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SECTION 17 GEOLOGIC INFORMATION

The permit and adjacent area are located on the west flank of the San Juan Structural Basin, within the Navajo Section of the Colorado Plateau in northwestern New Mexico. The Colorado Plateau, or Colorado Plateaus Province, is a physiographic region of the Intermontane Plateaus, roughly centered on the Four Corners region of the southwestern United States. The Colorado Plateau covers an area of approximately 130,000 sq mi within western Colorado, northwestern New Mexico, southeastern Utah, and northern Arizona (Leighty 2001). Within the Colorado Plateau, the San Juan Basin covers about 7,500 sq mi across the Colorado/New Mexico border and measures approximately 100 mi long in the north-south direction and 90 mi wide. The land surface elevations within the basin range from 5,100 ft on the western side to over 8,000 ft in the northern side. This basin is an asymmetric, structural basin with a northeast-trending axis parallel to the Hogback Monocline in northwestern New Mexico. It is bounded to the north by the San Juan Uplift and to the south by the Zuni Uplift and the Chaco Slope. The western rim is formed by the Defiance Uplift and Four Corners Platform and the eastern rim is formed by the Brazos Uplift and the Nacimiento Uplift. The Continental Divide trends north to south along the east side of the San Juan Basin.

The stratigraphic section in the permit area reflects the Late Cretaceous transition of shallow marine depositional environment to a terrestrial fluvial depositional environment. The four rock sequences encompassing this depositional environment change are (in descending order): Kirtland Shale, Fruitland Formation, Pictured Cliffs Sandstone (PCS), and Lewis Shale. Mining activities will occur in the Kirtland Shale and Fruitland Formation. The Fruitland Formation contains the mineable coal-bearing units.

17.1 Geologic Description

The geologic units to be mined or potentially influenced by mining include the Kirtland Shale, Fruitland Formation, and PCS. The geologic strata in the permit area outcrop along the western edge and dip approximately 2° to the east or northeast toward the center of the San Juan Basin. The surface topography in the area is described in Section 13 Topography. The area is generally arid, rolling terrain with some incised arroyos. A generalized geologic column of the rock sequence planned to be mined is provided as Figure 17.1-1.

The Kirtland Shale is the uppermost consolidated geologic layer within or adjacent to the permit area. It conformably overlies the Fruitland Formation. The Kirtland Shale is divided into two units, the upper shale member, which includes Farmington Sandstone, and the lower shale member. Sediments in the Kirtland Shale were deposited in an upland floodplain environment where aggrading stream channels were separated by narrow, parallel floodplains. The upper shale member is composed of a series of interbedded sandstone lenses and claystone shales. The shale beds in the upper shale member of the Kirtland Shale are much more colorful than those in the lower shale member and are purple, green, white, and gray. The lower shale member is composed of gray claystone shales that contain a few thin interbeds of siltstone and sandstone.

No coal beds exist in the Kirtland Shale (Fassett and Hinds 1971). A detailed discussion of ground water quantity, quality, and transport within the Kirtland Shale is provided in Section 18 Water Resources. Several deposits of Quaternary alluvial and eolian sands occur within the permit area. These are important sources of topdressing material for reclamation and are discussed in Section 14 Soil.

The Fruitland Formation, which conformably overlies the PCS, contains sediments deposited in fluvial delta-plain and adjoining back beach-bar depositional environments (Flores and Erpenbeck 1981). The lithologies of the rock units encountered in the Fruitland Formation include fine- to medium-grained sandstones, siltstones, sandy and silty claystones, carbonaceous claystones, bentonitic claystones, and coal. Although the rock-unit bedding is generally parallel, the units are not continuous throughout the permit area.

There are eight primary coal seams and eight corresponding overburden/interburden horizons defined by the geologic model within the permit area. Each interburden layer is referred to using the name of the coal seam directly below the interburden layer. Coal seams are numbered from deepest to shallowest. For example, the deepest coal seam to be mined is the No. 2 coal seam (S2) and the interburden above it and below the No. 3 coal seam (S3) is referred to as No. 2 interburden (I2). In situations where the coal seam splits, the coal seam number is followed by alphabetic designation (e.g., S2A and S2B). Interburden layers between splits in the No. 2 coal seam are referred to as I2A and I2B. Further, if interburden layers are composed of horizons of differing rock strata (e.g., sandstone and shale) the interburden number will be followed by numeric designation (e.g., I2-1 or I2A-1). For example, if the bottom horizon in I2 is primarily sandstone and the upper primarily shale, then the bottom horizon within this interburden would be labeled I2-1 and the next horizon above would be I2-2. An exhibit showing the No Name Permit (NNP) boundary and cross-section locations is presented as Exhibit 17.1-1. Cross-sections of the geologic model are provided as Exhibits 17.1-2 to 17.1-11. Crop lines, strike and dip angles for each seam are provided as Exhibit 17.1-12. Drill hole identifiers presented in Section 17 appendices, exhibits, and tables may be shown as either “407-41” or “40741.” These formats refer to the same drill hole. The hyphen is excluded in some tables, figures, and modeling outputs because the mine’s 3D subsurface modeling software requires drill hole IDs to contain only alphanumeric characters.

The production operations will remove units from the surface down to and including No. 2 coal seam. Coal seams below the No. 2 coal seam will not be extracted and the underlying PCS will not be mined. Some of the coal seams and interburdens within and adjacent to the permit area are under perched, saturated conditions due to recharge zones at the outcrops. However, the water is not of sufficient quantity to be of sustainable use or pose a challenge during mining or reclamation operations. A detailed discussion of groundwater quantity, quality, and transport within the Fruitland Formation is provided in Section 18 Water Resources.

The PCS conformably overlies and forms overlapping layers with the Lewis Shale. This formation consists of both delta-front and barrier-beach sediments and marks the change to a littoral (near-shore) depositional environment (Flores and Erpenbeck 1981). The upper two-thirds of the PCS consists of a generally coarsening upward sequence of light gray, fine- to medium-grained sandstone while the lower one-third of the formation consists of interbedded shale and sandstone. The upper 60 ft of this sandstone is consistently massive, light gray to light brown, fine to medium grained with predominately rounded quartz grains, and has a salt-and-pepper texture. The total thickness of the PCS is approximately 110 ft in the permit area. The PCS is the lowest potential water-bearing unit within and adjacent to the permit area that could be impacted by mining but it will not be mined. A detailed discussion of groundwater quantity, quality, and transport within the PCS is provided in Section 18 Water Resources.

The Lewis Shale contains the last purely marine shales deposited in the Upper Cretaceous epeiric seaway. It consists of gray to black shale with some interbeds of sandy limestone, brown sandstone, and bentonite. The Lewis Shale is located below the PCS and will not be mined; however, it is included in the groundwater model discussed in Section 18 Water Resources.

Geologic hazards within the mining area are limited to those created during the mining process, exposed highwalls and spoil piles. Hazards encountered during mining are managed in accordance with Mine Safety and Health Administration (MSHA) regulations. There is no history of landslide or mudslide potential within or adjacent to the permit area. No major faults cut the permit area, although minor low-angle compaction faults and slumps with up to 10 ft of displacement are not uncommon. The Colorado Plateau is considered tectonically stable. The U.S. Geological Survey National Seismic Hazard Map indicates the permit area is within a low-hazard zone for ground shaking, with a 2% chance of experiencing a seismic event that would cause ground shaking at a level of 4% to 8% of acceleration due to gravity in the next 50 years (Petersen et al. 2008). Of the nearly 1,800 seismic events with epicenters recorded in New Mexico between 1962 and 1995 approximately 10 occurred within 100 mi of the permit area (Sanford et al. 2002). In 1976 and 1977 two deep earthquakes with moment magnitudes of 4.6 and 4.2, respectively, occurred around Crownpoint, New Mexico, approximately 75 mi south of the permit area (Wong et al. 1984). The epicenter of these was about 26 mi below the surface at a tectonic transition zone between the Basin and Range-Rio Grande Rift and Colorado Plateau stress provinces.

17.2 Overburden Characteristics

The characteristics of in-situ overburden from 26 drill holes have been evaluated. Seventeen of these holes are in Area 4 South and nine are in Area 5. These holes were drilled as part of the 1998 drilling program and 2007 drilling program. During the 1998 drilling program, 10 holes in Area 4 South were cored. The core inventory logs for the 1998 holes in Area 4 South are included in Appendix 17.A. During the 2007 drilling program, seven holes in Area 4 South and nine holes in Area 5 were cored and the core inventory logs are included in Appendix 17.B and Appendix 17.C, respectively. Samples from the overburden/interburden material at defined intervals were analyzed for the physical/chemical properties outlined in Table 17.2-1. Results from the 1998 overburden/interburden analysis are provided in Tables 17.2-2 to 17.2-27.

The data collected in 1998 were used in the development of the first statistical analysis of interburden sampling in Area 4 South. This report was prepared by J.W. Kern, PhD, of Western EcoSystems Technology, Inc. and is included as Appendix 17.D. The objectives of the report included identifying which overburden/interburden layers contain high proportions of material unsuitable for root zone material, and estimating the volume of root zone suitable material available for reclamation. Kern's report focused on an area within Area 4 South from the western lease boundary to the southwest bank of Pinabete Arroyo.

The 2007 program expanded drilling into all of Area 4 South and Area 5. These data, along with the 1998 data, were used in the development of the 2008 statistical analysis of the overburden/interburden sampling. This report is included as Appendix 17.E. The objectives of the 2008 study are to estimate the total volume of root zone suitable material in the interburden layers most likely to be used for reclamation, characterize the in-situ interburden layers and spatial patterns, and characterize mixed material (spoil) suitability and spatial patterns. When characterizing the suitability of in-situ overburden/interburden layers and modeled spoil material, two potential criteria limits were used: Office of Surface Mining Reclamation and Enforcement (OSM) Southwestern U.S. criteria limits and Navajo Mine site-specific criteria limits. These root zone suitability criteria, provided in Table 17.2-28, were selected because of the location of the NNP site in proximity to Navajo Mine. Section 36 Post-Reclamation Soil and Table 36-4 Root-Zone Suitability Criteria specifically identify the approved root-zone suitability criteria for the NNP area.

The recoverable suitable root zone material will come from overburden strata above the first seam to be mined. Suitable root zone thickness for each drill hole was determined by comparing the weighted average of analytical results to both OSM and Navajo Mine criteria. The results of suitable thickness calculations are summarized in Appendix 17.E.`

Characterization of the in-situ interburden above each coal seam suggests that, in some locations, the rock strata associated with the interburden above the No. 7 coal seam (I7) and interburden above the No. 6 coal seam (I6) in Area 4 South have total selenium concentrations that exceed OSM criteria limits, but are below Navajo Mine criteria limits. In-situ acid-base potential (ABP) characterization suggests a net alkaline environment for the majority of interburden layers across both Area 4 South and Area 5. The characterization suggests that in some drill hole locations, the rock strata associated with I6 and the interburden above No. 3 coal seam (I3) have pyritic sulfur ABPs that are outside criteria limits. These layers are thin and make up less than 14% of the total thickness of interburden to be excavated during mining in Appendix 17.E. Characterization of the in-situ interburden above each coal seam suggests that, in general, the rock strata present in I6, I4, I3, and I2 across Area 4 South and Area 5 possess saturation percent, sodium adsorption ratio (SAR), and pH values that are outside criteria limits established by OSM and Navajo Mine for root zone suitability.

Spoil material quality was modeled by computing the weighted mean for each analyte within each drill hole (Appendix 17.E). These data are used to characterize spoil at each drill hole location and estimate spoil variability within and among each operational area. The results of these computations are included in Appendix 17.E. In summary, modeled spoil samples exceeded criteria limits for saturation percent and SAR only. ABP values are greater than criteria limits, suggesting the modeled spoils represent alkaline or neutralizing rock strata. The saturation percent criteria limit is exceeded by 9 of 17 drill holes in Area 4 South from 3.3 to 42.9% and by two of nine drill holes in Area 5 by up to 5.7%. SAR criteria limits are exceeded by 5 of 17 drill holes by up to 32.4, but the average SAR values for Area 4 South are below both OSM and Navajo Mine criteria limits. SAR criteria limit for Navajo Mine is exceeded by three of nine drill holes in Area 5.

In conclusion, there is no widespread occurrence of potentially acid- and toxic- forming materials (PATFM) within Area 4 South or Area 5. ABP characterization suggests a net alkaline environment for the majority of interburden layers across both Area 4 South and Area 5. Two in-situ interburden layers in Area 4 South, I6 and I3, possess APB values that are outside criteria limits. These layers are thin compared to the total thickness of interburden to be excavated during mining, constituting less than 14%, respectively, of the in-situ interburden thickness at each drill hole location. Characterization of the in-situ interburden also suggests that the rock strata present in I6, I4, I3, and I2 in Area 4 South and Area 5 possess values for saturation percent, SAR, and pH that are outside criteria limits established by OSM and Navajo Mine for root zone suitability. These characteristics are common to alkaline subsurface environment where weathering has not altered the rock strata.

However, when analyzed as a composite to model mine spoil conditions, the influence of these layer characteristics is attenuated and the overall values for physical and chemical analytes, with the exception of saturation percent and SAR, for the spoil are within suitability limits and PATFM is not a concern. Despite containing these thin layers of low pyritic sulfur ABP interburden, all modeled spoil columns have net alkaline values (Appendix 17.E).

17.3 Coal Characteristics

The areal extent of the Fruitland Formation coal seams varies across the permit area due to strata dip and localized pinch outs, as shown by the cross-sections in Exhibits 17.1-2 through 17.1-11. Some of these seams split locally to form thinner seams. Defined croplines are not typically expressed at the topographic surface due to deep weathering and burn areas. The general characteristics and extent of the coal are discussed in the following section.

The No. 2 coal seam is the lowest seam to be mined and lies above the PCS. In some areas, the coal seam is in contact with the PCS and in others is separated from the PCS by interburden. The cropline is located on the west side of the permit area, outside of the coal lease. The seam has two splits, No. 2A and No. 2B, with No. 2A being the lower of the two. In Area 4 South, these seams have additional splits locally, named Nos. 2A2, 2A1, 2B2 and 2B1. No significant rock partings occur in this seam.

The No. 3 coal seam lies above the No. 2 seams and is separated by the interburden above the No. 2 coal seam (I2). The cropline is located on the west side of the permit area, outside of the coal lease. This seam has two splits, No. 3A and No. 3B, with No. 3A being the lower of the two. No significant rock partings occur in this seam.

The No. 4 coal seam lies above the No. 3 seam and is separated by the interburden above the No. 3 coal seam (I3). The cropline is located on the west side of the permit area, outside of the coal lease. In Area 5 this seam splits locally into No. 4A and No. 4B, with No. 4A being the lower of the two. No significant rock partings occur in this seam.

The No. 6 coal seam lies above the No. 4 coal seam, separated by the No. 4 coal seam interburden (I4). The cropline is located on the west side of the permit area, outside of the coal lease. The No. 6 coal seam splits locally into No. 6A and No. 6B, with the No. 6A being the lower of the two. No significant rock partings occur in this seam.

The No. 7 coal seam lies above the No. 6 coal seam, separated by the No. 6 coal seam interburden (I6). Croplines can be seen along bluffs and in valley floors throughout the permit area. The seams are absent or more weathered in the western portion of the permit area in Area 4 South. The No. 7 coal seam splits locally into No. 7A and No. 7B, with No. 7A being the lower of the two. No significant rock partings occur in this seam.

The No. 8 coal seam lies above the No. 7 coal seam, separated by the No. 7 interburden (I7). Croplines can be seen along bluffs and in valley floors throughout the permit area. In Area 4 South, the outcrops can be seen within Pinabete Arroyo. The seams are absent or more weathered in the western portion of the permit area in Area 4 South. This seam has two splits, No. 8A and No. 8B, with No. 8A being the lower of the two. In Area 4 South, these seams have additional splits locally, named Nos. 8A2, 8A1, 8B2 and 8B1. No. 8B coal seam splits into 8B2 and 8B1 in only localized areas within Area 4 South but does not split in Area 5. No significant rock partings occur in this seam.

