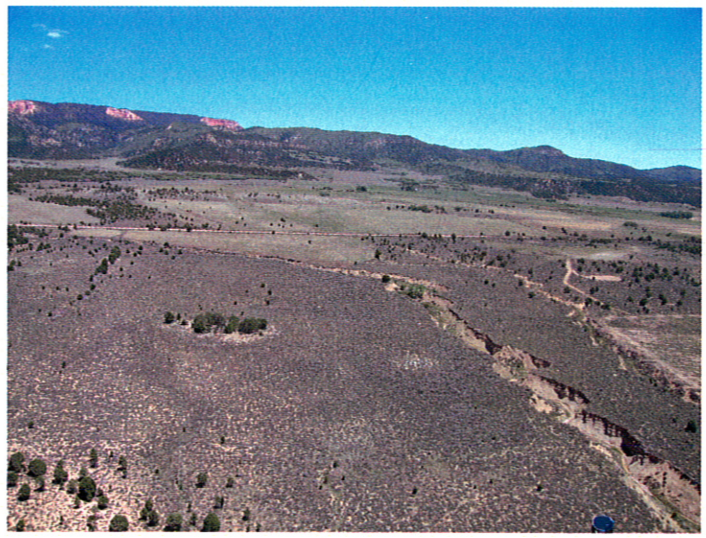
Supplemental Information for Utah Division of Oil, Gas and Mining Alluvial Valley Floor Finding for the Proposed Coal Hollow Mine



15 January 2008

Alton Coal Development, LLC
Cedar City, Utah

PETERSEN HYDROLOGIC, LLC
CONSULTANTS IN HYDROGEOLOGY

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1.0 Introduction

Alton Coal Development, LLC has made an application for a Utah State coal mining permit from the Utah Division of Oil, Gas and Mining (Division) to mine coal at the proposed Coal Hollow Mine permit area. The proposed Coal Hollow Mine permit area is located on private lands in the Alton Coal Field of south-central Utah, approximately three miles south of the town of Alton, Utah (Figure 1).

In its 27 August 2007 Administrative Completeness Review, the Division requested more information from Alton Coal Development, LLC to make an alluvial valley floor finding. The purpose of this document is to provide the additional information requested by the Division.

This document is organized according to the R645 Rules cited by the Division as the basis for the information request. The information requested by the Division is presented in the following sections of this document.

2.0 R645-302-321.210

2.1 Alluvial sediment deposition

Sink Valley is an upland area located at approximately 7,000 feet elevation, situated at the base of the precipitous Paunsaugunt Plateau escarpment. In such geomorphologic settings, alluvial fan deposition in the arid western United States is common. The alluvial fan system in Sink Valley consists of a series of coalesced fans derived from sediments shed from the adjacent highland regions on the Paunsaugunt Plateau. Sediment deposition processes in the alluvial fan system are likely dominated by sheet floods, mudflows, and debris flows. The sediments near the distal portions of the fan complex in Sink Valley (as observed in drill holes, surface outcrops, and soils pits within the Coal Hollow Project area) are dominated by fine-grained materials including silts, clays, and fine-grained sands (see Chapters 6 and 7, Coal Hollow Project MRP). Coarser sediments are observed in surface exposures nearer the apex of the alluvial fans along the base of the precipitous Paunsaugunt Plateau escarpment. Coarse-grained sediments, including boulders, gravels, and coarse-grained sands, which would be more typical of stream-laid deposits, were almost entirely absent in at least the upper 50 feet of alluvium drilled in Sink Valley in and around the proposed Coal Hollow Project area.

As stated in the OSM alluvial valley floor identification and study guidelines (1983), the SMCRA definition of an alluvial valley floor "does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by unconcentrated runoff or slope wash, together with talus, or other mass-movement accumulations and windblown deposits" (OSM, page II-5). Further, an alluvial valley floor is defined by the existence of flood plains and terraces underlain by unconsolidated stream-laid deposits (page II-11). Included in the AVF definition are only those areas characterized as being "within that valley, those surface landforms that are either flood plains or terraces if these landforms are underlain by unconsolidated deposits...Alluvial valley floors are not merely those valleys filled with alluvium".

2.2 Lack of continuous stream channel

The locations of existing stream channels in the Coal Hollow Project and adjacent area are plotted on an infrared aerial photograph in Plate 1. Spring discharges are also plotted on Plate 1. It is apparent in this plate, and based on field investigations, that although there are many discontinuous drainage segments in the area, there is no continuous stream channel through Sink Valley. The lack of a continuous stream channel in Sink Valley is likely largely attributable to the manner of sediment deposition in the valley (i.e. mudflows, debris flows, and sheet floods). It should be noted that the various historical activities of landowners in the valley may have influenced surface drainage patterns to some extent. However, it seems likely that prior to the settlement and agricultural development of the valley by humans, conditions in the valley similar to those currently present likely prevailed as a result of the fan depositional regime.

It should also be noted that the greater Sink Valley Wash and Kanab Creek drainages appear to currently be in unstable condition. Significant down-cutting of stream channels is currently occurring throughout large portions of these drainages. The Lower Robinson Creek drainage is deeply incised throughout the extent of the proposed Coal Hollow Project permit area. In several locations in the project area, the Lower Robinson Creek stream bed has been incised several tens of feet below the surrounding topography. Based on recent observations, it is apparent that stream channel down-cutting and erosion/collapse of the steep arroyo walls adjacent to Lower Robinson Creek is actively ongoing at present. As shown on Plate 1, the unstable, incised stream channel in the Lower Robinson Creek drainage (located north of Sink Valley) is continuous through the northern portion of the project.

It is also evident that active head-cutting in the Sink Valley Wash drainage is currently occurring near the southern extent of Sink Valley in the northwest corner of Section 32, T39S, R5W, near Alluvial Groundwater Discharge Area B (see Appendix 7-1 in Chapter 7 of Coal Hollow Project MRP). As the drainage channels become increasingly incised and migrate northward further into Sink Valley, water levels in alluvial groundwaters adjacent to these drainages channels will likely decline (i.e. the incised drainages will act as drains).

2.3 USGS 7.5 minute topographic maps

On the 7.5 minute Alton, Utah USGS topographic map, a continuous stream channel is shown for Sink Valley Wash from its headwaters area to the southern extents of Sink Valley. However, field surveys of stream drainages in Sink Valley indicate that the stream channels are ***not*** continuous through the valley, but rather exist as a series of discontinuous drainage segments. It is not uncommon for inaccuracies of this sort to exist on USGS topographic maps, as these maps are commonly constructed using large-scale aerial photographs and photogrammetric mapping techniques. Ground truthing of all mapped features is not routinely performed. In the absence of ground truthing of the stream drainages in Sink Valley and adjacent areas, it is not unexpected that the delineation of continuous stream channels in Sink Valley has been incorrectly delineated on the topographic map. Field investigations in the Lower Robinson Creek drainage indicate that this drainage is continuous through the Coal Hollow Project and adjacent area.

2.4 Flood plains and terraces

No flood plains or stream terrace deposits have been identified by studies in the Coal Hollow Project area. Consequently, a map showing the locations of flood plains and terraces in the project area has not been prepared. A drawing showing surface drainage patterns, including the flow from springs is provided as Plate 1.

As shown on the USGS 7.5 minute Alton, Utah quadrangle topographic map, the surface morphology of Sink Valley is moderately convex in cross-fan section and consists of several lobes formed by sediment deposition derived from several different drainages. A drawing showing examples of valley cross-sections showing some possible relations in valley alluvium (with terracing) is shown in Figure 2. The surface morphology in Sink Valley is typical of an alluvial fan system. In contrast, a flood plain is, by definition, a planar feature. "Stream terraces are flat surfaces along the valley sides of stream courses marking the level of former valleys. They are vestiges of former flood plains formed by streams which were higher in elevation than the present stream" (OSM, 1983). No such stream terraces are observed in Sink Valley. The lack of a characteristic flood plain, the convex cross-fan surface topography, and the lack of a continuous stream channel through Sink Valley, are all inconsistent with both the scientific and the regulatory definitions of an alluvial valley floor.

2.5 Surface water drainages

A map showing the extent and details for all watersheds that can contribute runoff to the Coal Hollow Project and adjacent area is presented in Plate 2.

2.6 Alluvial groundwater systems potentiometric information

A map showing potentiometric levels in alluvial groundwater systems in the Coal Hollow Project and adjacent area has been previously provided as Drawing 7-13 in Chapter 7 of the Coal Hollow Project MRP. This map was created using the elevations of springs and Alluvial Groundwater Discharge Areas A and B and the elevations of waters encountered in the Sink Valley Wash stream channel. Additional information on alluvial groundwater systems, including the approximate directions of shallow groundwater flow has been provided as Figure 21 in Appendix 7-1 to Chapter 7 of the Coal Hollow Project MRP. Long-term seasonal variability in water levels in alluvial groundwater systems in the project area is documented with historic monitoring data at alluvial monitoring wells and springs in Appendix 7-1 of Chapter 7 of the Coal Hollow Project MRP and in baseline water monitoring data submitted to the Utah Division of Oil, Gas and Mining on-line hydrology database (UDOGM, 2008). Information on depth below the ground surface of potentiometric levels measured in existing and newly constructed alluvial monitoring wells in and around the Coal Hollow Project area during 2007 is presented in Table 1. These data are plotted in a series of hydrographs in Figure 3. It should be noted that the water levels measured in the piezometers are representative of the potentiometric pressure in the piezometer screened intervals. Where confined groundwater conditions exist in the alluvial groundwater system, the water levels measured in the piezometers are generally not the same as the depth at which groundwater would first be encountered in an excavated hole (or the depth at which a plant's roots may encounter water). For example, the shut-in potentiometric head measured at well Y-61 is several feet above the ground surface at the well site. However, an excavated hole near the well may not encounter groundwater in the shallow subsurface, due to groundwater confinement by low-permeability strata overlying the strata with artesian pressure.

To facilitate the evaluation of climatic effects on potentiometric levels in the alluvial groundwater systems, an updated plot of the Palmer Hydrologic Drought Index (PHDI) for the region (Utah Region 4) is provided as Figure 4. A description of the use and interpretation of PHDI data is provided in Appendix 7-1 of Chapter 7 of the Coal Hollow Project MRP.

A perhaps more meaningful measurement of the depth to first water in the shallow alluvial sediments is provided in Table 2 and Figure 5. Table 2 includes hydrologic and soils information obtained from 60 soils pits dug in the Coal Hollow Project and adjacent area. Included in Table 2 and Figure 5 for each soils pit are the depth below the ground surface at which groundwater was first encountered in the soils pit, the uppermost extent of any soil mottling (red or gray coloration in cracks or pores in the soil matrix resulting from iron precipitation related to changing redox conditions with changes in soil water saturation) observed, and the uppermost extent of the presence of any aquic soils observed in the pit. The construction of an isopach map of the depth to groundwater was not created using these data. This is because of the significant heterogeneity of the alluvial groundwater system in the Coal Hollow Project area. Groundwater was encountered in some of the soil pits while other nearby pits were dry. Additionally, groundwater in the alluvial system in many locations in and around the Coal Hollow Project area occurs under perched conditions. Consequently, extrapolation of observed saturation conditions in a soils pit or monitoring well to surrounding areas where saturation data are not available would be arbitrary and not meaningful. Under such groundwater conditions, the direction of groundwater flow is largely constrained by the geometry of permeable and lower-permeability sediments and local microtopography and is not readily predictable. Given these conditions, it is not possible to create a meaningful potentiometric surface map in these areas, or to infer shallow groundwater flow directions and, consequently, no such attempt has been made to do so herein.

The drilling of the shallow exploration boreholes referenced in Appendix 5-1 of Chapter 5 of the Coal Hollow Project MRP occurred during seasonal high-flow runoff conditions in late February and early March 2007. At the time of the drilling of these boreholes, copious amounts of snowmelt water was running over the ground surface and ponding on the low-permeability clayey sediments. While appreciable shallow groundwater was noted during drilling, the groundwater encountered was likely shallow in origin and most likely occurred under perched conditions. Within several weeks of the drilling of the exploration boreholes, the conditions in the soils and shallow alluvial sediments were found to have dried out appreciably and little groundwater was found to be present. This information suggests that, while seasonal snowmelt and shallow perched groundwater was present in the area of the exploration boreholes at the time of the drilling, a continuously saturated alluvial groundwater system through which appreciable groundwater flow was occurring was not present.

2.7 Alluvial groundwater systems maps and cross-sections

A series of six east-west cross-sections through the alluvial sediments in and around the proposed Coal Hollow Mine permit area are presented in Figure 6. A map showing the locations of streams, ponds, springs, and wells in relation to the surface geology is presented in Figure 8. The locations of proposed disturbances and mine pit locations are also shown on the map in Figure 8. It should be noted that in Figure 6, extrapolation of potentiometric levels between some monitoring wells was not performed. This is because, as discussed previously, alluvial groundwaters in many parts of the Coal Hollow Project area occur under perched conditions with discontinuous zones of saturation. Consequently, the extrapolation of potentiometric levels between distant monitoring wells under such conditions would be incorrect. In other areas, particularly near the eastern margins of Sink Valley, where a more continuous artesian alluvial groundwater system exists, some extrapolation of hydraulic head between piezometers is more meaningful.

In the various field investigations conducted in the Coal Hollow Project, specific correlation between seasonal variation in alluvial water levels and vegetation changes have not been noted.

Additional geologic information on the stratigraphy and hydrostratigraphy of the alluvial sediments, Tropic Shale overburden, the Smirl Coal Zone, and the Dakota Formation underburden is provided in Appendix 6-1 in Chapter 6 of the Coal Hollow Project MRP.

3.0 R645-302-321.220

3.1 Land type map

The locations of undeveloped rangeland, "improved" rangeland and pasture lands are shown on the Vegetation Map, Drawing 3-1 in Chapter 3 of the Coal Hollow Mine MRP. A table correlating the vegetative type map units shown on Drawing 3-1 and the land type as requested by the Division under R645-302-321.220 is provided below.

Drawing 3-1 map unit	R645-302-321.220 description
P-J (Pinyon/Juniper)	Undeveloped rangeland
S/G (Sagebrush / Grass)	Undeveloped rangeland
SB (Sagebrush)	Undeveloped rangeland
SB (chipped P-J)	Improved rangeland for sage-grouse habitat
RB/SB (Rabbitbrush / Sagebrush)	Undeveloped rangeland
P (Pasture Land)	Crop lands and pastures
M (Meadow)	Undeveloped Rangeland
OB (Oak Brush)	Undeveloped rangeland

3.2 Productivity measurements

Annual biomass productivity measurements of the plant communities of the area are provided in Section 321.200 and summarized in Table 3-34 of Chapter 3 of the Coal Hollow Project MRP.

3.3 Subirrigated pasture map

The locations of subirrigated lands are shown in Drawing 7-7 of Chapter 7 of the Coal Hollow Project MRP.

It should be noted that some small areas that may potentially be subirrigated lands, which are identified as dry meadows in the western portion of the project area in Drawing 3-1 in Chapter 3 of the Coal Hollow Project MRP, are not marked as subirrigated lands on Drawing 7-7. The land areas of these dry meadows are small, and conditions in which these dry meadows occur may be at least in part due to microtopgraphy.

3.4 Depth to groundwater information

Potentiometric data from piezometers including the season of use (April – November) in the alluvial groundwater systems in the project area in and near the pastures are provided in Table 1. This information together with additional water level information in the alluvial groundwater systems has been submitted to the Division's on-line hydrology database (UDOGM 2008). Depth to groundwater information in excavated soils pits is provided in Table 2 and Figure 5. Additional characterization of conditions in the soils pits is provided in Chapter 2 of the Coal Hollow Project MRP. Generally, the depths to alluvial groundwater in the subirrigated areas are within several inches to a few feet below the ground surface and are seasonally variable, with water levels typically declining gradually during the summer and fall months. Depths to groundwater in the pasture land areas in the southern portions of the proposed permit area range from about one to two feet under high-flow conditions, and up to several feet below the ground surface during low-flow conditions (see Table 1). During 2007, the depths to shallow groundwater in the subirrigated areas were least during the early winter season and declined gradually during the remainder of the year (Table 1). In most other areas, where subirrigation is not occurring, the depths to alluvial groundwater below the ground surface were generally greater.

Discharge monitoring of seeps SP-28, SP-29, SP-30, SP-31, and SP-32 in lower Sink Valley demonstrate the seasonal variability of the alluvium in this location. Visible discharges were observed in all of these seeps in June 2005, which was a particularly wet year (Figure 4). By August of 2005 all of these seeps were dry as alluvial water levels dropped below the elevations of the spring discharge locations (see Appendix B of Appendix 7-1 of Chapter 7 of the Coal Hollow Project MRP).

4.0 R645-302-321.230

4.1 Locations of flood irrigated or subirrigated lands

The locations of historically flood irrigated and subirrigated lands are shown on Drawing 7-7 in Chapter 7 of the Coal Hollow Project MRP.

The subirrigated lands are located in the meadow areas east of the Tropic Shale ridge that bisects the Coal Hollow Project area (see Drawing 7-7 in the Chapter 7 of the Coal Hollow Project MRP). These areas have been identified as subirrigated based on considerations of alluvial groundwater conditions, water quality, soil moisture, rooting depth, soil mottling, the water requirements of vegetation, and from analysis of the infrared imagery of the region. Additionally, some areas of dry meadow located west of the Tropic Shale ridge in the project area also have also been identified as having localized subirrigation potential. These areas are of limited extent (see "Meadows (dry)" in Drawing 3-1 in Chapter 3 of the Coal Hollow Project MRP. However, based on recent observations, it is apparent that these dry meadows are wet only early in the year and the soils dry out rapidly during the spring. The early-season wet conditions in the dry meadows may be at least in part due to microtopography. Consequently, although there is some potential for these lands to be subirrigated, they are not delineated as subirrigated in Drawing 7-7 of Chapter 7 of the Coal Hollow Project MRP).

The delineation of historically flood irrigated lands in the Coal Hollow Project area is problematic. Historically, attempts at irrigated crop production in the area have occurred in a few homestead locations in and around the Coal Hollow Project area (personal communication, Darlynn Sorensen, 2008). Most of the flood irrigation at these locations was probably of relatively small scale, consisting primarily of irrigation of domestic gardens (personal communication, Darlynn Sorensen, 2008). Some limited flood irrigation occurred at the Swapp Ranch and Pugh Homesteads historically, although there is no indication that any flood irrigation at these properties has occurred in the past several years. Irrigation and crop production on a larger scale has occurred on the Darlynn Sorensen property (discussed below). With the exception of the crop production at the Sorensen property, none of the other attempts at irrigation and crop production were ultimately successful and all have since been abandoned.

Historically, the most significant use of flood irrigation in the Coal Hollow Project area has occurred at the Sorensen property (Drawing 7-7 in Chapter 7 of Coal Hollow Project MRP). Crops (hay and grain) in these fields were periodically flood irrigated using surface water from Swapp Hollow creek stored temporarily in pond 29-7 (see Drawing 7-7 in the Coal Hollow Project MRP). Flood irrigation at the Sorensen property has typically consisted of the application of a single watering event to the fields in the springtime during wet years when adequate water was available for use. The application of the single springtime irrigation watering resulted in improved hay or grain crop yield relative to the yield in years when no irrigation water could be applied (personal communication, Darlynn Sorensen, 2008). During years with dryer climatic conditions, there was not sufficient surface water available to flood irrigate the lands. Recently (for the past many years) the quantity of water in Swapp Hollow creek has not been sufficient to allow flood irrigation. During this many year period, flood irrigation of the Sorensen property has occurred on only one occasion (during the very wet year 2005). During other recent years, adequate water for useful irrigation of the fields has not been available and flood irrigation of Mr. Sorensen's fields has not been performed (personal communication, Darlynn Sorensen, 2008).

It should be noted that the lack of appreciable flood irrigation currently in Sink Valley and the failures of historic flood irrigation attempts is a direct result of the lack of a reliable supply of water in sufficient quantities to irrigate useful acreage of agricultural lands in the valley.

4.2 General construction and use of water holding ponds

The water holding ponds identified in Drawing 7-7 in the Coal Hollow Project MRP have the appearance of having been constructed as simple earthen embankments. Discussions with the local property owners support this conclusion (personal communication, Darlynn Sorensen, 2008). The earthen embankments for the water holding ponds are typically situated across the bottoms of surface water drainages and are intended to store surface-water runoff. Most of the water holding ponds are used to impound water for stock watering use. A few water holding ponds have also been equipped with water outlet control devices to facilitate the release of the stored water for irrigation or other use. The outlet control structure typically consists of a pipe buried near the base of the pond which is equipped with a control valve to regulate the flow from the pond. The water holding ponds that are equipped with water outlet controls to facilitate irrigation releases include the following:

Water holding ponds equipped with outlet structure for irrigation use

Pond	Water source	Use
29-7	Swapp Hollow creek	Stock watering and flood irrigation of the Sorensen property irrigated lands
20-1	Groundwater diversion from Water Canyon high elevation spring (via some sections of irrigation pipe and some sections of unlined earthen ditches)	Stock watering and historic flood irrigation of Pugh Homestead
29-3	Groundwater from alluvial spring SP-20	Stock watering and historic flood irrigation of Swapp Ranch
24-1 25-1	Kanab Creek	Stock watering and flood irrigation of lands in Kanab Creek drainage (not in project area)

See Drawing 7-7 in the Coal Hollow Project MRP for pond locations

4.3 Conveyance systems between ponds

For most of the ponds in the Coal Hollow Project area, there are no constructed conveyance systems between ponds. Rather, pond overflow or bypass typically runs down the surface drainage to a pond lower in the same drainage (if any). The conveyance systems for the water holding ponds used either currently or historically for irrigation consist of unlined earthen ditches as shown in Drawing 7-7 in Chapter 7 of the Coal Hollow Project MRP.

5.0 R645-302-321-240

5.1 Subirrigation potential (groundwater monitoring)

Monitoring information from shallow groundwater systems in the proposed Coal Hollow Project and adjacent area has been submitted electronically to the Division's on-line hydrology database (UDOGM, 2008). These data have been analyzed and a characterization of the shallow groundwater systems in the area is provided in Appendix 7-1 of Chapter 7 of the Coal Hollow Project MRP. Potentiometric data from alluvial monitoring wells as monitored during 2007 is presented in Table 1. Depth to water hydrographs for these wells are presented in Figure 3. Additional information pertinent to alluvial saturation levels in near-surface sediments in the Coal Hollow Project area is provided in Table 2 and Figure 5.

5.2 Subirrigation potential (water quality)

As described previously, subirrigated lands in the Coal Hollow Project area include lands in two regions. Both of these regions are located east of the north-south trending Tropic Shale bedrock ridge that bisects the Coal Hollow Project area into eastern and western regions (see Appendix 7-1 of the Coal Hollow Project MRP for information on the hydrogeologic influence of the Tropic Shale ridge). To characterize the suitability of shallow groundwater for subirrigation use in these two areas, the average water quality characteristics of two nearby alluvial springs is evaluated here. Spring SP-8 discharges to the surface from the artesian alluvial groundwater system in the vicinity of the northern potentially subirrigated area. Spring SP-6 discharges to the surface from the alluvial groundwater system in the vicinity of the southern potentially subirrigated area. Water quality characteristics of shallow groundwaters in the northern and southern subirrigation areas, as represented by groundwaters from springs SP-8 and SP-6, respectively, are presented in Table 3. These data have also been submitted electronically to the Division's on-line hydrology database (UDOGM, 2008). Water quality suitability criteria for irrigation use as presented in the OSM Alluvial Valley Floor Identification and Study Guidelines (1983) are used in this analysis. The water quality suitability for the northern and southern subirrigation areas are depicted on Figure 9.

5.2.1 Northern subirrigation area water quality

It is apparent from Figure 9 that the shallow groundwater available for subirrigation in the northern subirrigation area plots near the boundary between C2-S1 and C3-S1 class waters on the SAR – conductivity classification of irrigation water (OSM, 1983). This indicates a medium to high salinity hazard with low sodium danger. As a result of the medium to high salinity hazard, the groundwater could be used if a moderate amount of leaching occurs. Waters falling in the C3-S1 area indicate that waters in this class cannot be used on soils with restricted drainage. Special management for salinity control may be required and plants with good salt tolerance should be selected. Shallow alluvial groundwater from the northern subirrigation area as represented by SP-8, averages 424 mg/L (Table 3). Based on the dissolved-solids hazard for irrigation water (Table B-5, OSM, 1983) as a result of irrigation using this water, no detrimental effects will usually be noticed, and the salinity hazard is low. Using the criteria shown on Table B-6 (OSM, 1983), which considers boron, SAR, chloride, sulfate, specific conductance, and TDS levels, the water in the northern subirrigation area is a Class I, which is excellent to good for overall soil/climate management, and suitable for irrigation of all or most plants, including boron-sensitive species.

5.2.2 Southern subirrigation area water quality

It is apparent from Figure 9 that the shallow groundwater available for subirrigation in the southern subirrigation area plots near the boundary between C3-S1 and C4-S1 class waters on the SAR – conductivity classification of irrigation water (Figure B-5, OSM, 1983). This indicates a high to very high salinity hazard with a low sodium danger. Waters classified as C3-S1 indicate that the water cannot be used on soils with restricted drainage. Special management for salinity control may be required and plants with good salt tolerance should be selected. Waters falling in the C4-S1 area contain very high salinity water, which is not suitable for irrigation under normal conditions. Shallow alluvial groundwater from the northern subirrigation area averages 1,330 mg/L (Table 3). Based on the dissolved-solids hazard for irrigation water (Table B-5, OSM, 1983) irrigation with this water can have detrimental effects on sensitive crops. Using the criteria shown on Table B-6 (OSM, 1983), which considers boron, SAR, chloride, sulfate, specific conductance, and TDS levels, the water in the northern subirrigation area is a Class II water, which is good to injurious; harmful under certain conditions of soil, climate, and practices. Irrigation with Class II water is not suitable for most salinity- and boron-sensitive plants, but is suitable for all tolerant and many semitolerant species.

It should be noted that shallow alluvial groundwaters in areas west of the subirrigated lands in the Coal Hollow Project and adjacent area commonly contain water that is appreciably elevated in dissolved solids concentrations (UDOGM, 2008). Shallow alluvial groundwaters were sampled from trenches in the alluvial system in the eastern ¼ of Section T39S, R5W in April 2006. Locations and chemical information for these trenches is provided in Appendix 7-1 of Chapter 7 of the Coal Hollow Project MRP and has been submitted electronically to the Division's on-line hydrology database. Alluvial groundwater sampled from these trenches had specific conductance values ranging from 1,142 to 3,700 uS/cm with TDS concentrations ranging from 903 to 3,608 mg/L. This information suggests that shallow groundwater in some of these areas may not be suitable for subirrigation.

Monitoring of alluvial seeps SP-28, SP-29, SP-30, SP-31, and SP-32 in the southern end of Sink Valley near the southern subirrigation area indicate that the quality of shallow groundwater potentially available for subirrigation in this area is of poor quality, with measured specific conductance values ranging from 2,110 to 4,150 uS/cm, and averaging about 2,900 uS/cm. Waters of this quality are classified as high-salinity waters and are not usually useful for crop irrigation.

5.3 Subirrigation potential (soil moisture)

Qualitative soil moisture evaluations were performed in excavated soils pits by qualified soil scientists. Information on soil moisture is provided in Chapter 2 of the Coal Hollow Project MRP. This information has been utilized in performing the analysis of alluvial systems presented in this document.

5.4 Subirrigation potential (soil mottling, rooting depth, soil moisture)

Root size and density (abundance) data was collected at each soil pit as part of the description of the soils. Data for each individual soil pit was provided on the profile description sheets of the soil survey report (MRP Appendix 2-1). Summarized depths of roots including sizes, densities and mottles of the major soil types (named) for each soil map unit (by plant community) was evaluated and has been presented in Table 4.

The parameters for root density and size are described in the Field Book for Describing Soils, version 2 (Schoeneberger et. al., 2002). Table 5 defines the terms used to describe roots in the Coal Hollow Project soil survey.

5.4.1 Soil Mottles

The presence of soil mottles suggests that the soil depths where they appear were saturated with water at some time. Groundwater studies in the Coal Hollow Project area indicated that the periods of highest groundwater elevations are during late winter and early spring before the plants' consumptive use of water is at their peak. In addition, lab analysis of the groundwater indicated that it has TDS values that may diminish the benefit of the water to plants.

Figure 10 and Figure 11 illustrate the relationship of average root density and size versus depth for each plant community identified in the MRP for the Coal Hollow Project area. The figures also compare root density and size with the depth to soil mottles for specific plant communities when mottling was the dominant condition. The *dominant condition* is justified in the "Notes" on Table 4. This data evaluation was limited by the variety of soil pit depths.

5.4.2 Results of the Root Data Evaluation by Plant Community

The **meadow** (M) plant community was characterized by sedges, rushes, and wild iris. There were "many" roots in the upper 11 inches of the soil profile. The root density was "common" from 11 inches down to 37 inches and a "few" roots extended down to 52 inches. The depth of the "many" roots zone corresponds closely with the average depth to soil mottles of 10 inches. The meadow plant community is analogous to soil map unit 7. *Coarse* roots were not "common" in these soils, but *medium* roots extended down to 39 inches. *Fine* roots extended to 44 inches and *very fine* roots to 49 inches. This soil type and plant community could be classified as sub-irrigated.

