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D7 SOILS

D7.1 Introduction

This section describes the soils of the Permit Area. The soil survey fieldwork, maps, and reports were completed by AATA in 2006 and 2007. Laboratory analysis was conducted by Energy Laboratories.

The Permit Area had not been previously surveyed for soil by the Natural Resources Conservation Service (NRCS) or Soil Conservation Service (SCS). Two empirical studies were conducted at the 1:100,000 and the 1:500,000 scales (Munn and Arneson, 1998). These studies do not provide sufficient level of details necessary for this application.

Prior to the start of field survey, AATA discussed the scope of the soil surveys with the WDEQ. A soil work plan was subsequently prepared, submitted and approved by the WDEQ. The soil work plan and correspondence with WDEQ is included in **Attachment D7-1**.

The objectives of this assessment were to:

- characterize baseline soil conditions and generate surface soil maps for the Lost Creek claim area;
- determine appropriate stripping depths for each of the identified soil units, based on their physical and chemical properties; and
- provide adequate topsoil fertility information for site reclamation.

Field survey data were digitized and incorporated in a Geographic Information System (GIS) database. Soil maps were created with ESRI ArcGIS 9.1.

D7.2 Methods

D7.2.1 Review of Existing Literature

The Sweetwater County soils have been described at the 1:500,000 and the 1:100,000 scales by Munn and Arneson (1998). Both data sets were established based on a simplified five-factor soil formation model. Independent variables for this model were parent material, climate, biota, topography, and time. Parent material was derived from

the state geology and surficial geology maps; climate and topography were estimated using the elevation and relief; the biota was estimated using temperature regimes; and time was estimated using the elevation, surficial geology, and bedrock geology. The soil maps at both scales show that the entire Permit Area is covered with only one Soil Mapping Unit (SMU), e.g., Rock Outcrop and Typic Torriorthents, loamy-skeletal, mixed, frigid (WY17) on the 1:500,000 map and Ustic Haplargids, fine-loamy and coarse-loamy, mixed, frigid- Ustic Haplocambids, sandy, mixed, frigid (SW12) on the 1:100,000 map.

The closest third-order soil survey to the Permit Area was conducted in 1994 for the permitting of the Kennecott Uranium Company's Sweetwater Mill, which, at the time was owned by Sweetwater Syndicate Inc. This survey used soil associations as the mapping unit and described six soil associations within a 12-square-mile study area on the Sweetwater property.

D7.2.2 Soil Survey

The soil survey work plan (**Attachment D7-1**) was developed based on the WDEQ Land Quality Division Guideline No 1 and consultation with WDEQ. The soil survey was conducted according to protocols in the National Soil Survey Handbook (1993) which provides all the major principles and practices needed for making soil surveys.

In mid-April 2006, a reconnaissance survey was conducted to identify all landforms present in the Permit Area. Select pits were excavated to determine the relationship between soil types and the landforms. Base maps were created from this survey and were compared with climate data, preliminary vegetation data, and the 1:100,000 and 1:500,000 Munn and Arneson (1998) soil maps.

All preexisting data were used when selecting sites for the primary soil survey, which began in June 2006. Pit locations and the density of the soil pits were determined on the basis of vegetation, landform type, and position within a landform unit. The Permit Area was relatively consistent with respect to vegetation and landforms. Therefore, 19 soil pits were excavated and described there, which was sufficient to characterize the Permit Area.

Data from the soil profiles were used to create soil map units (SMU) on the base map. SMU boundaries were refined with surface soil pits excavated to a depth of 12 inches. SMUs were numbered from north to south. Because this was the first soil survey to be completed in the Permit Area, the soils were classified to the family level instead of the series level. The descriptions of each family (in this case, each SMU), are discussed below.

D7.2.3 Field Sampling

Field samples were collected from all soil pits in the Permit Area. The pits were excavated with a backhoe to a depth of at least four feet (**Figure D7-1**). Soil horizon depths, physical properties, and reactivity with acid were examined and recorded. Composite samples of each exposed soil horizon were collected with a stainless steel shovel or trowel. The sampling tool was decontaminated before each sampling. Decontamination consisted of rinsing the sampling apparatus with tap water, scrubbing it in a solution of Alconox, rinsing it with distilled water, and then air drying it before reuse.