Coal seams and splits, described above, were sampled and analyzed for total sulfur and pyritic sulfur content. The average total sulfur percent and average pyritic sulfur percent of each seam are summarized in Table 17.3-1. Average thickness of each seam is summarized in Table 17.3-2 and detailed in Appendix 17.A, Appendix 17.B, and Appendix 17.C. Average total sulfur values range from 0.53% to 1.27%, with No. 2A and No. 7 coal seams showing the highest values. Weighted average total sulfur, as a function of average seam thickness, for all seams is 0.76%. Average pyritic sulfur values range from 0.10% to 0.71%, with No. 2A and No. 7 coal seams showing the highest values. Weighted average pyritic sulfur, as a function of average seam thickness, for all seams is 0.28%. Pyritic sulfur is the main contributor to acid-forming materials through oxidation processes and makes up a small percentage of both the coal seams and the overburden/interburden materials. As stated in Section 17.2, the overburden/interburden rock strata have a large positive ABP that can neutralize any acidic groundwater that may be generated by the unmined coal faces in the highwall and any waste coal that may be placed in the backfill, as described in Section 21 Waste Disposal Structure and Facilities. In addition, baseline groundwater from coal seams is described in Section 18 Water Resources and does not indicate the presence of any PATFM. Therefore, the coal seams do not contain PATFM.

17.4 Geologic Information Collection and Analysis

Geologic information is collected as part of NTEC's drilling programs. The goals of the drilling programs are to enhance understanding of the coal geology for geologic modeling, collect samples for coal quality evaluation, and collect samples for overburden/interburden characterization. NTEC maintains a 3-dimensional geologic model in Vulcan software. This model is the source of cross-sections presented in this section.

10 holes were completed for the 1998 drilling program. Each hole was logged and continuous core samples were collected Appendix 17.A. The core log information from this drilling program is provided in Appendix 17.A. Wyoming Analytical Laboratories, Inc. conducted the coal quality and overburden analysis. The results from overburden analyses are provided in Tables 17.2-1 to 17.2-10. 16 holes were completed for the 2007 drilling program. Continuous coring was utilized for sample collection. Core log information for these data is provided in Appendix 17.B and Appendix 17.C. SGS Labs conducted the coal quality analysis, and Green Analytical Laboratory performed the overburden analysis. Results from the overburden analyses are contained in Table 17.2-11 to 17.2-26. The location of drill holes is shown on Exhibit 17.1-1. Drill hole elevations and coordinates can be found in Table 17.4-1.

Subsequent drilling programs will be initiated through the life of the operation. Data collected through these drilling programs will be used to enhance understanding of the geologic model. Additional sampling and testing will also take place for further overburden characterization if necessary.

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Appendix 17.D

Statistical Analysis of Phase I Interburden Sampling

No Name Permit

Statistical Analysis of Phase I Interburden Sampling

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3 August, 1998

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STATISTICAL ANALYSIS OF PHASE I INTERBURDEN DATA

I. INTRODUCTION

The first phase of drilling to sample overburden at the site consisted of 10 drill holes. Each drill hole resulted in continuous core samples through overburden, interburden and coal seams. The continuous cores were sampled at no greater than 5-foot increments for chemical assay and samples were taken at each change in lithology. The objectives of the phase I statistical analysis are to

1. Assess the adequacy of the phase I drilling program to conclude that either A) overburden is adequately sampled, or B) that further drilling is needed in order to make an adequate decision, and

2. Estimate the percent suitable material for reclamation and establishment of an adequate root zone to support vegetation,

3. Determine if particular stratigraphic layers contain high proportions of unsuitable materials,

4. Investigate spatial patterns in the proportion of suitable material and average value of analytes of interest,

5. Estimate the total volume of suitable material in the interburden layers most likely to be used for reclamation.

II. LITHOLOGY AND NAMING CONVENTIONS

The area is composed of 8 coal seams and 8 corresponding overburden horizons with the Picture Cliffs sandstone comprising the deepest unit described in these investigations. Throughout this report, each interburden layer is referred to using the name of the coal seam directly below the layer.

Coal seams are numbered from deepest to shallowest. For example the deepest coal seam is seam 1 and the interburden above seam 1 and below seam 2 would be referred to as I1. In situations where there may be splits resulting in coal seams say 1A and 1B, then the interburden between these splits is referred to as I1A and I1B. Further if interburden layer I1A were composed of several horizons, say one horizon of primarily sandstone and the other of primarily shale, then the bottom horizon within this interburden would be labeled I1A1 and the next horizon above would be I1A2.

In general, each horizon within interburden is classified based on lithology, although some horizons may be composed of 2 or more lithologies, sandstone (SS), siltstone (SLTS) or shale (SH). Table 1 gives a list of each of the horizons and the composition of each in terms of percent of samples labeled SS, SLTS or SH. Thin (generally less than 12 inches) carbonaceous shale (CS) exists adjacent to the top or bottom of some coal seams. In most cases, the CS intervals were sent to the coal lab for BTU analysis and have to date not been analyzed by the soil lab; therefore occurrences of CS are not included with this analysis and because of the small quantities of CS, the effects will not be significant. There were 9 interburden samples labeled as carbonaceous shale that have been eliminated from the analysis.

Geologic Cross Section

The locations of two cross sections through the area are shown in plan view in Figure 1, and cross sections one and two are presented in Figures 2 and 3. These cross sections are lumped into interburden layers (white) and coal layers (shaded). In addition to the cross sections, the mining area limit and combined polygons of influence are plotted for the area of influence of drill holes 498-01, 498-03, 498-04, 498-05, 498- 06, 498-07. These polygons were selected for investigation because mixed material was 100 percent suitable within each of these drill holes.

Table 1. Interburden horizon labels and lithologic composition.

Horizon	Percent Sandstone	Percent Shale	Percent Siltstone	Number of Observations
I1A	25	42	33	12
I2A	18	55	27	11
I2B	100	0	0	1
I2C1	0	100	0	10
I2C2	80	0	20	15
I2C3	0	91	9	23
I3A	0	100	0	1
I3A 1	100	0	0	2
I3A 2	0	0	100	2
I3B	100	0	0	1
I3C	0	72	28	16
I4A	0	100	0	2
I4C1	5	86	9	22
I4C2	70	15	15	26
I4C3	0	100	0	25
I6A	0	100	0	3
I6B	0	100	0	15
I7A 1	0	100	0	10
I7A 2	88	0	11	18
I7A 3	0	100	0	9
I7A 4	100	0	0	1
I7A 5	0	100	0	1
I8A	0	100	0	2
I8B1	0	100	0	1
I8B2	85	15	0	7
I8C1	0	80	20	5
I8C2	61	13	26	23
I8C3	0	100	0	4
I9A	0	100	0	4
I9B1	0	100	0	2
I9B2	75	25	0	4
PCSS	Picture Cliffs Sandstone			15
T7A 2	Topsoil			4
T7A 3	Topsoil			4
T8A	Topsoil			4
T8B 2	Topsoil			1
T8C 2	Topsoil			8
T9B 2	Topsoil			4

III. STATISTICAL METHODS

Proportion Suitable and Analyte Distributions

Interburden characterization data were obtained in electronic spreadsheets. The data were exported to ASCII comma delimited text files for import into SAS statistical processing software. Analyses of interest include the characterization of percentage of suitable interburden material based on 9 analytes: sodium absorption ratio (SAR), pH, electrical conductivity (EC), acid-basepotential (ABPT), texture (percent clay CLA) saturation percentage (SAT), Boron (B), and total and soluble Selenium (TSE and SSE). Determination of suitability was made on a sample by sample basis using both Office of Surface Mining guidelines and site specific guidelines currently in use at Navajo Mine. Due to the proximity of the No Name mine site to the Navajo Mine, a similar site-specific standard is appropriate. Office of Surface Mining southwestern United States, and Navajo Mine suitability criteria can be found in Table 2.

Table 2. Office of Surface Mining Reclamation and Enforcement, Southwestern United States and Navajo Mine suitability criteria.

SUITABILITY LIMITS

Characteristic	Navajo Mine Site Specific	OSM Southwestern U. S. Criteria
1. SAR	≤18 OR ≤40 only if EC≥4 mmhos/cm	sandy loam≤20 loam, clay loam≤16 40% clay≤14
2. pH	≥5 and ≤9	≥5.5 and ≤9.0
3. EC	≤16 mmhos/cm	≤12 mmhos/cm
4. Acid-Base Account	≥-5 t $CaCO_3$/1000 t	same
5. Texture	≥50% clay	≥45% clay
6. Saturation	≤85% OR ≤100% only if EC≥4 mmhos/cm	same
7. Boron	≤10 ppm	same
8. Total Selenium	≤0.8 ppm	same
9. Soluble Selenium	≤0.15 ppm	same

Box plots (Refer to Figures 6 to 14) were constructed to display the statistical distribution of analyte values as a function of lithology and interburden layer. The box in each plot represents the 25th and 75th percentiles. The horizontal line in each box represents the median. The whiskers represent the range of the data up to 1.5 times the box length (interquartile range) from the box center. Observations further from the box center are plotted as ”+”symbols. Boxes that do not overlap can be thought of informally to represent differences in distribution, although this is not a rigorous statistical test.

Percent of suitable material was estimated within each interburden horizon. In general each horizon represented is composed primarily of one lithologic type (Table 1). The analysis methods followed Kern 1998, ***Draft Statistical Analysis Plan for Phase I Overburden Characterization Appendix A***. This is an analysis weighted by length of sample where each drill hole is treated as an independent experimental unit (i.e. a sample of at most 10 independent observations from each layer, with layers treated separately). The parameter estimates and precision were used to determine sample adequacy. For example, when the proportion suitable is very high or very low, low precision is acceptable and additional drilling would not be required. Conversely, if parameter estimates are marginal, then a higher level of precision is needed to make adequate decisions. The results of this analysis are presented in Figures 24 through 33 in plots of one-sided 90% confidence intervals for the percent of suitable material for each of 9 analytes.

Volume of Suitable Material

The total volume of material and total volume of suitable material in the I7A (interburden and overburden) was estimated. Information available from the 10 continuous core drill holes to estimate the percent suitable, and additional information on the total volume from 64 coal exploration drill holes was also used in the volume calculations. The analysis was applied to the mining area limit, within I7A, and to the combined polygons of influence for drill holes 498-01, 498-03, 498-04, 498-05, 498-06 and 498-07. These were the areas with the most suitable material.

In the mining process, mixing of the interburden material can be expected prior to reclamation as a result of loading, stockpiling and/or truck-dumping activities. Mixing will tend to improve the suitability of the material in that unsuitable intervals will tend to be diluted. An alternative approach is to utilize only the in-place (un-mixed) suitable materials for reclamation. Therefore, volumes of suitable material have been estimated under two conditions: 1) that the I7A interburden zone is mixed as a result of the mining process, and 2) that the in-place (un-mixed) suitable material is not mixed with intervals that are unsuitable. These conditions are evaluated because the mining and reclamation plans are likely to be different depending on whether interburden mixing is used.

Volume of in-place suitable material--Because additional coal exploration data are available, improved estimates can be constructed by estimating the total volume of an individual interburden layer independently from the continuous core data, and then multiplying by the proportion of suitable material. If V_{tot} represents the estimated total volume and $P_{suitable}$ represents the estimated proportion of suitable material, then the estimated volume of suitable material is

$$V_{suitable} = P_{suitable} V_{total}$$

and the estimated variance of the estimate is (Reed et al 1989)

$$\mathrm{var}(V_{suitabl}) = P^2{}_{suitable}\ \mathrm{var}(V_{total}) + V^2{}_{total}\ \mathrm{var}(P_{suitable}) - \mathrm{var}(P_{suitable})\ \mathrm{var}(V_{total}).$$

As described previously, the proportion of suitable material was estimated from the 10 continuous core drill holes. The total volume of material was estimated by kriging (Cressie 1991) the thickness of interburden layers using 64 additional drill holes from the exploratory drilling program. This allowed more accurate estimates of the volume of interburden layers than estimates based on the sparser continuous core data. Thickness was treated as the variable of interest and the mean thickness was estimated. When mean thickness is multiplied by total area of interest, it provides an estimate of the total volume. It should be noted that this is mathematically equivalent to developing kriged estimates of the thickness on a fine mesh grid using point kriging followed by adding the products of thickness by pixel area and summing. The advantage of this method is that variance estimates are also available for the estimated volume. In addition to estimating total volume, an isopach map showing interburden I7A over the mine site is provided in figure 5.

Volume of mixed suitable material--Although the volume of in-place suitable material can be estimated, it is of interest to consider the mixed volume of interburden and overburden which can be expected to be suitable. The continuous core data were averaged within interburden I7A and within drill hole and the resulting averages were compared to the suitability criteria to determine which areas could be expected to contain suitable interburden after mixing. The combined polygons of influence for these drill holes were used to delineate an area expected to be suitable after mixing. The total volume and a lower 90 percent confidence bound for mixed suitable material in interburden I7A was estimated using kriging.

Spatial Distribution of Suitable Interburden in I7A

The spatial distribution of suitable material was investigated in two ways;

1) The percent of suitable material on a sample by sample basis was plotted in plan view. Both OSM and Navajo criteria were investigated and results are displayed on Figure 4 as percent suitable by Navajo Mine Criteria / percent suitable by OSM criteria.

2) Under the assumption that material will be mixed in handling, data were pooled within interburden and drill hole, and the average analyte values were calculated using a weighted average with weights proportional to length of core. The weighted averages were compared to both OSM and Navajo criteria, and the results were posted in plan view showing which drill holes resulted in suitable average analyte values.

Regression Analysis for Trend in Parameters

If substantial gradients exist across the proposed mine site, one might encounter a situation where the mean parameters are suitable, while in fact there may be spatial strata which are composed of extremely poor material or extremely good material. In order to assess this question, a standard multiple regression analysis was conducted (Neter et al. 1996). The linear statistical model used was of the form

$$Analyte = \mu_0 + \mu_{litho\log y} + \beta_1 depth + \beta_2 Easting + \beta_3 Northing + Interactions + error$$

To take into account the unequal weighting inherent in the continuous core samples the regression coefficients and variance estimates were obtained using a weighted regression with weights proportional to the length of core sampled.

Statistical Quality Assurance

A set of 33 measurements was chosen for duplicate analysis following IML quality assurance procedures (QAP). To assess the relative magnitude of analytical error in the database, 95% confidence intervals were calculated for the relative difference between original measurements and duplicate measurements. Relative error was defined to be ([original value - duplicate value] / original value). Reported values for boron, total and soluble selenium were occasionally zero resulting in relative errors that were not defined. For this reason the QA analysis for these analytes was reported in absolute units (ppm). Table (4) summarizes the results of this analysis.

IV. RESULTS

Analyte Distribution

Box plots of the distribution of each analyte are presented in figures 6 through 14 for all interburden layers pooled. Each analyte is broken out into separate box plots for each lithology, sandstone, shale and siltstone. It was found that interburden layer I7A was the most likely to provide adequate suitable material so box plots of analyte distributions are also presented by lithology within horizon I7A in figures 15 through 23.

Confidence Intervals for Percent Suitable

One-sided 90% confidence intervals for percent suitable material (Navajo Mine thresholds) are presented in graphical form in figures 24 through 34. Although the upper confidence limit on percent suitable is not of interest, it should be noted that the two-sided confidence interval should be interpreted as an 80% confidence interval. In general, it can be said that we are 90% confident that the true proportion of suitable material is greater than the lower confidence limit shown in the figures. These figures show that interburden I7A is the most promising target for suitable materials.

Estimated Volume of Suitable Material in Interburden I7A

All volumetric calculations are based on suitability for all analytes simultaneously. If the material is unsuitable for any analyte then it is considered unsuitable.

Volume of in-place suitable material-- Total volume of in-place suitable material in interburden I7A, and the overburden was estimated for the full mining area limit and in combined polygons of influence for drill holes 01, 03, 04, 05, 06, and 07. The results are summarized in table (3). Application of the kriging model requires estimation of a spatial correlation function. The estimated model was an isotropic spherical model with nugget effect 0.11 and range of influence 3,463 feet.

The estimated total volume of interburden I7A over the mining area limit is 91.7 Mcy. Of that, the estimated in-place volume of suitable material is 37.6 Mcy with a standard error of 12.4 Mcy. The estimated probability that there are at least 21.8 Mcy of in-place suitable material in the planned mine area in interburden I7A is 90%.

When interburden I7A is restricted to just the polygons of influence associated with drill holes 01, 03, 04, 05, 06, and 07, (those with suitable mixed material), the total volume of material is estimated to be 47.0 Mcy. The estimated volume of in-place suitable material is 36.2 Mcy with standard error 13.0 Mcy. The probability that there are at least 19.4 Mcy of in-place suitable material in this portion of the planned mine area in interburden I7A is 90%.

Table 3. Estimated volume of suitable material based on estimates of percent suitable from continuous core drilling and average thickness based on coal exploration drilling.