The **dry meadow** [M(dry)] plant community had characteristics of both meadow and upland (pasture and sagebrush/grass) plant communities. Delineations of this plant community and soil type were in micro-depressions where off-site surface runoff collects and perches on deep clay horizons. The dominant vegetation consisted of upland grasses with scattered shrubs and some meadow vegetation. There were "many" roots in the upper 8 inches of the soil profile. "Common" roots extended from 8 to 18 inches. A "few" roots extended from 18 inches to 79 inches. *Coarse* roots from shrubs were limited to the upper 8 inches. *Medium* roots extended to 18 inches. *Fine* roots extended to 72 inches and *very fine* roots to 80 inches. The depth to soil mottles ranged from 6 to 58 inches with an average of 36 inches. The average soil mottle depth corresponds with depth of "common" root density. This soil type and plant community demonstrates characteristics of potential sub-irrigation in localized area, but it is of limited extent in the Coal Hollow Project area.

The **oak brush** (OB) plant community had roots that extended to 90 inches. "Many" roots were limited to the upper 3 inches. "Common" roots extended from 3 to 35 inches. A "few" roots extended to 91 inches. *Coarse* roots from the oak brush extended to 69 inches. *Medium* and *fine* roots extended to 78 inches. *Very fine* roots reached to 90 inches. One of two data points representing this plant community had a few soil mottles at 15 inches, but none in the other soil pit. The dominant soils and vegetation for this plant community indicate that it is not sub-irrigated.

The **pasture land** (P) plant community was dominated by introduced upland grass species. "Many" roots were limited to the upper 3 inches. "Common" roots extended from 3 to 23 inches. A "few" roots extended to 65 inches. Only one of the 16 soil data points had *coarse* roots (limited to upper the 10 inches at that soil pit). *Medium* roots extended to 18 inches. *Fine* roots extended to 46 inches. *Very fine* roots reached to 64 inches. Only seven of the 16 soil data points had any soil mottles (average 50 inches for the seven soil pits). Soil and vegetation characteristics suggest that this plant community is not sub-irrigated. Small localized areas within the pasture land community may have potential for sub-irrigation.

The **pinyon-juniper** (PJ) plant community was dominated by pinyon pine and Utah juniper. The average soil depth was 41 inches to Tropic Shale. "Common" roots were in the upper 15 inches. A "few" roots extended to 30 inches. *Coarse* roots occurred in the upper 14 inches. *Medium* roots extended to 18 inches. *Fine* roots extended to 24 inches. *Very fine* roots reached 30 inches. Soil mottles occurred in one of five pits, but were most likely the result of moisture perching in the very fine clay textures (greater than 60 percent clay). Soil and native vegetation suggest that this plant community is not sub-irrigated.

The **rabbitbrush/sagebrush** (RB/SB) plant community was limited to disturbed areas. It was of very limited extent in the Coal Hollow Project area and there was only one soil data point.

This soil type and plant and soil community does not exhibit any characteristics of being sub-irrigated.

The **sagebrush/grass** (S/G) plant community was dominated by big sagebrush and upland grasses. "Many" roots were in the upper 4 inches. "Common" roots were from 4 to 18 inches. A "few" roots reached to 57 inches. *Coarse* roots were in the upper 7 inches. *Medium* roots extended to 17 inches. *Fine* roots extended to 34 inches. *Very fine* roots extended to 57 inches. Soil mottles occurred in only 5 of 20 soil data points (average 52 inches for the 5 soil pits). Soils and native vegetation indicate this plant community is not sub-irrigated.

5.4.3 Soil Map Units

Soil map unit 7 had characteristics of sub-irrigation (Table 6). Soil mottling was identified within one foot of the soil surface. The presence of water is usually at or near the soil surface during the spring and early summer depending on the annual precipitation. Occasional seasonal localized ponding may also occur in this map unit.

Map units 6 and 13 have localized potential for sub-irrigation depending on the soil type. Upland soils comprise 80 percent of the soil map unit. Aquic soils occurred in micro-depressions and may be the result of localized runoff water perching on top of deep clay layers.

5.4.4 Summary

Table 7 identifies the plant communities that exhibit soil and plant characteristics of sub-irrigation. Only the meadow and dry meadow plant communities exhibit characteristics of sub-irrigation in the major soil types of the associated soil map units.

5.5 Subirrigation potential (water requirements of pasture and meadow vegetation)

The areas called "pasture lands" in the Coal Hollow Project area are plant communities that have been altered to increase herbaceous cover and productivity for domestic livestock. Prior to pasture lands, these communities were probably native sagebrush/grass plant communities. Like the native and unaltered plant communities in the area, and because they are not irrigated, the water requirements for the pasture lands in the study area are solely dependent on the annual precipitation regime (which averages about 16 inches per year; see MRP Chapter 7, Section 724.400) and other environmental variables described below.

Native plant communities called "meadows" are also present in and adjacent to the project area. Dry meadows are located on the west side of the permit area and wetter meadows can be found on the east side. Factors that influence establishment and survival of these meadows are local climatic conditions as well as other environmental variables such as: exposure to light, soil texture, salinity and permeability, hydrologic regimes, saturation periods in the growing season, stratigraphy, topography, morphological, physiological and reproductive adaptations of the plant species present, and evapotranspiration rates. For specific onsite quantitative data and other applicable information regarding the above environmental conditions at the Coal Hollow Project area, refer to MRP Chapter 2 (soils), Chapter 3 (vegetation) and Chapter 7 (hydrology and climate).

Published information regarding water requirements of selected plant types for Alton, Utah area is presented in Table 8.

6.0 R645-301-321-250

6.1 Flood irrigation potential (streamflow and water yield)

The potential for successful flood irrigation of lands in the Coal Hollow Project area is directly limited by the amount of water available for that use. Discharge and water quality data for waters that could potentially be utilized for flood irrigation in the Coal Hollow Project and adjacent area are presented in Table 9. Baseline monitoring data including discharge and water quality measurements for these potential sources of flood irrigation water have been submitted electronically to the Division's on-line hydrology database (UDOGM, 2008). Each of the potential surface water sources for flood irrigation in the Coal Hollow Project and adjacent area is discussed below.

6.1.1 Swapp Hollow creek

The largest source of surface water for potential flood irrigation use in the Coal Hollow Project area is from Swapp Hollow creek. Monitoring on Swapp Hollow creek has been performed at monitoring site SW-8 (see Drawing7-10 in Chapter 7 of the Coal Hollow Project MRP). Historical discharge and water quality data for Swapp Hollow creek are provided in Table 9. Discharge measurements performed at SW-8 indicate considerable seasonal and climatic variability. The long-term average instantaneous discharge in the creek as monitored at SW-8 is 55 gpm (0.12 cfs). Flow has been present during all monitoring events at SW-8. Assuming an average discharge of 55 gpm, an annual yield of 88.7 acre-feet is calculated.

Assuming an alfalfa plant evapotranspiration requirement of 27.2 inches over the irrigation season (May – early September; Table 8) and an average precipitation during the same irrigation period of about 5 inches, it was calculated that about 1.85 acre-feet per acre of alfalfa is required for the growing season. Thus, during an average year a total of about 48 acres of alfalfa could be irrigated, assuming that ***all*** of the water that flowed in the creek could successfully be applied to the irrigated crop. Similarly, the requirement for pasture irrigation is 23.31 inches in the Alton area over the irrigation season (April through September; Table 8). Thus, assuming a seasonal irrigation requirement of 1.35 acre-feet per acre of irrigated pasture, and assuming average precipitation occurred during the growing period, it is calculated that about 66 acres of pasture could be irrigated assuming that ***all*** of the water flowing through Swapp Hollow creek during an average year could be efficiently applied to the pasture vegetation. However, for several reasons, both of these approximations likely considerably overestimate the actual acreage that could be flood irrigated. Using a commonly used "rule-of-thumb" approximation, about 50 percent of the flood irrigation water transmitted through an earthen ditch from the point of diversion to the point of application to the crops is lost in transmission. Consequently, a more realistic estimate of the amount of flood irrigation that could be accomplished using the entire annual yield from Swapp Hollow creek is about half of that estimated above, or about 24 acres of alfalfa, or about 33 acres of pasture land using all of the average annual yield for flood irrigation. Additionally, it should be noted that groundwater and surface-water resources in the region are fully appropriated by the State of Utah. Consequently, no new water rights are available that could be used for this potential flood irrigation. Much of the water in Swapp Hollow creek is currently being used for stock watering use and would not be available for flood irrigation. Thus, the acreage that could be irrigated is likely appreciably less than that estimated above. Additionally, it should be noted that these calculations are based on the *average* annual yield from Swapp Hollow creek. The annual yield in the drainage will fluctuate year to year because of climatic variability. Because there is no excess capacity in the creek, the actual amount of land that could be flood irrigated will vary correspondingly. Such conditions are not conducive to agricultural planning and successful flood irrigation in the area.

The results of these calculations are not intended to provide specific flood irrigation requirements for crop irrigation in the Coal Hollow Project area. Rather these calculations are presented to demonstrate the very limited potential for flood irrigation in the Coal Hollow Project and adjacent area.

The other potential sources of flood irrigation waters in the Coal Hollow Project area include the Lower Robinson Creek/Dry Canyon drainage, Section 21 canyon drainage, the spring diversion in upper Water Canyon, and Sink Valley Wash. Discharge measurements from these waters are listed in Table 9. Additionally, while not surface-water related, spring discharge from some alluvial groundwater systems has historically provided limited quantities of water for irrigation use. None of these sources of flood irrigation water are as significant as that in Swapp Hollow creek and none of these are deemed as acceptable sources for successful flood irrigation of lands in the Coal Hollow Project area. The streamflow and water yield characteristics of these potential sources are described below.

6.1.2 Lower Robinson Creek/Dry Canyon

Discharge in the Lower Robinson Creek/Dry Canyon drainage occurs only in direct response to torrential precipitation events or substantial snowmelt. Discharge measurements from Lower Robinson Creek (below the confluence with Dry Canyon) have been performed historically at monitoring site SW-4 (see Drawing 7-10 in Chapter 7 of the Coal Hollow Project MRP). Monitoring site SW-101 is also located on this drainage. During baseline monitoring at the project area, discharge has been monitored at SW-4 only during a snowmelt event in May of 2005, which was a very wet year (Figure 4). Additionally, in direct response to a torrential thunderstorm event, surface water in the drainage at SW-101 was monitored. It should be noted that the duration of the surface flow at that time was only a few minutes. On all other monitoring events, this stream has been dry. Consequently, the Lower Robinson Creek/Dry Canyon drainage is not considered a reasonably potential source for flood irrigation activities in the Coal Hollow Project and adjacent area.

6.1.3 Section 21 canyon drainage

Discharge has not been observed in Section 21 canyon during the period of baseline monitoring (as monitored at baseline monitoring site SW-7). This drainage is not considered a reasonably potential source for flood irrigation activities in the Coal Hollow Project and adjacent area.

6.1.4 Upper Water Canyon spring diversion

Historically, water from a spring in the upper reaches of the Water Canyon drainage about two miles east of the Coal Hollow Project area has been conveyed to pond 20-1 (see Drawing 7-7 of Chapter 7 of the Coal Hollow Project MRP). Discharge is monitored in this diversion at site RID-1, located near the USDA Forest Service boundary above pond 29-1 (see Drawing 7-10 of Chapter 7 of the Coal Hollow Project MRP). Discharge and water quality data for this site are presented in Table 9. Discharge at RID-1 averages 21.7 gpm or 35.0 acre feet per year. As discussed above (see Swapp Hollow creek discussion), quantities of water on this scale are not sufficient to sustain appreciable flood irrigation activities in the Coal Hollow Project area.

6.1.5 Sink Valley Wash

Sink Valley Wash is monitored at site SW-6 (see Drawing 7-10 in Chapter 7 of the Coal Hollow Project MRP). Discharge data for SW-6 are presented in Table 9. It is apparent that discharge in Sink Valley Wash is not useful for subirrigation purposes in the Coal Hollow Project area. During baseline monitoring activities, flowing water has only been observed on one occasion at SW-6 during March of 2006. On this occasion, sheet floods were occurring in Sink Valley in direct response to the copious melting of snow in the valley. It is noteworthy that on this occasion the waters in the fields above SW-6 were not flowing through any discernable stream drainage. Rather the surface flow was running down the valley over a large upstream area in an unconcentrated sheet flood.

6.1.6 Alluvial groundwater spring discharges

Historically, some small-scale domestic flood irrigation (likely domestic flood irrigation of gardens for family use) of lands near the historic homestead locations has occurred using water from alluvial springs in the Coal Hollow Project and adjacent area. Currently, groundwater from spring SP-20 gravity flows from the spring discharge area to pond 29-3.

At the current time, when available, water from this pond overtops the water holding pond and runs into the field below the pond and is lost to evapotranspiration. The water is used currently for stock watering, and is not used for irrigation. The discharge from alluvial spring SP-20 averages about 6 gpm. Groundwater from spring SP-8 is currently collected in a spring box and conveyed via a buried pipe to the Swapp Ranch house for domestic use. Surplus water from SP-8 is piped to a newly constructed water holding pond (pond 29-5; see drawing 7-7 of the Coal Hollow Project MRP) adjacent to the ranch house. The water in the pond is not currently used for irrigation. Discharge from spring SP-8 averages about 13.8 gpm, or about 22.3 acre-feet per year.

6.2 Flood irrigation potential (water quality)

Groundwater discharge data for all streams that may potentially provide surface water for flood irrigation in Sink Valley have been submitted electronically to the Division's on-line hydrology database. Discharge and water quality data for streams that could potentially be used for flood irrigation are presented in Table 9. As described above, the two streams with the greatest annual discharge, and consequently the best potential for flood irrigation use in the project area are Swapp Hollow creek and the Water Canyon spring diversion. The water quality characteristics of these two sources are described below.

6.2.1 Swapp Hollow creek

Surface water at Swapp Hollow creek is monitored at site SW-8 (see Drawing 7-10 in Chapter 7 of the Coal Hollow Project MRP). It is apparent from Figure 12 that the surface water in Swapp Hollow creek is a C2-S1 class water on the SAR – conductivity classification of irrigation water (Figure B-5, OSM, 1983). This indicates medium-salinity water. The water may be used for flood irrigation if a moderate amount of leaching occurs. The sodium hazard is low. The surface water in Swapp Hollow creek averages 311 mg/L (Table 9). Based on the dissolved-solids hazard for irrigation water (Table B-5, OSM, 1983) irrigation with this water will not usually result in detrimental effects. Using the criteria shown on

Table B-6 (OSM, 1983), which considers boron, SAR, chloride, sulfate, specific conductance, and TDS levels, the Swapp Hollow water is a Class I water. This indicates excellent to good water with a low salinity hazard that is suitable for most conditions. It is suitable for irrigation of all or most plants, including salinity- and boron-sensitive species.

6.2.2 Water Canyon spring diversion

Waters in the Water Canyon spring diversion are monitored at site RID-1 (see Drawing 7-10 in Chapter 7 of the Coal Hollow Project MRP). It is apparent from Figure 12 that waters in the Water Canyon spring diversion are C2-S1 class waters on the SAR – conductivity classification of irrigation water (Figure B-5, OSM, 1983). This indicates medium-salinity water. The water may be used for flood irrigation if a moderate amount of leaching occurs. The sodium hazard is low. The waters in the Water Canyon spring diversion average 248 mg/L (Table 9). Based on the dissolved-solids hazard for irrigation water (Table B-5, OSM, 1983) irrigation with this water will not usually result in detrimental effects. Using the criteria shown on Table B-6 (OSM, 1983), which considers boron, SAR, chloride, sulfate, specific conductance, and TDS levels, the Water Canyon spring diversion waters are Class I waters. This indicates excellent to good water with a low salinity hazard that is suitable for most conditions. The water in this class is suitable for irrigation of all or most plants, including salinity- and boron-sensitive species.

6.2.3 Alluvial groundwater springs

A characterization of the water quality characteristics of alluvial groundwater systems from which spring discharges could potentially be used for flood irrigation (SP-20 and SP-8) is presented in Section 5.2.1 above. In that analysis, the water quality conditions at spring SP-8 were characterized. The water quality characteristics of springs SP-8 and SP-20 are similar to each other and to other springs originating in Alluvial Groundwater Discharge Area A (see Appendix 7-1 in Chapter 7 of the Coal Hollow Project MRP). Water quality data for springs and wells in the alluvial groundwater system in this area have been submitted electronically to the Division's on-line hydrology database (UDOGM, 2008).

6.3 Flood irrigation potential (soils measurements)

Information on soil characteristics in the Coal Hollow Project area are provided in Chapter 2 of the Coal Hollow Project MRP. This information includes physical and chemical properties of the soils sampled in 60 soils pits excavated and surveyed by qualified soils scientists. Also included in Chapter 2 are qualitative evaluations of prevailing soil moisture conditions in the shallow subsurface in the project area.

6.4 Flood irrigation potential (topographic characteristics)

The topographic characteristics of the land surface in the Coal Hollow Project have been documented using high-accuracy aerial surveys. A contour map depicting this information is provided in Drawing 5-1 in Chapter 5 of the Coal Hollow Project MRP. The surface topography of the Coal Hollow Project and adjacent area is also shown on a digitally shaded USGS topographic map in Figure 1. Based on this information, it is apparent that the topographic characteristics of most lands in the project and adjacent area are compatible with flood irrigation techniques. This conclusion is based on the fact that 1) the streams entering the project area originate in upland areas with considerably hydraulic head appreciably greater than the elevations in the project area, and 2) consequently, based on the surface topography, it is apparent that conveyance ditches could be constructed that could convey surface waters from the highland areas in the east to most locations within the project area. Areas that could not reasonably be irrigated by flood irrigation techniques include the steep, isolated hills located mostly in the western portions of the project area.

7.0 R645-302-321-260

7.1 Aerial photographs and infrared imagery

Aerial photographs of the Coal Hollow Project and adjacent area are provided in Plates 3 and 4. The late summer/fall infrared imagery has been analyzed extensively in the analysis of the valley floor in Sink Valley. The infrared imagery has been utilized by researchers in each of the various scientific disciplines and was an important investigative tool in developing the conclusions presented in this report

8.0 References Cited

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OSM, 1983, Alluvial valley floor identification and study guidelines, U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement.

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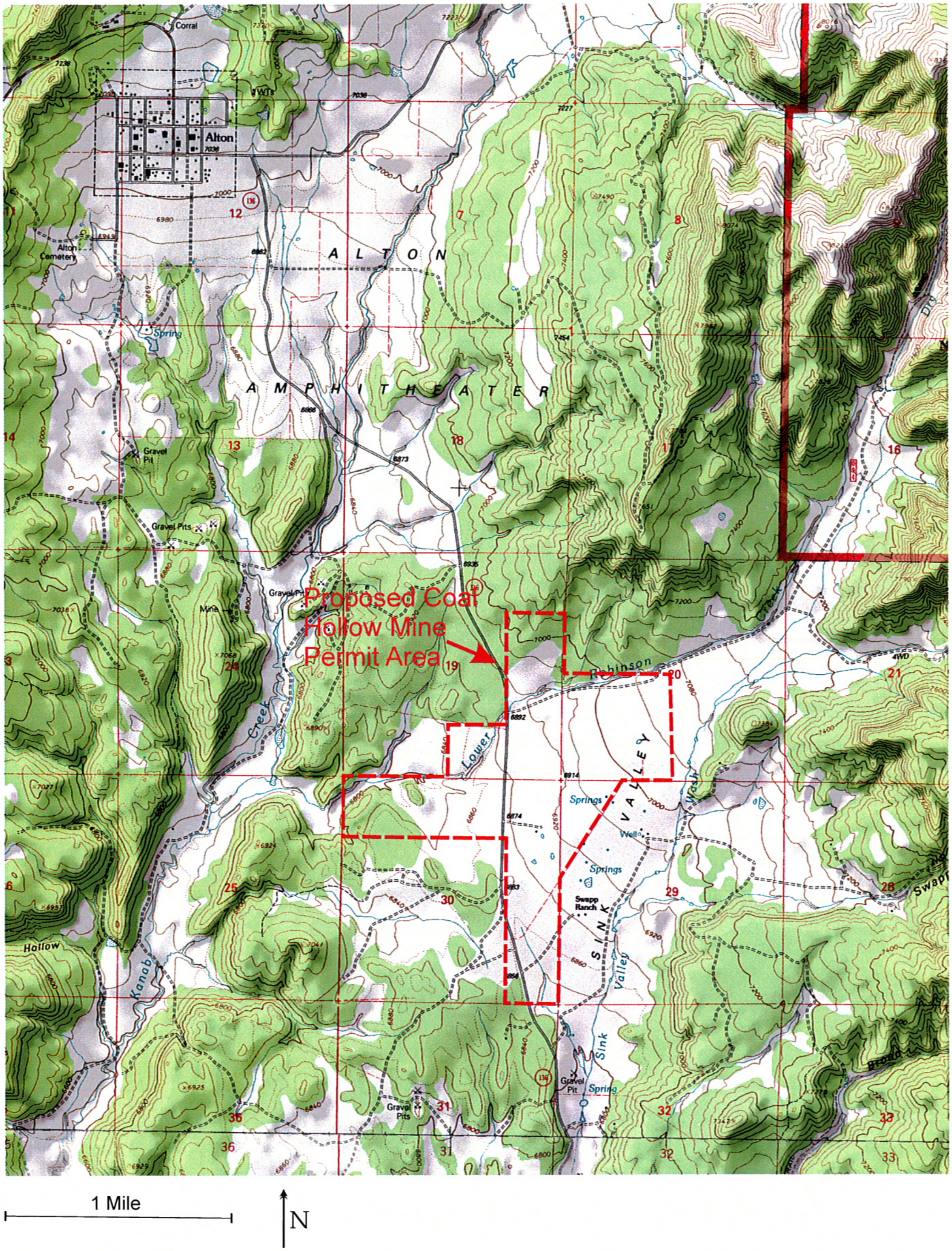


Figure 1 Location map of proposed Coal Hollow Mine permit and adjacent area and the town of Alton, Utah.

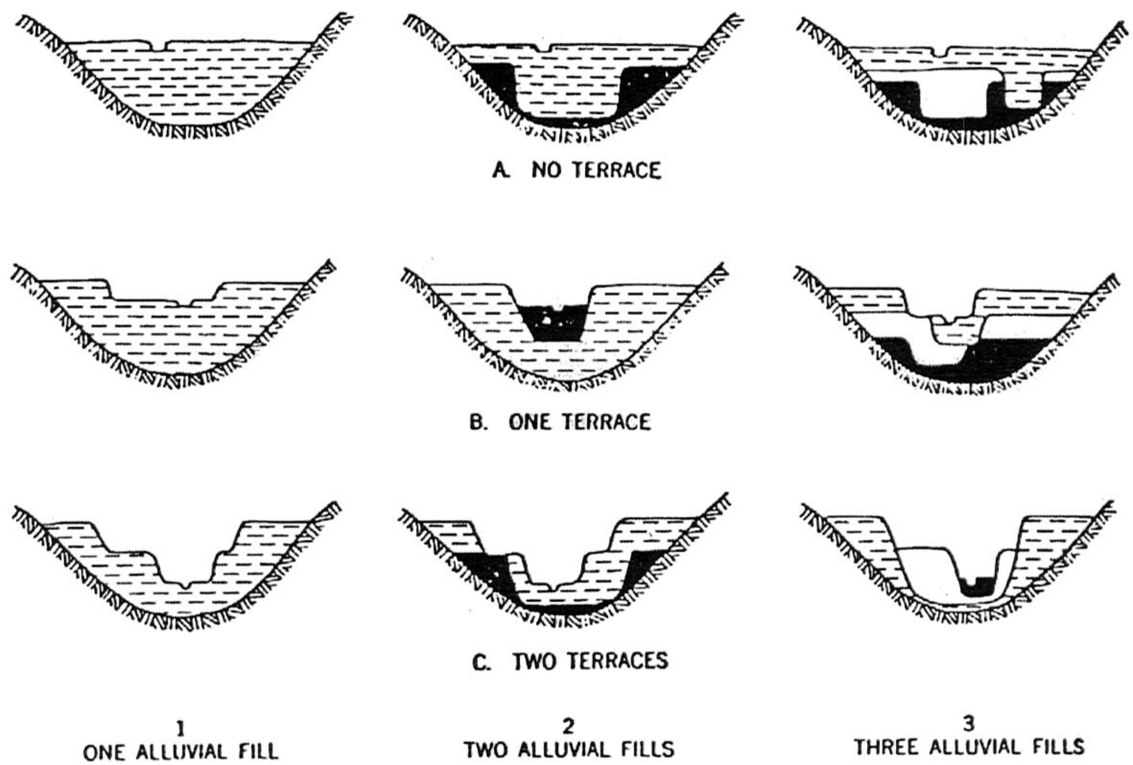
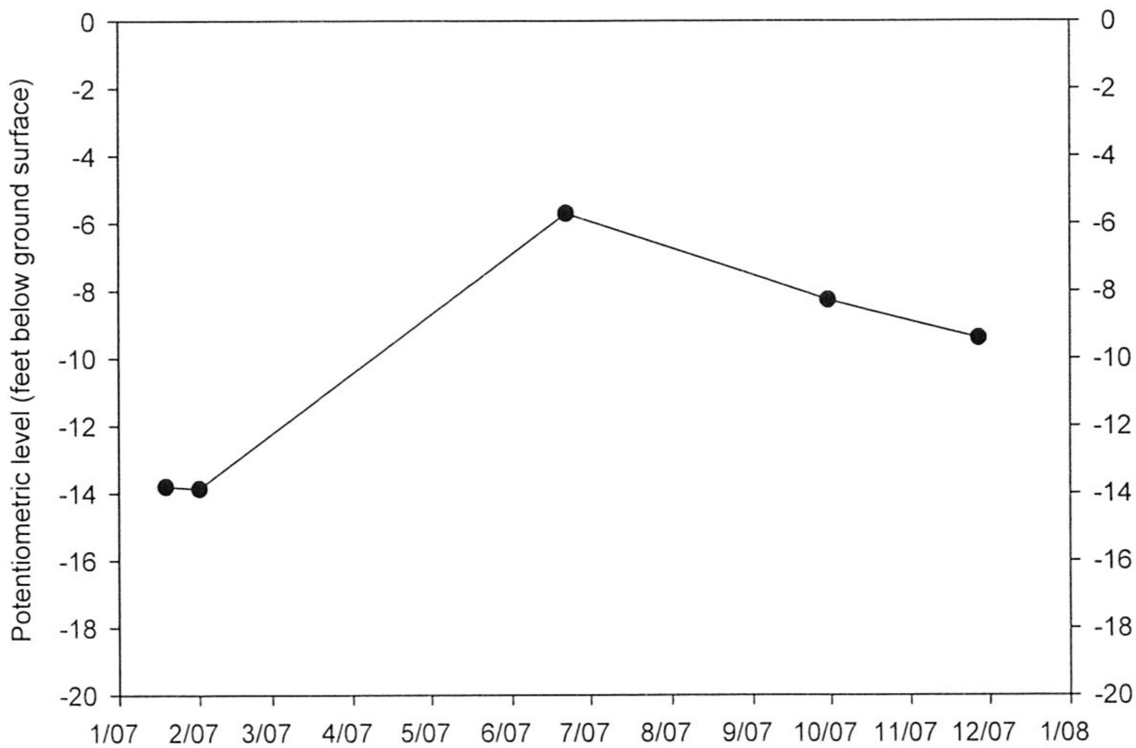


Figure 2 Examples of valley cross-sctions showing some possible relations in valley alluvium (from OSM, 1983).

Figure 3

Depth to groundwater hydrographs for alluvial piezometers for 2007.

