area. A miscellaneous land type.

runoff--The rate that water flows from the land surface. Relative terms used to describe runoff are very rapid, rapid, medium, slow, very slow, and ponded.

salic horizon--A mineral soil horizon of enrichment with secondary salts more soluble in cold water than gypsum. A salic horizon is 15 cm or more in thickness, contains at least 2% salt, and the product of the thickness in centimeters and percent salt by weight is 60 cm or more.

saline-alkali soil--(i) A soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants and containing appreciable quantities of soluble salts. The exchangeable sodium percentage is >15, the conductivity of the saturation extract is >4 milliamhos/cm (at 25° C), and the pH is usually 8.5 or less in the saturated soil. (ii) A saline-alkali soil has a combination of harmful quantities of salts and either a high alkalinity or high content of exchangeable sodium, or both, so distributed in the profile that the growth of most crop plants is reduced.

saline-sodic soil--A soil containing a combination of soluble salts and exchangeable sodim sufficient to interfere with the growth of most crop plants. The electrical conductivity and sodium-adsorption ratios of the saturation extract are > 15, respectively. The pH is usually 8.5 or less in the saturated soil paste.

saline soil--A nonsodic soil containing sufficient soluble salt to impair its productivity. The electrical conductivity of the saturation extract is >2 mmhos per centimeter at 25° C.

sand--(i) A soil particle between 0.005 and 2.0 mm in diameter. (ii) Any one of five soil separates, namely: very coarse sand, coarse sand, medium sand, fine sand, and very fine sand. (iii) A soil textural class.

sedimentary rock--A rock formed from materials deposed from suspension or precipitated from solution and usually being more or less consolidated. The principal sedimentary rocks are sandstones, shales, limestones, and conglomerates.

silt--(i) A soil separate consisting of particles between 0.05 and 0.002 mm in equivalent diameter. (ii) A soil textural class.

silt loam--A soil textural class containing a large amount of silt and small quantities of sand and clay. See soil texture and class, soil.

silty clay--A soil textural class containing a relatively large amount of silt and clay and a small amount of sand. See soil texture and class, soil.

silty clay loam--A soil textural class containing a relatively large amount of silt, a lesser quantity of clay, and a still smaller quantity of sand. See class, soil and soil texture.

slick spots--Small areas in a field that are slick when wet, due to a high content of alkali or of exchangeable sodium.

Slope, soil--In this report, slope is expressed in general descriptive terms. Each term refers to the range of slope expressed in percent (number of feet of vertical rise or fill in 100 feet horizontal distance). Slope terms are given for both single and complex slopes as follows:

Simple Slopes	Complex Slopes	Percent Slope
Nearly flat		Less than 1 percent
Nearly level	Gently undulating	1 to 3 percent
Gently sloping	Undulating	3 to 8 percent
Sloping	Gently rolling	8 to 15 percent
Moderately steep	Rolling	15 to 30 percent
Steep		30 to 45 percent
Very stee;		45 percent plus

sodic soils--(i) A soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants. (ii) A soil in which the sodium-adsorption ratio of the saturation extract is 15 or more.

sodium-adsorption ration (SAR)--A relation between soluble sodium and soluble divalent cations which can be used to predict the exchangeable-sodium percentage of soil equilibrated with a given solution. It is defined as follows:

$$SAR = \frac{\text{sodium, mmoles/liter}}{(\text{calcium + magnesium})(\text{mmoles/liter})1/2}$$

soil--(i) The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. (ii) The unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of: parent material, climate (including moisture and temperature effects), macro- and microorganisms. amd topography, all acting over a period of time and producing a product--soil--that differs from the material from which it is derived in many physical, chemical, biological and morphological properties, and characteristics.

soil auger--A tool for boring into the soil and withdrawing a small sample for field or laboratory observation.

soil complex--A mapping unit used in detailed soil surveys where two or more defined taxonomic units are so intimately intermixed geographically that it is indesirable or impractical, because of the scale being used, to separate them. A more intimate mixing of smaller areas of individual taxonomic units than that described under soil association.

soil-formation factors--The variable, usually interrelated natural agencies that are active in and responsible for the formation of soil. The factors are usually grouped into five major categories as follows: parent rock, climate, organisms, topography, and time.

soil horizon--A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical and biological properties or characteristics such as color, structure, texture, consistency, kinds and numbers or organisms present, degree of acidity or alkalinity, etc.

soil map--A map showing the distribution of soil types or other soil mapping units in relation to the prominent physical and cultural features of the earth's surface.

soil moisture--Water contained in the soil.

soil morphology--(i) The physical constitution, particularly the structural properties, or a soil profile as exhibited by the kinds, thickness, and arrangements of the horizons in the profiles, and by the texture, structure, consistency, and porosity or each horizon. (ii) The structural characteristics of the soil or any of its parts.