				Mixed Volume			In-place Volume		
Region	Surface Area $1x10^6$ ft^2	Percent Suitable	SE	Total Volume $1x10^6$ yd^3	SE Feet	Lower 90% Limit $1x10^6$ yd^3	Volume Suitable $1x10^6$ yd^3	SE $1x10^6$ yd^3	Lower 90% Limit $1x10^6$ yd^3
Mining Area Limit Overburden	153.7 ($17x10^6$ yd^2)	48%	15%	127.7	8.0	116.8	60.9	18.9	36.8
Polygons 1 3 4 5 6 7 Overburden	74.42	67%	28%	60.0 [a]	5.0	43.6 [a]	40.0	17.0	18.0
Mining Area Limit I7A Interburden	153.7 ($17x10^6$ yd^2)	41%	13%	91.7	3.6	87.1	37.6	12.4	21.8
Polygons 1 3 4 5 6 7 I7A Interburden	74.42	77%	28%	47.0 [a]	2.2	44.2 [a]	36.2	13.0	19.4
Overburden Seam 8	38.78	81%	28%	32.5 [a]	6.7	23.9 [a]	26.1	7.3	16.8

[a] Suitable material when mixing occurs.

Volume of suitable mixed interburden material in I7A—The estimated total volume of suitable mixed interburden material in interburden I7A within the combined polygons of influence for drill holes 01, 03, 04, 05, 06, and 07, is 47.0 Mcy. The probability that there are at least 44.2 Mcy of suitable mixed material in this portion of the planned mine area in interburden I7A is 90%.

Sample adequacy – There are at least two ways to demonstrate that adequate in-place suitable material exists in the permit area with 90% confidence. First, there is a 90% probability that the volume of in-place suitable material in the overburden, (material above uppermost coal seam) is at least 36.8 Mcy. Second, the total combined volume in the overburden associated with seam 8 and the material in the I7A interburden is estimated to be greater than 16.8+19.4 = 36.2 Mcy with 90% confidence. Either of these estimates indicates that the total volume is well above the 22.7 Mcy needed for successful reclamation.

Spatial Distribution of Suitable Material within Interburden I7A

Weighted averages of analyte values were computed for each drill hole. These values were compared to OSM and Navajo Mine criteria to assess the spatial distribution of suitable material after mixing, in anticipation of the mining and handling process. Drill holes were marked with a solid circle if all analytes passed the OSM southwestern United States Criteria, and drill holes were marked with a hatched circle if one or more OSM criteria were not met, while the Navajo Mine criteria were met for all analytes. The results of these investigations can be seen in figure (2). When mixing is assumed, drill holes 498-01, -03, -04, -05, and -06 contained suitable material by OSM criteria. In addition, mixed material in drill hole 498-07 was suitable by Navajo Mine Site specific criteria.

Isopach of Interburden I7A

Analysis of the interburden thickness data resulted in spatial correlations which ranged up to 3,463 feet but which included a nugget effect of 0.11. These parameters were used to krige the 74 isopach measurements to develop point estimates of the isopach on a regular grid with 200 foot spacing. The resulting isopach map can be seen in figure (5).

Regression Analysis

Regression analysis results are presented in Table 5, where R-squared statistics are listed along with variables that are statistically significant predictors of analyte values. In particular, acid base potential, percent clay, percent saturation and soluble selenium each vary with lithology. These relationships to lithology are most easily discerned by looking at the box plots. For example the distribution of acid base potential (figure 6) shows that ABP is significantly higher in sandstone and siltstone than in shale. Similarly, (and perhaps obviously) percent clay also varies across lithology (R^2 = 0.72), as one would expect with shale, siltstone and topsoil all having more clay than sandstone. In addition, there is an interaction between depth and lithology and easting and lithology. The indication of significant interactions is that percent clay may be increasing with easting for some lithologies and decreasing or not changing with easting for others. For further interpretation of these relationships one is referred to Appendix B, where full regression outputs are available. Selenium concentration is also correlated with lithology, easting and depth (R^2 = 0.61). Again for additional interpretation see Appendix B.

Statistical Quality Assurance

A summary of results of the statistical quality assurance can be found in Table 4. Average relative analytical measurement error was less than 2 percent for pH, EC, SAT, SAR, CLAY, Neut-pot, and Total Sulfur. Ninety five percent confidence intervals for the average error ranged from –4% to 6.57%. Because Boron, and total and soluble SE were often recorded as 0.00 when rounded to 2 decimals, absolute precision was calculated for these analytes. Duplicate measurements for Boron were on average within 0.015 ppm with a 95% interval of (-0.04, 0.1 ppm). Total selenium averaged $1x10^{-18}$ ppm with a 95% confidence interval of (-0.008, 0.012). Soluble selenium averaged 0.0064 (ppm) analytical error, with a 95% confidence interval of (–0.002, 0.020). IML quality standards are that duplicate analytical measurements are within 15% of original measurements.

V. CONCLUSIONS

The primary objective of these investigations is to identify interburden horizons that contain sufficient volume of material suitable for establishment of a root zone in reclamation, and to determine if the present level of drilling is adequate to characterize the volume of suitable material.

Based on the plots of percent suitable by analyte and interburden layer, I7A interburden is the most likely interburden layer to contain adequate suitable material. There may be smaller pockets of suitable material within other interburden layers such as I8 and I9 although I7A was the primary focus of these investigations. If I7A can be established as containing adequate volume, then any additional interburden layers later found to contain suitable material can simply be incorporated in the mine plan.

The 10 continuous core samples used to estimate the percentage of suitable material represent a random sample of the mining area limit. As such, statistical inferences apply to this region. To make a decision regarding drilling adequacy, some form of definition of adequacy is required. In these studies, adequacy is defined to mean sufficient number of samples to allow a decision *with 90% statistical confidence* that either yes, *there is sufficient volume of mixed suitable material, or no there is not sufficient volume of mixed suitable material* for reclamation. An inadequate number of drill holes would be characterized by a situation where neither of the above statements can be made, (i.e. 90% confidence intervals for volume of mixed suitable material overlap the minimum volume of material needed to reclaim). Based on a target of 4 feet of soil depth over all of the mining area limit (3530 acres) 22.7 Mcy of suitable material are needed.

In the mining process, mixing of the interburden material can be expected prior to reclamation as a result of loading, stockpiling and/or truck-dumping activities. Mixing will tend to improve the suitability of the material in that unsuitable intervals will tend to be diluted. An alternative approach is to utilize only the in-place (un-mixed) suitable materials for reclamation. Therefore, volumes of suitable material have been estimated under two conditions (see Table 3): 1) that the I7A interburden zone is mixed as a result of the mining process, and 2) that the in-place (un-mixed) suitable material is not mixed with intervals that are unsuitable. These conditions are evaluated because the mining and reclamation plans are likely to be different depending on whether interburden mixing is used.

Consider the total volume of mixed suitable material (i.e. material from the polygons of influence for drill holes 01, 03, 04, 05, 06, and 07). Based on the 64 drill holes from coal exploration drilling and the 10 continuous core holes (i.e. N=74 total), the estimated total volume of mixed suitable material is 47.0 Mcy. ***Based on this analysis, we can say with 90% confidence that the volume of mixed suitable material in the combined polygons of influence for holes 1,3,4,5,6,and 7 in I7A interburden (44.2 Mcy) is greater than the needed 22.7 Mcy.***

It has also been shown with 90% confidence that the volume of in-place (un-mixed) suitable material in the combined polygons of influence for holes 1, 3, 4, 5, 6 and 7 in the I7A interburden plus the I8 overburden combined is at least 36.2 Mcy. There is also a 90% probability that the volume of in-place suitable material in the overburden, (material above uppermost coal seam) is at least 36.8 Mcy

In summary, it has been demonstrated with 90% confidence that there is sufficient mixed suitable material from the I7A interburden zone to allow development of a 4-foot root zone as part of the reclamation strategy. It has also been demonstrated with 90% confidence that there is sufficient in-place (un-mixed) suitable material from the I7A interburden and I8 overburden zones to allow development of a 4-foot root zone. It can be concluded based on these studies that additional drilling to verify the presence of adequate volume of suitable material is not required in order to proceed with mine planning.

Table 4. Statistical quality assurance analysis of laboratory duplicate chemical analysis. Ninety five percent confidence intervals were developed for the relative difference between duplicates and original measurements. When upper confidence limits are positive and lower confidence limits are negative the relative error is not significantly different from zero.

	PH	EC	SAT	SAR	CLAY	Neut-pot	Total Sulphur	Boron[a] (ppm)	Total Se[a] (ppm)	Soluble Se[a] (ppm)
Mean	-0.07%	2.00%	-0.42%	0.04%	-0.32%	-1.73%	-1.73%	0.015	1.7e-18	0.0064
Variance	0.001%	0.65%	0.10%	1.01%	0.06%	0.36%	0.42%	0.023	0.0005	0.0005
Lower Confidence Limit	-0.21%	-0.91%	-1.56%	-3.58%	-1.23%	-3.90%	-4.05%	-0.039	-0.008	-0.0020
Upper Confidence Limit	0.15%	6.57%	1.36%	5.72%	1.11%	1.68%	1.92%	0.101	0.012	0.0195

[a] Boron and total and soluble selenium are reported in absolute units (ppm) because reported values were often 0.00 ppm when rounded to 2 significant digits.

Table 5. Summary of regression analysis results. The models were fit one analyte at a time and the table presents R-squared values for all models and lists variables (if any) which were statistically significant at the 10% level.

Analyte (Dependent Variable)	R^2	Significant parameters at $p<0.10$ Parameter	Statistical Significance
Acid Base Potential (ABP)	0.53	Lithology	0.044
Boron (BOR)	0.57	None	$p>0.14$
Percent Clay (CLA)	0.79	Lithology	0.001
		Easting	0.034
		Easting*Lithology	0.001
EC	0.43	None	$p>0.15$
PH	0.48	None	$p>0.13$
Sodium Absorption Ratio (SAR)	0.49	None	$p>0.16$
Percent Saturation (SAT)	0.51	Lithology	0.09
		Depth*Lithology	0.06
		Easting*Lithology	0.09
Soluble Selenium (SSE)	0.24	None	$p>0.23$
Total Selenium	0.63	Lithology	0.003
		Depth	0.001
		Easting	0.001
		Depth*Lithology	0.001
		Easting*Lithology	0.004

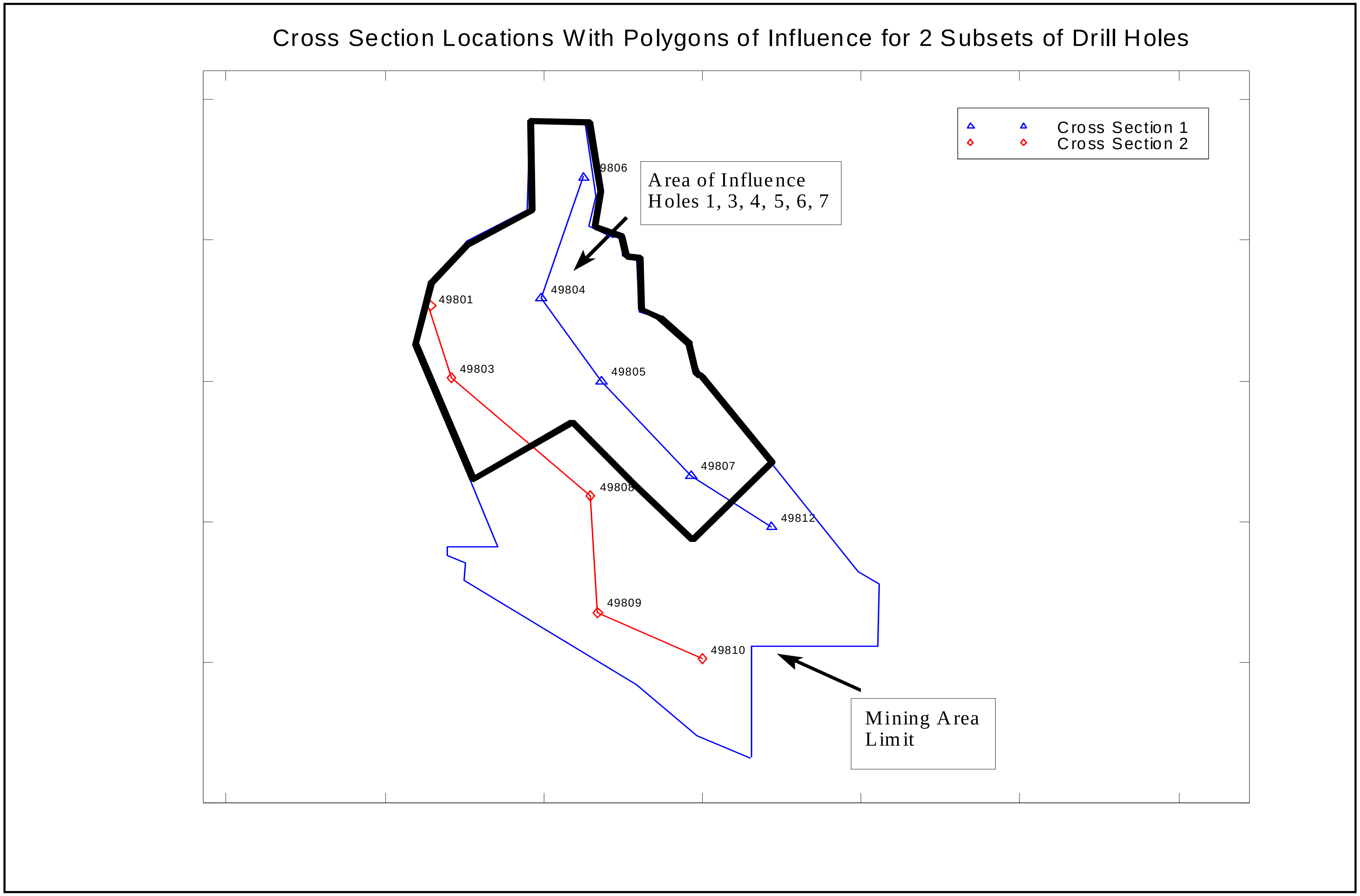

Figure 1. **Plan view of area with locations of cross sections (1) and (2) and combined polygons of influence associated with continuous core samples 498-01, 498-03, 498-04, 498-05, 498-06, and 498-07. Total volume of suitable material was estimated on both polygons.**

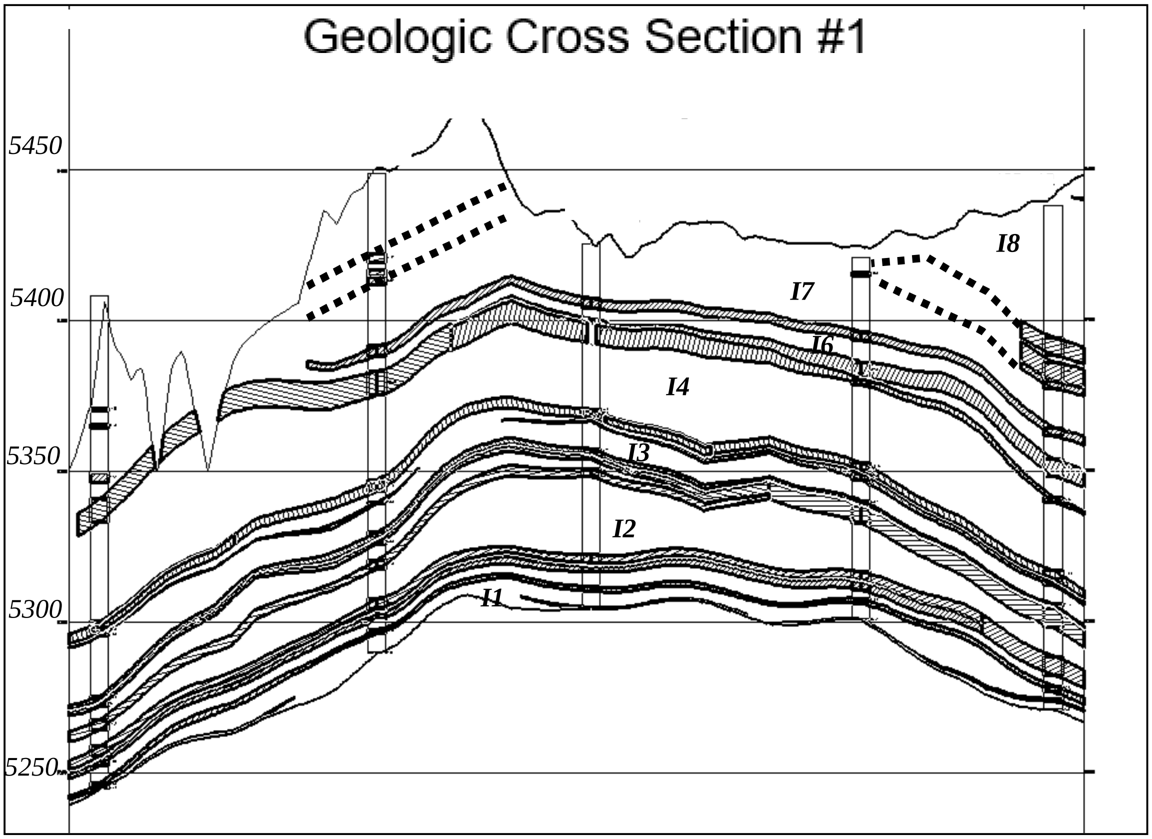

Figure 2. Geologic cross section number 1. For a plan view, see figure 1.