C0-18



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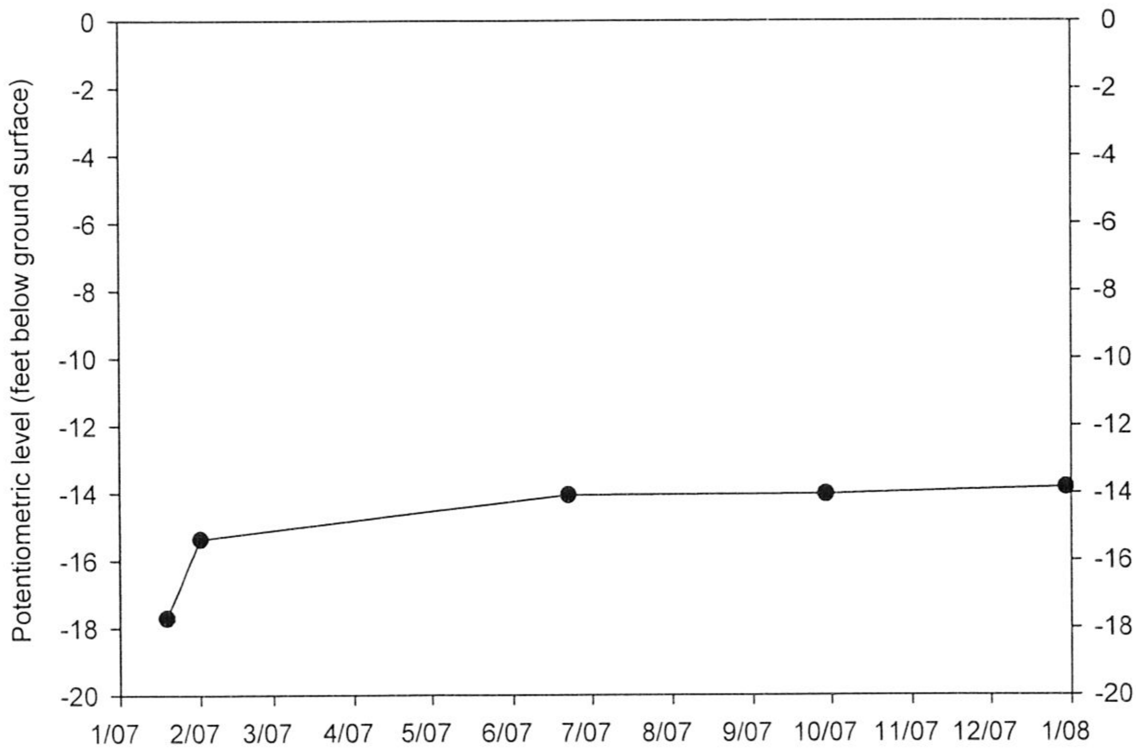
C1-24



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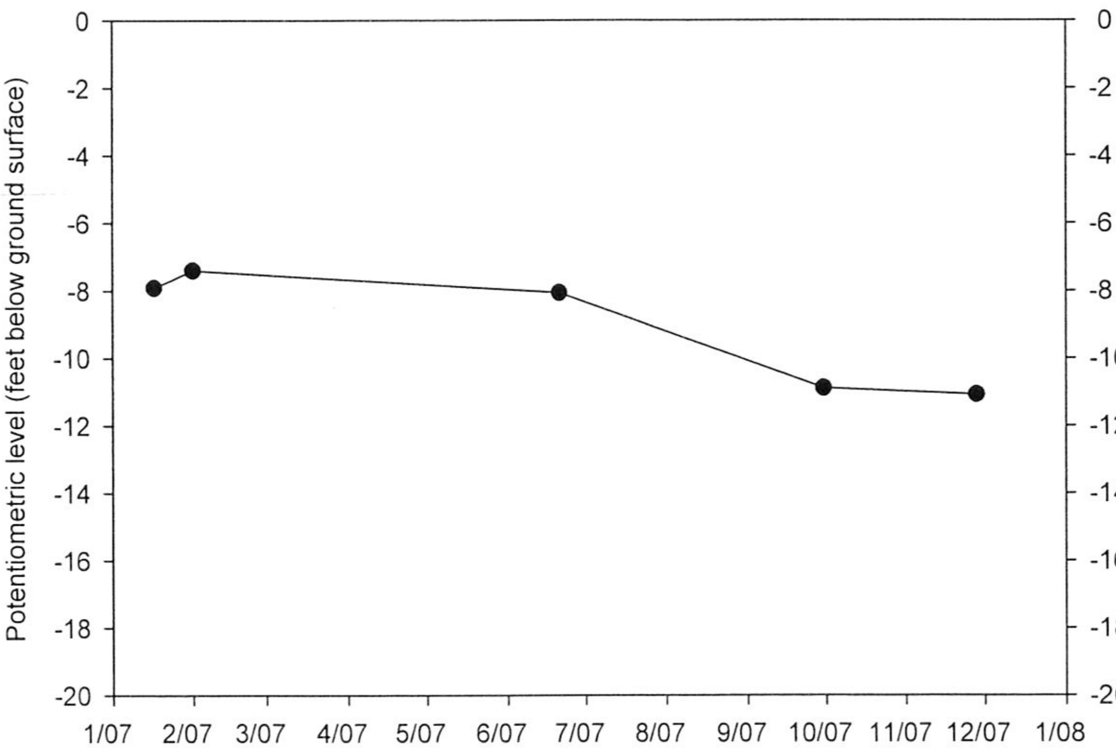
C2-15



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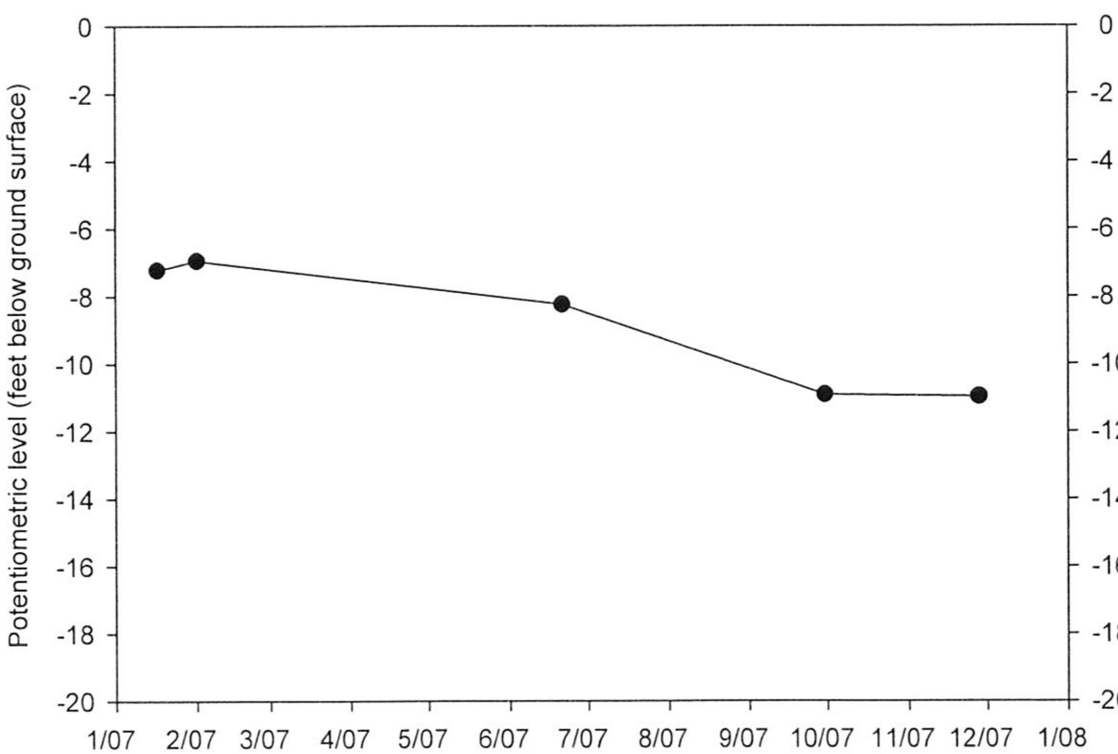
C2-28



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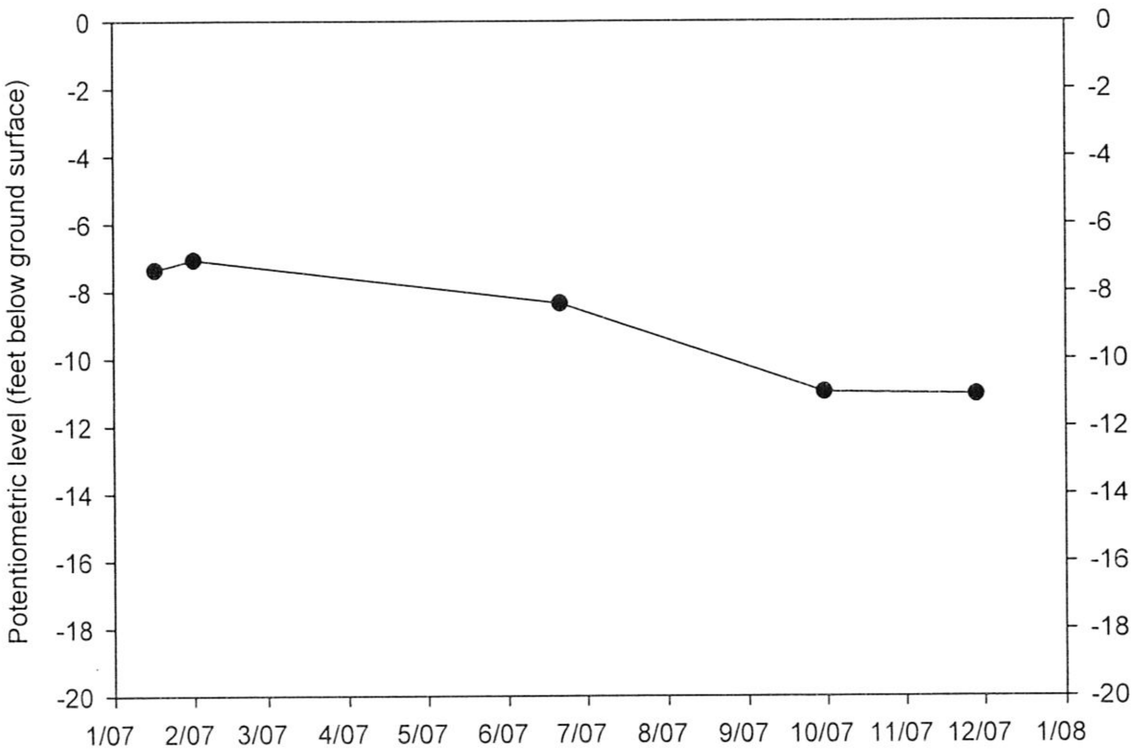
C2-40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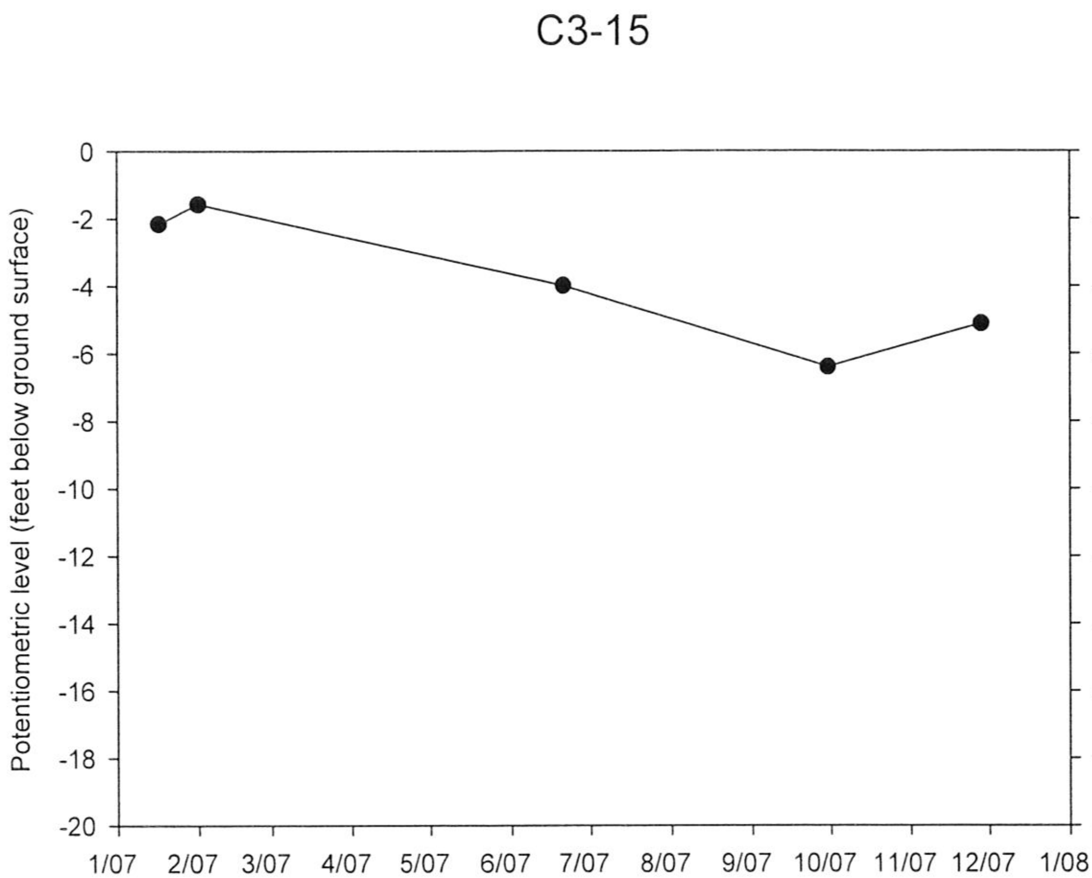
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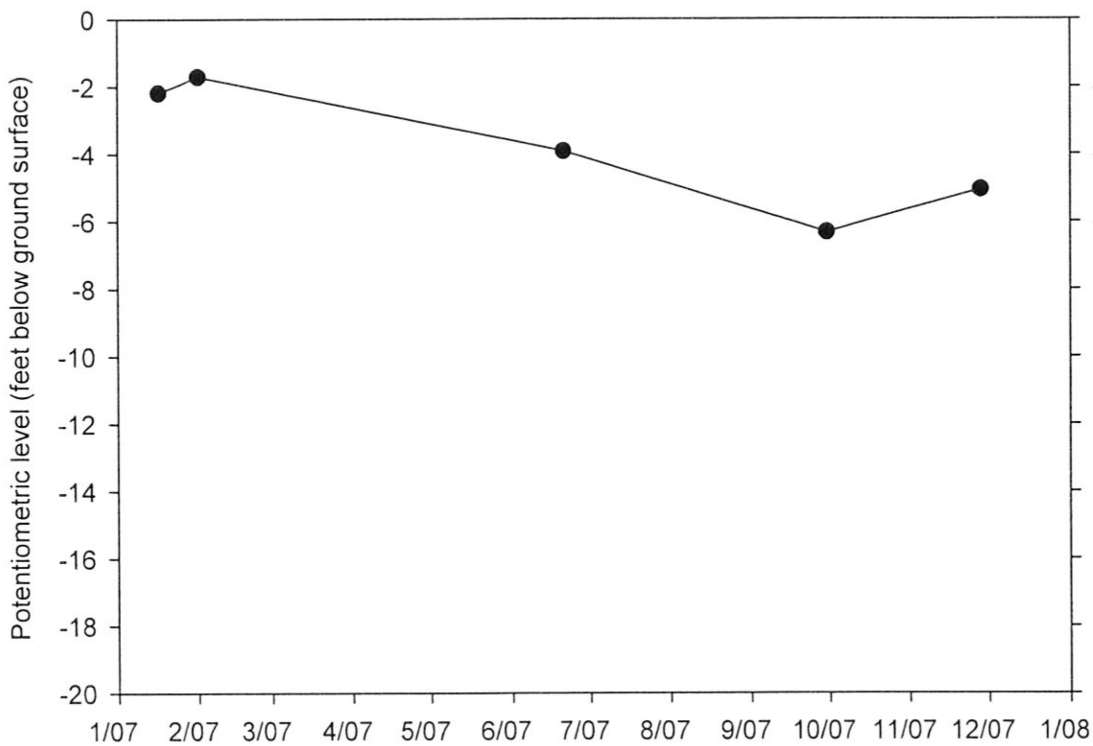

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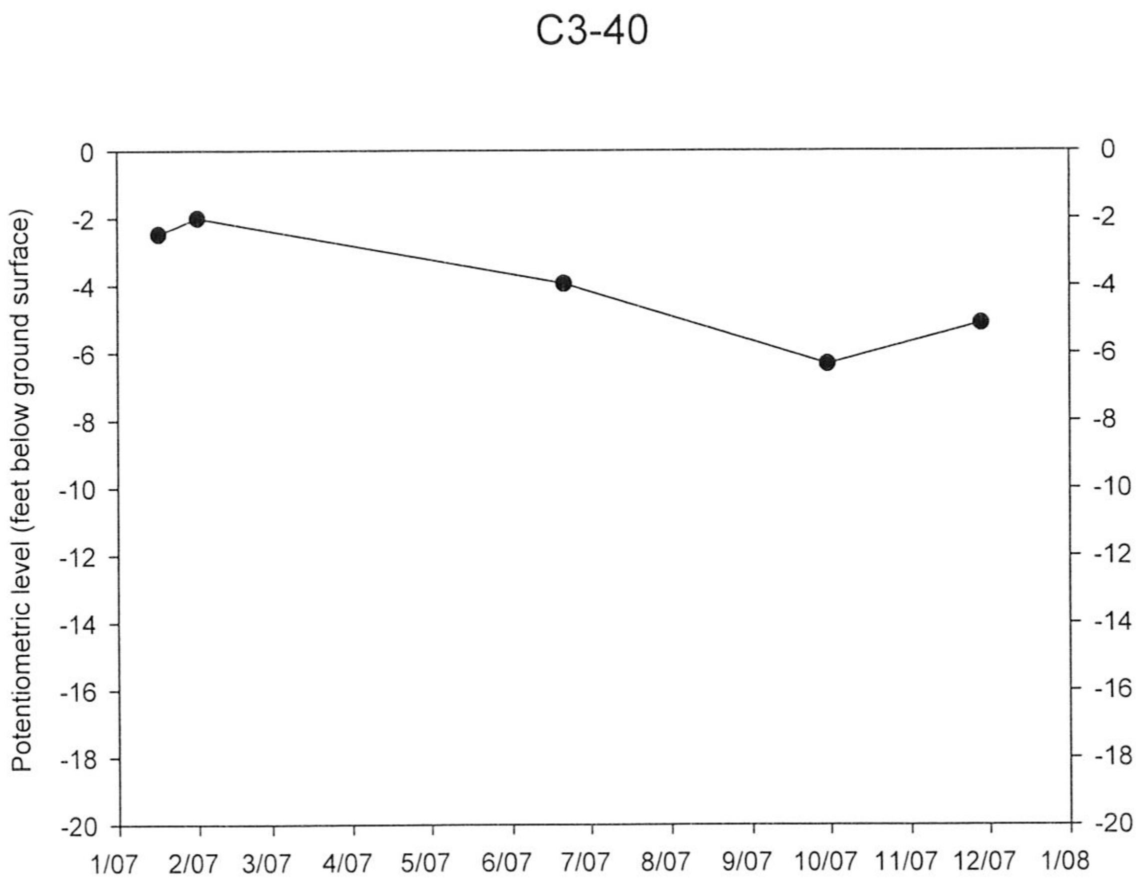

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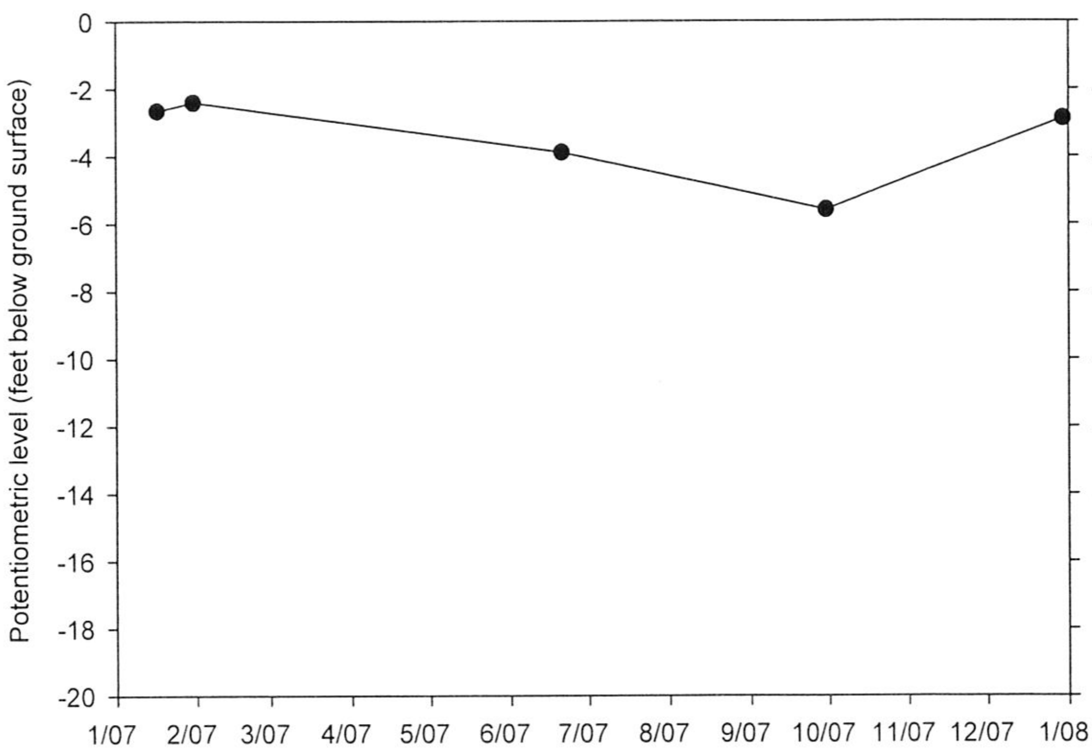

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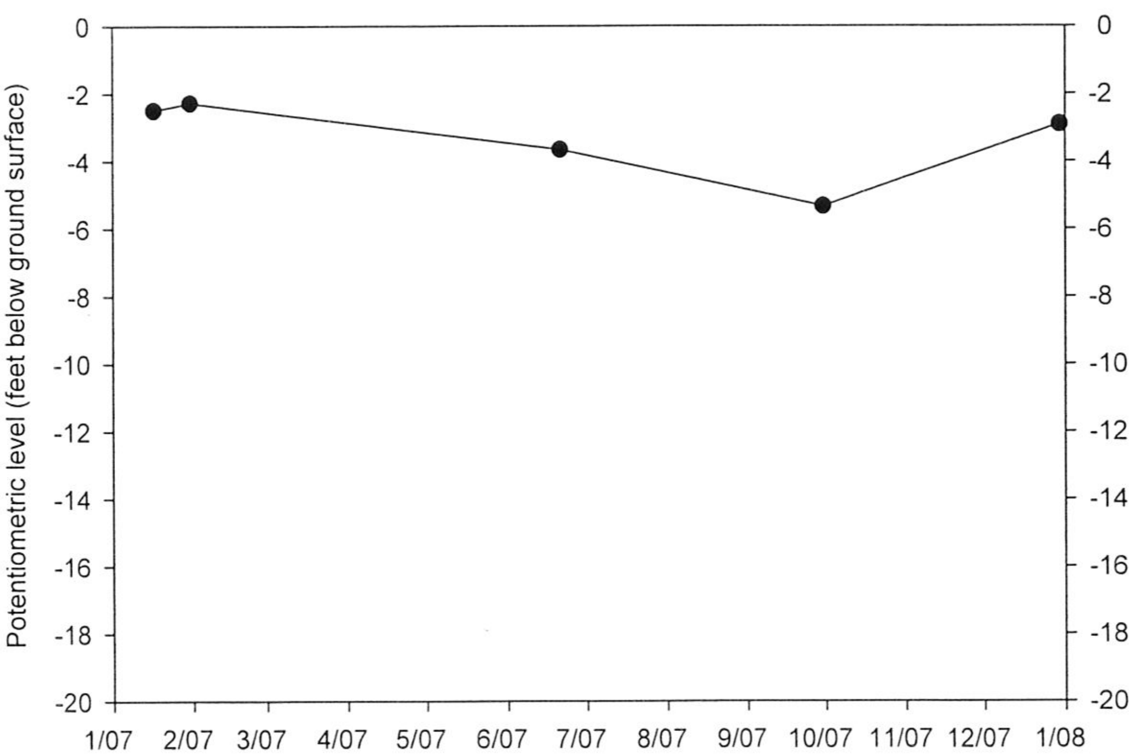

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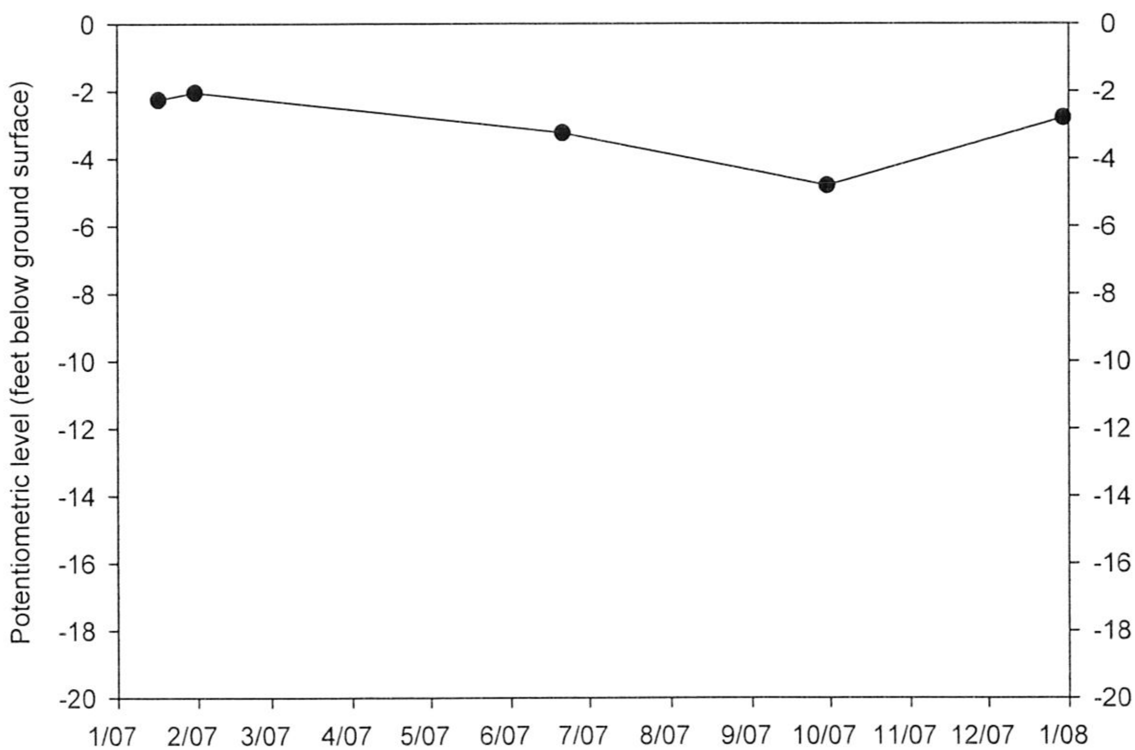

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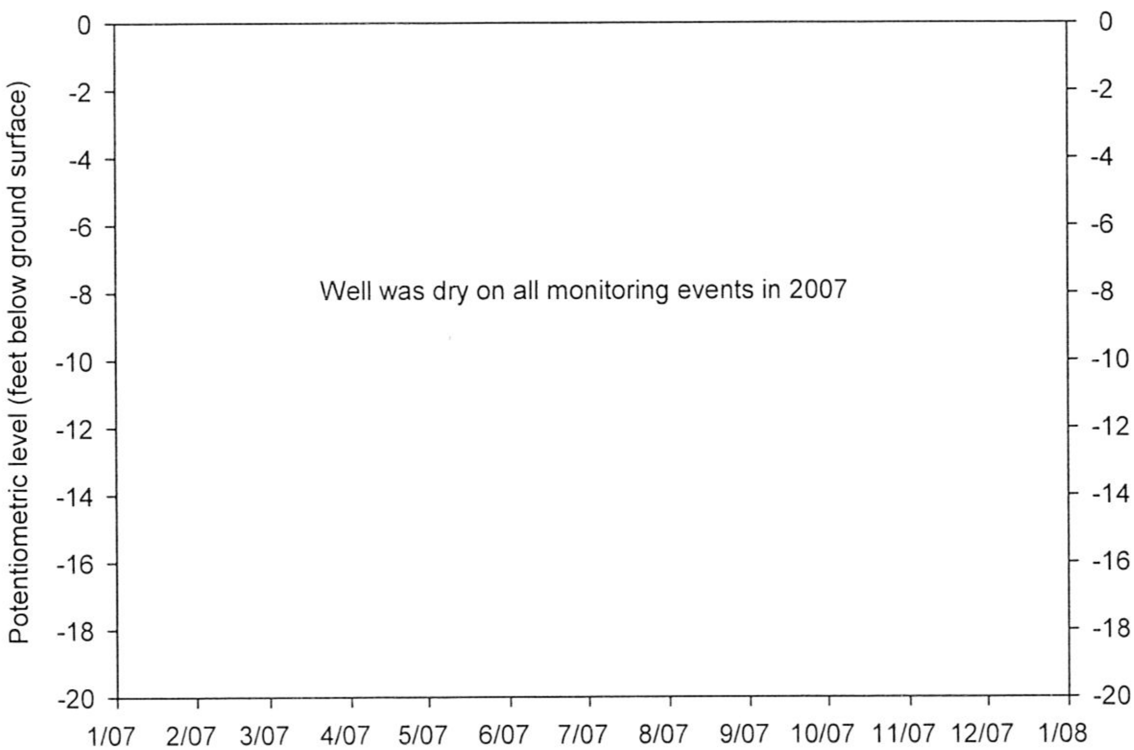

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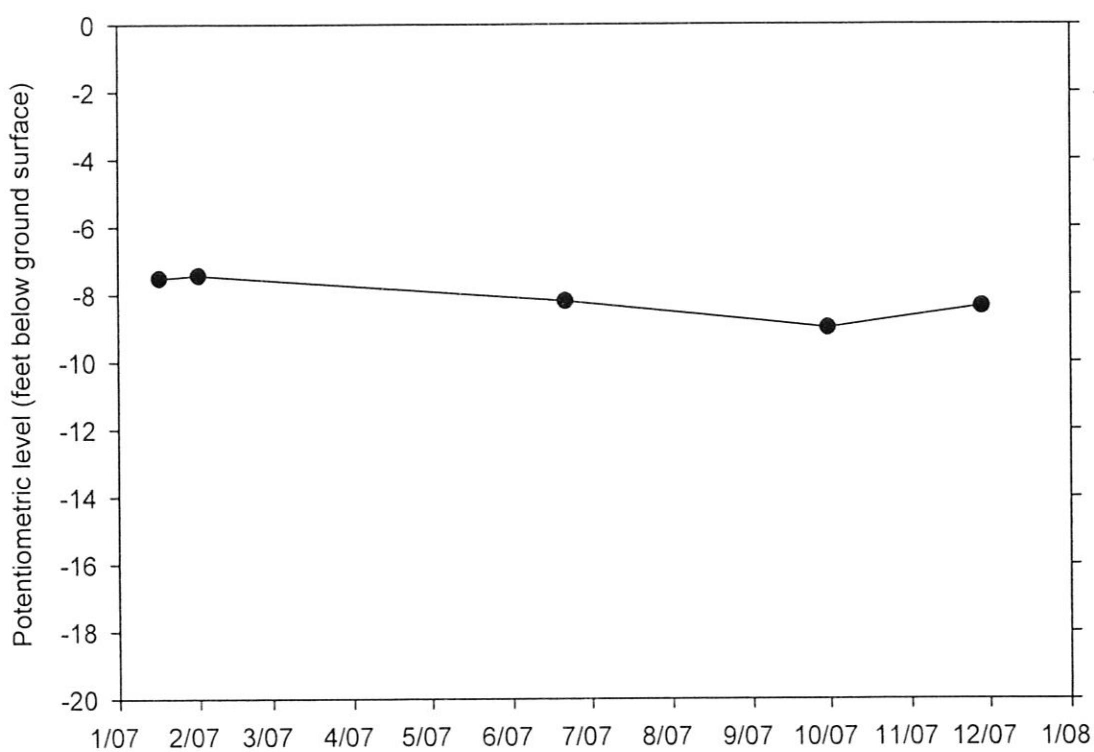