soil pores--The part of the bulk volume of soil not occupied by soil particles; interstices; voids.

soil series--The basic unit of soil classification being a subdivision of a family and consisting of soils which are essentially alike in all major profile characteristics except the texture of the A horizon.

soil separates--Mineral particles, < 2.0 mm in equivalent diameter, ranging between specifies size limits. The names and size limits of separates recognized in the United States are: very coarse sand, 2.0 to 1.0 mm; coarse sand, 2.0 to 1.0 mm; coarse sand, 1.0 to 0.5 mm; medium sand, 0.5 to 0.25 mm; fine sand, 0.25 to 0.10 mm; very fine sand, 0.10 to 0.05 mm; silt, 0.05 to 0.002 mm, and clay < 0.002 mm.

soil structure--The combination or arrangement or primary soil particles into secondary particles, units, or peds. These secondary units may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively. See soil structure classes, soil structure grades and soil structure types.

soil survey--The systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to the kind and intensity of field examination.

soil texture--The relative proportions of the various soil separates in a soil as described by the classes of soil texture. The textural classes may be modified by the addition of suitable adjective when coarse fragments are present in substantial amounts; for examply, "stony silt loam", or "silt loam, stony phase". The sand, loamy sand, and sandy loam are further subdivded on the basis of the proportions of the various sand separates present.

soil variant--A soil whose properties are believe to be sufficiently different from other know soils to justify a new series name but comprising such a limited geographic area that cretion of a new series is not justified.

stones--Rock fragments >10 inches in diameter if rounded, and >15 inches along the greater axis if flat. See coarse fragments.

stoniness--The relative proportion of stones in or on the soil. Used in classification of soils. See coarse fragments.

stony--Containing sufficient stones to interfere with or to prevent tillage. To be classified as stony, >0.1% of the surface of the soil must be covered with stones. Used to modify soil class, as stony clay loam or clay loam, stony phase. See coarse fragments.

stratified--Arranged in or composed of strata or layers.

surface soil--The uppermost part of the soil, ordinarily moved in tillage or its equivalent in uncultivated soils and ranging in depth from 3 or 4 inches to 8 or 10. Frequently designated as the "plow layer", the "Ap layer", or the "Ap horizon".

tilth--The physical condition of soil as related to its ease of tillage, fitness as a seedbed, and its impedence to seedling emergence and root penetration.

topsoil--(i) The layer of soil moved in cultivation. See surface soil. (ii) The A horizon. (iii) The A1 horizon, (iv) Presumably fertile soil material used to topdress roadbanks, gardens, and lawns.

torric--A soil moisture regime defined like aridic moisture regime but used in a different catgory of the soil taxonomy.

ustic--A soil moisture regime that is intermediate between the aridic and udic regimes and common in temperate subhumid or semiarid regions, or in tropical and subtropical regions with a monsoon climate. A limited amount of moisture is available for plants but occurs at times when the soil temperature is optimum for plant growth.

value, color--The relative lightness or intensity of color and approximately a function of the square root of the total amount of light. One of the three variables of color. See Munsell color system, hue, and chroma.

water table--The upper surface of ground water or that level in the ground where the water is at atmospheric pressure.

xeric--A soil moisture regime common to Mediterranean climates that have moist cool winters and warm dry summers. A limited amount of moisture is present but does not occur at optimum periods for plant growth. Irrigation or summer fallow is commonly necessary for crop production.

Soil Series Differentiae

Series	Soil Depth	Elevation Range (ft)	Occurrence	Depth to Bedrock or Paralithic Contact	Parent Material	Vegetation	Color Range	Alkalinity
Abbott	deep	6,000-6,075	alluvial fans and flood plains	> 60 in.	alluvium derived from shale	sedges, galleta grass, greasewood	2.5Y, 5Y to 10YR	fluxuating water table
Beebe	deep	5,930-5,965	alluvial fans and flood plains	> 60 in.	alluvium derived from sedimentary sandstone	greasewood, rabbitbrush, shadscale	10YR, 7.5YR to 2.5Y	strongly affected by alkali
Billings	deep	6,000-6,150	alluvial fans and narrow alluvial valleys	> 60 in.	alluvium washed from alkaline, gypsum-bearing, marine shale	greasewood, shadscale, Indian ricegrass	2.5Y to 5Y	calcareous, little horizonation
Bunderson	very deep	5,900-5,960	alluvial fans and bottomlands	> 60 in.	alluvium washed from alkaline, gypsum-bearing, marine shale and sandstone	greasewood and halogeton	2.5Y to 5Y	little range value, landscape may be hummocky
Castle Valley	shallow	5,950-6,350	upland benches, mesas and piedmont surfaces	9-20 in. fractured sandstone	interbedded sandstone and shale	pinon, juniper, galleta grass	10YR to 2.5YR	argillic horizon
Chipeta	shallow	5,900-6,100	broad fans, ridges and toeslopes	12-19 in. soft, weathered shale	residuum that weathered from alkaline, gypsum-bearing, marine shale	mat saltbush and shadscale	2.5Y to 5Y	not suited well for range
Ferron	very deep	5,800-6,075	low areas, alluvial fans, floodplains and bottoms of narrow valleys	> 60 in.	alluvium washed from sandstone and marine shale	sedges, salt grass, wiregrass, redtop grass	2.5Y to 5Y	fluxuating watertable
GP Series	deep	6,000-6,100	alluvial fans and mesa surfaces	> 60 in.	alluvium and glacial outwash material	greasewood, big sage, four-wing saltbush	2.5Y to 5Y	
Harding Variant	deep	6,000-6,100	benches, mesa tops	> 60 in.	alluvium washed from sedimentary rocks	greasewood, shadscale, rabbitbrush	10YR or 7.5YR	sodium affected