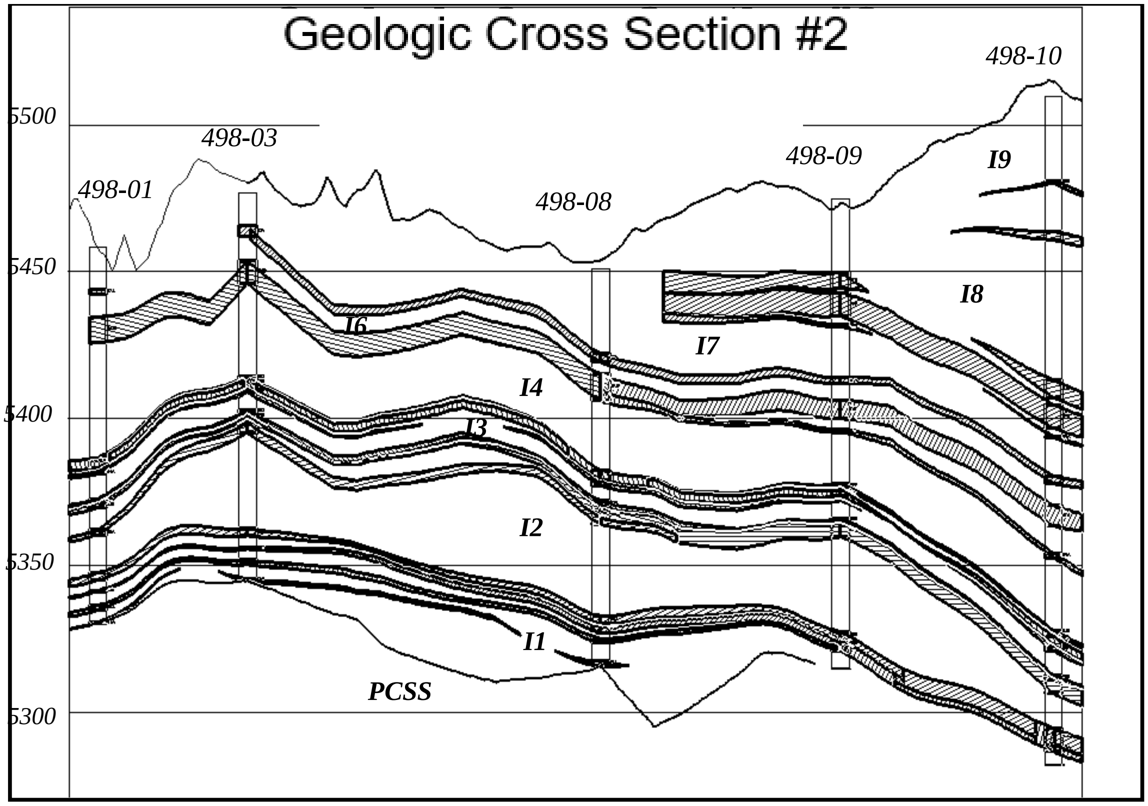

Figure 3. **Geologic cross section number 2. For a plan view, seefigure (1).**

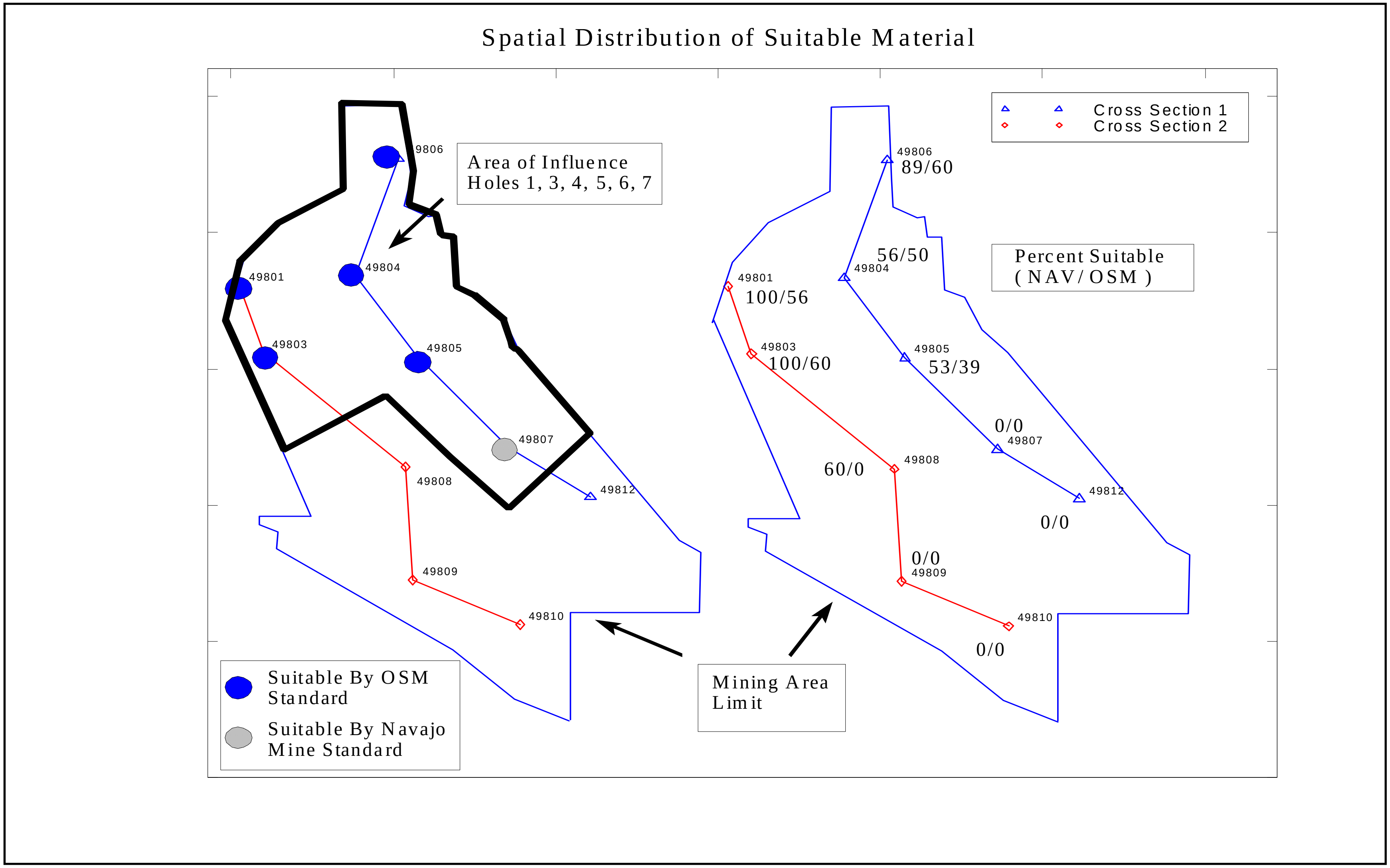

Figure 4. **Spatial distribution of Suitable material in the I7A interburden. In the left pane, filled circles indicate that the weighted average of each analyte met OSM and Navajo Mine criteria. Hatched circles indicate thatthe Navajo Mine criteria were met but the OSM criteria were not. In the right pane, the percentage of suitable material on a sample by sample basisi is posted at each drill hole. The percentages are listed by (Navajo Criteria/OSM Criteria). Drill hole 498-08 failed on SE= 1.3ppm.**

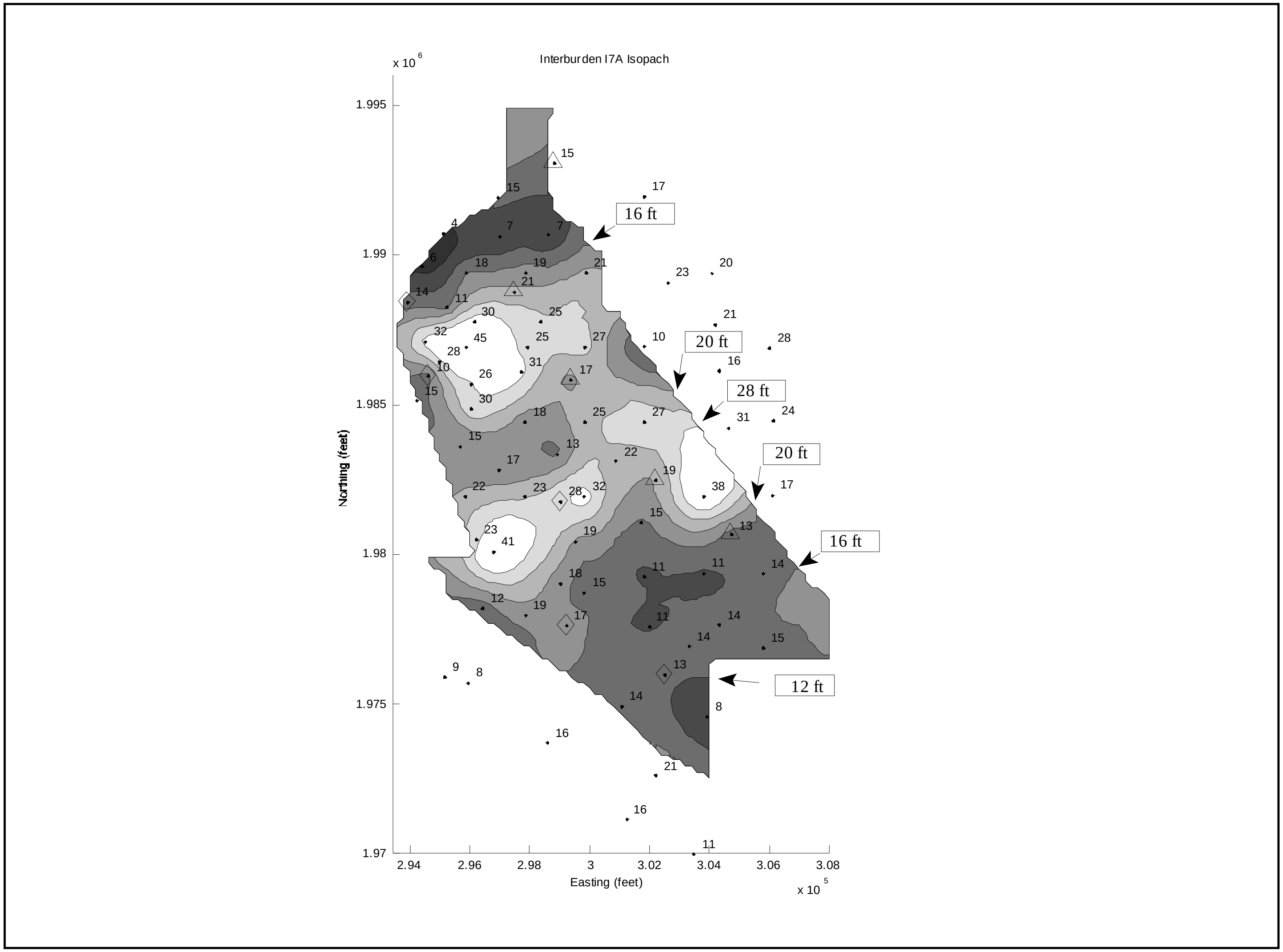

Figure 5. **Kriged isopach map of the I7A interburden. The contour interval is 4 feet and the actual data are posted. Triangles represent drill holes on cross section 1 and diamonds represent drill holes on cross section 2.**

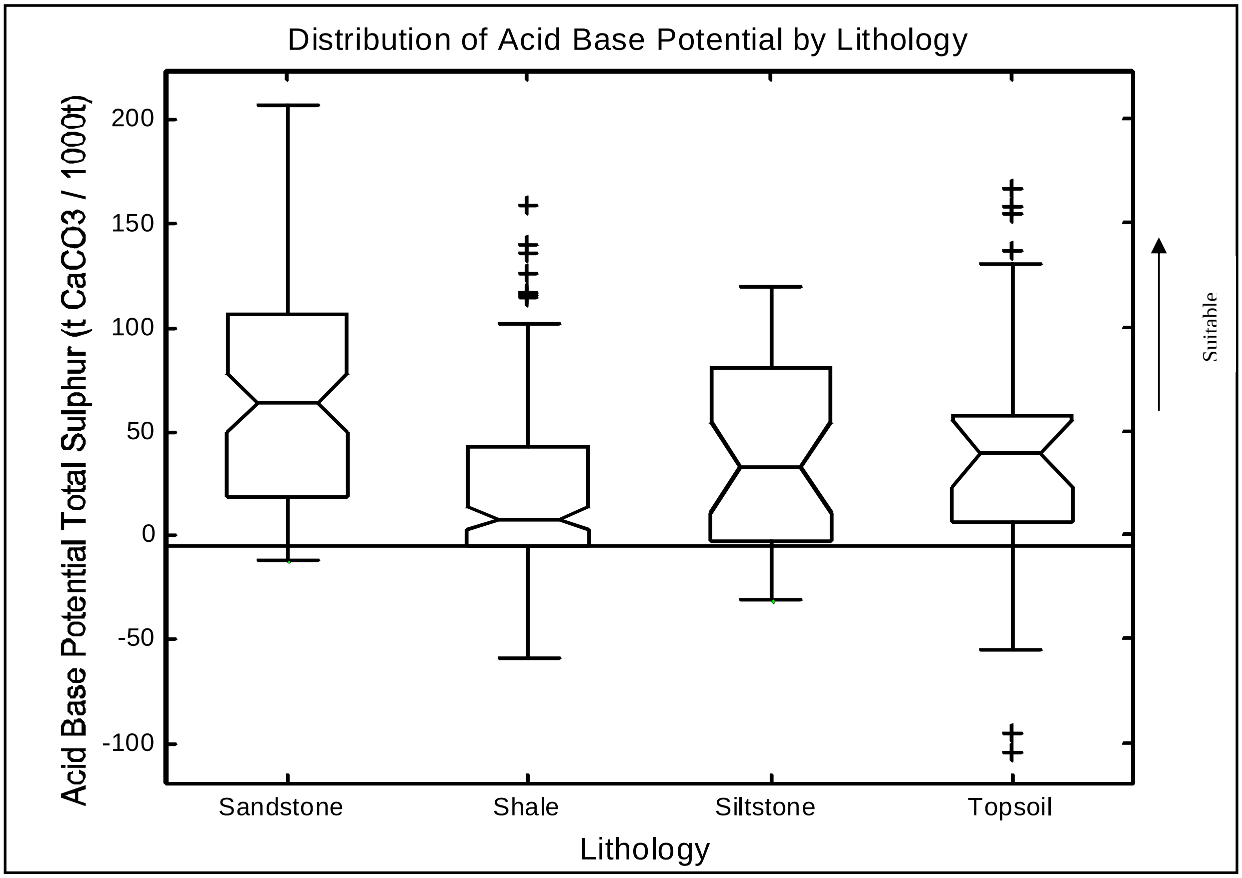

Figure 6. Box and whisker plots of Acid Base Potential stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.