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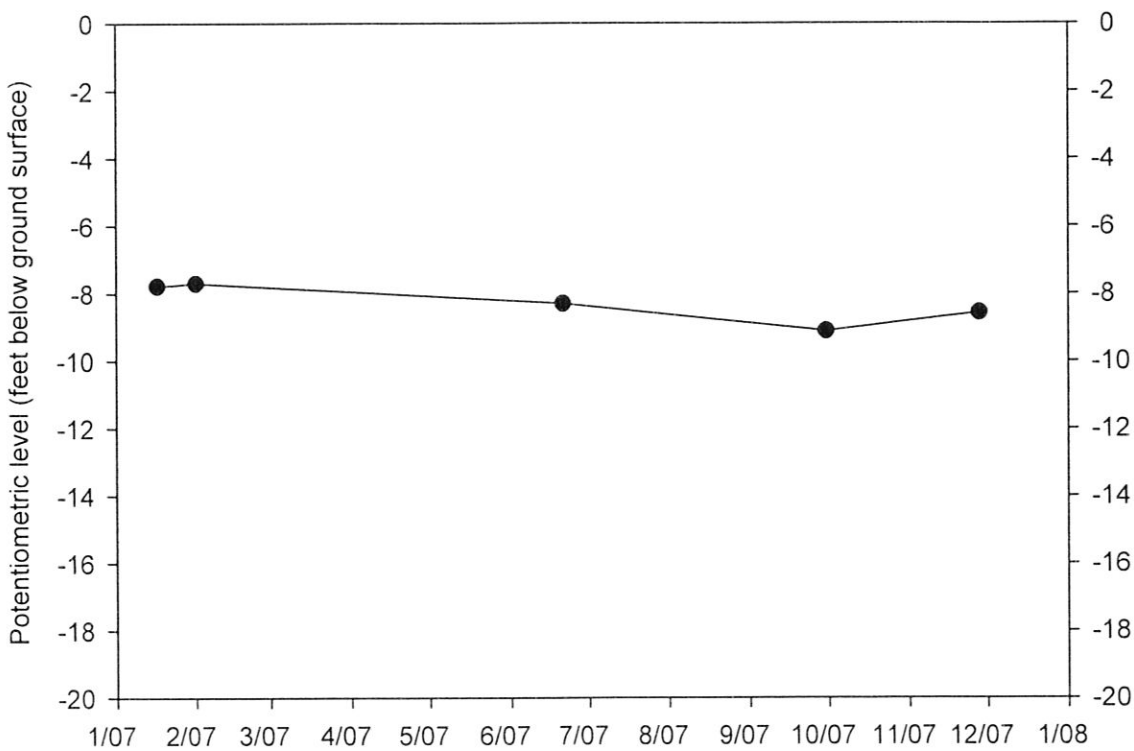

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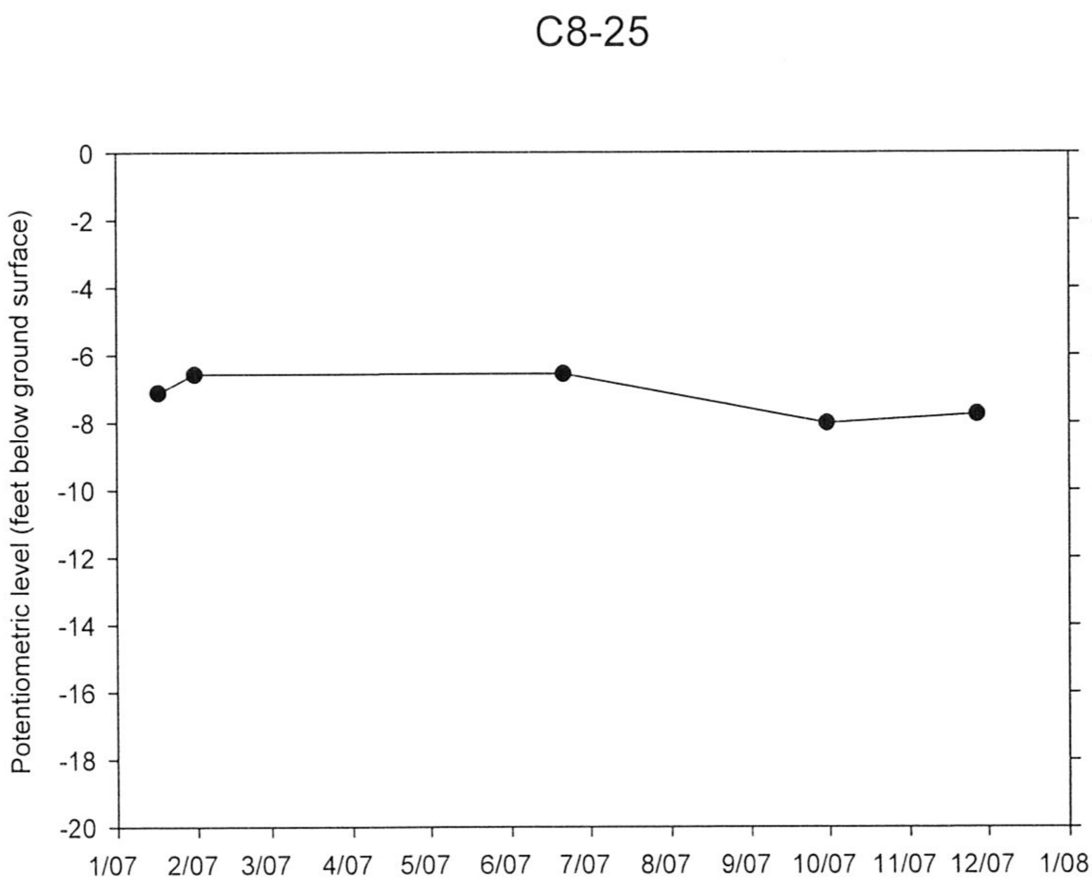
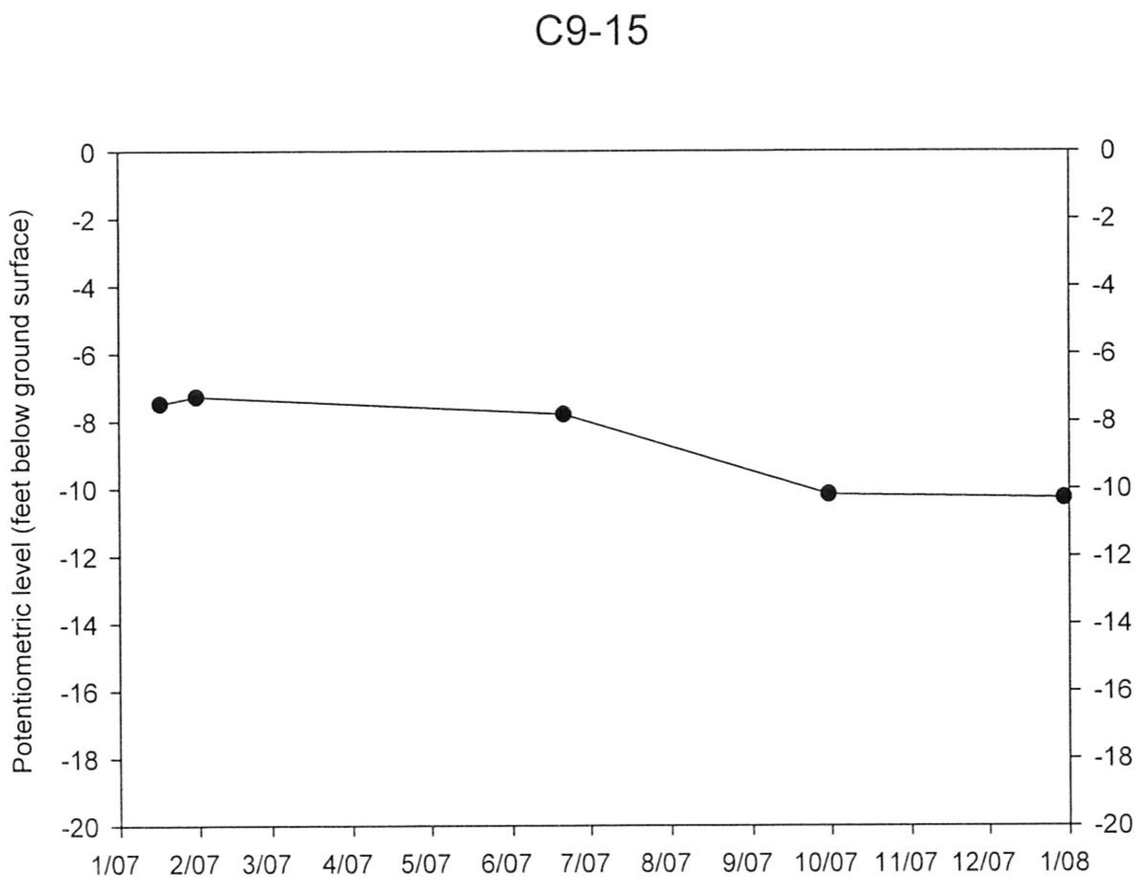
-20
1/07 2/07 3/07 4/07 5/07 6/07 7/07 8/07 9/07 10/07 11/07 12/07 1/08

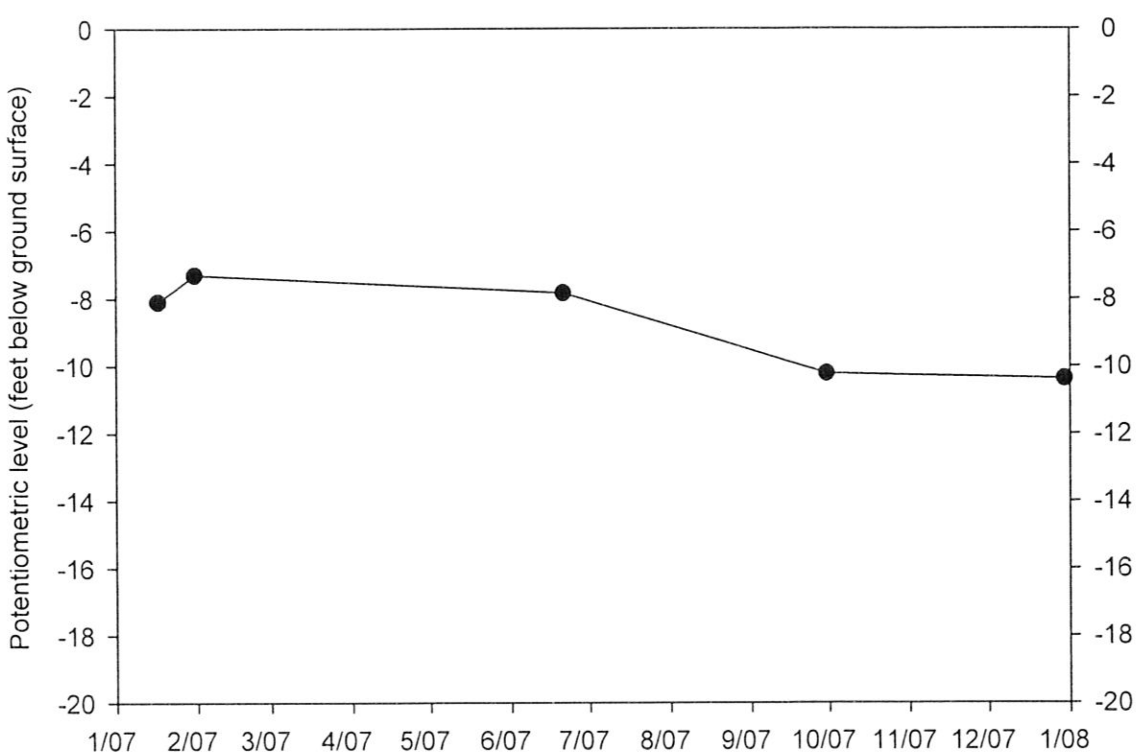


C8-25
Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

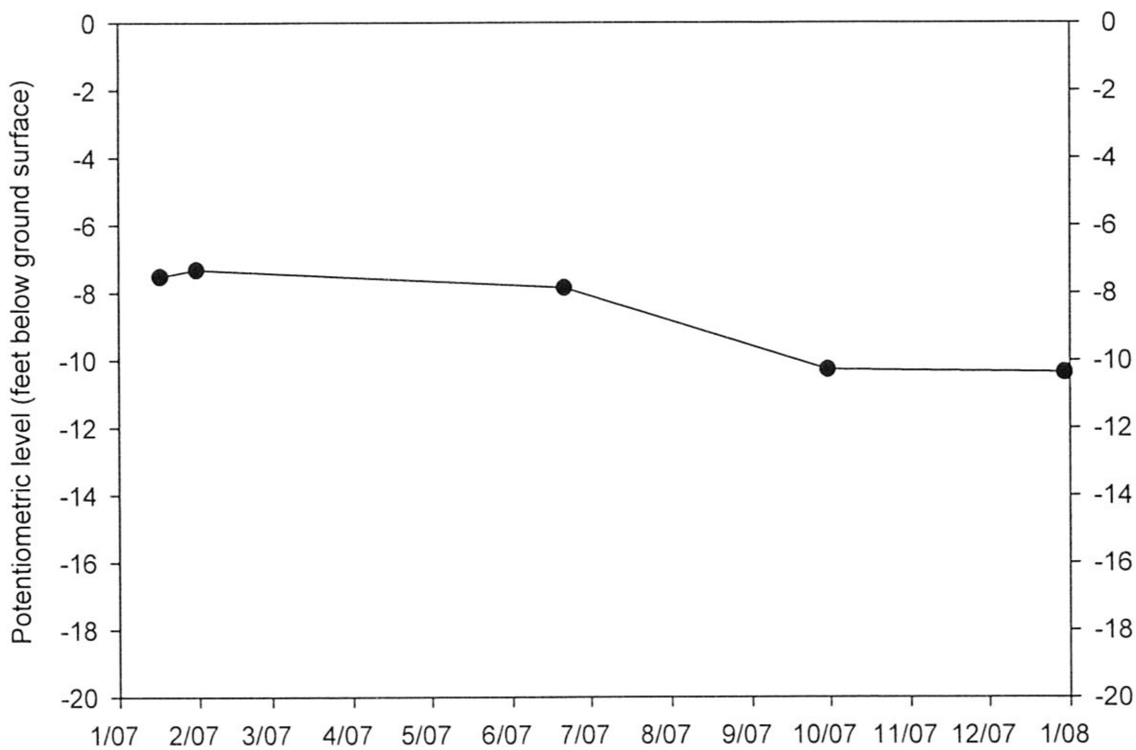


C9-15
Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

C9-25

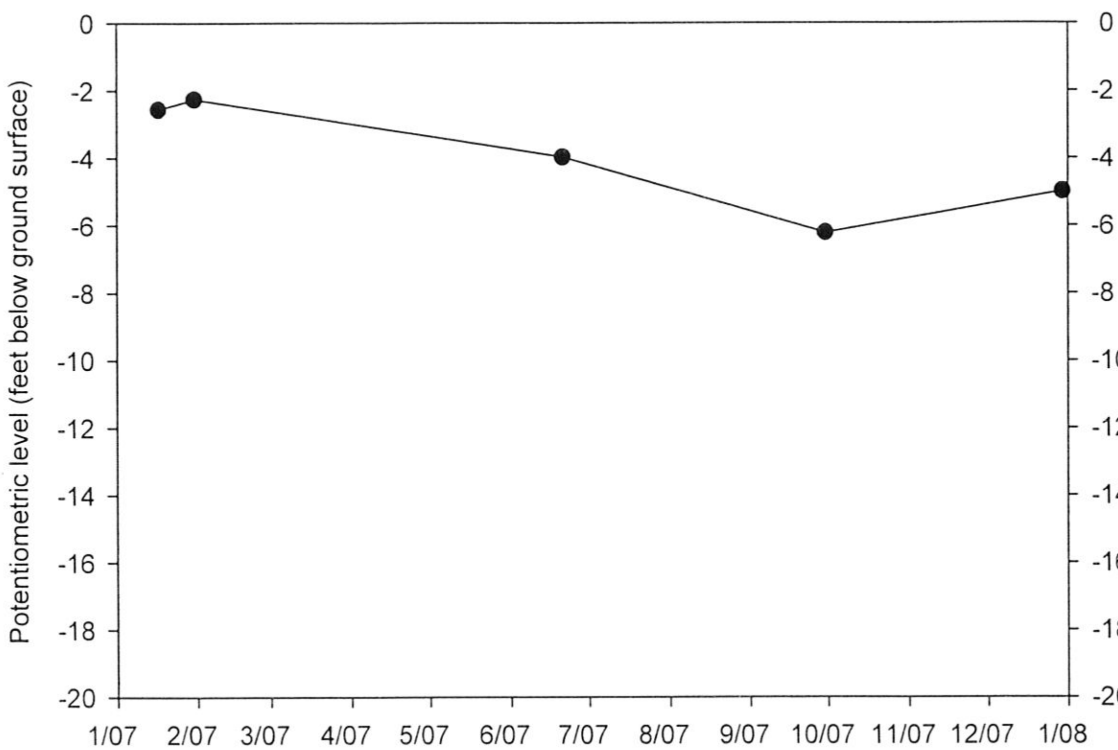

Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

C9-40



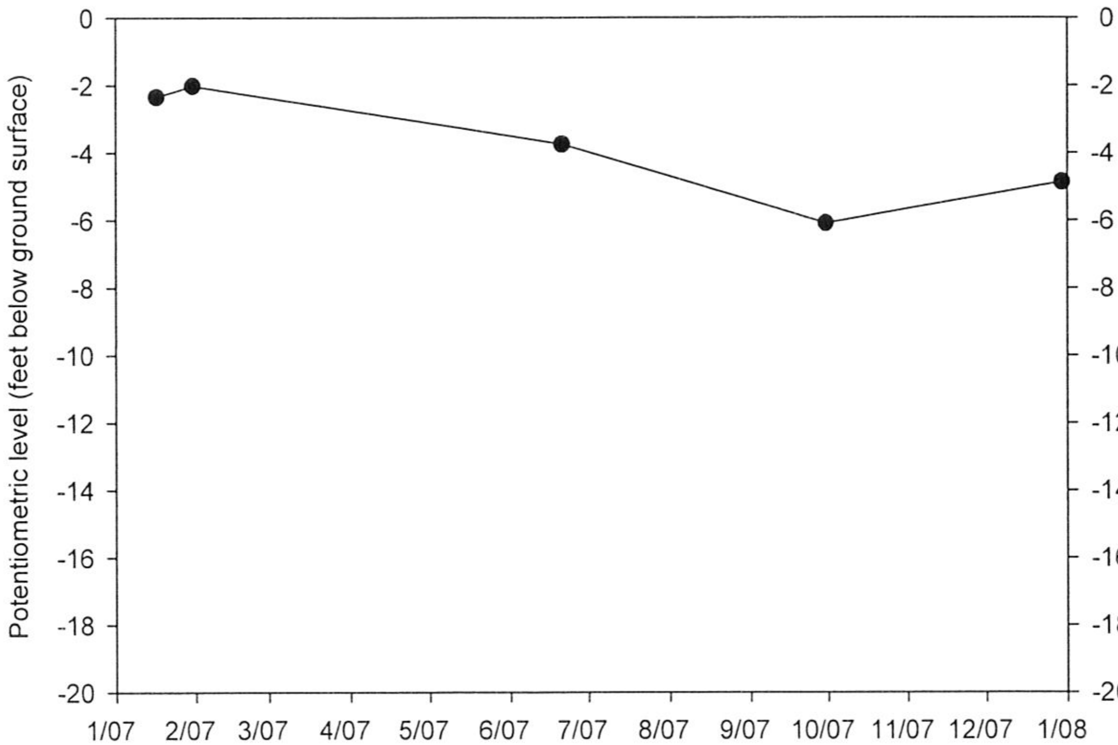
Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

SS-15



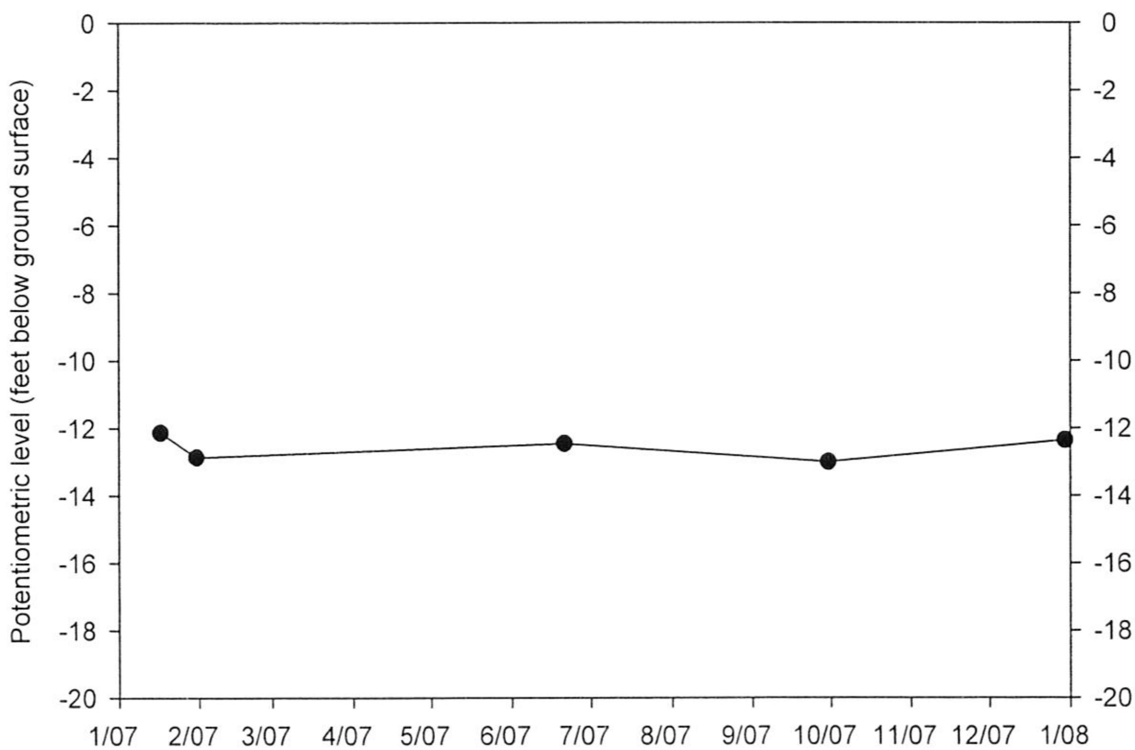
Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

SS-30

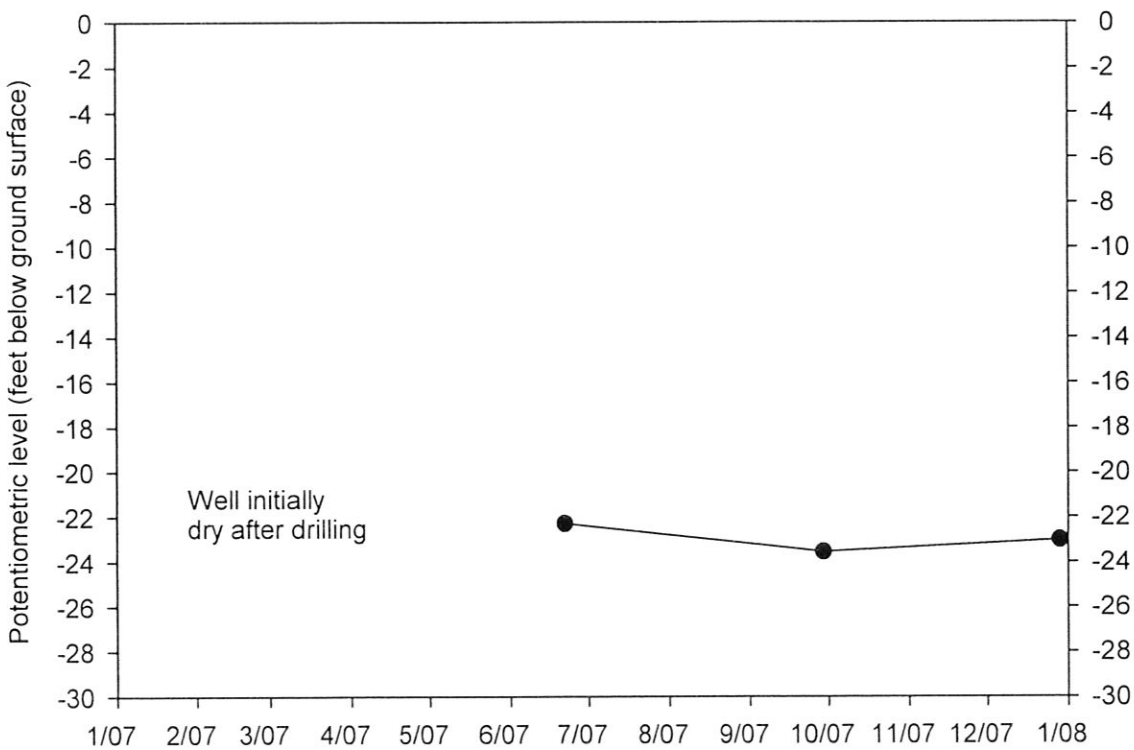


Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

SS-75

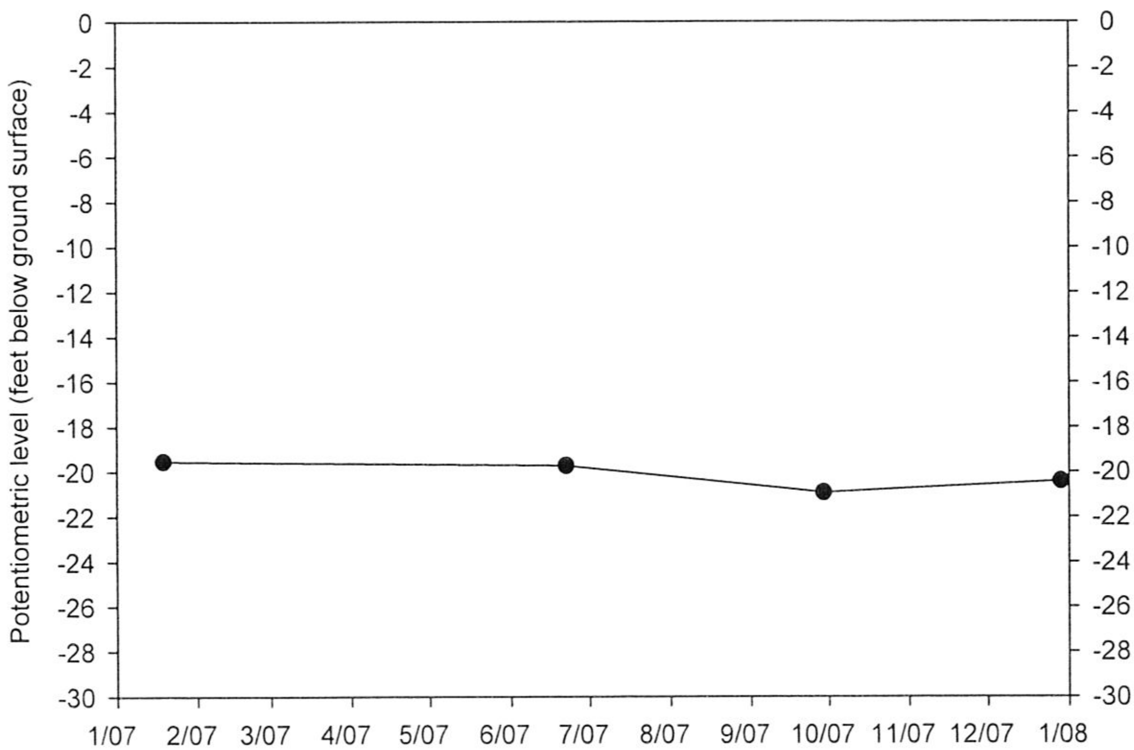

Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

UR-29



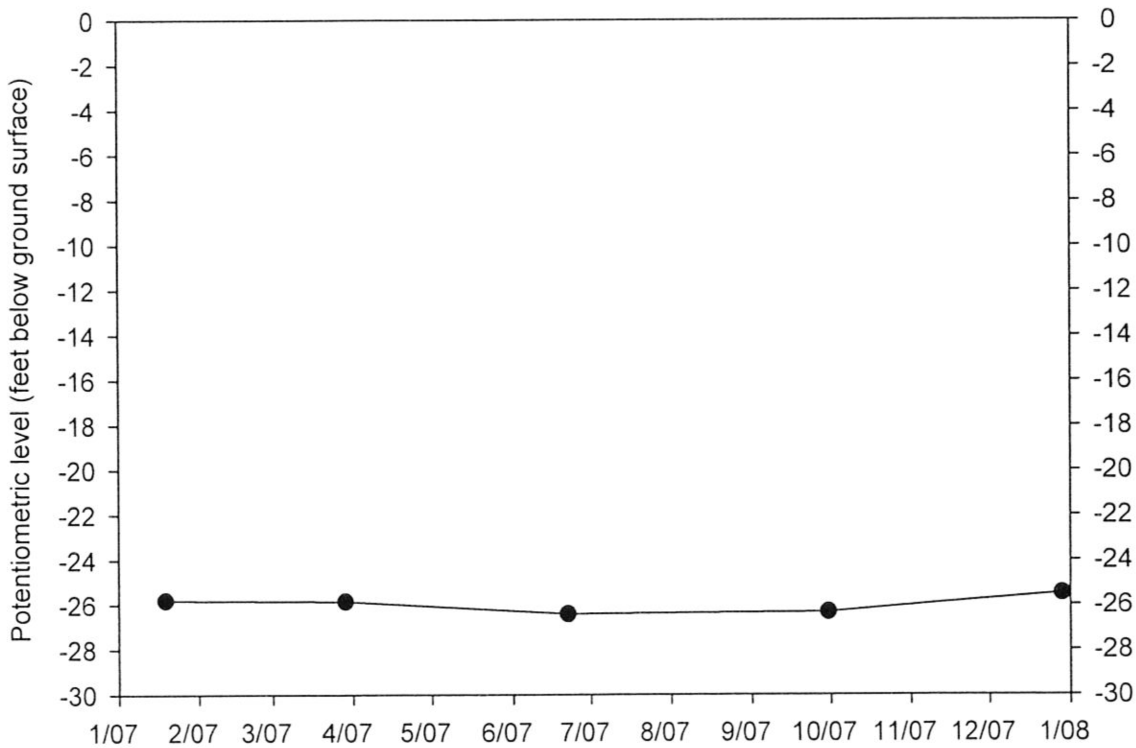
Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
Well initially
dry after drilling
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