Field sampling forms were completed and photographs were taken at each of the survey locations (**Attachment D7-2**).

D7.2.4 Laboratory Analysis

Soil samples from nine representative locations in the Permit Area were selected and prepared for the laboratory analyses. Each soil horizon present at the selected locations was analyzed independently. Sampling locations selected for laboratory analysis are shown on the soil map (**Figure D7-2**). Samples were analyzed in accordance with the parameters and procedures defined in WDEQ Guideline 1, Topsoil Suitability, Table I-1 (1994).

Soil texture and chemistry analysis were performed by Energy Laboratories in Casper, Wyoming and the results are presented in **Attachment D7-3**.

D7.3 Results and Discussion

D7.3.1 General Characteristics

The soils within the Permit Area are typical of the semiarid areas of the western US. Most of the soil has developed from the sedimentary bedrock of the Permit Area. The precipitation of the region is not enough to leach the majority of calcium and divalent cations from the soil profile. As a result, the soil pH tends to be slightly alkaline. Vegetation is also limited by the amount of precipitation in this region. The soils in the Permit Area tend to have low organic matter.

D7.3.2 Soil Mapping Unit Interpretation

The vertical relief of the Permit Area is approximately 260 feet with an average gradient of 1.5 percent. Due to the relative lack of relief and uniform surficial geology, there are only three exposed soil types within the Permit Area. The three units are very similar in color, depth of horizons, and geomorphic surface. The primary difference between the three soils is the texture; and, therefore, the soil texture is the only difference in the three SMU names.

All soil units within the Permit Area support similar vegetation types. The Lowland Big Sagebrush Shrubland is present in and immediately surrounding the ephemeral channels; and the Highland Big Sagebrush Shrubland is present over the remainder of the Permit Area. The uniformity in vegetation across the Permit Area indicates that the three soil units are roughly equally productive, and that plant growth is limited by precipitation and not by soil fertility.

Figure D7-2 and Plate D7-1 shows the distribution of the three soil units identified in the Permit Area and **Table D7-1** lists the acreage for each soil units identified within the Permit Area.

Thirty-four percent of the Permit Area (1,435 acres) is Typic Torriorthent, loamy, mixed, mesic. The soil is brown to yellowish-brown, and is typically five to 15 inches thick. It generally occurs on the lower foot-slopes, where slopes are less than ten percent but can be as steep as 30 percent. The dominant vegetation is low-growing sagebrush with intermittent patches of grasses. The geomorphic surface ranges from bare loamy soil to pebbles and gravel-sized particles. A typical profile of this soil is brown to yellowish-brown sandy loam; and the subsoil is a brown to pale brown sandy loam that extends to depths greater than 30 inches.

Forty-six percent of the Permit Area (1,941 acres) is Typic Torriorthent, fine loamy, mixed, mesic. This soil is abundant in the down-slope areas of the Permit Area, where slopes are very gradual. The dominant vegetation is sagebrush, with scattered grasses and cactuses. The geomorphic surface consists of bare, fine sandy loam. The upper profile contains a dark grayish-brown silt loam to loam that is about nine inches thick. The subsoil is dark yellowish-brown to light yellowish-brown, and extends to a depth of at least 27 inches.

Twenty percent of the Permit Area (844 acres) is Typic Torriorthent, fine loamy over sandy, mixed, mesic. Slopes are less than five percent; and the dominant vegetation is

low-growth sagebrush and scattered grasses. The geomorphic surface is bare loamy soil with approximately 25 percent gravel. The surface layer consists of a brown loam that is ten to 15 inches thick. The subsoil is a brown to a light yellowish-brown sandy loam that extends to a depth greater than 20 inches.