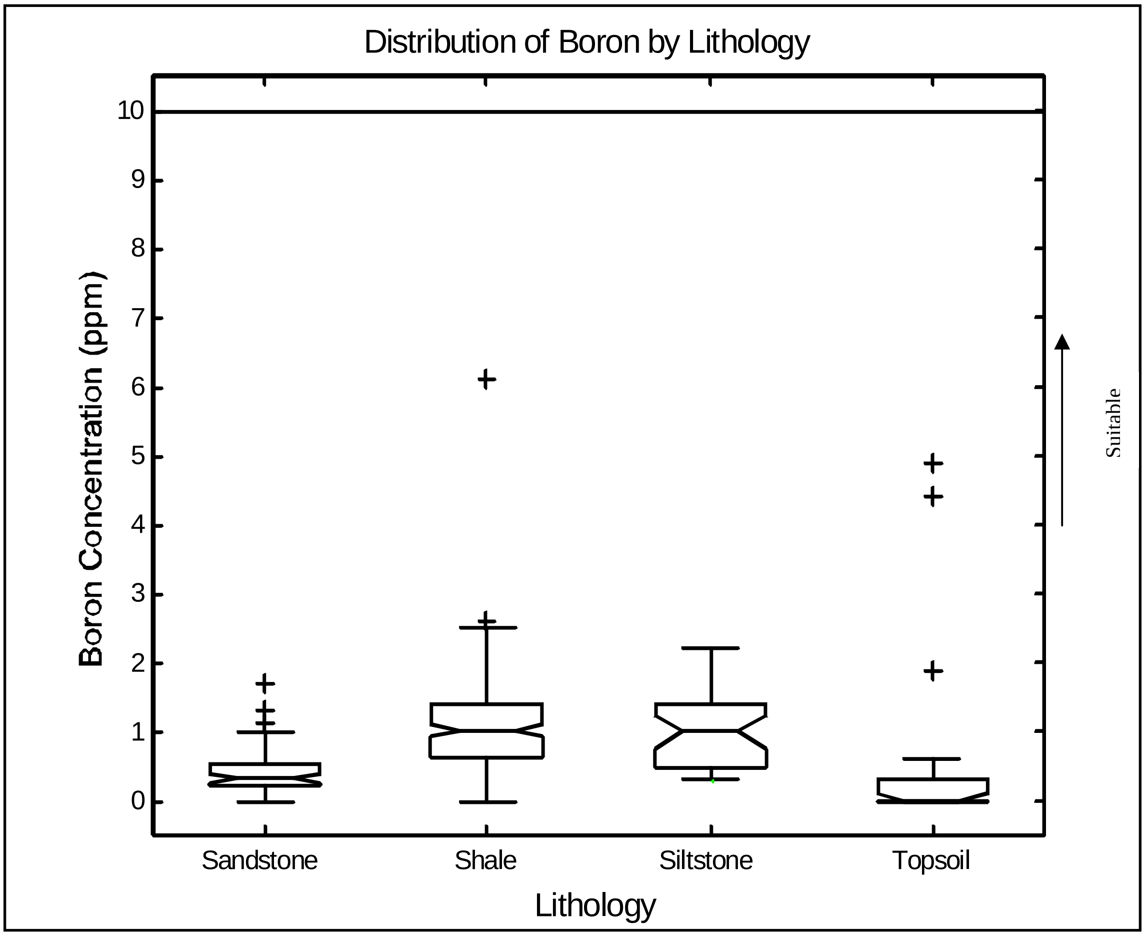

Figure 7. **Box and whisker plots of Boron concentration in parts per million stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

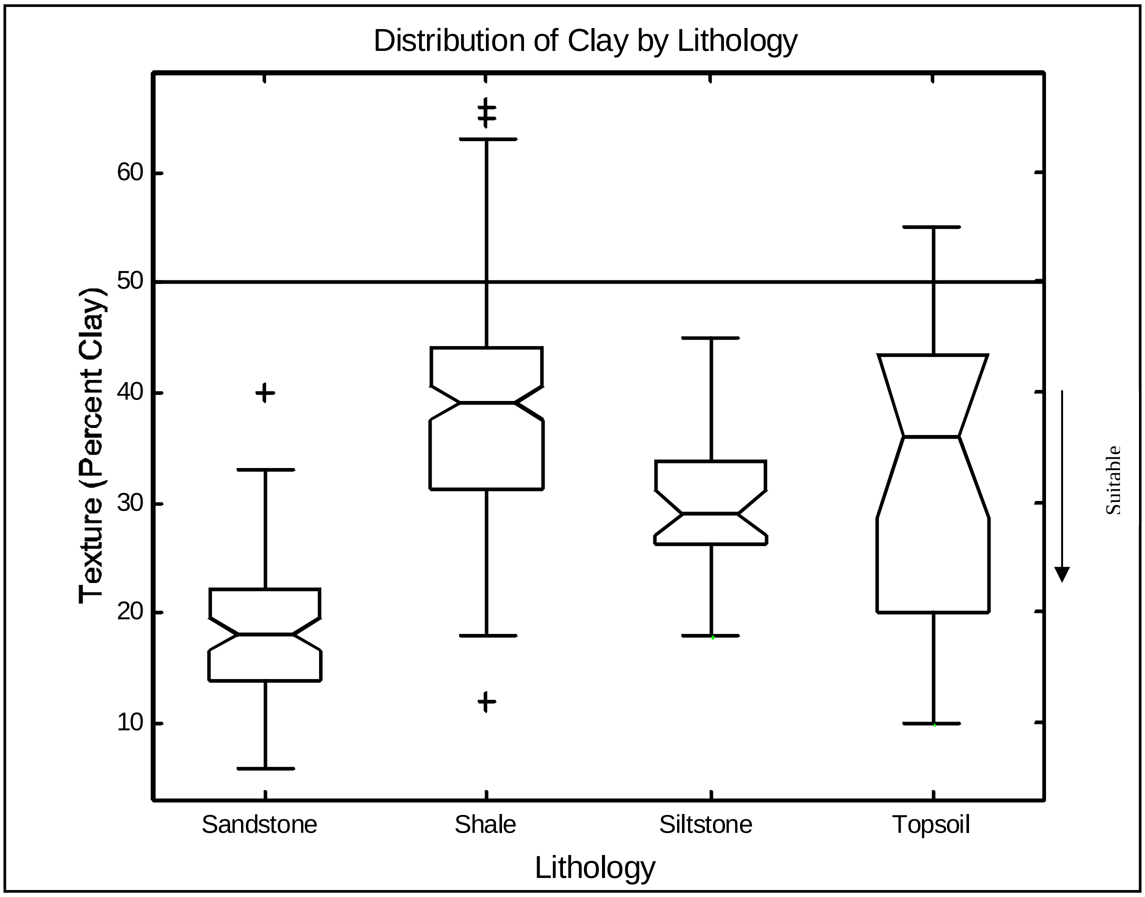

Figure 8. **Box and whisker plots of percent clay stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

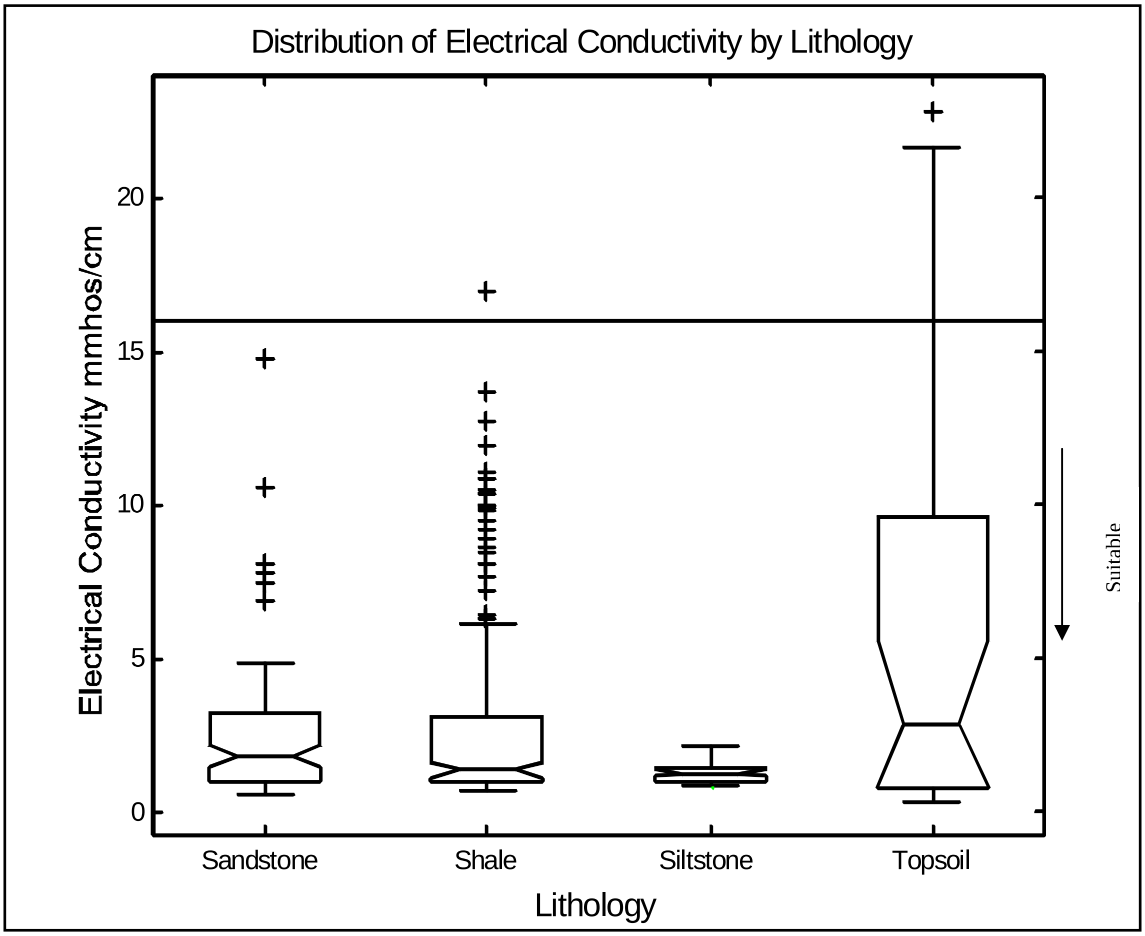

Figure 9. **Box and whisker plots of electrical conductivity stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

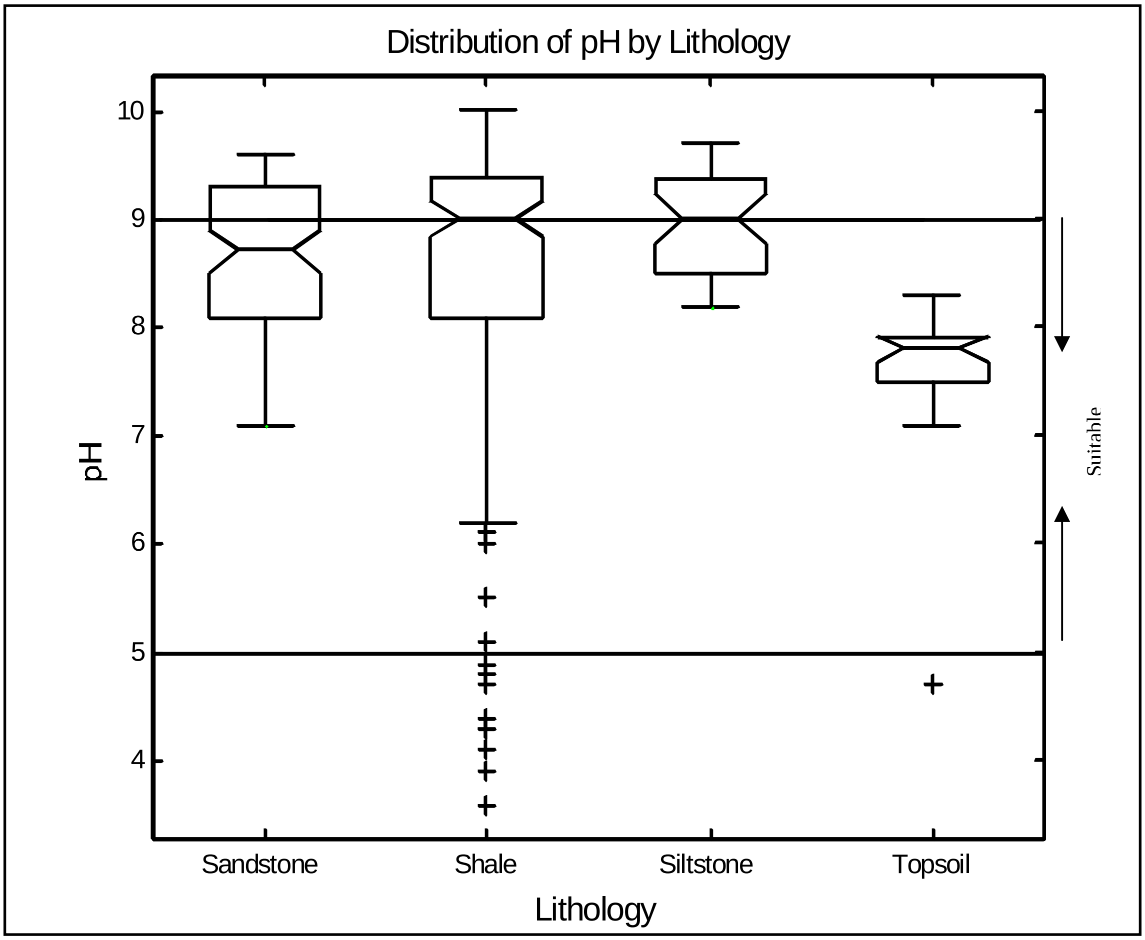

Figure 10. **Box and whisker plots of pH stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

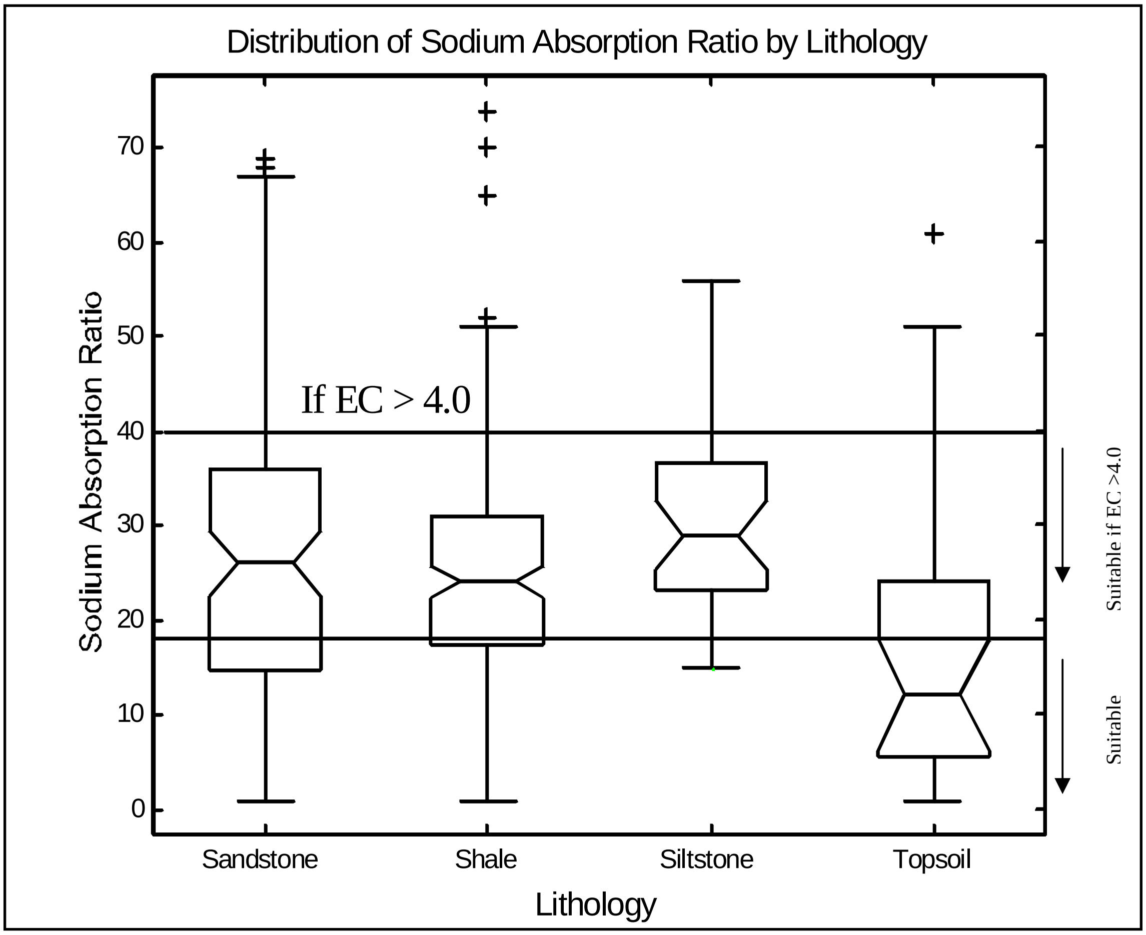

Figure 11. **Box and whisker plots of sodium absorption rate stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