UR-70



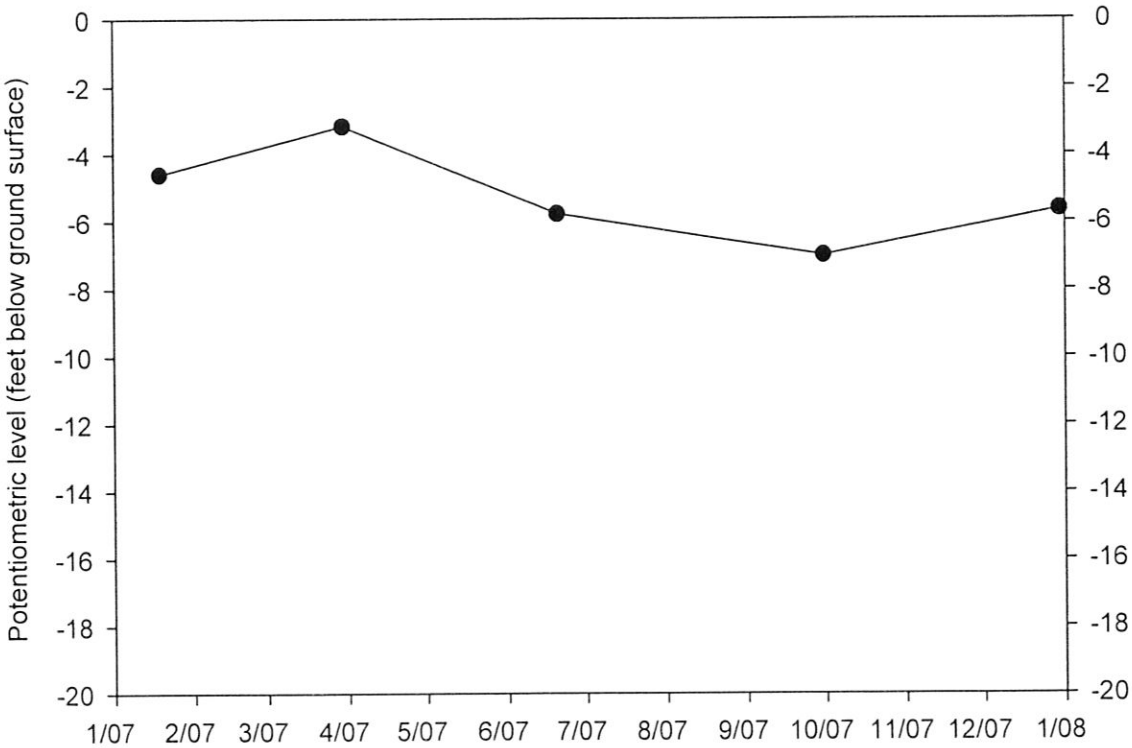
Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

LR-45

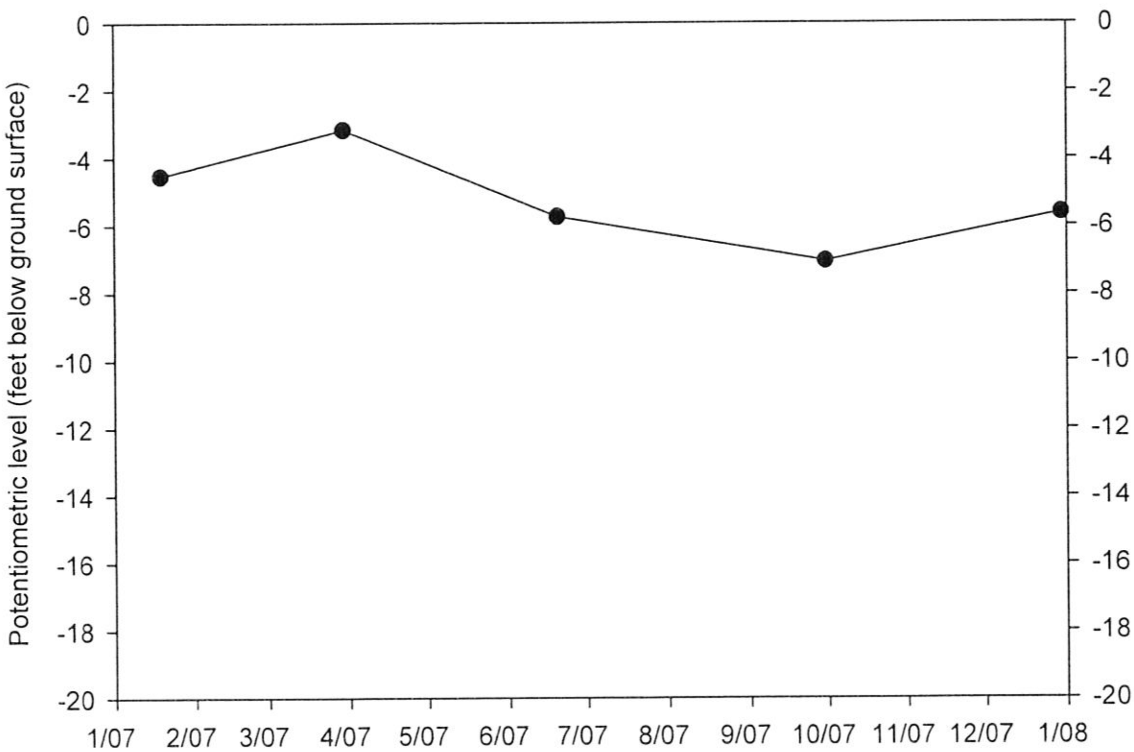


Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

LS-15

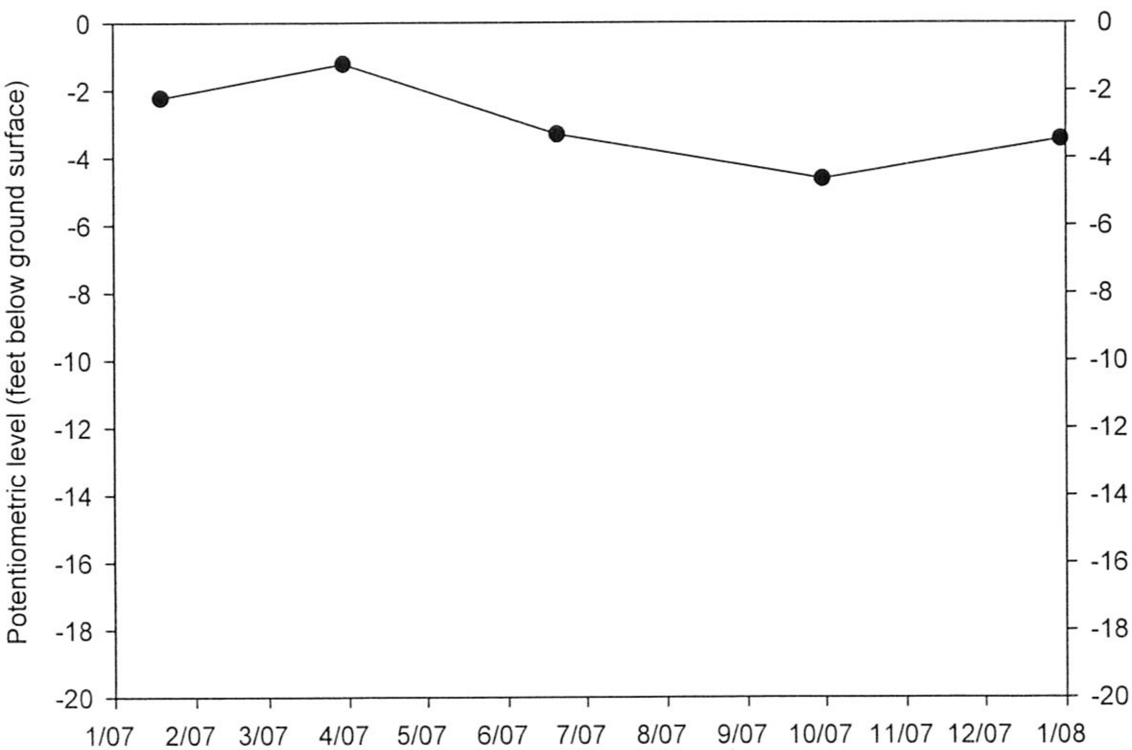

Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

LS-28

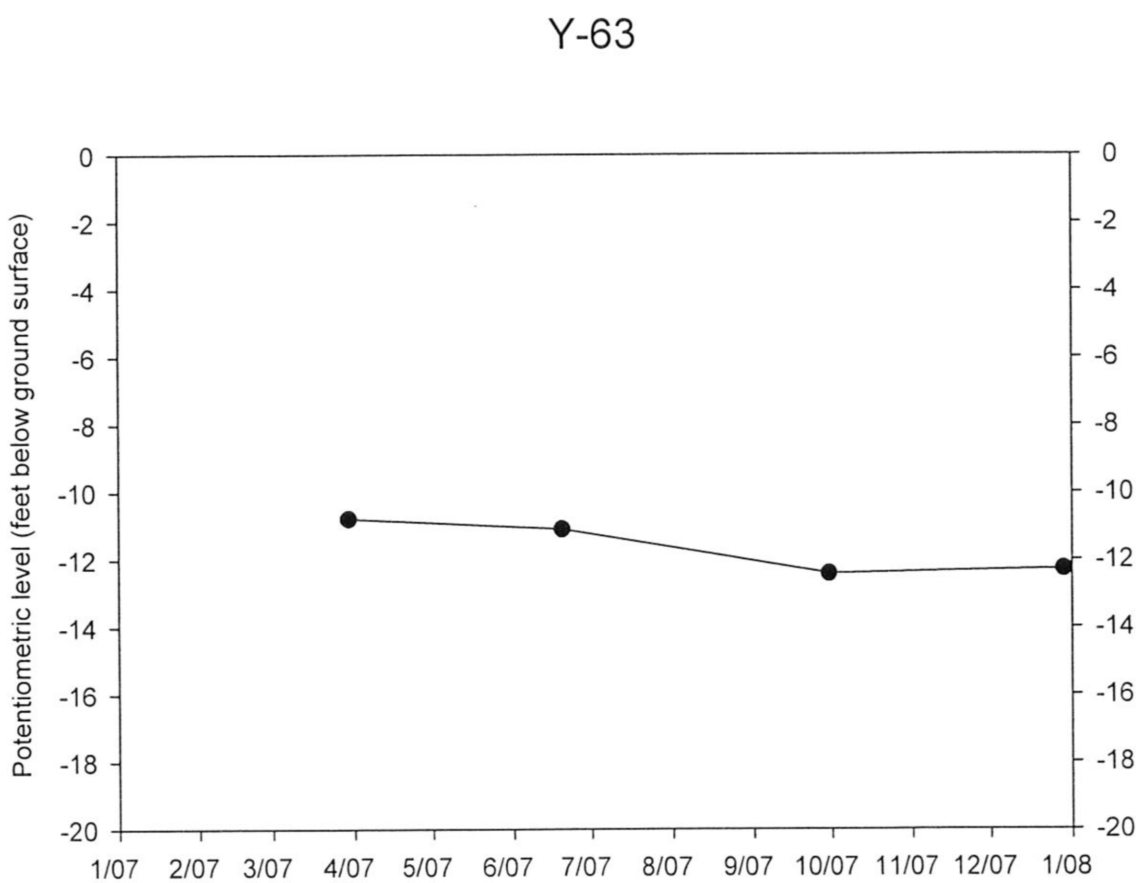


Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

LS-60

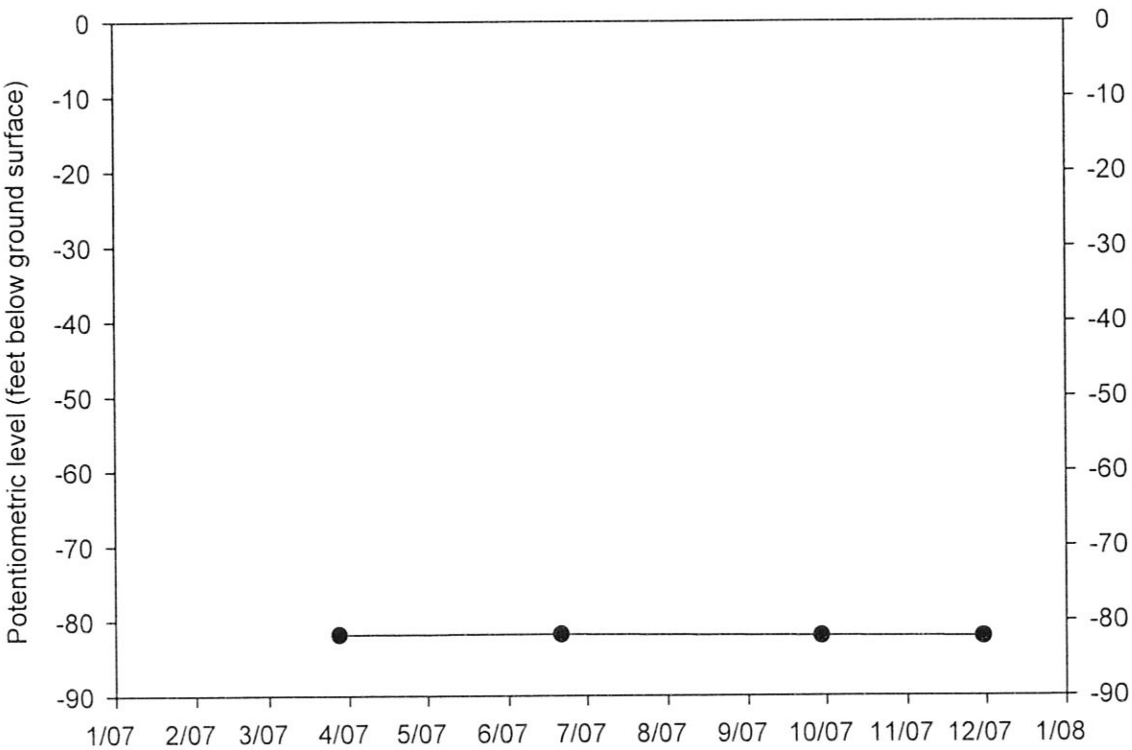


Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

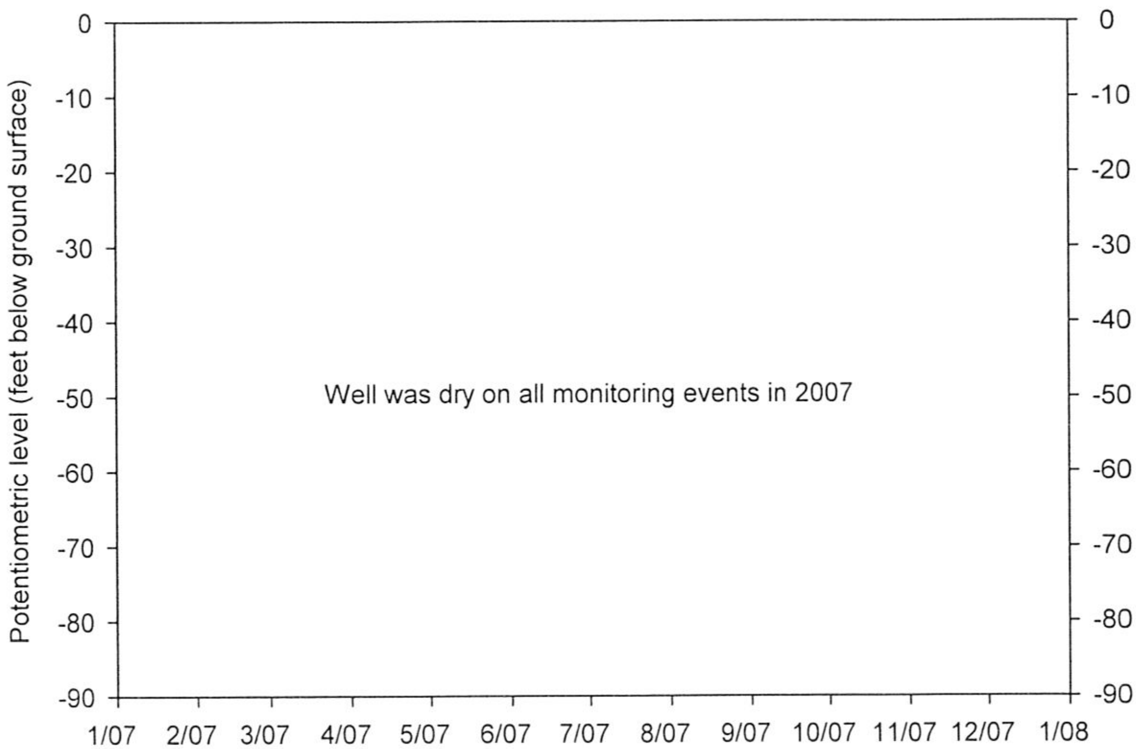


Y-63
Potentiometric level (feet below ground surface)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

Y-98

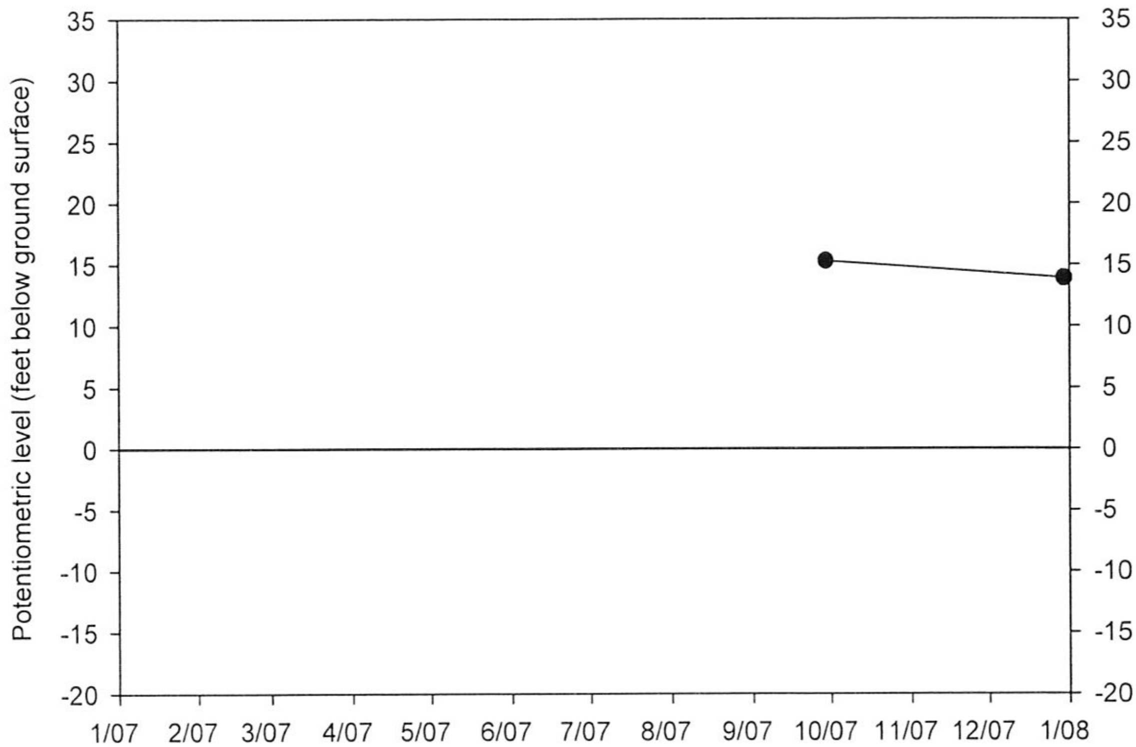

Potentiometric level (feet below ground surface)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

Y-99



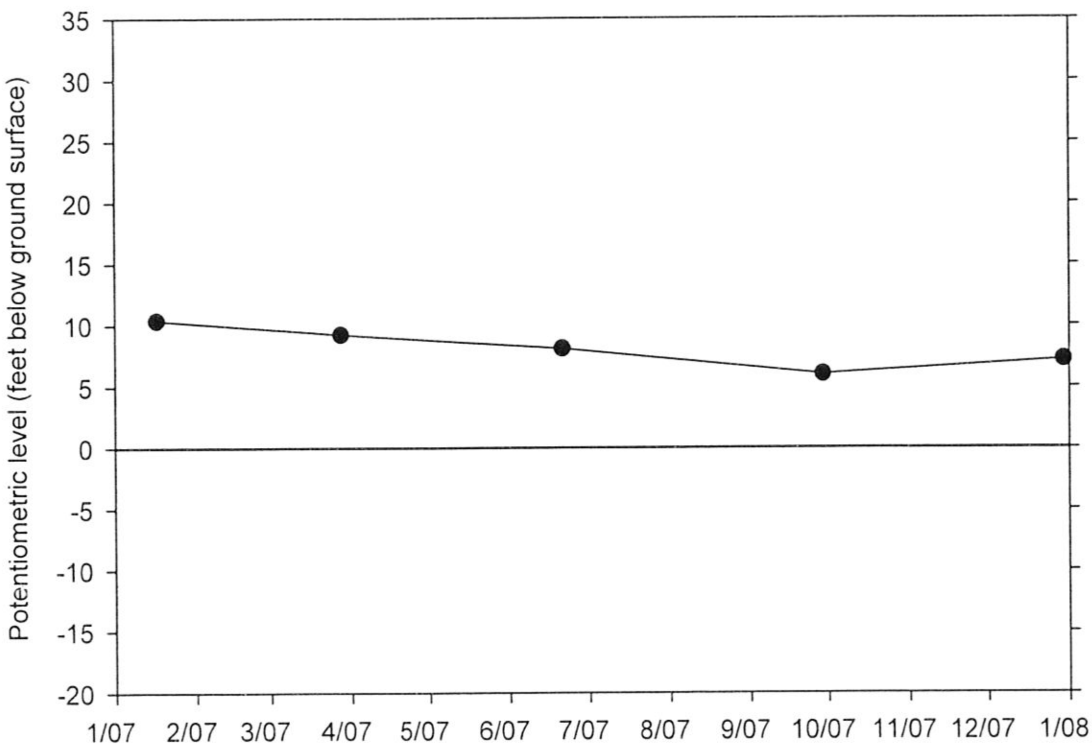
Potentiometric level (feet below ground surface)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Well was dry on all monitoring events in 2007
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

Y-61



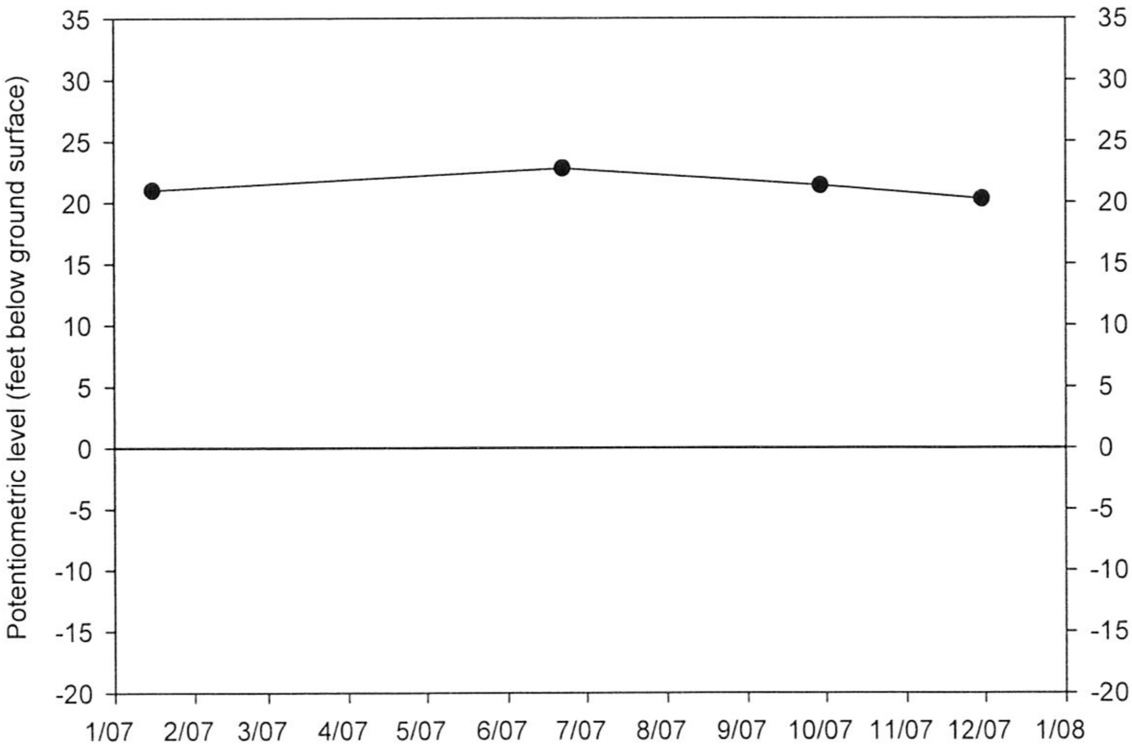
Potentiometric level (feet below ground surface)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

Y-102



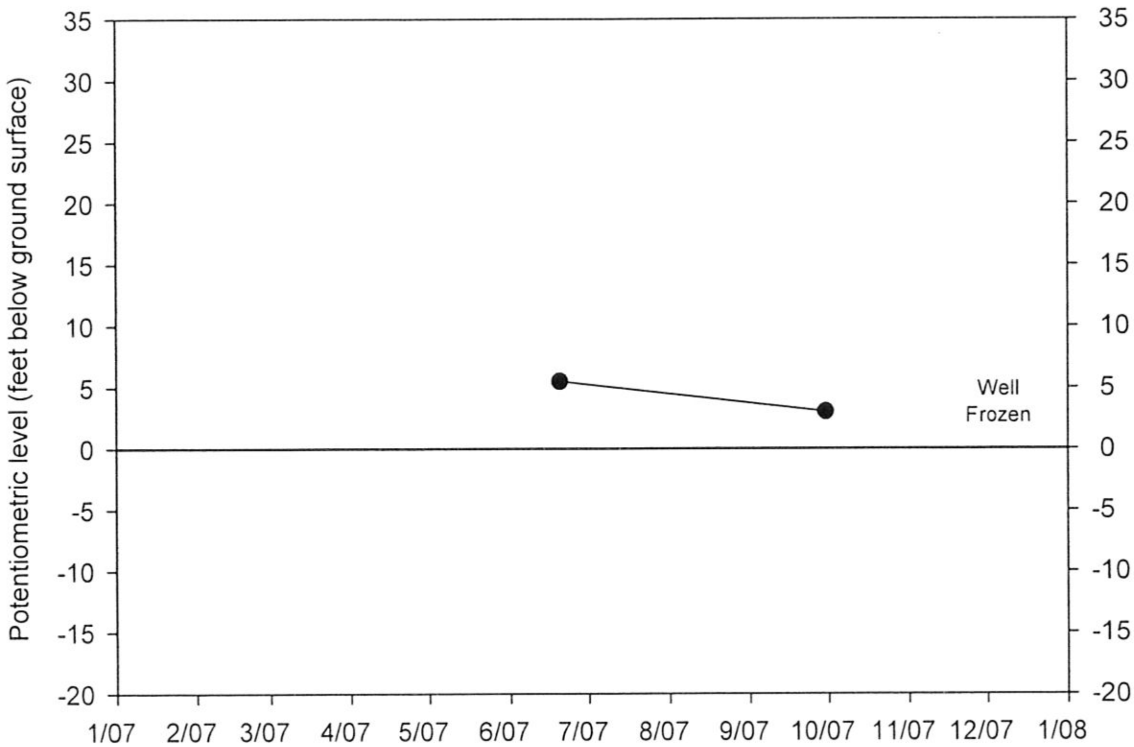
Potentiometric level (feet below ground surface)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