Soil Series Differentiae (continued)

Series	Soil Depth	Elevation Range (ft)	Occurrence	Depth to Bedrock or Paralithic Contact	Parent Material	Vegetation	Color Range	Alkalinity
Hunting	deep	6,000-6,100	alluvial fans, flood-plains and narrow alluvial valleys	> 60 in.	alluvium washed from marine shale and sandstone	greasewood, saltgrass, galleta grass	2.5Y or 5Y	mottles at 20-40 in., some moderately saline
Ildefonso	deep	5,975-6,125	fans, benches and ridge crests	> 60 in.	alluvium and gravelly alluvial sediments	greasewood, halogeton, shadscale	10YR to 2.5YR	gravelly
Killpack	moderately deep	6,000-6,150	fans and shale hills	29 in. soft, calcareous shale	residuum that weathered from clayey, marine shale	shadscale, big sage, galleta grass	10YR to 5Y	slightly to moderately saline
Libbings	moderately deep	6,000-6,150	alluvial fans and flats	30-50 in.	alluvium washed from shale	greasewood and saltgrass	10YR to 5Y	strongly saline, wet, fluxuating water table, salt crusts
Minchey	deep to very deep	6,100-6,180	benches and mesas	> 60 in.	glacial outwash from sandstone and quartzite	galleta grass, big sage, bluebunch, wheatgrass	7.5YR to 10YR	small stones
Palisade	deep to very deep	6,000-6,300	upland benches, mesas and piedmont surfaces	> 60 in.	alluvium and mixed glacial outwash material	big sage, shadscale, galleta and Indian ricegrasses	7.5YR to 10YR	Cecada casts are common and calcified
Penoyer	very deep	5,900-6,150	alluvial fans and flood plains	> 60 in.	alluvium from sandstone, limestone, and basic igneous rocks	sage, shadscale, Indian ricegrass, galleta grass	10YR to 2.5YR	strongly calcareous

Soil Series Differentiae (concluded)

Series	Soil Depth	Elevation Range (ft)	Occurrence	Depth to Bedrock or Paralithic Contact	Parent Material	Vegetation	Color Range	Alkalinity
Porsayo	shallow	5,900-6,200	broad fans, toeslopes and hills	10-20 in. soft, calcareous, weathered shale	residuum that weathered from shale	galleta grass and shadscale	2.5Y to 5Y	may be highly eroded
Rafael	deep	5,900-6,200	narrow alluvial valleys	> 60 in.	alluvium derived from marine shale	sedge, wiregrass, saltgrass, redtop grass	2.5Y, 5Y to 10YR	moderately to strongly saline, mottled throughout
Ravola	deep	5,900-6,150	alluvial fans and bottomlands	> 60 in.	alluvium washed from shale and sandstone	galleta grass, shadscale, greasewood	2.5Y, 5Y to 10YR	slight to moderately saline
Saltair	deep	5,900-5,975	alluvial fans, flood plains and narrow alluvial valleys	> 60 in.	alluvium washed from shale and sandstone	greasewood and saltbush	2.5Y to 5Y	strongly calcareous, very strongly saline, highly contrasting mottles, salt crusts are commo
Sanpete	very deep	5,900-6,150	mesa tops and benches	> 60 in.	glacial outwash derived from sandstone, quartzite and basalt	greasewood and saltbush	10YR, 5YR to 7.5YR	small stones
Sh Series	moderately deep	6,000-6,200	upland benches, mesas and piedmont surfaces	> 40 in.	sedimentary rocks	galleta grass and shadscale	2.5YR to 10YR	some layers may be red burned shales and sandstones
Woodrow	deep	5,900-6,150	alluvial fans, flood plains	> 60 in.	alluvium derived from mixed sedimentary rock	mixed, short grasses	10YR to 7.5YR	