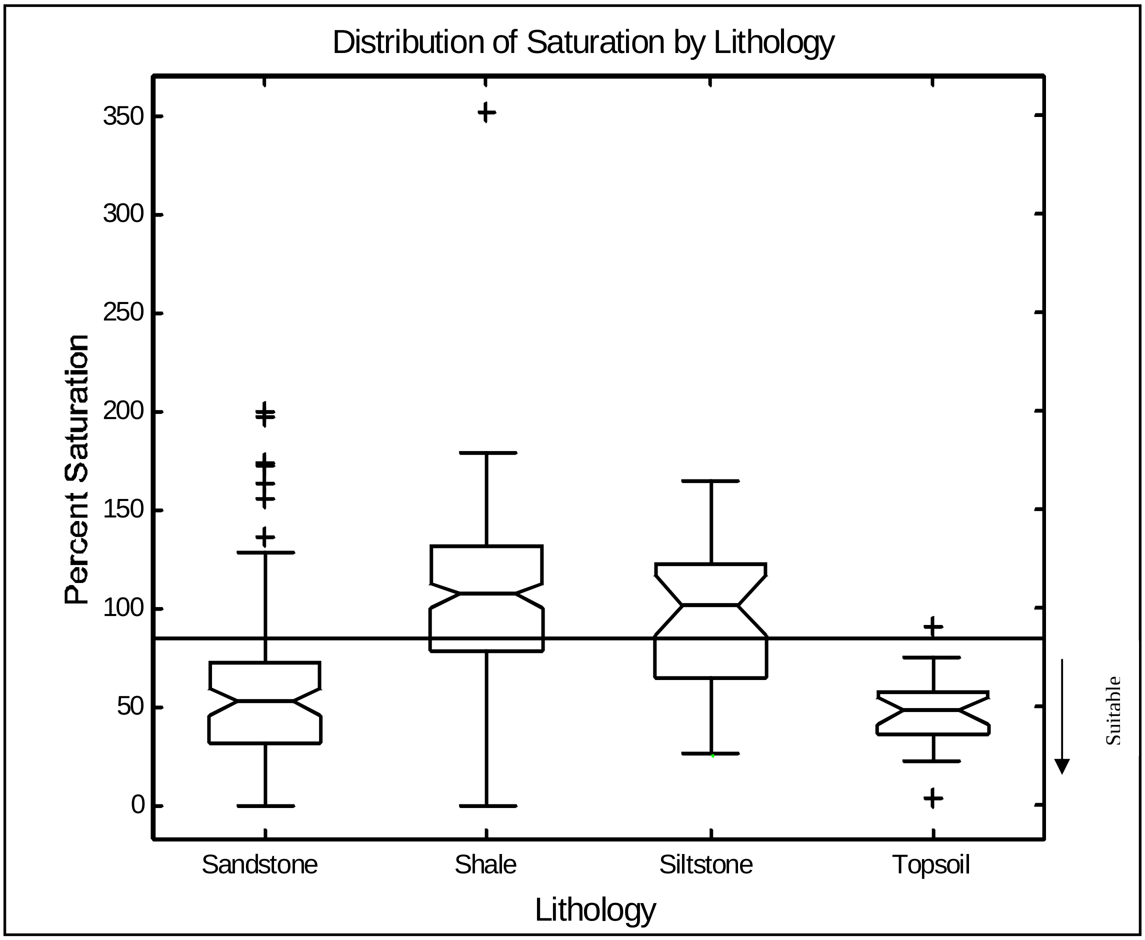

Figure 12. **Box and whisker plots of percent saturation stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

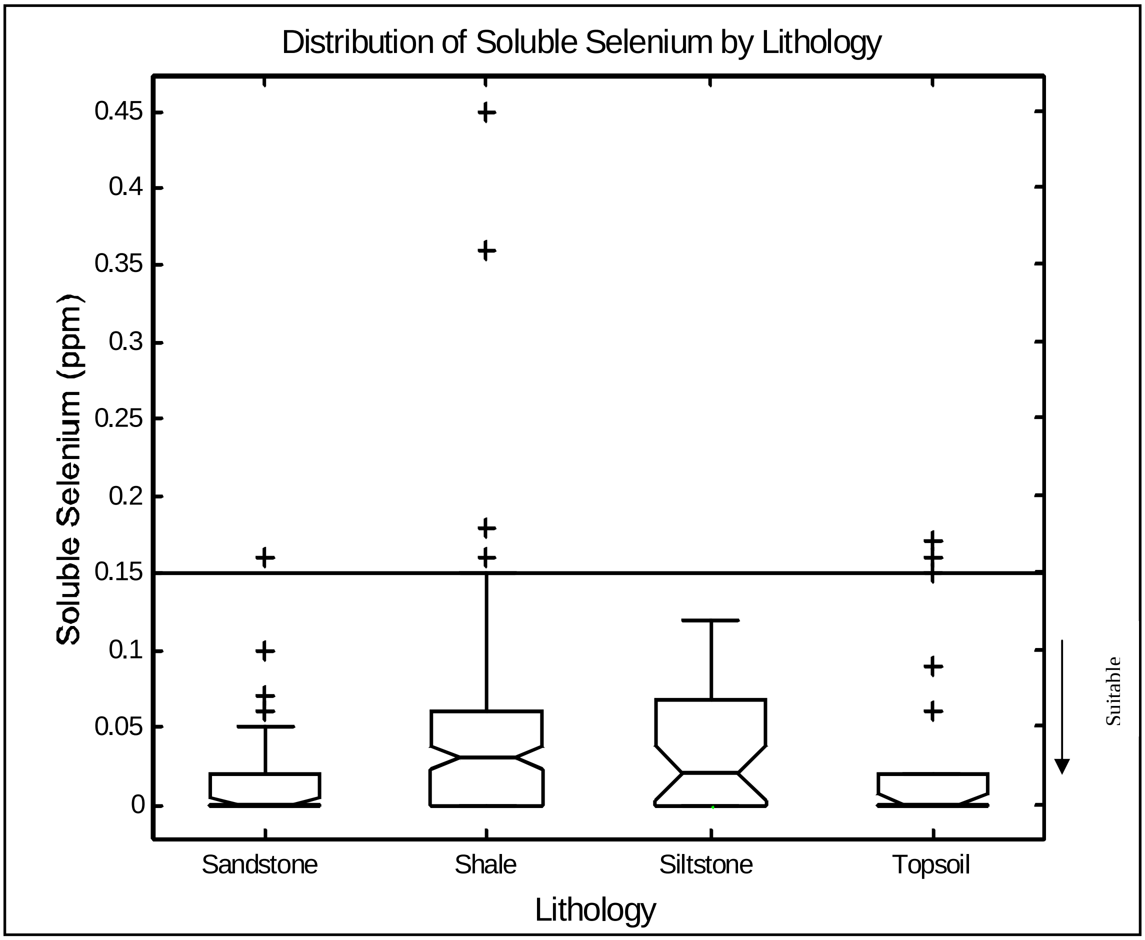

Figure 13. **Box and whisker plots of soluble selenium by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

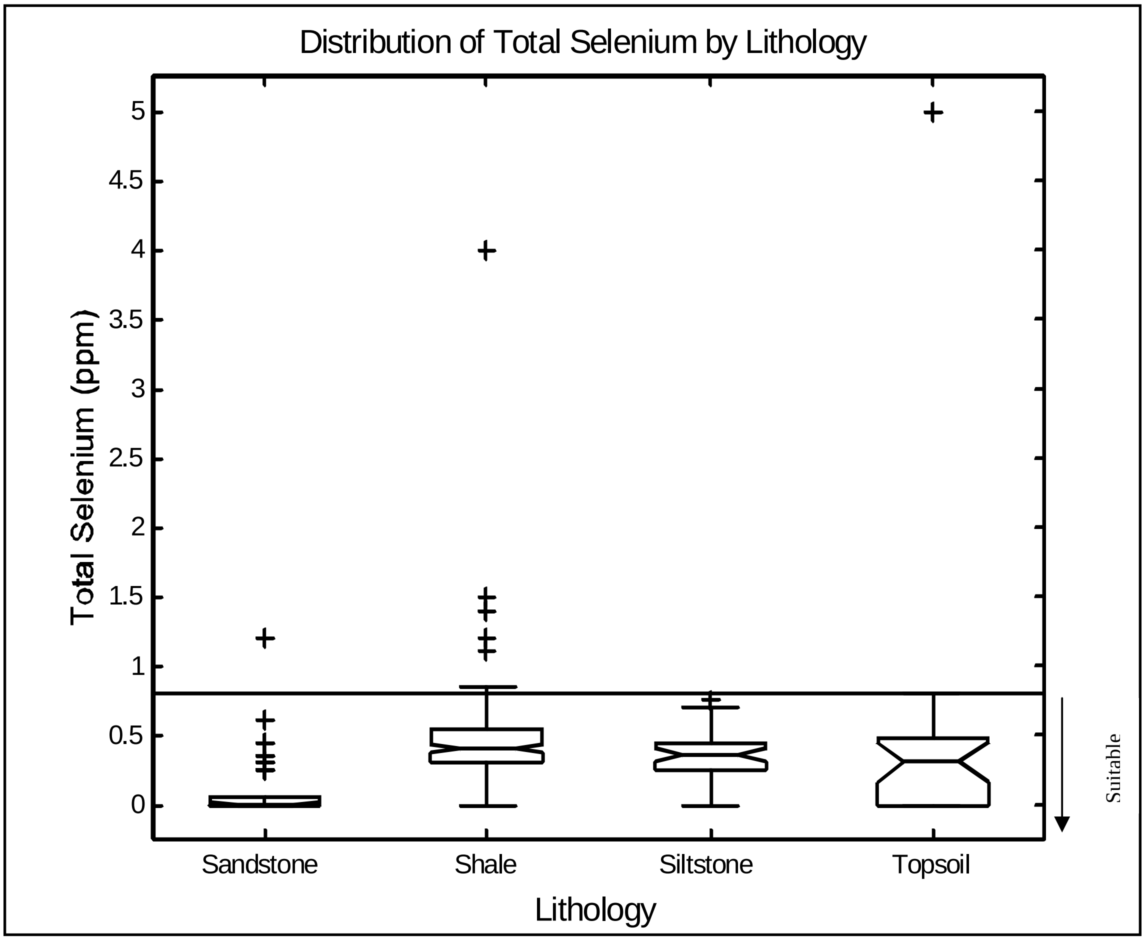

Figure 14. **Box and whisker plots of total selenium by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

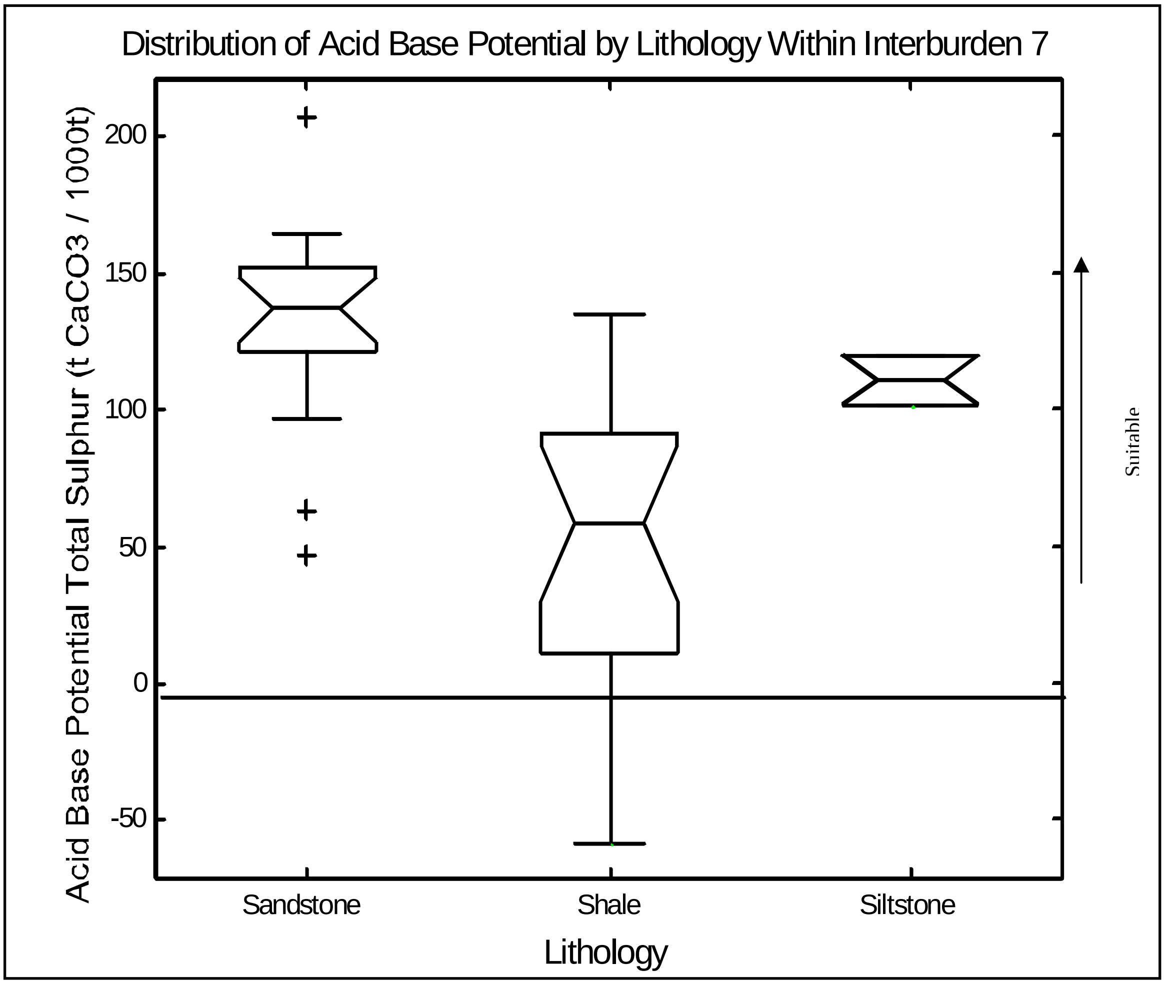

Figure 15. **Box and whisker plots of acid base potential within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

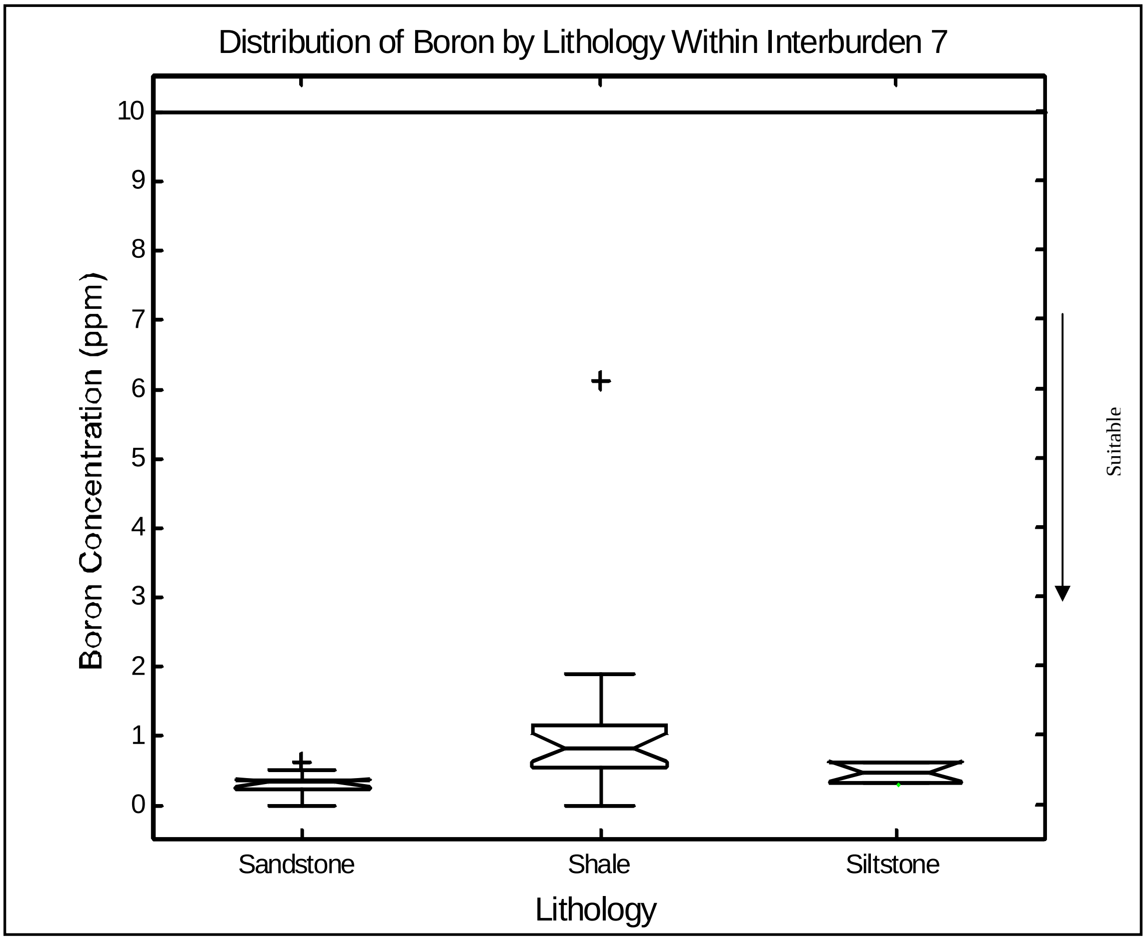

Figure 16. **Box and whisker plots of boron concentration within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