Y-59



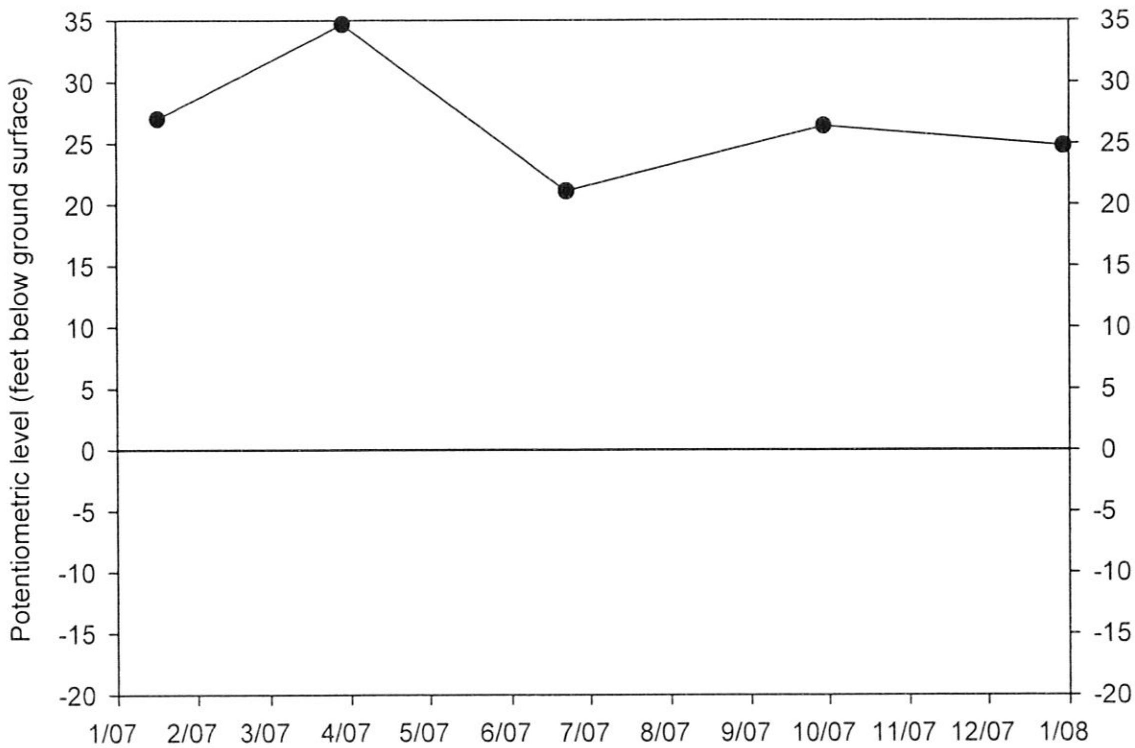
Potentiometric level (feet below ground surface)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08

LS-85

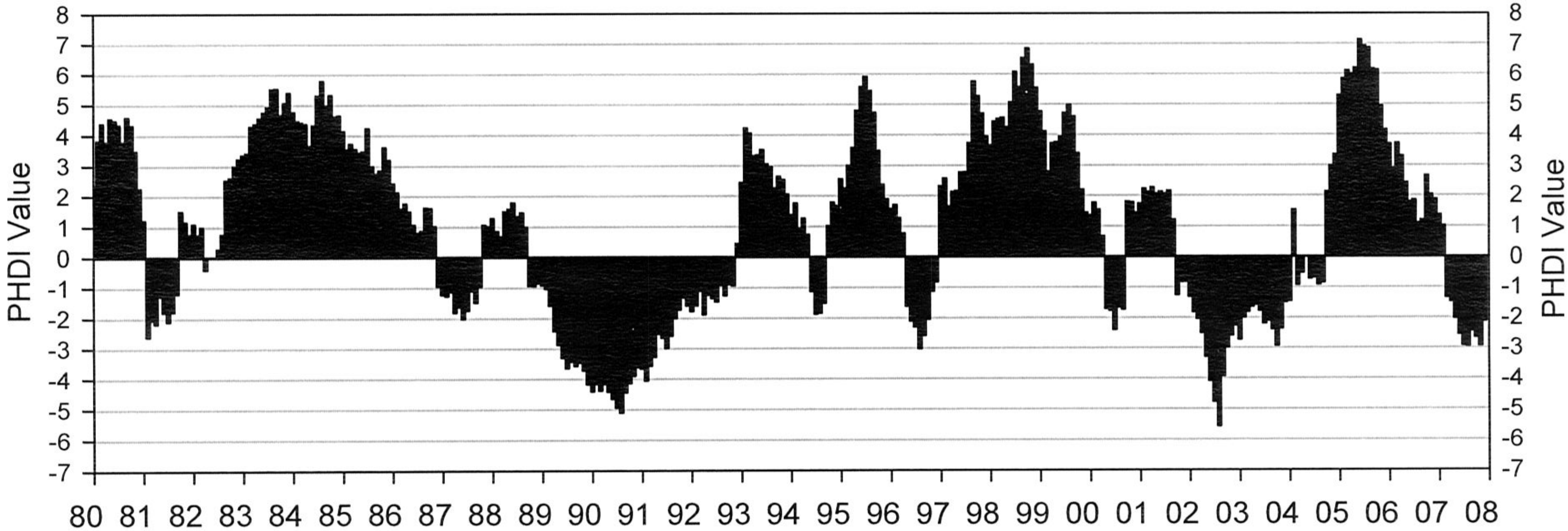


Potentiometric level (feet below ground surface)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08
Well
Frozen

C5-130



Potentiometric level (feet below ground surface)
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1/07
2/07
3/07
4/07
5/07
6/07
7/07
8/07
9/07
10/07
11/07
12/07
1/08



-1 to -2 Mild Drought
-2 to -3 Moderate Drought
-3 to -4 Severe Drought
-4 to -5 Extreme Drought

1 to 2 Mild Wet Spell
2 to 3 Moderate Wet Spell
3 to 4 Severe Wet Spell
4 to 5 Extreme Wet Spell

Figure 4 Plot of Palmer Hydologic Drought Index for Utah Region 4.

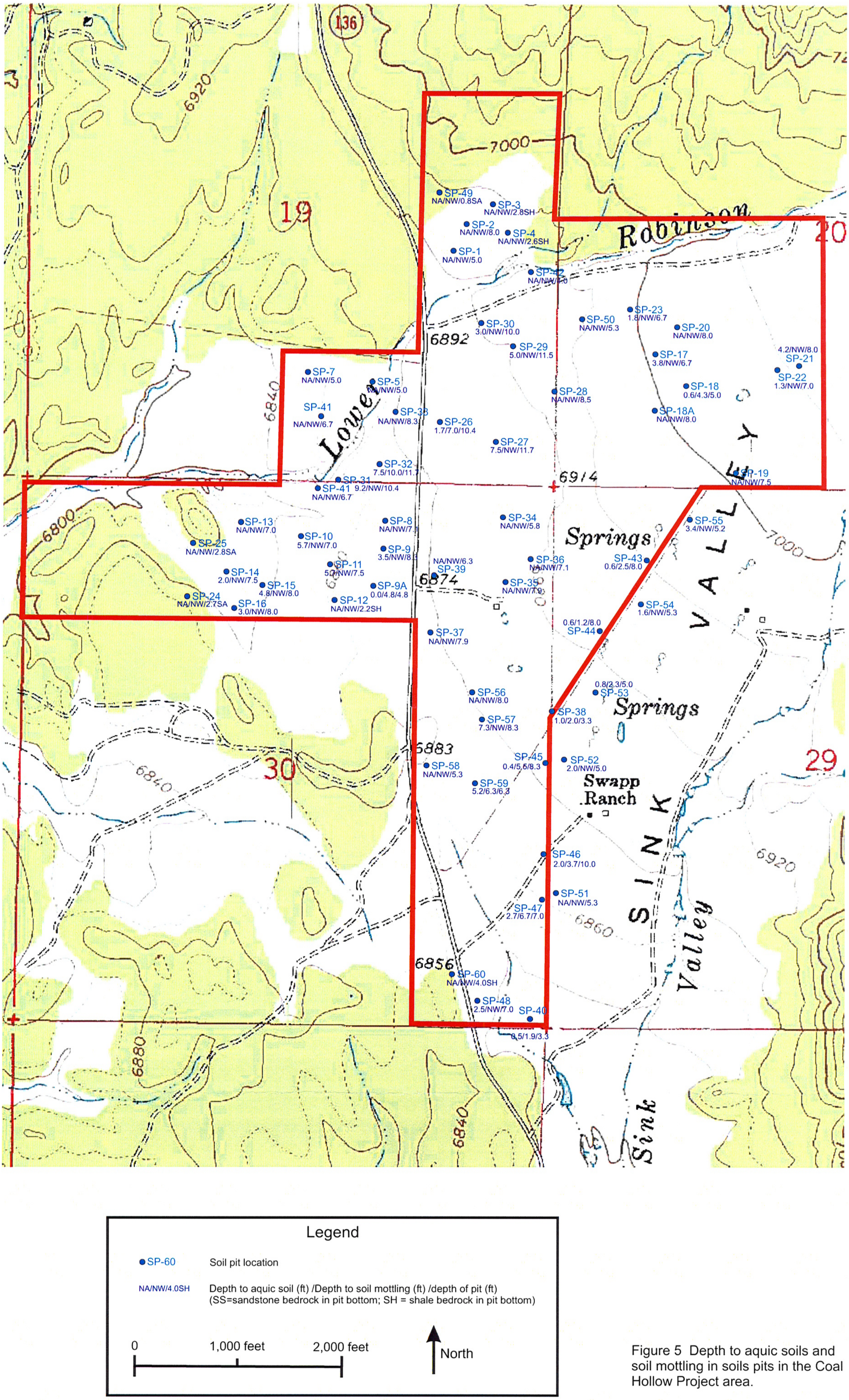


Figure 5 Depth to aquic soils and soil mottling in soils pits in the Coal Hollow Project area.

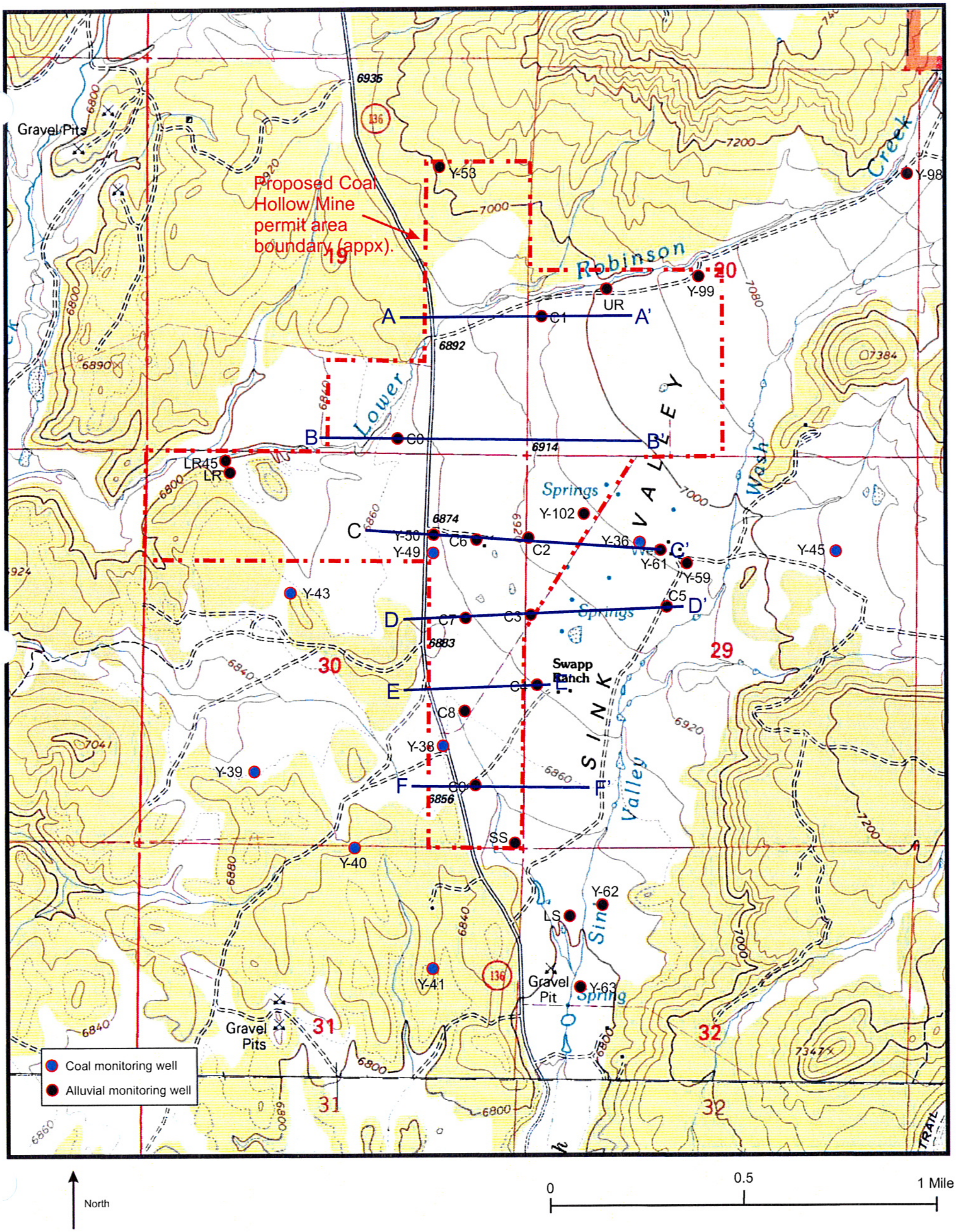


Figure 6a Cross-sections location map.

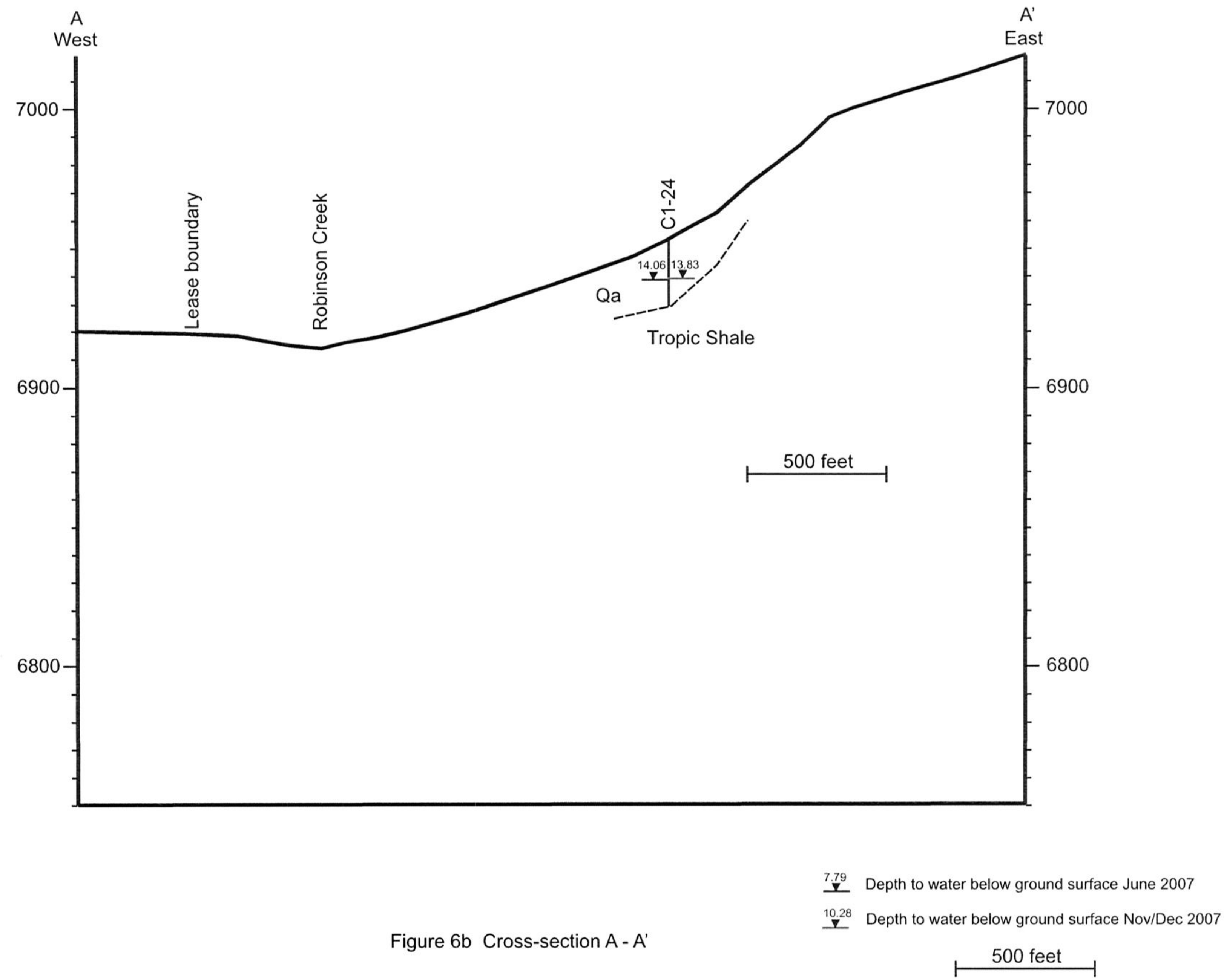
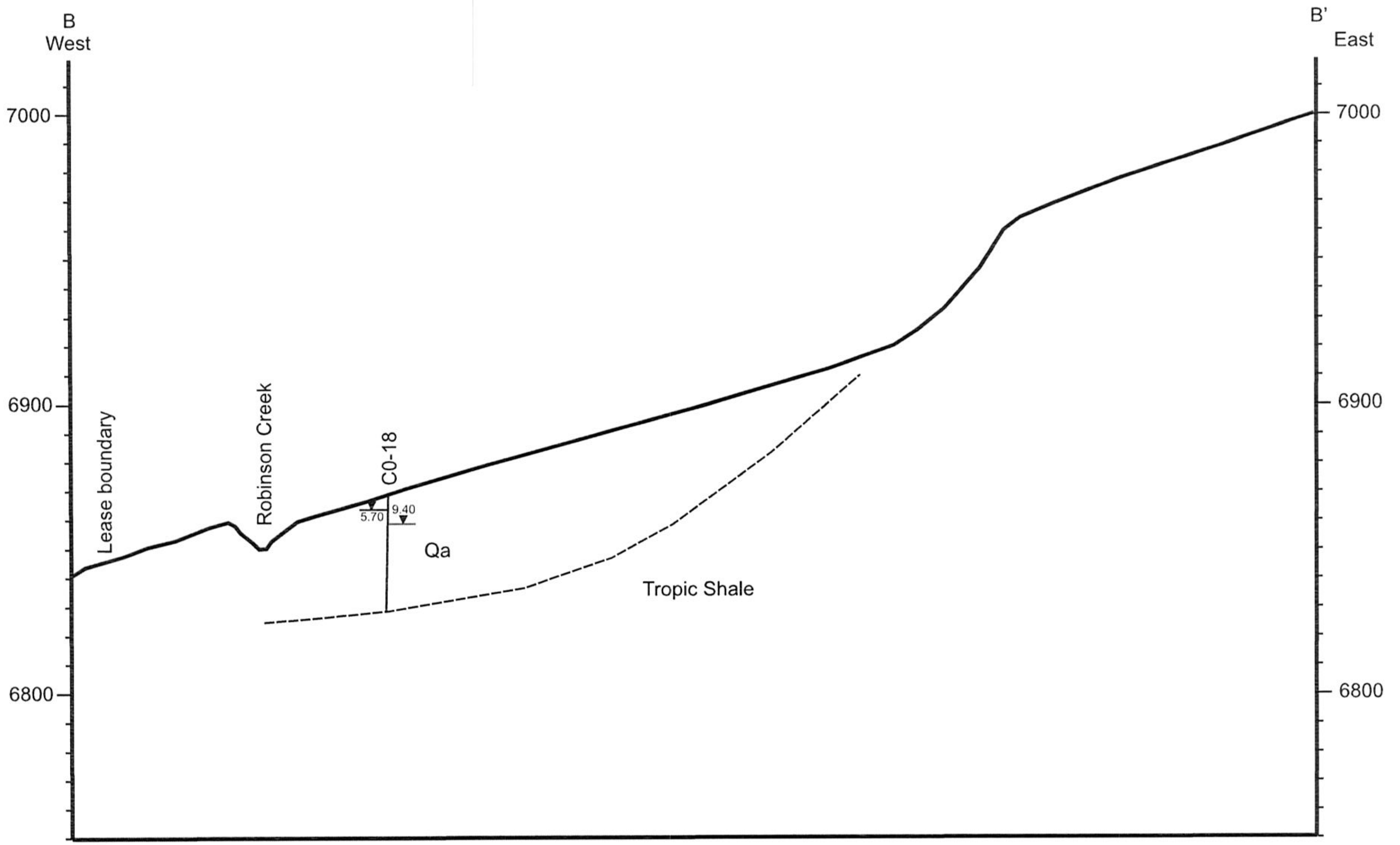


Figure 6b Cross-section A - A'



7.79 Depth to water below ground surface June 2007

10.28 Depth to water below ground surface Nov/Dec 2007

500 feet

Figure 6c Cross-section B - B'

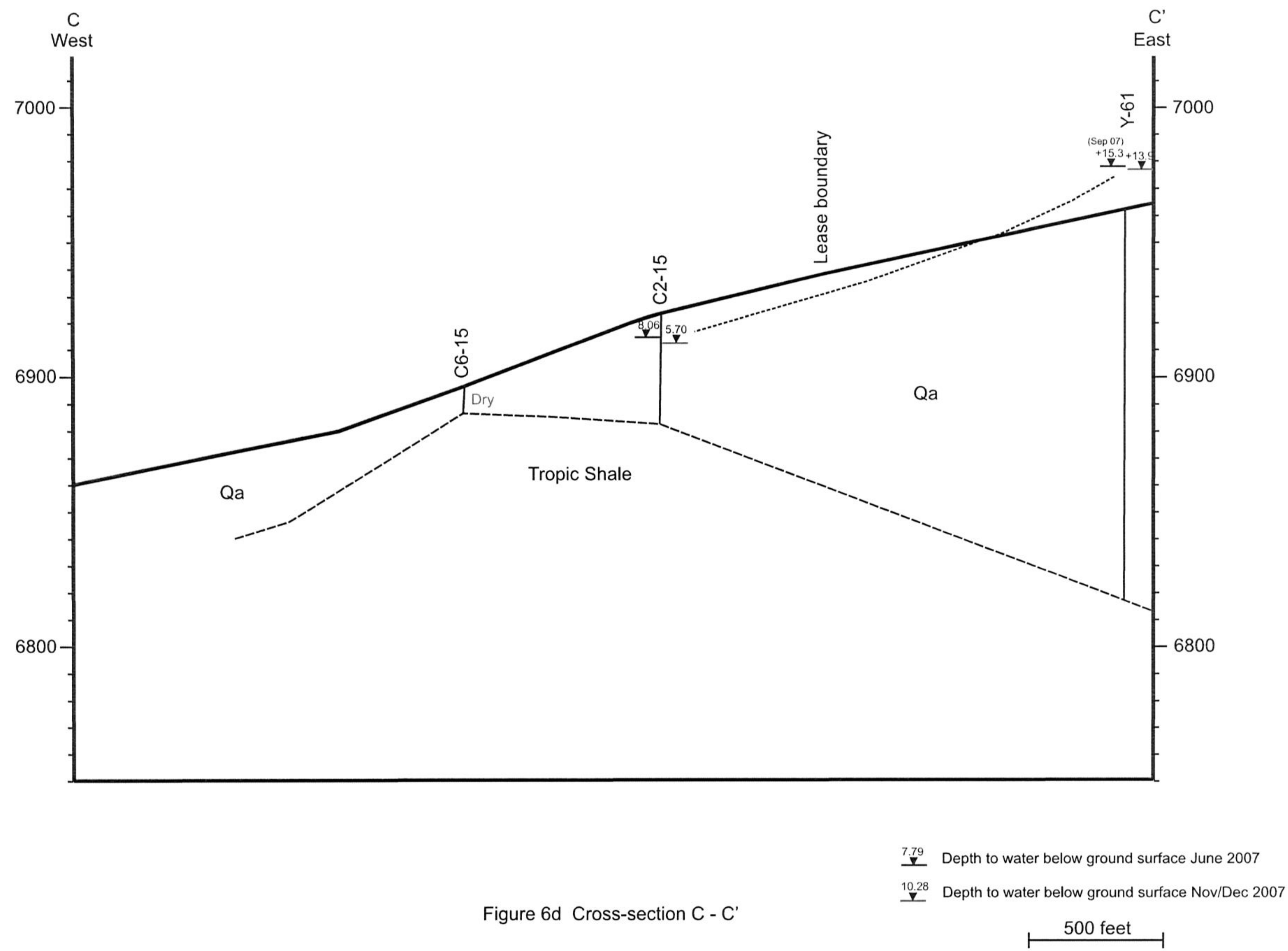


Figure 6d Cross-section C - C'

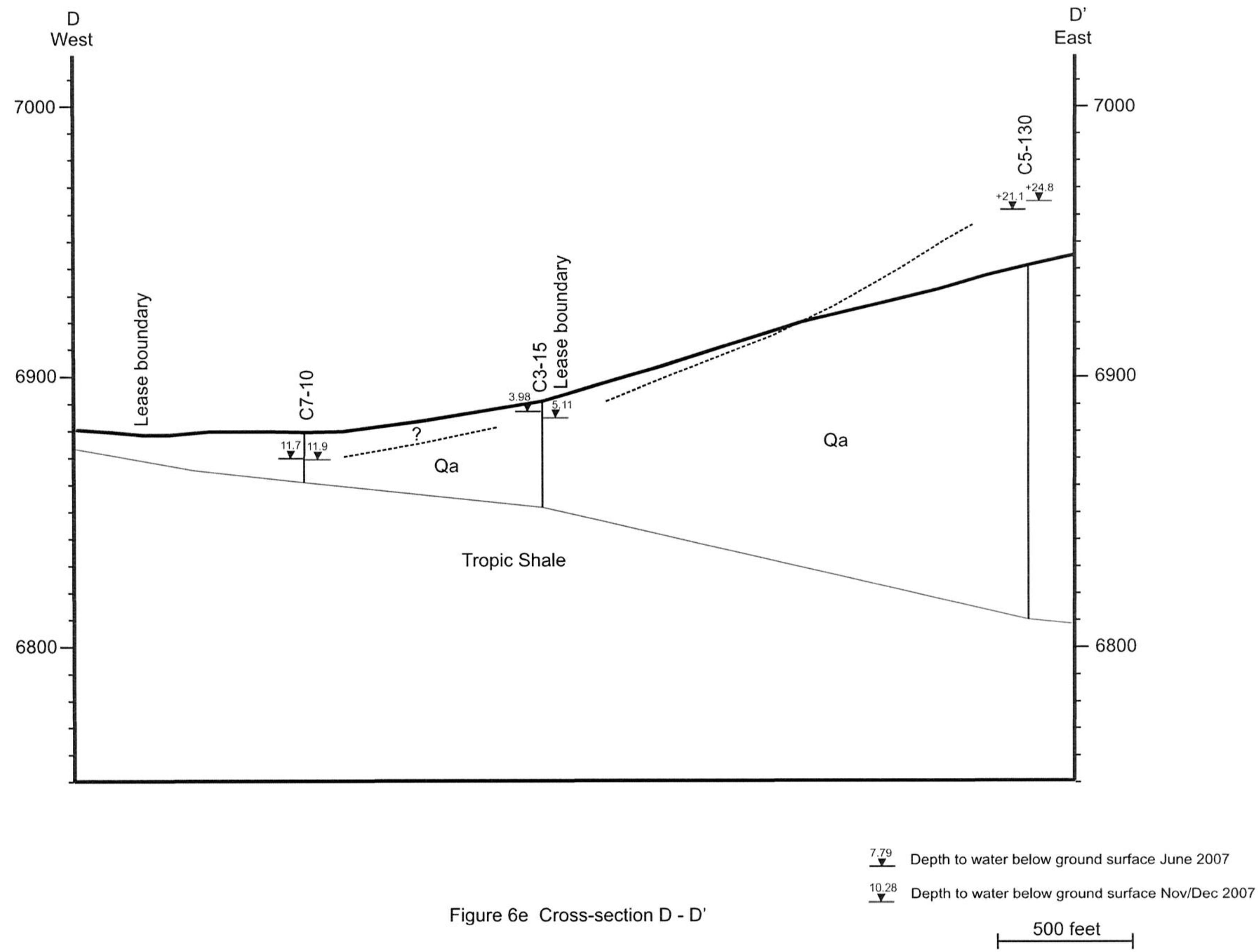


Figure 6e Cross-section D - D'