D7.4 Topsoil Suitability

Topsoil suitability was evaluated based on field soil and vegetation surveys, as well as laboratory soil texture and chemistry analysis. Based on WDEQ Guideline No. 1 Topsoil Suitability, Table I-2 (WDEQ, 1994), all of the Lost Creek samples were within the range for suitable plant growth media for pH, conductivity, sodium adsorption ratio (SAR), texture, selenium, and boron (**Table D7-2**).

Of the 28 Permit Area samples, 11 were classified as marginally suitable for topsoil because of low saturation percentages. The measured saturation percentages of these marginally suitable soils ranged from 16 to 24 percent. These 11 samples were from seven different profiles, and represented all SMUs present in the Permit Area.

Two out of the 28 Order 3 soil survey samples may be considered unsuitable for topsoil. One sample, collected from the B horizon of soil profile 11 in the third SMU, contains 39 percent coarse fragment (compared to a 35 percent threshold for unsuitable soil). However, LQD recommends that coarse fragments not be used as the determining factor for soil suitability if the soil resource is limited and marginal in quality. Therefore, this sample may be deemed suitable for topsoil. The other sample is considered marginally suitable due to a pH value of greater than 8.5. During reclamation, the use of marginal soils as topsoil will be avoided where possible, except in areas where the undisturbed topsoil is limited and marginal in quality.

D7.5 Topsoil Protection

Topsoil will be conserved wherever and whenever possible for reclamation. Order 1 soil surveys were conducted in 2008 and 2009 for the Plant site (2008), the deep injection well locations (2009), and Mine Unit One (2008). Three soil types were identified during these surveys, and these three soil types can generally be identified by surface indicators. Pepal Sandy Loam is the dominant soil type, found in areas of upland big sagebrush habitat, where sagebrush is moderate to dense. The Poposhia Loam is found exclusively in drainages, where there is Lowland Big Sagebrush habitat and dense, larger sagebrush. The Teagulf Sandy Loam occurs in upland areas on subtle ridges and west-facing slopes

where the sagebrush is sparse, cushion plants are common, and there is a concentration of pebbles and gravels on the soil surface due to aeolian erosion.

The results of the surveys for the Plant site and the deep well locations are included in **Attachments OP-5a and OP-5b** to the **Operations Plan**. The results of the survey of Mine Unit One will be included with the mine unit package. As the areas for additional mine units are delineated in more detail, Order 1 surveys will be conducted and the results submitted with the respective mine unit packages.

D7.6 Geotechnical Investigations

A preliminary geotechnical evaluation of the soils at the proposed ISR facility sites was conducted in September 2007. The evaluation found that the subsurface conditions consist of unconsolidated sand with clay lenses from ground surface to depths of up to 20 ft bgs, transitioning to weathered to competent sandstone bedrock of the Battle Spring Formation through at least 600 ft bgs. It is unlikely that expansive, soft, or otherwise unsuitable soils will be encountered within the depth of anticipated shallow foundation excavations.

An evaluation of the soil conditions underlying the locations of the Storage Ponds is included in **Attachment OP-7** to the **Operations Plan**.

D7.7 Historical Surface Disturbances

There was surface disturbance prior to LC ISR, LLC operations within the Permit Area. Most of this disturbance was due to historical exploration activities for oil and gas, as well as for uranium, and to support livestock and wildlife grazing. The primary activities included vehicle traffic, drilling activities, and stock tank usage. Approximately 26 miles of existing roads were delineated from the 2002 aerial photo of the Permit Area (**Figure D7-3**). Field measurements in 2007 indicate that the roads range from 6.9 to 9.4 feet wide. Using a default width of ten feet, the disturbance associated with the existing two-track roads is on the order of 31 acres. A few of these roads may still be used by grazing lessees, hunters, and for on-going exploration activities. Evidence of abandoned drill sites and stock tanks is more difficult to delineate; but numerous small areas are evident on the aerial photograph.

The roads caused compaction to the soil, which limits infiltration rates and decreases the vegetation regrowth (**Figure D7-4**). Active road surfaces have little to no organic matter, and most of the topsoil has been eroded from the road surface.