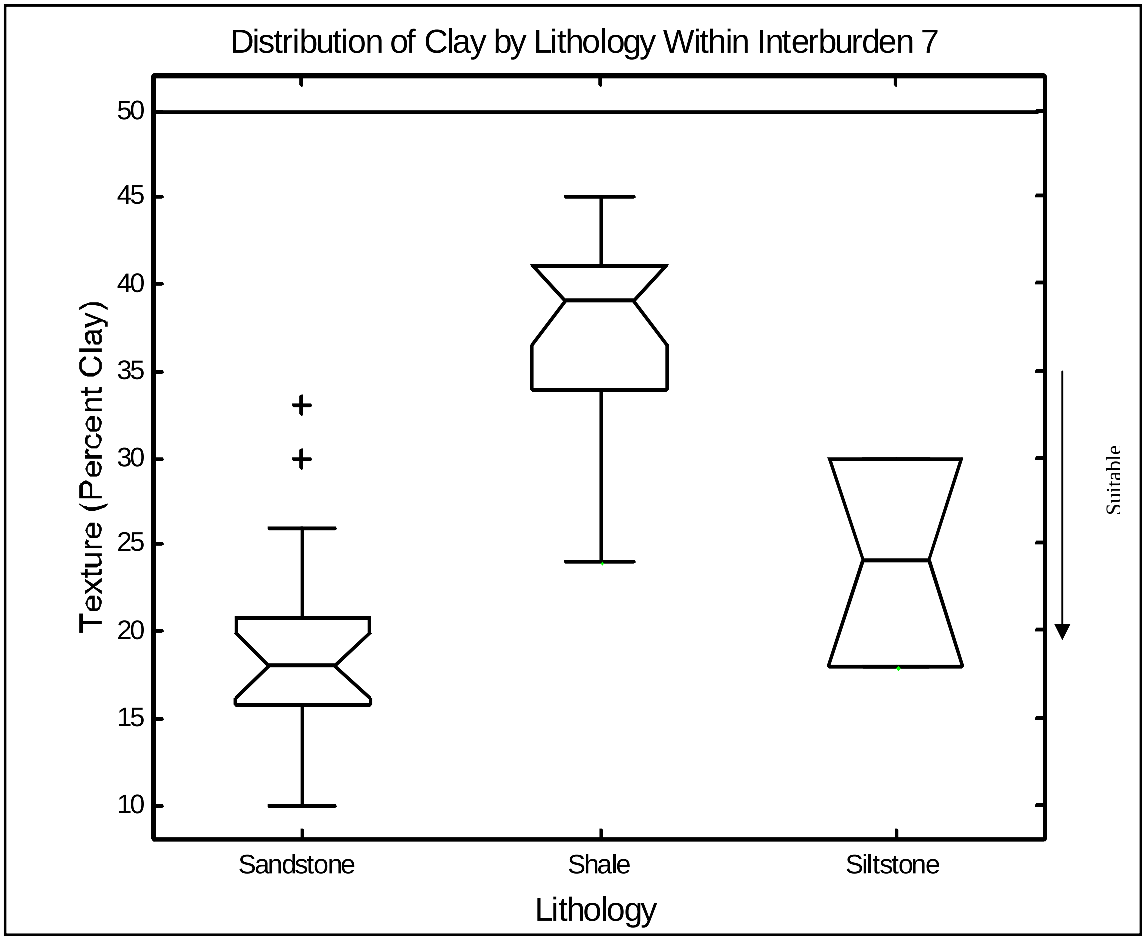

Figure 17. **Box and whisker plots of percent clay within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

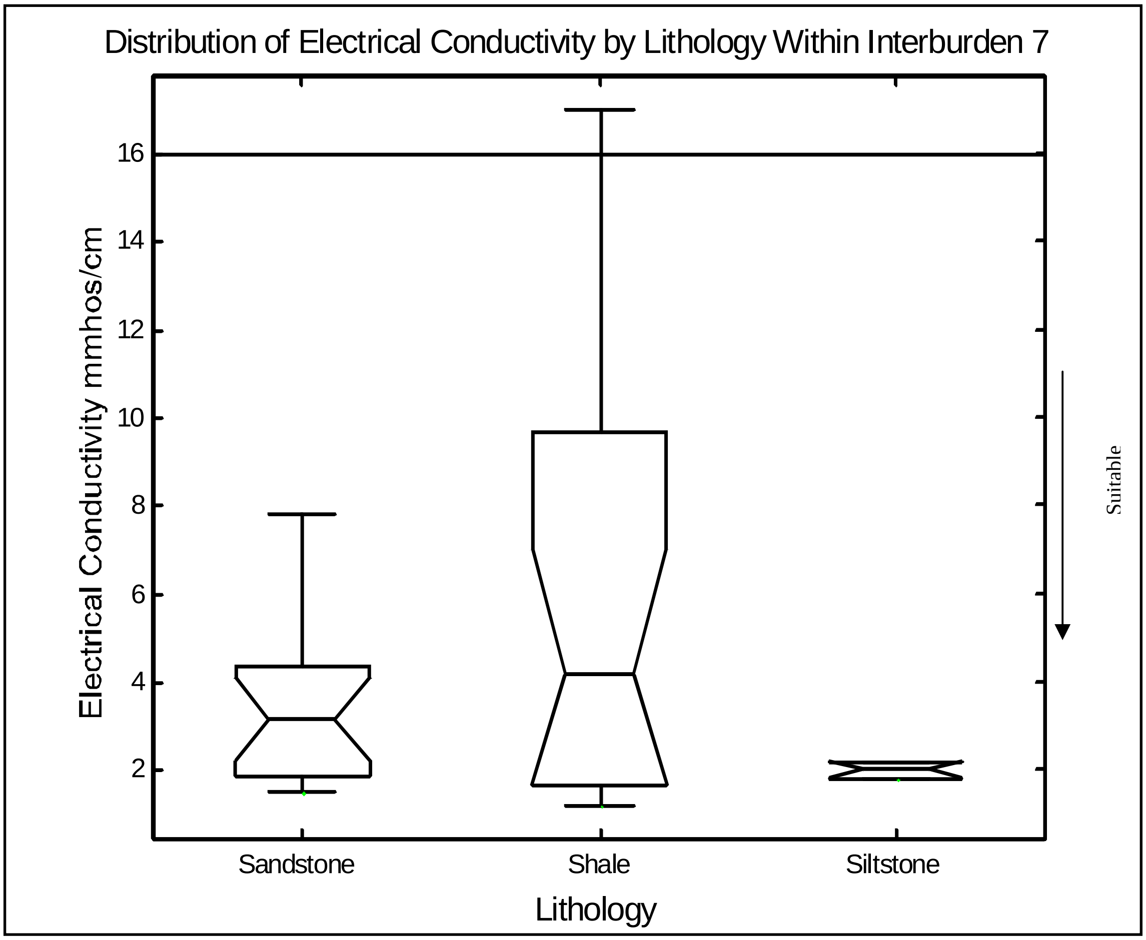

Figure 18. **Box and whisker plots of electrical conductivity within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

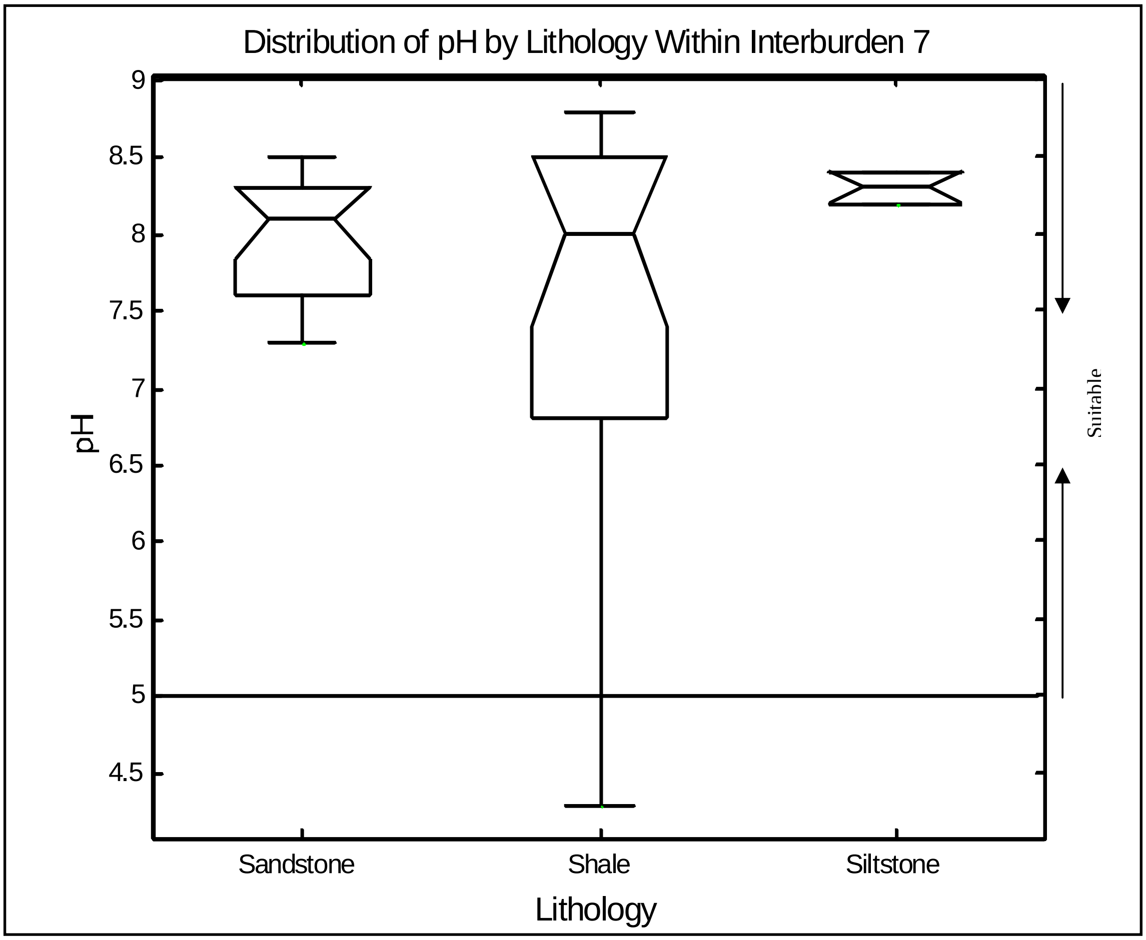

Figure 19. **Box and whisker plots of pH within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

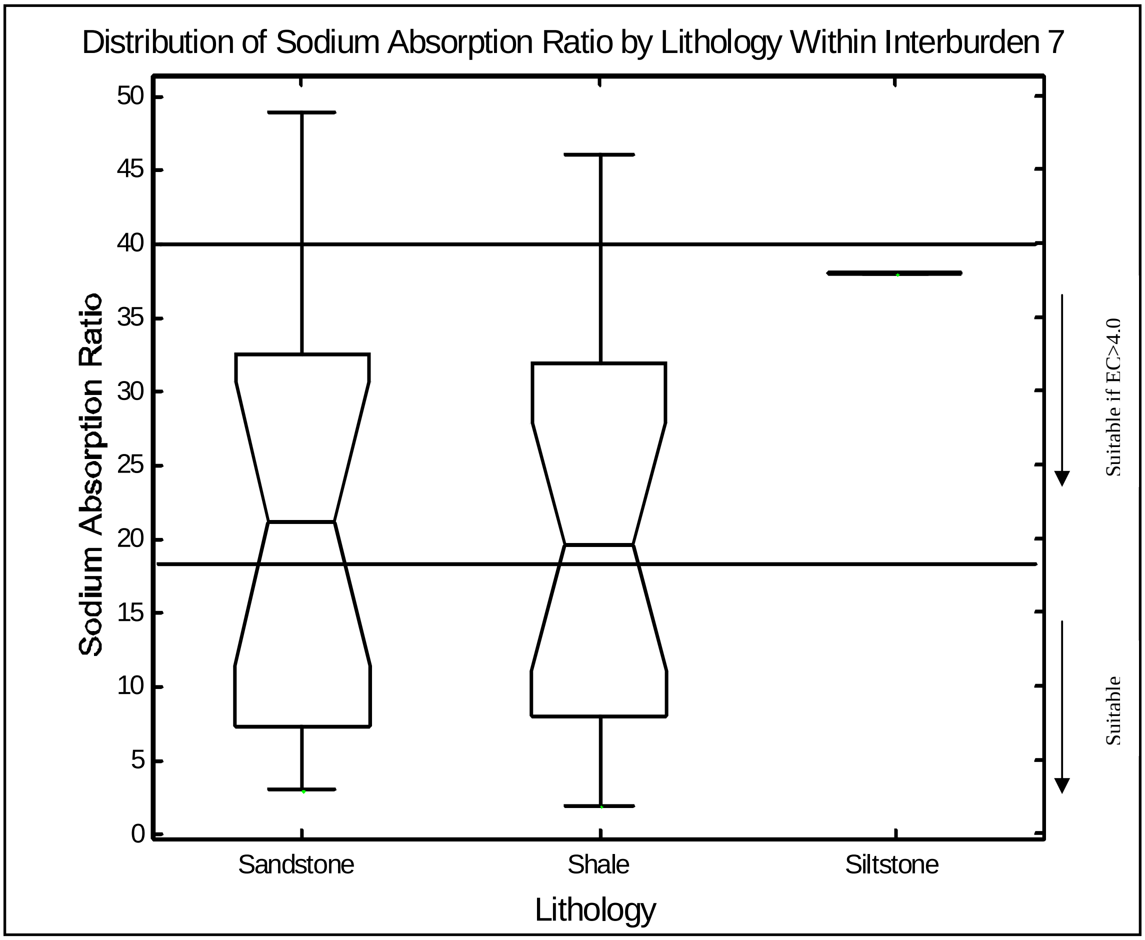

Figure 20. **Box and whisker plots of sodium absorption ratio within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