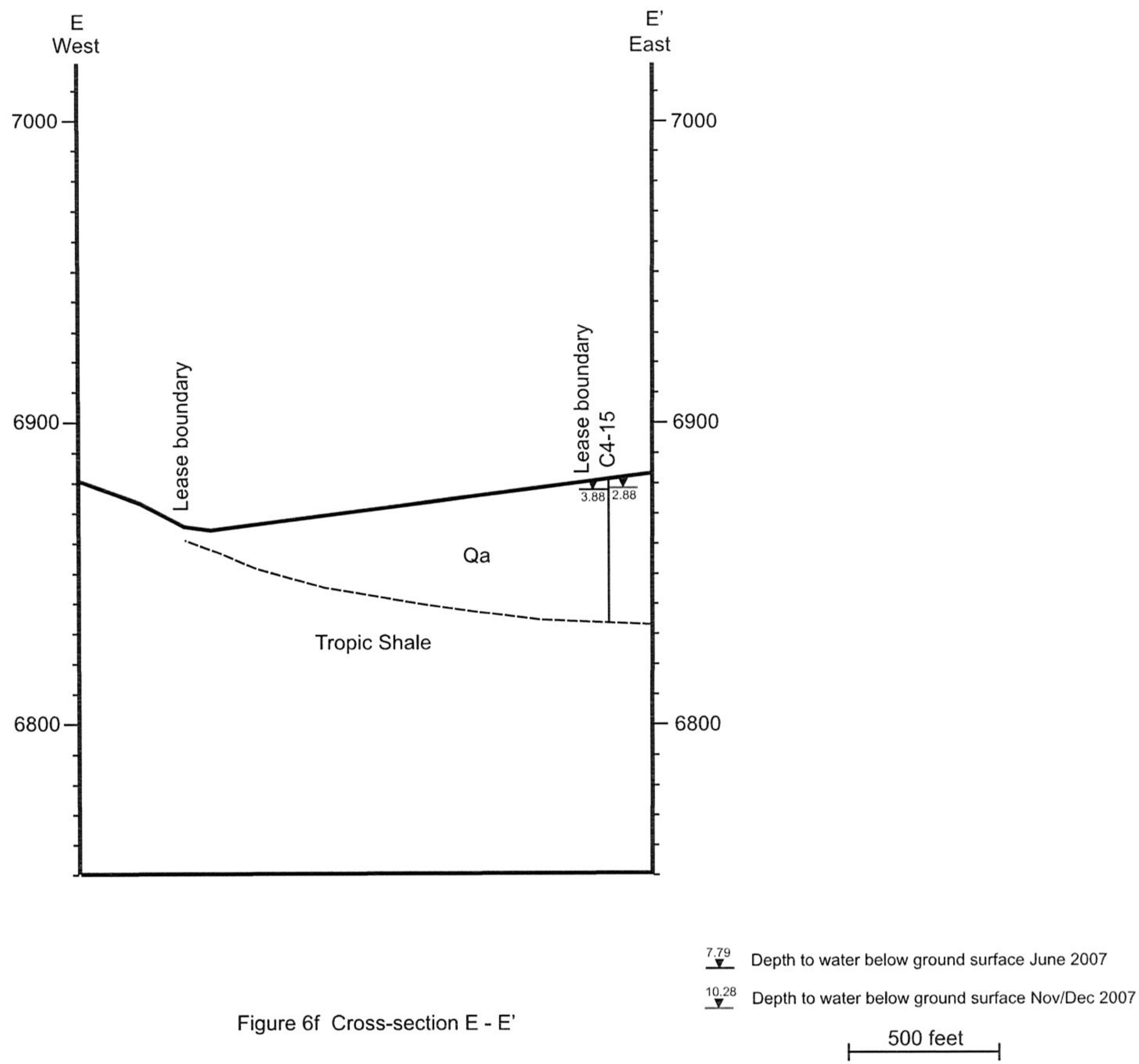


Figure 6f Cross-section E - E'

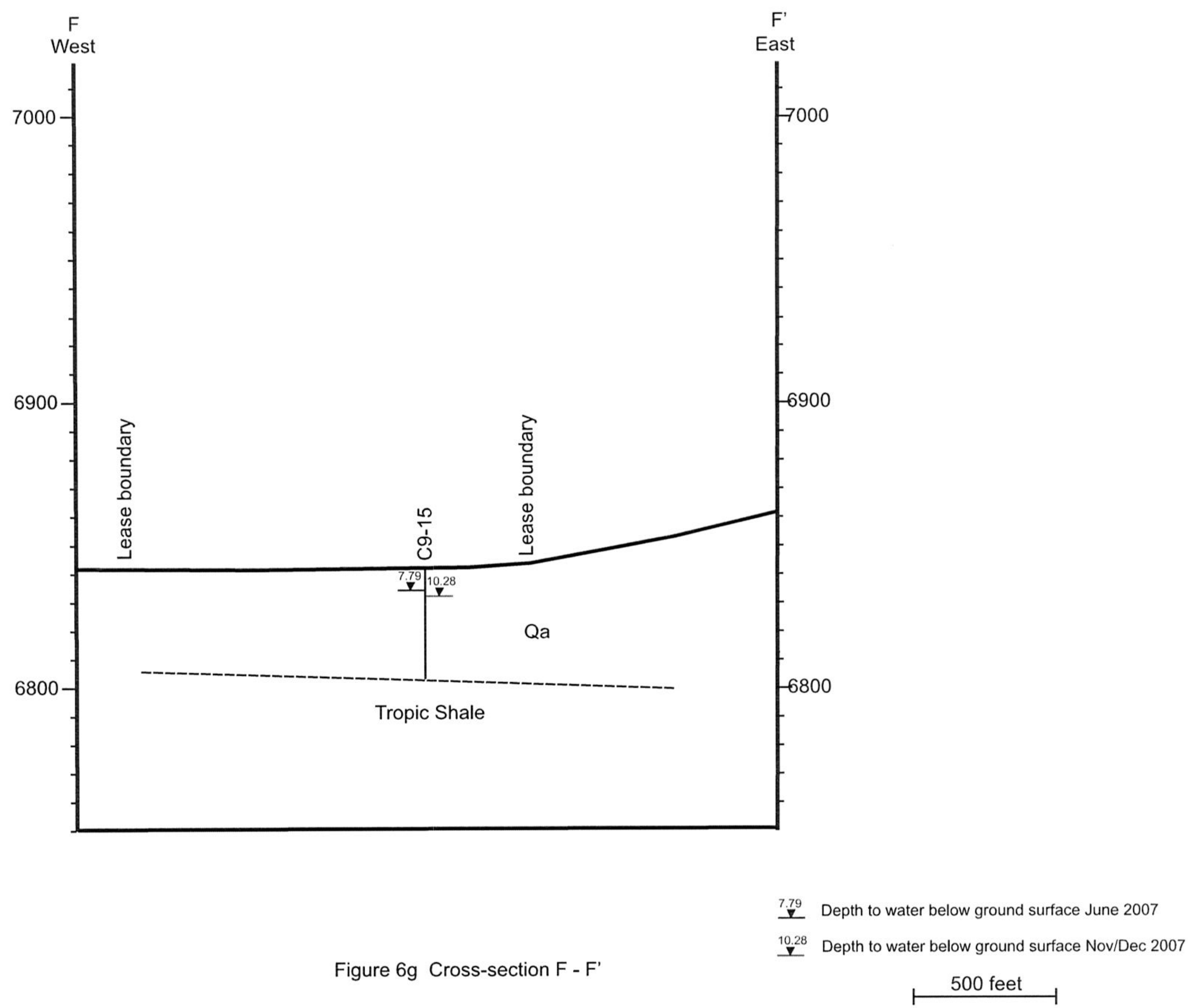


Figure 6g Cross-section F - F'

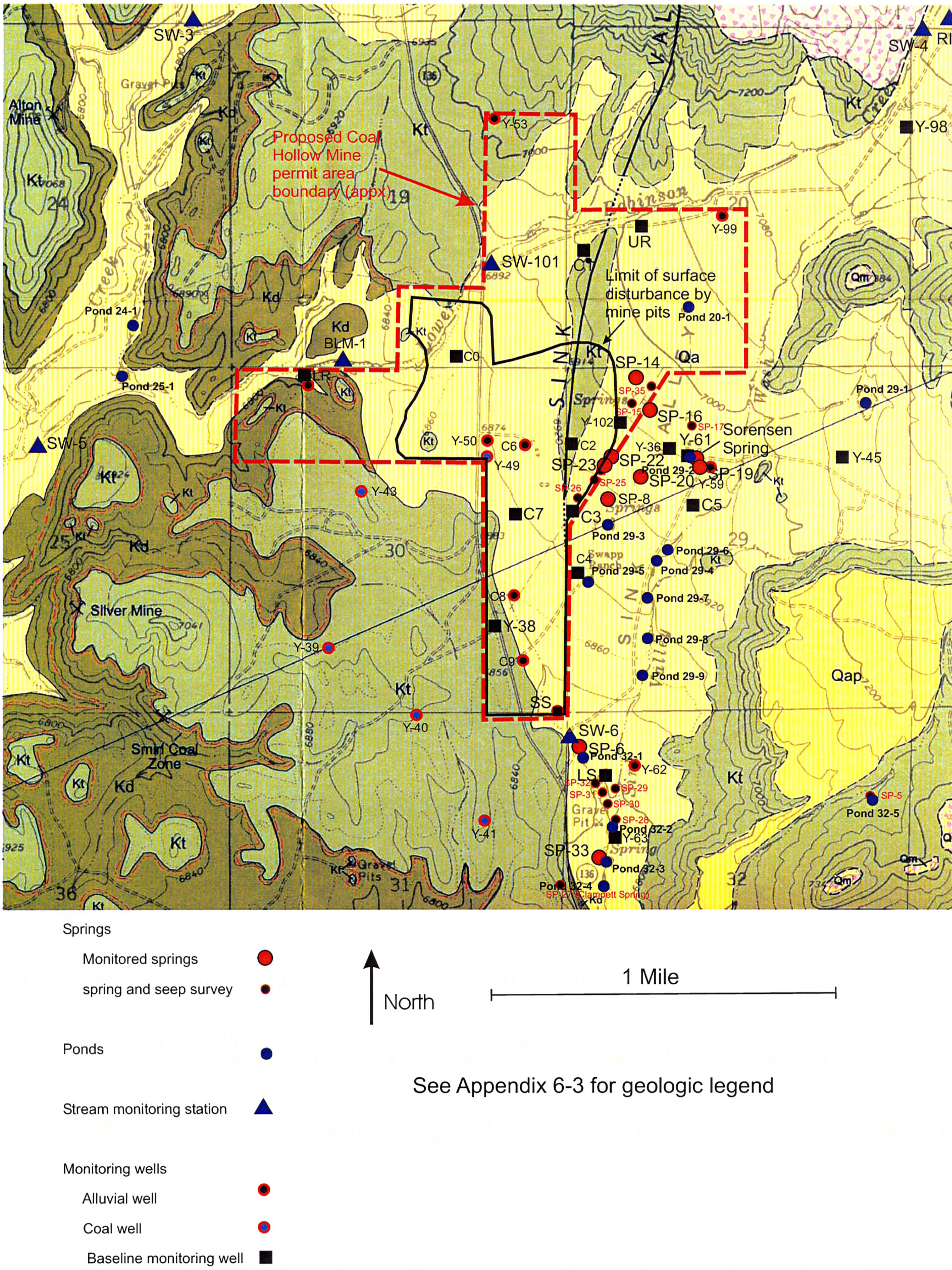
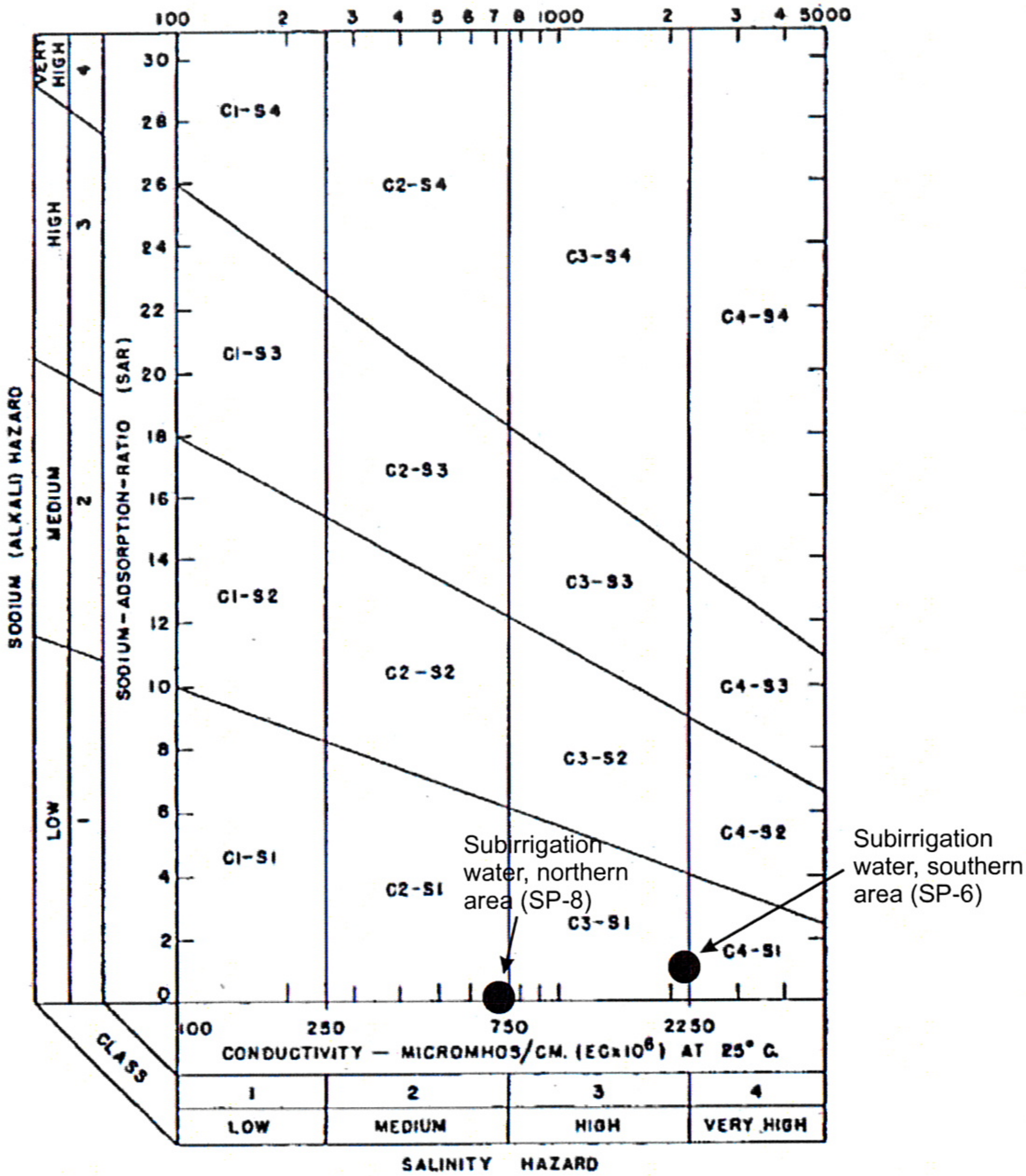


Figure 8 Locations of streams, ponds, springs and wells in relation to surface geology.



After OSM (1983)

Conductivity

C1 Low-salinity water: Can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop.
C2 Medium-salinity water: Can be used in a moderate amount of leaching occurs.
C3 High-salinity water: Cannot be used on soils with restricted drainage. With adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.
C4 Very high salinity water: Is not suitable for irrigation under ordinary conditions.

Sodium

S1 Low-sodium water: Can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium.
S2 Medium-sodium water: Will present an appreciable sodium hazard in fine-textured soils having a high cation-exchange capacity, especially under low-leaching conditions.
S3 High-sodium water: May produce harmful levels of exchangeable sodium in most soils and will require special management – good drainage, high leaching, and organic matter additions.
S4 Very high sodium water: Is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity.

Figure 9 Water quality suitability criteria for potential subirrigation waters.

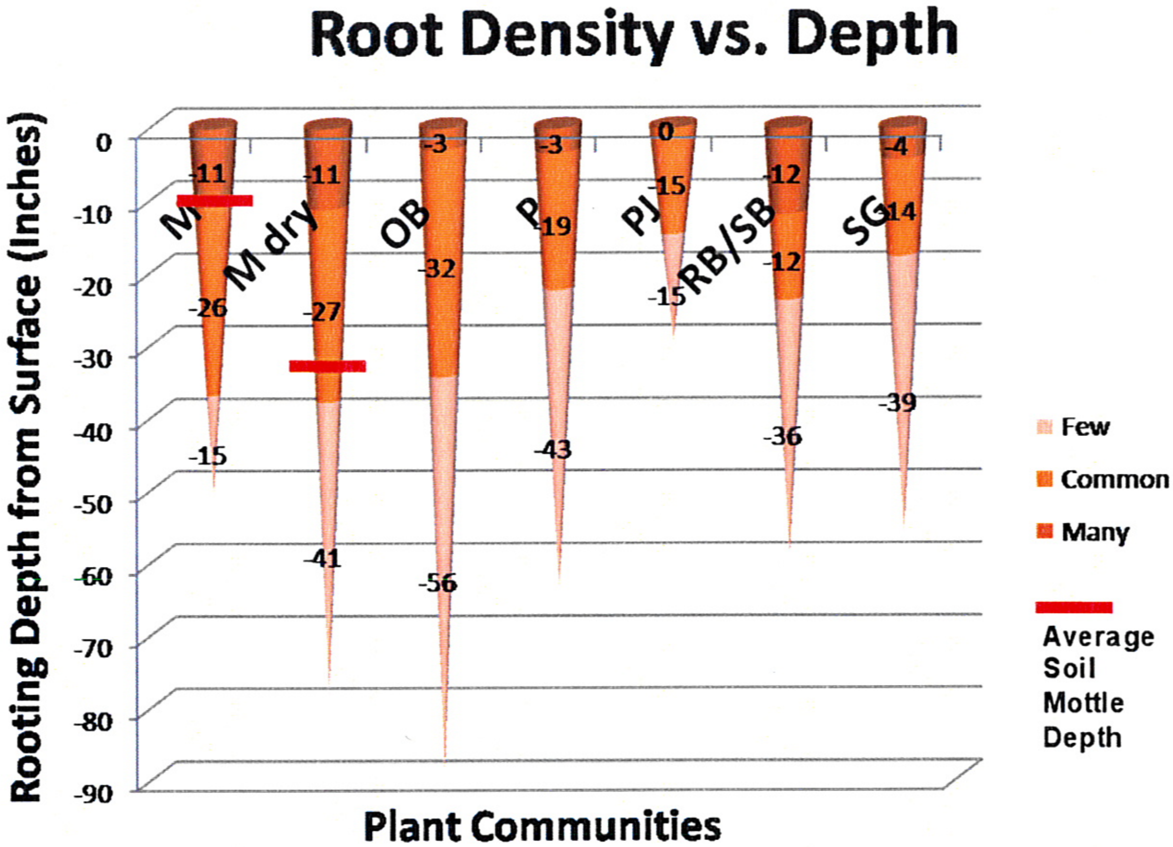


Figure 10 Root density versus depth and depth of soil mottles. (depth of mottles are shown only in those plant communities where they were the dominant condition).

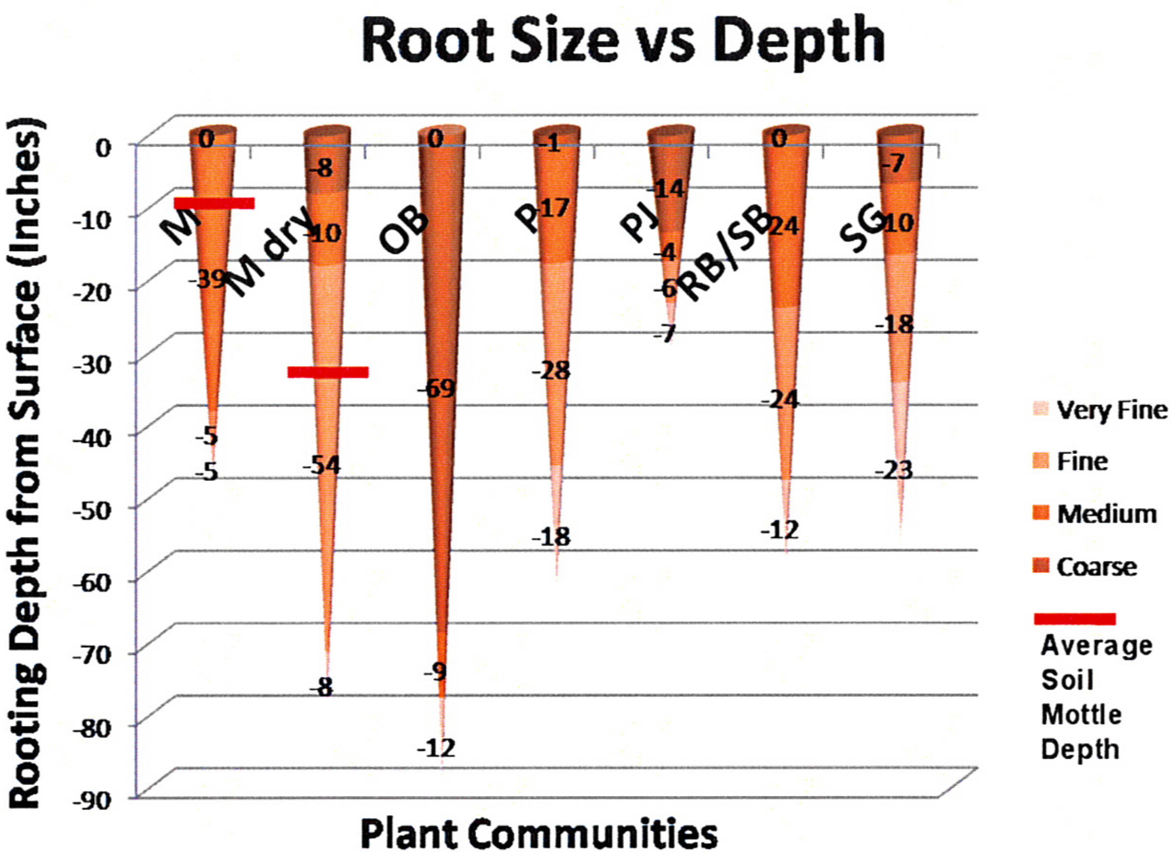
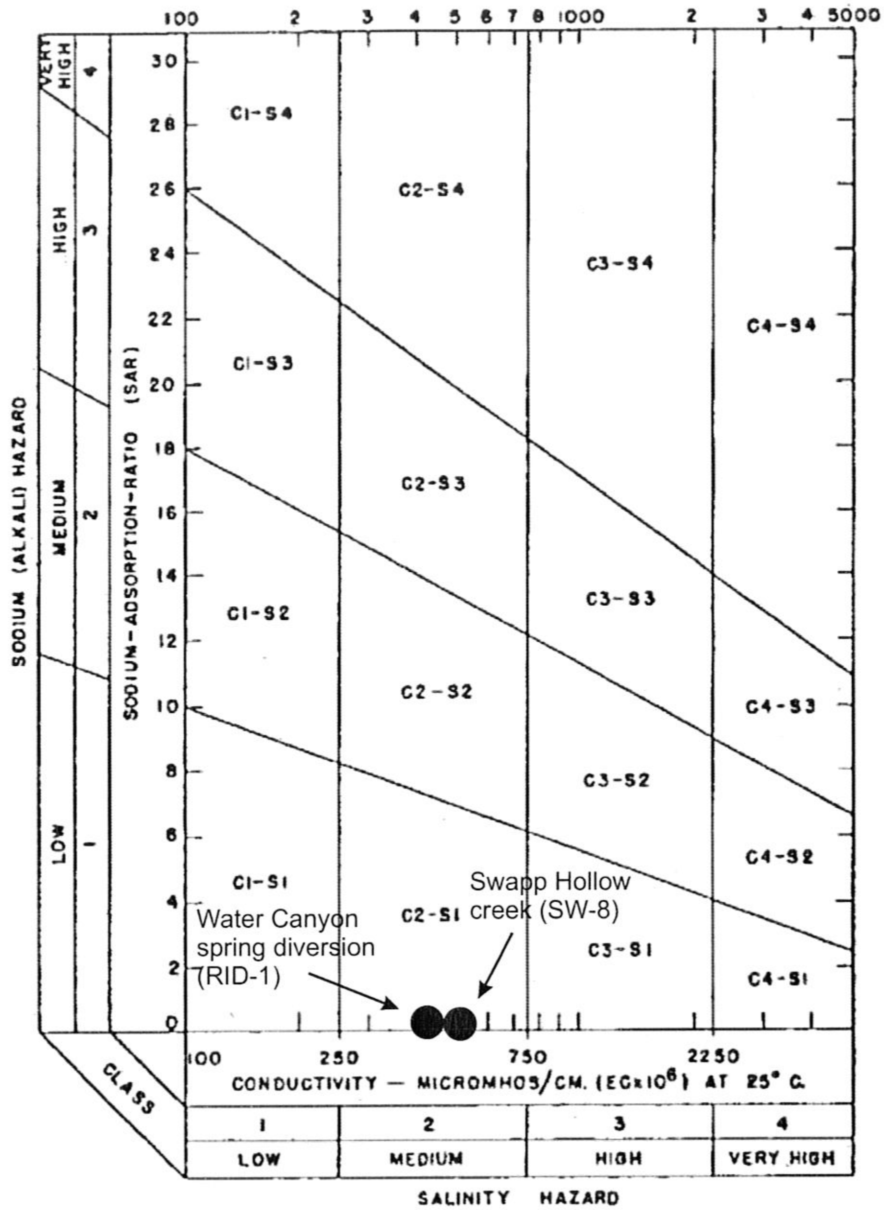


Figure 11 Root size versus depth and depth of soil mottles (depth of mottles are shown only in those plant communities where they were the dominant condition).



After OSM (1983)

Conductivity
C1 Low-salinity water: Can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop.
C2 Medium-salinity water: Can be used in a moderate amount of leaching occurs.
C3 High-salinity water: Cannot be used on soils with restricted drainage. With adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.
C4 Very high salinity water: Is not suitable for irrigation under ordinary conditions.

Sodium
S1 Low-sodium water: Can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium.
S2 Medium-sodium water: Will present an appreciable sodium hazard in fine-textured soils having a high cation-exchange capacity, especially under low-leaching conditions.
S3 High-sodium water: May produce harmful levels of exchangeable sodium in most soils and will require special management – good drainage, high leaching, and organic matter additions.
S4 Very high sodium water: Is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity.

Figure 12 Water quality suitability criteria for potential flood irrigation waters.

Table 1 Coal Hollow Project alluvial monitoring well depth to water information for 2007.

Well	Collar elevation (feet)	Stick-up (feet)	Date	Depth to water (feet below top of casing)	Depth to water (feet below ground surface)
C0-18	6864.14	4.32	19-Jan-07	18.13	13.81
C0-18	6864.14	4.32	1-Feb-07	18.19	13.87
C0-18	6864.14	4.32	22-Jun-07	10.02	5.70
C0-18	6864.14	4.32	30-Sep-07	12.59	8.27
C0-18	6864.14	4.32	27-Nov-07	13.72	9.40
C1-24	6949.19	2.92	19-Jan-07	20.63	17.71
C1-24	6949.19	2.92	1-Feb-07	18.29	15.37
C1-24	6949.19	2.92	22-Jun-07	16.98	14.06
C1-24	6949.19	2.92	29-Sep-07	16.96	14.04
C1-24	6949.19	2.92	30-Dec-07	16.75	13.83
C2-15	6920.28	1.69	17-Jan-07	9.60	7.91
C2-15	6920.28	1.69	1-Feb-07	9.09	7.40
C2-15	6920.28	1.69	21-Jun-07	9.75	8.06
C2-15	6920.28	1.69	30-Sep-07	12.58	10.89
C2-15	6920.28	1.69	28-Nov-07	12.77	11.08
C2-28	6919.81	1.21	17-Jan-07	8.43	7.22
C2-28	6919.81	1.21	1-Feb-07	8.15	6.94
C2-28	6919.81	1.21	21-Jun-07	9.45	8.24
C2-28	6919.81	1.21	30-Sep-07	12.12	10.91
C2-28	6919.81	1.21	28-Nov-07	12.18	10.97
C2-40	6919.58	0.98	17-Jan-07	8.34	7.36
C2-40	6919.58	0.98	1-Feb-07	8.04	7.06
C2-40	6919.58	0.98	21-Jun-07	9.33	8.35
C2-40	6919.58	0.98	30-Sep-07	11.96	10.98
C2-40	6919.58	0.98	28-Nov-07	12.04	11.06
C3-15	6890.41	1.12	17-Jan-07	3.27	2.15
C3-15	6890.41	1.12	1-Feb-07	2.69	1.57
C3-15	6890.41	1.12	21-Jun-07	5.10	3.98
C3-15	6890.41	1.12	30-Sep-07	7.52	6.40
C3-15	6890.41	1.12	28-Nov-07	6.23	5.11
C3-30	6890.77	1.49	17-Jan-07	3.67	2.18
C3-30	6890.77	1.49	1-Feb-07	3.19	1.70
C3-30	6890.77	1.49	21-Jun-07	5.40	3.91
C3-30	6890.77	1.49	30-Sep-07	7.81	6.32
C3-30	6890.77	1.49	28-Nov-07	6.54	5.05
C3-40	6890.73	1.45	17-Jan-07	3.92	2.47
C3-40	6890.73	1.45	1-Feb-07	3.45	2.00
C3-40	6890.73	1.45	21-Jun-07	5.39	3.94
C3-40	6890.73	1.45	30-Sep-07	7.78	6.33
C3-40	6890.73	1.45	28-Nov-07	6.56	5.11

Well	Collar elevation (feet)	Stick-up (feet)	Date	Depth to water (feet below top of casing)	Depth to water (feet below ground surface)
C4-15	6873.92	1.64	17-Jan-07	4.29	2.65
C4-15	6873.92	1.64	31-Jan-07	4.04	2.40
C4-15	6873.92	1.64	21-Jun-07	5.52	3.88
C4-15	6873.92	1.64	30-Sep-07	7.22	5.58
C4-15	6873.92	1.64	30-Dec-07	4.52	2.88
C4-30	6873.91	1.62	17-Jan-07	4.11	2.49
C4-30	6873.91	1.62	31-Jan-07	3.89	2.27
C4-30	6873.91	1.62	21-Jun-07	5.27	3.65
C4-30	6873.91	1.62	30-Sep-07	6.95	5.33
C4-30	6873.91	1.62	30-Dec-07	4.52	2.90
C4-50	6873.52	1.24	17-Jan-07	3.48	2.24
C4-50	6873.52	1.24	31-Jan-07	3.27	2.03
C4-50	6873.52	1.24	21-Jun-07	4.47	3.23
C4-50	6873.52	1.24	30-Sep-07	6.03	4.79
C4-50	6873.52	1.24	30-Dec-07	4.02	2.78
C5-130	6938.92	2.13	17-Jan-07	10.75 psi	+27.0
C5-130	6938.92	2.13	29-Mar-07	14.1 psi	+34.7
C5-130	6938.92	2.13	22-Jun-07	8.2 psi	+21.1
C5-130	6938.92	2.13	29-Sep-07	10.5 psi	+26.4
C5-130	6938.92	2.13	30-Dec-07	9.8 psi	+24.8
C6-15	6897.63	1.84	19-Jan-07	dry	---
C6-15	6897.63	1.84	21-Jun-07	dry	---
C6-15	6897.63	1.84	30-Sep-07	dry	---
C6-15	6897.63	1.84	28-Nov-07	dry	---
C7-10	6873.77	3.54	17-Jan-07	11.05	7.51
C7-10	6873.77	3.54	1-Feb-07	10.97	7.43
C7-10	6873.77	3.54	21-Jun-07	11.73	8.19
C7-10	6873.77	3.54	30-Sep-07	12.53	8.99
C7-10	6873.77	3.54	28-Nov-07	11.9	8.36
C7-20	6872.89	2.66	17-Jan-07	10.44	7.78
C7-20	6872.89	2.66	1-Feb-07	10.36	7.70
C7-20	6872.89	2.66	21-Jun-07	10.96	8.30
C7-20	6872.89	2.66	30-Sep-07	11.78	9.12
C7-20	6872.89	2.66	28-Nov-07	11.23	8.57
C8-25	6859.70	2.69	17-Jan-07	9.80	7.11
C8-25	6859.70	2.69	31-Jan-07	9.26	6.57
C8-25	6859.70	2.69	21-Jun-07	9.25	6.56
C8-25	6859.70	2.69	30-Sep-07	10.71	8.02
C8-25	6859.70	2.69	27-Nov-07	10.44	7.75
C9-15	6846.77	2.02	17-Jan-07	9.50	7.48
C9-15	6846.77	2.02	31-Jan-07	9.29	7.27
C9-15	6846.77	2.02	21-Jun-07	9.81	7.79
C9-15	6846.77	2.02	30-Sep-07	12.19	10.17

Well	Collar elevation (feet)	Stick-up (feet)	Date	Depth to water (feet below top of casing)	Depth to water (feet below ground surface)
C9-15	6846.77	2.02	30-Dec-07	12.3	10.28
C9-25	6846.36	1.61	17-Jan-07	9.71	8.10
C9-25	6846.36	1.61	31-Jan-07	8.91	7.30
C9-25	6846.36	1.61	21-Jun-07	9.44	7.83
C9-25	6846.36	1.61	30-Sep-07	11.83	10.22
C9-25	6846.36	1.61	30-Dec-07	11.98	10.37
C9-40	6846.94	2.19	17-Jan-07	9.71	7.52
C9-40	6846.94	2.19	31-Jan-07	9.51	7.32
C9-40	6846.94	2.19	21-Jun-07	10.04	7.85
C9-40	6846.94	2.19	30-Sep-07	12.47	10.28
C9-40	6846.94	2.19	30-Dec-07	12.55	10.36
SS-15	6831.57	1.57	17-Jan-07	4.13	2.56
SS-15	6831.57	1.57	31-Jan-07	3.82	2.25
SS-15	6831.57	1.57	21-Jun-07	5.54	3.97
SS-15	6831.57	1.57	30-Sep-07	7.78	6.21
SS-15	6831.57	1.57	30-Dec-07	6.55	4.98
SS-30	6830.47	0.47	17-Jan-07	2.81	2.34
SS-30	6830.47	0.47	31-Jan-07	2.48	2.01
SS-30	6830.47	0.47	21-Jun-07	4.21	3.74
SS-30	6830.47	0.47	30-Sep-07	6.56	6.09
SS-30	6830.47	0.47	30-Dec-07	5.33	4.86
SS-75	6832.06	2.06	17-Jan-07	14.20	12.14
SS-75	6832.06	2.06	31-Jan-07	14.93	12.87
SS-75	6832.06	2.06	21-Jun-07	14.52	12.46
SS-75	6832.06	2.06	30-Sep-07	15.07	13.01
SS-75	6832.06	2.06	30-Dec-07	14.42	12.36
UR-29	7004.14	0.97	17-Jan-07	dry	---
UR-29	7004.14	0.97	22-Jun-07	23.27	22.30
UR-29	7004.14	0.97	29-Sep-07	24.53	23.56
UR-29	7004.14	0.97	29-Dec-07	24.00	23.03
UR-70	7005.14	1.97	19-Jan-07	21.51	19.54
UR-70	7005.14	1.97	22-Jun-07	21.69	19.72
UR-70	7005.14	1.97	29-Sep-07	22.9	20.93
UR-70	7005.14	1.97	29-Dec-07	22.38	20.41
LR-45	6798.41	1.71	19-Jan-07	27.51	25.80
LR-45	6798.41	1.71	29-Mar-07	27.56	25.85
LR-45	6798.41	1.71	22-Jun-07	28.12	26.41
LR-45	6798.41	1.71	30-Sep-07	28.03	26.32
LR-45	6798.41	1.71	29-Dec-07	27.2	25.49
LS-15	6810.28	1.79	19-Jan-07	6.38	4.59
LS-15	6810.28	1.79	30-Mar-07	4.96	3.17
LS-15	6810.28	1.79	20-Jun-07	7.56	5.77

Well	Collar elevation (feet)	Stick-up (feet)	Date	Depth to water (feet below top of casing)	Depth to water (feet below ground surface)
LS-15	6810.28	1.79	30-Sep-07	8.79	7.00
LS-15	6810.28	1.79	30-Dec-07	7.43	5.64
LS-28	6810.23	1.74	19-Jan-07	6.27	4.53
LS-28	6810.23	1.74	30-Mar-07	4.89	3.15
LS-28	6810.23	1.74	20-Jun-07	7.47	5.73
LS-28	6810.23	1.74	30-Sep-07	8.79	7.05
LS-28	6810.23	1.74	30-Dec-07	7.36	5.62
LS-60	6810.35	1.85	19-Jan-07	4.07	2.22
LS-60	6810.35	1.85	30-Mar-07	3.06	1.21
LS-60	6810.35	1.85	20-Jun-07	5.15	3.30
LS-60	6810.35	1.85	30-Sep-07	6.47	4.62
LS-60	6810.35	1.85	30-Dec-07	5.29	3.44
LS-85	6810.53	2.03	20-Jun-07	1.5 psi	+5.5
LS-85	6810.53	2.03	30-Sep-07	0.42 psi	+3.00
LS-85	6810.53	2.03	30-Dec-07	frozen	---
Y-59	6959.06	2.50	16-Jan-07	8.00 psi	+21.0
Y-59	6959.06	2.50	22-Jun-07	8.8 psi	+22.8
Y-59	6959.06	2.50	29-Sep-07	8.2 psi	+21.4
Y-59	6959.06	2.50	30-Nov-07	7.7 psi	+20.3
Y-61	6962.10	2.80	29-Sep-07	5.4 psi	+15.3
Y-61	6962.10	2.80	30-Dec-07	4.8 psi	+13.9
Y-63-62	6789.34	2.67	30-Mar-07	13.45	10.78
Y-63-62	6789.34	2.67	20-Jun-07	13.76	11.09
Y-63-62	6789.34	2.67	30-Sep-07	15.09	12.42
Y-63-62	6789.34	2.67	29-Dec-07	14.95	12.28
Y-98 (A1)	7173.50	3.00	28-Mar-07	84.84	81.84
Y-98 (A1)	7173.50	3.00	21-Jun-07	84.79	81.79
Y-98 (A1)	7173.50	3.00	29-Sep-07	85.02	82.02
Y-98 (A1)	7173.50	3.00	30-Nov-07	85.13	82.13
Y-99 (A2)	7055.54	3.00	28-Mar-07	dry	---
Y-99 (A2)	7055.54	3.00	21-Jun-07	dry	---
Y-99 (A2)	7055.54	3.00	29-Sep-07	dry	---
Y-99 (A2)	7055.54	3.00	30-Nov-07	dry	---
Y-102 (A4)	6950.06	1.41	17-Jan-07	3.9 psi	+10.4
Y-102 (A4)	6950.06	1.41	28-Mar-07	3.4 psi	+9.26
Y-102 (A4)	6950.06	1.41	21-Jun-07	2.9 psi	+8.1
Y-102 (A4)	6950.06	1.41	29-Sep-07	2.0 psi	+6.0
Y-102 (A4)	6950.06	1.41	30-Dec-07	2.5 psi	+7.2

Table 2 Depth to aquic soil conditions and water table in Coal Hollow Project soils pits.

Soil Pit	Depth to Aquic Soil Conditions	Depth to Water Table	Pit Depth	Soil Pit	Depth to Aquic Soil Conditions	Depth to Water Table	Pit Depth	Soil Pit	Depth to Aquic Soil Conditions	Depth to Water Table	Pit Depth
	Inches	Inches	Inches		Inches	Inches	Inches		Inches	Inches	Inches
1	NA	NW	60	20	NA	NW	96	41	NA	NW	80
2	NA	NW	96	21	50	NW	96	42	NA	NW	48
3	NA	NW	33 sh	22	15	NW	84	43	7	30	96
4	NA	NW	31 sh	23	22	NW	80	44	7	14	96
5	NA	NW	60	24	NA	NW	32 sa	45	5	66	100
6	NA	NW	60	25	NA	NW	33 sa	46	24	44	120
7	NA	NW	60	26	20	84	125	47	32	80	84
8	NA	NW	85	27	90	NW	140	48	30	NW	84
9A	42	NW	100	28	NA	NW	102	49	NA	NW	10 sa
9B	Surface	57	57	29	60	NW	138	50	NA	NW	19 sh
10	68	NW	84	30	36	NW	120 sh	51	NA	NW	64
11	NA	NW	90	31	110	NW	125	52	24	NW	60
12	NA	NW	26 sh	32	90	120	140	53	9	27	60
13	NA	NW	84	33	NA	NW	100	54	19	NW	64
14	24	NW	90	34	NA	NW	70	55	41	NW	62
15	58	NW	96	35	NA	NW	95	56	NA	NW	96
16	36	NW	96	36	NA	NW	85	57	88	NW	100
17	45	NW	80	37	NA	NW	90	58	NA	NW	64
18A	7	51	60	38	12	24	40	59	62	75	76
18B	NA	NW	96	39	NA	NW	75	60	NA	NW	48 sh
19	NA	NW	90	40	6	23	40				
NA	No Aquic conditions			sh	Shale bedrock						
NW	No Water Table			sa	Sandstone bedrock						

Table 3 Discharge and water quality information for shallow alluvial groundwater in subirrigated areas.

	Date	discharge (gpm)	T (°C)	pH	Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	HCO_3 (mg/L)	CO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Cl (meq/L)	B (mg/L)	SAR
SP-6	3-Jul-87	Seep	18.8		3485												
SP-6	5-Aug-87	Seep	19.1		2900												
SP-6	17-Sep-87	Seep	12.0		3140	2280	32	426	156		1268	<5	798	56	1.58	0.47	1.59
SP-6	28-Oct-87	Seep	12.3		2520												
SP-6	17-Nov-87	Seep	7.9		2830												
SP-6	9-Dec-87	Seep	6.1		2385	1638	19	371	95		1069	<5	492	44	1.24	0.31	1.04
SP-6	15-Jan-88	Seep	5.6		2350												
SP-6	15-Feb-88	Frozen	---	---	---												
SP-6	11-Mar-88	Seep	3.0		2265	1598	14	334	72		913	<5	572	46	1.30	0.20	0.83
SP-6	24-Sep-05	Seep	16.0	7.41	1310	707	84.1	98.1	33	7.87	602	<5	112	6	0.17	0.10	0.58
SP-6	3-Nov-05	Seep	10.5	7.76	1602	1083	84.5	133	81.3	18.8	612	<5	301	44	1.24	0.14	1.28
SP-6	3-Nov-05		10.5	7.76	1602	1083	84.5	133	81.3	18.8	746.16	<5.	301	44	1.24	0.14	1.28
SP-6	29-May-06	0	25.2	8.12	1475	944	63.4	162	55.6	5.58	948.55	<5.	139	6	0.17	0.21	0.84
SP-6	7-Sep-06	<0.05	15.4	7.53	1038	666	71.06	89.43	38.5	10.14	587.66	<5.	126	23	0.65	0.1	0.72
SP-6	30-Dec-06	<0.05	5.6	7.91	1175	935	81.17	152.19	46.92	4.08	657.16	<5.	300	19	0.54	0.09	0.71
SP-6	30-Mar-07	0	2.2	8.46	2920	2365	13.3	505	113	4.52	1569.1	<5.	807	52	1.47	0.25	1.07
SP-8	3-Jul-87	10.0	10.9		785												
SP-8	5-Aug-87	8.6	10.7		795												
SP-8	18-Sep-87	10.0	11.2	7.25	725	386	81	56	6	2	308	<5	76	5	0.14	<0.02	0.13
SP-8	27-Oct-87	10.7	10.8		750												
SP-8	15-Nov-87	10.0	7.5		715												
SP-8	9-Dec-87	10.0	10.0	6.8	765	420	88	60	6	2	329	<5	76	5	0.14	<0.02	0.12
SP-8	9-Jan-88	15.9	12.0		685												
SP-8	18-Feb-88	15.4	7.8		675												
SP-8	18-Mar-88	12.2	10.1	7.4	725	438	77	50	6	2	324	<5	82	5	0.14	<0.02	0.13
SP-8	27-May-05	17.6	10.3	7.89	642	456	73.6	54.5	7.44	1.37	328	<5	77	4	0.11	0.02	0.16
SP-8	24-Sep-05	9.1	9.6	7.27	704	426	83.7	54.5	6.87	1.60	338	<5	71	3	0.08	0.02	0.14
SP-8	27-May-05	17.6	10.3	7.89	642	456	73.6	54.5	7.44	1.37	399.9	<5.	77	4	0.11	0.02	0.16
SP-8	24-Sep-05	9.1	9.6	7.27	704	426	83.7	54.5	6.87	1.6	412.09	<5.	71	3	0.08	0.02	0.14
SP-8	4-Nov-05	12.8	9.6	7.48	706	413	80.1	47.7	6.47	1.43	406	<5.	65	2	0.06	0.02	0.14
SP-8	31-Mar-06	20.3	9.3	7.1	716	407	79.7	49.4	6.55	1.47	335	<5	74	4	0.11	0.02	0.14
SP-8	31-Mar-06	20.3	9.3	7.1	716	407	79.7	49.4	6.55	1.47	408.44	<5.	74	4	0.11	0.02	0.14
SP-8	29-May-06	14.3	10.5	7.75	701	432	83.8	52.4	6.99	1.67	410.88	<5.	69	4	0.11	0.03	0.15
SP-8	30-Dec-06	19.3	8.1	7.79	668	417	85.06	50.96	6.98	1.34	413.31	<5.	72	3	0.08	0.02	0.15
SP-8	29-Mar-07	19.6	9.4	7.5	696	433	81.8	51.4	7.02	1.38	413.31	<5.	75	4	0.11	0.02	0.15

Table 4. Average root density and size by depth for plant communities in the Coal Hollow project area.

	Plant Community						
	M	M dry	OB	P	PJ	RB/SB	SG
			Soil Depth to Bottom of Root Feature (Inches)				
Root Density							
Many	11	11	3	3	0	12	4
Common	37	38	35	23	15	24	18
Few	52	79	90	65	30	60	57
Root Size							
Coarse	0	8	69	1	14	0	7
Medium	39	18	78	18	18	24	17
Fine	44	72	78	46	24	48	34
Very Fine	48	79	90	64	30	60	57
Soil Features							
Bedrock					31		
Depth to Mottles	11	36	Note 1	Note 2	Note 3		Note 4
Hole Depth	65	85	90	93	41	84	85

Notes

1 One of two soil data points in the oak brush (OB) plant community had soil mottles (15 inches in soil pit 22).

2 Seven of sixteen soil data points in the pasture (P) plant community had soil mottles (50 inch average depth for the seven soil data points).

3 One of five soil data points in the pinyon-juniper (PJ) plant community had soil mottles at 30 inches, but these were most likely the result of infiltrating surface water perching within the very dense clay subsoil.

4 Five of twenty soil data points in the sage-grass (SG) plant community had soil mottles (52 inch average depth for the five soil data points).

Table 5. Definitions of root density and size terms used in soil pit descriptions (Schoeneberger et. al., 2002).

Root Density		Root Size	
Many	>5 roots per unit area	Coarse	5 to 10 mm
Common	1 to 5 roots per unit area	Medium	2 to 5 mm
Few	<1 root per unit area	Fine	1 to 2 mm
		Very fine	<1 mm

Table 6. Soil map units that exhibit soil characteristics of potential sub-irrigation.

Soil Map Unit	Soil map Unit Name[1]	Sub-Irrigated[2]
1	A family – Wapiti Family complex, 3 to 8% slopes	No
2	M Family – Calendar family – D Family complex, 3 to 8% slopes	No
3	Cibeque Family – Wapiti Family complex, 3 to 8% slopes	No
4	Jonale Family – Graystone cobbly substratum Family – Wapiti Family complex, 3 to 8% slopes	No
5	Calendar Family – M Family – Drififty Family complex, 8 to 25% slopes	No
6	Graystone – Cookcan – Jonale family complex, 1 to 5% slopes	Localized Potential[3]
7	Happyhollow Family – Alamosa complex, 1 to 5% slopes	Yes
8	Brumley – Graystone – Snilloc complex, 3 to 8% slopes	No
9	D Family – Deacon complex, 5 to 30% slopes	No
10	Zigzag clay, 8 to 25% slopes	No
11	A Family clay, 8 to 25% slopes	No
12	Manzanst Taxadjunct Family clay, 3 to 12% slopes	No
13	A Family – Happyhollow Family complex, 1 to 5% slopes	Localized Potential[3]

Footnotes:

1 Soil map unit descriptions are available in section 2 of the Coal Hollow soil survey report (Appendix 2-1 of MRP).

2 Potential for sub-irrigation is based on the taxonomic classification of the soil components in each map unit.

3 Localized potential occurs when one major soil component has the potential for sub-irrigation.

Table 7 Plant communities that exhibit soil and vegetation characteristics of sub-irrigation based on the dominant conditions.

Plant Community	Sub-Irrigated
Meadow (M)	Yes
Meadow – dry (M dry)	Localized Potential
Oak brush (OB)	No
Pasture (P)	No
Pinyon Juniper (PJ)	No
Rabbitbrush – sagebrush (RB/SB)	No
Sagebrush – grass (S/B)	No

Table 8 Monthly water requirements (evapotranspiration) for plants in Alton, Utah (after Hill and Heaton, 2001).

	Monthly Crop Evapotranspiration (inches)						
Plant	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Season Total**
Alfalfa	---	4.96	8.31	6.26	7.11	0.51	27.16
Pasture	0.61	4.01	5.4	5.59	4.85	2.85	23.31
Sp. Grain	0.30	3.13	8.05	8.28	1.97	---	21.73
Turf	1.06	3.72	4.65	4.82	4.18	2.89	

Adapted from: Consumptive Use of Irigated Crops in Utah, Utah Agricultural Experiment Station Research Report No. 145. Oct. 1994.

Table 9 Discharge and water-quality information for surface waters that could potentially be used for flood irrigation.

	Date	discharge (gpm)	T (°C)	pH	Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	HCO_3 (mg/L)	CO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Cl (meq/L)	B (mg/L)	SAR
Section 21 Canyon drainage																	
SW-7	2-Jul-87	Dry															
SW-7	4-Aug-87	Dry															
SW-7	6-Sep-87	Dry															
SW-7	27-Oct-87	Dry															
SW-7	15-Nov-87	Dry															
SW-7	4-Dec-87	Dry															
SW-7	5-Jan-88	Dry															
SW-7	16-Feb-88	Dry															
SW-7	18-Mar-88	Dry															
SW-7	4-Nov-05	Dry															
SW-7	7-Sep-06	Dry															
SW-7	21-Dec-06	Dry															
SW-7	28-Mar-07	Dry															
SW-7	21-Jun-07	Dry															
SW-7	29-Sep-07	Dry															
SW-7	30-Nov-07	Dry															
Swapp Hollow																	
SW-8	6-Jul-87	36	10.3	8.5	490	286	37	38	7.00	1	228	<5	31	10	0.28	<0.01	0.19
SW-8	6-Aug-87	22	14.1	8.4	490	262	44	36	5.00	1	241	<5	14	3	0.08	<0.02	0.14
SW-8	17-Sep-87	40	7.1	8.5	480	245	51	40	4.00	1	232	<5	21	3	0.08	<0.02	0.10
SW-8	28-Oct-87	36	18.2	8.2	430	256	48	38	5.00	1	241	<5	27	4	0.11	<0.02	0.13
SW-8	17-Nov-87	40	9	8.2	525	302	49	36	4.00	1	243	<5	29	3	0.08	<0.02	0.11
SW-8	15-Dec-87	13	0.8	7.7	585	338	57	40	6.00	1	300	<5	33	7	0.20	<0.02	0.15
SW-8	13-Jan-88	40	0.3	8.2	550	306	47	38	4.00	1	250	<5	33	7	0.20	<0.02	0.11
SW-8	17-Feb-88	49	-0.3	8.1	565	324	61	40	4.00	1	273	<5	31	3	0.08	<0.02	0.10
SW-8	21-Mar-88	49	1.5	8.2	610	290	56	38	4.00	1	263	<5	29	<1		<0.02	0.10
SW-8	18-Jun-05	290	17.5	8.38	566	366	59.2	44.1	6.75	1.03	368	<5.	34	5	0.14	0.02	0.16
SW-8	12-Aug-05	130	17.8	8.41	493	274	51.4	37.7	6.63	1.03	243	<5	38	4	0.11	0.02	0.17
SW-8	24-Sep-05	69	14.0	8.36	536	298	48.4	38.9	6.09	0.99	250	<5	33	4	0.11	<0.02	0.16
SW-8	24-Sep-05	69	14	8.36	536	298	48.4	38.9	6.09	0.99	305	<5.	33	4	0.11	0.02	0.16
SW-8	4-Nov-05	71	6.2	8.63	555	321	59.8	39	7.95	1.04	265	<5	49	4	0.11	0.01	0.20
SW-8	30-May-06	35	23.2	8.89	586	350	44.7	39.4	11.7	1.22	274	<5.	69	7	0.20	0.03	0.31
SW-8	7-Sep-06	50.7	12.5	8.01	576	331	47.48	39.92	17.75	1.75	288	<5.	89	7	0.20	0.02	0.46
SW-8	20-Dec-06	32.1	10.1	8.84	553	337	64.07	39.43	8.45	0.91	335	<5.	46	5	0.14	0.64	0.20
SW-8	29-Mar-07	33.6	2.2	8.68	524	324	59.6	36.4	9.2	0.96	322	<5.	49	5	0.14	0.01	0.23

	Date	discharge (gpm)	T (°C)	pH	Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	HCO_3 (mg/L)	CO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Cl (meq/L)	B (mg/L)	SAR
SW-8	22-Jun-07	13.8	20.2	8.66	566	356	55.1	41.0	10.5	6.52	328	<5	45	8	0.23		0.26
SW-8	29-Sep-07	10.4	13.6	8.70	561	353	58.7	42.6	9.94	1.94	334	<5	56	6	0.17		0.24
SW-8	30-Nov-07	12.5	0.4	8.16	445												
Sink Valley																	
SW-6	17-Sep-87	Dry	11.0	8.70	860	556	34	98	29.00	11	292	40	140	18	0.51	0.21	0.57
SW-6	15-Dec-87	Dry	0.8	8.3	1840	1212	51	209	73.00	9	602	37	418	41	1.16	0.21	1.01
SW-6	11-Mar-88	Dry	1.5	8.4	1600	992	45	182	63.00	5	590	<5	344	34	0.96	0.16	0.93
SW-6	17-Jun-05	Dry															
SW-6	30-Mar-06	58	13.8	8.91	1352	1028	58.9	161	31.30	12.5	436	47	361	22	0.62	0.17	0.48
SW-6	16-May-06	Dry															
SW-6	29-May-06	Dry															
SW-6	7-Sep-06	Dry															
SW-6	30-Dec-06	Dry															
SW-6	20-Jun-07	Dry															
SW-6	30-Sep-07	Dry															
SW-6	30-Dec-07	Dry															
Robinson Creek																	
SW-4	2-Jul-87	Dry															
SW-4	4-Aug-87	Dry															
SW-4	6-Sep-87	Dry															
SW-4	27-Oct-87	Dry															
SW-4	15-Nov-87	Dry															
SW-4	4-Dec-87	Dry															
SW-4	5-Jan-88	Dry															
SW-4	16-Feb-88	Dry															
SW-4	18-Mar-88	Dry															
SW-4	27-May-05	539	19.1	8.4	453	283	47.7	35.8	2.23	0.6	297.49	<5.	18	2		0.01	0.06
SW-4	4-Nov-05	Dry															
SW-4	16-May-06	Dry															
SW-4	8-Sep-06	Dry															
SW-4	21-Dec-06	Dry															
SW-4	28-Mar-07	Dry															
SW-4	29-Mar-07	Dry															
SW-4	21-Jun-07	Dry															
SW-4	29-Sep-07	Dry															
SW-4	29-Dec-07	Dry															
SW-5	10-Aug-87	13.5	27.5	8.65	1680	984	39	160	69	7	433	49	403	24	0.68	0.17	1.09

	Date	discharge (gpm)	T (°C)	pH	Cond. (µS/cm)	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	HCO_3 (mg/L)	CO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Cl (meq/L)	B (mg/L)	SAR
SW-5	14-Sep-87	13.5	9.0	8.65	1480	1008	49	162	61	5	444	12	368	3	0.08	0.11	0.94
SW-5	29-Oct-87	58	12.5	8.10	1070	666	42	105	49	4	290	<5	298	19	0.54	0.08	0.92
SW-5	18-Nov-87	Puddle	1.2	8.00	1305	886	54	129	58	4	402	16	350	21	0.59	0.06	0.98
SW-5	11-Feb-88	36	0.0	8.00	665	446	46	59	23	6	204	<5	163	10	0.28	0.02	0.53
SW-5	17-Mar-88	4.5	9.1	8.20	1670	876	54	104	55	5	378	<5	344	21	0.59	0.06	1.01
SW-5	17-Mar-88	4.5	9.1	8.2	1670												
SW-5	27-May-05	410	18	8.46	721	469	63	60.6	20.2	1.84	405	8.3	144	6	0.17	0.04	0.44
SW-5	25-Sep-05	Dry															
SW-5	30-May-06	5.37	11.4	8.88	1543	1205	69.8	148	85.2	5.67	513	<5.	503	26	0.73	0.16	1.32
SW-5	7-Sep-06	4.96	13.7	8.36	1394	1081	59.04	143.68	83.11	6.02	456	<5.	474	27	0.76	0.16	1.33
SW-5	30-Dec-06	Dry															
SW-5	29-Mar-07	Dry															
SW-5	22-Jun-07	Dry															
SW-5	29-Sep-07	14.1	9.6	8.56	960	751	75.3	95.7	38.3	6.57	372	<5	300	15	0.42		0.69
SW-5	29-Dec-07	Dry															
SW-101	27-May-05	734	17.7	8.41	495	309	54.2	36	4.67	1.02	421	13	45	4	0.11	0.02	0.12
SW-101	31-Mar-06	20.8	8.6	8.62	3120	3013	356	148	282	16.4	820	<5	1899	47	1.33	0.19	3.17
SW-101	21-May-06	Dry															
SW-101	25-Sep-05	Dry															
SW-101	3-Nov-05	Dry															
SW-101	21-Dec-06	Dry															
SW-101	30-Dec-06	Dry															
SW-101	20-Jun-07	Dry															
SW-101	30-Sep-07	Dry															
SW-101	26-Dec-07	Dry															
Water Canyon																	
RID-1	4-Nov-05	64.7	1.0	8.73	376	250	47.5	36.8	1.76	0.87	290	<5	16	2	0.06	<0.01	0.05
RID-1	29-May-06	48.6	10.4	8.89	412	265	36.3	36.1	1.9	0.88	267	<5	17	3	0.08	0.01	0.05
RID-1	8-Sep-06	31.0	18.3	8.37	440	222	43.8	34.9	1.64	0.9	271	<5	17	3	0.08	<0.01	0.04
RID-1	21-Dec-06	6.2	0.1	8.87	470	273	54.32	35.8	1.85	0.9	295	18	19	2	0.06	<0.01	0.05
RID-1	28-Mar-07	12.8	1.5	8.83	412	254	43.7	32.6	1.69	0.64	272	20	17	2	0.06		0.05
RID-1	21-Jun-07	3.45	14.2	8.97	359	224	24.9	37.1	2.28	1.21	218	17	18	2	0.06		0.07
RID-1	29-Sep-07	6.64	12.7	8.81	416	245	41.4	37.5	1.83	1.12	257	27	19	2	0.06		0.05
RID-1	29-Dec-07	Dry															