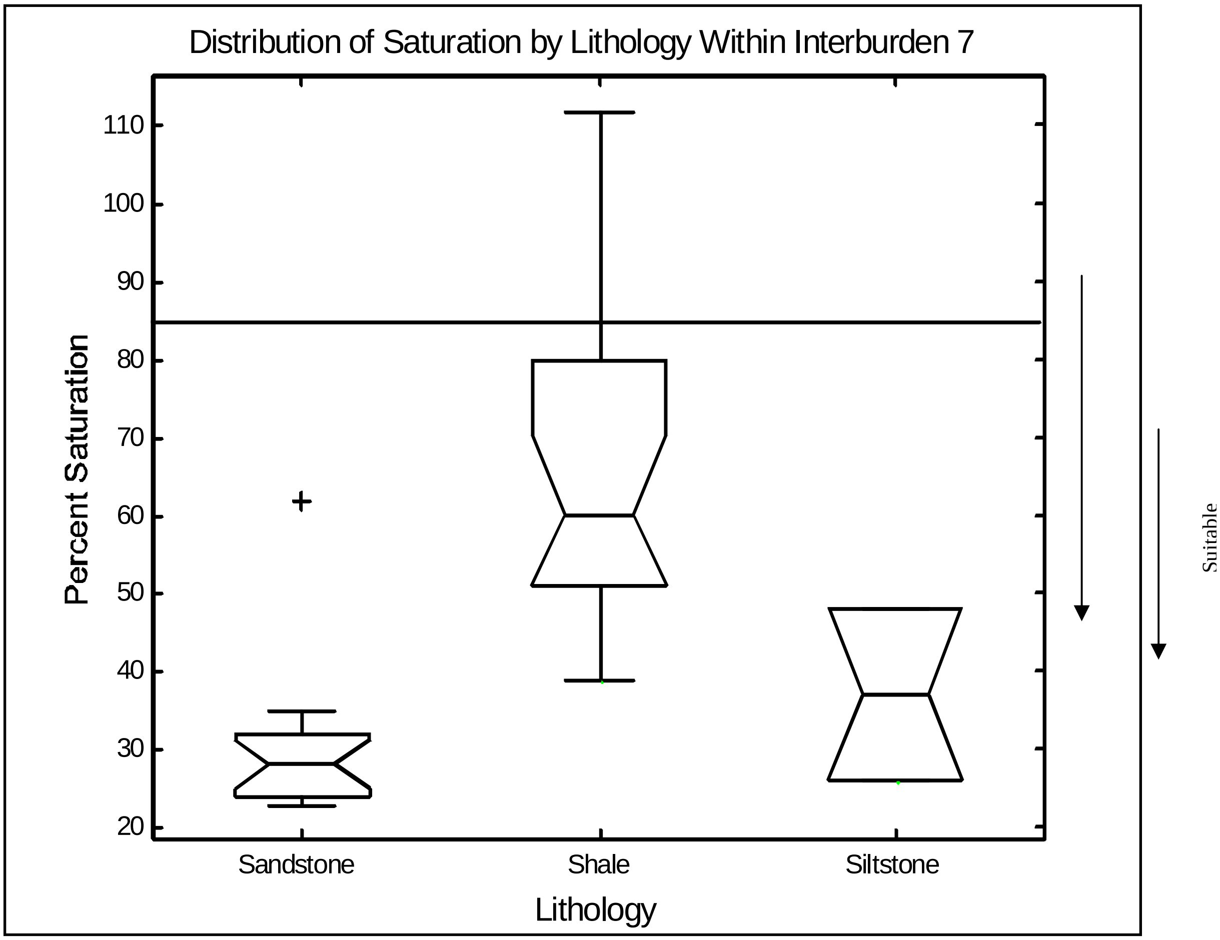

Figure 21. **Box and whisker plots of percent saturation within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

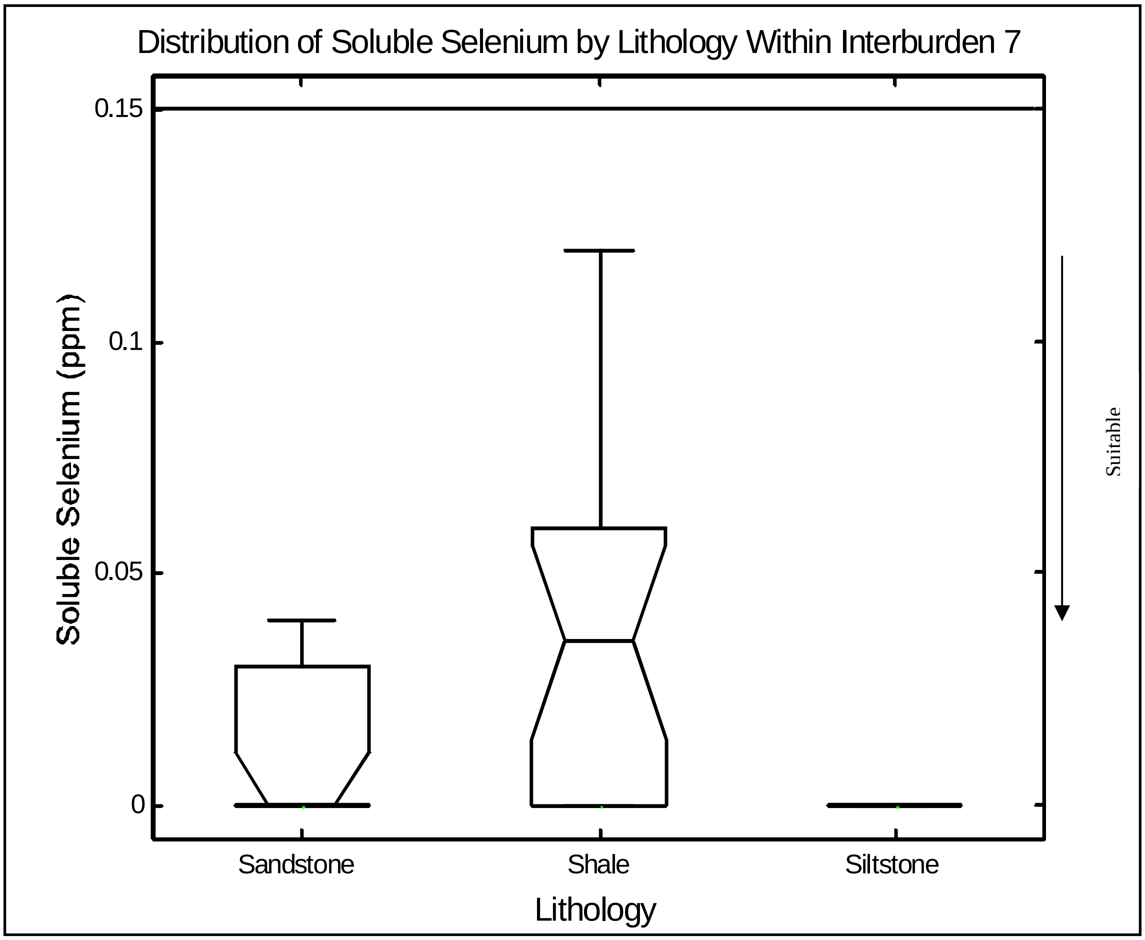

Figure 22. **Box and whisker plots of soluble selenium within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

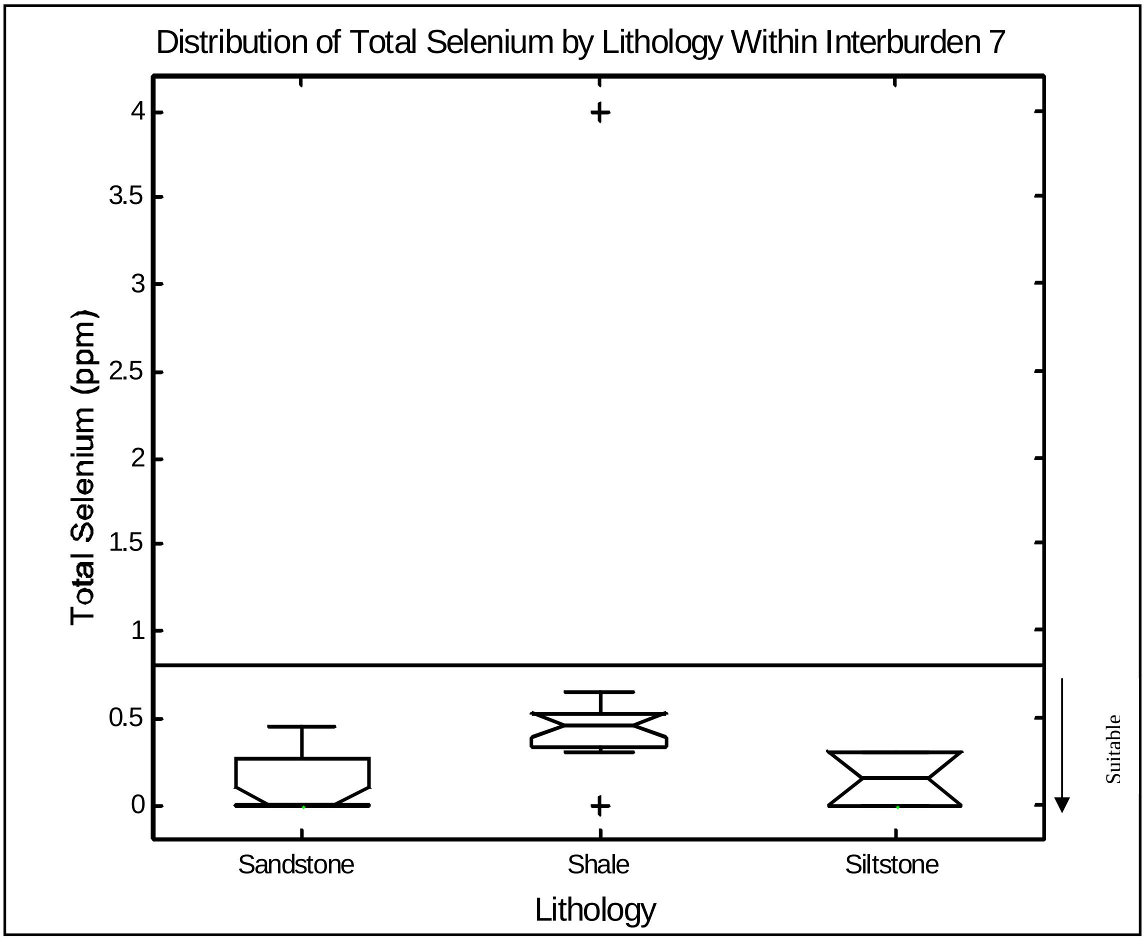

Figure 23. **Box and whisker plots of total selenium within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

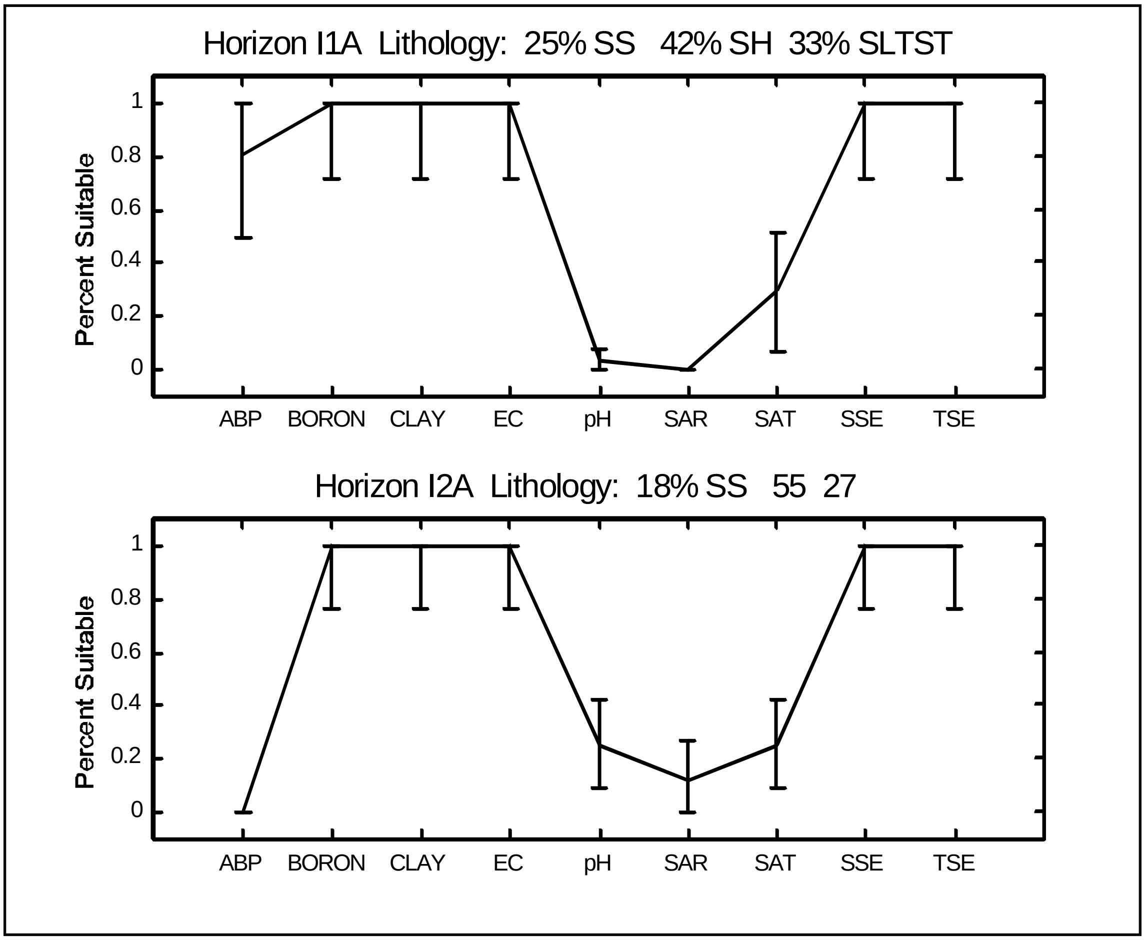

Figure 24. **One-sided 90% confidence intervals on the percent suitable material by horizon based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

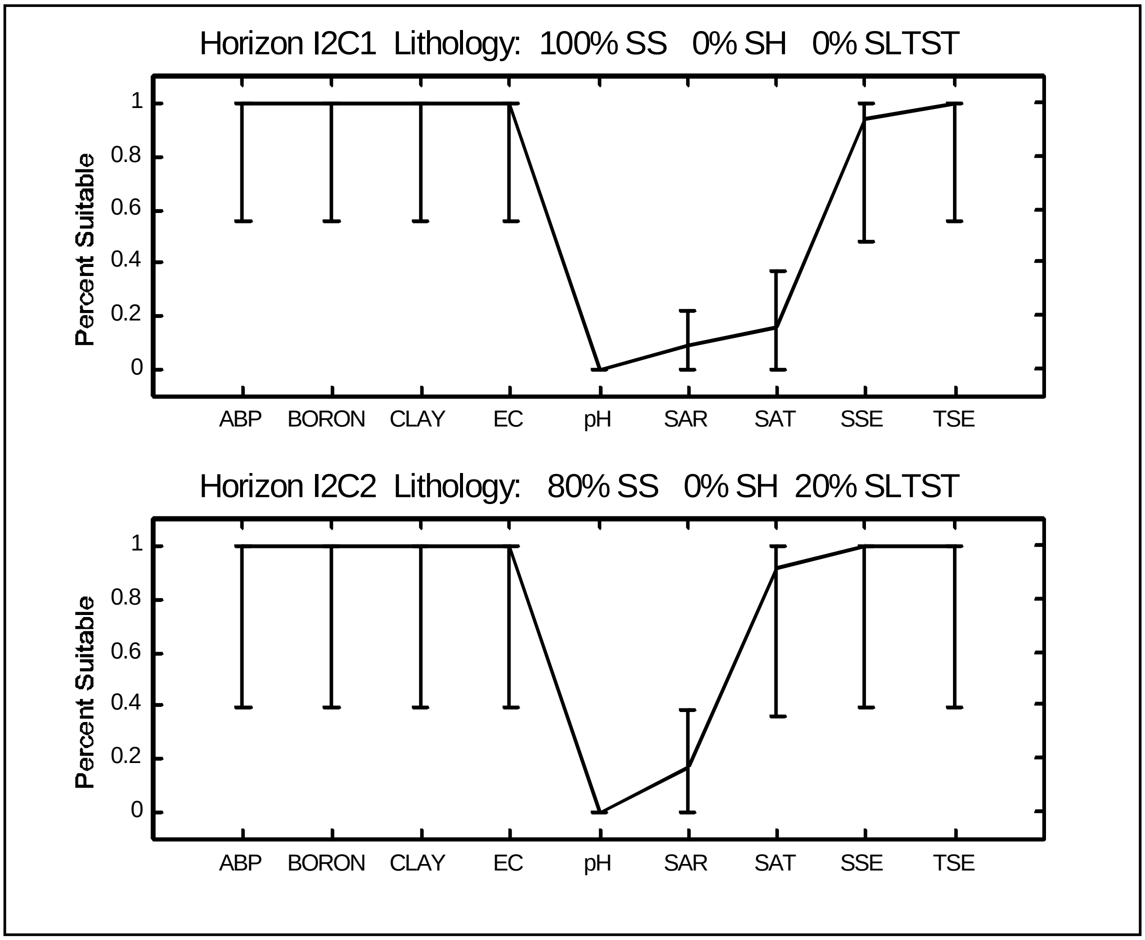

Figure 25. **One-sided 90% confidence intervals on the percent suitable material for the I2C1 and I2C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

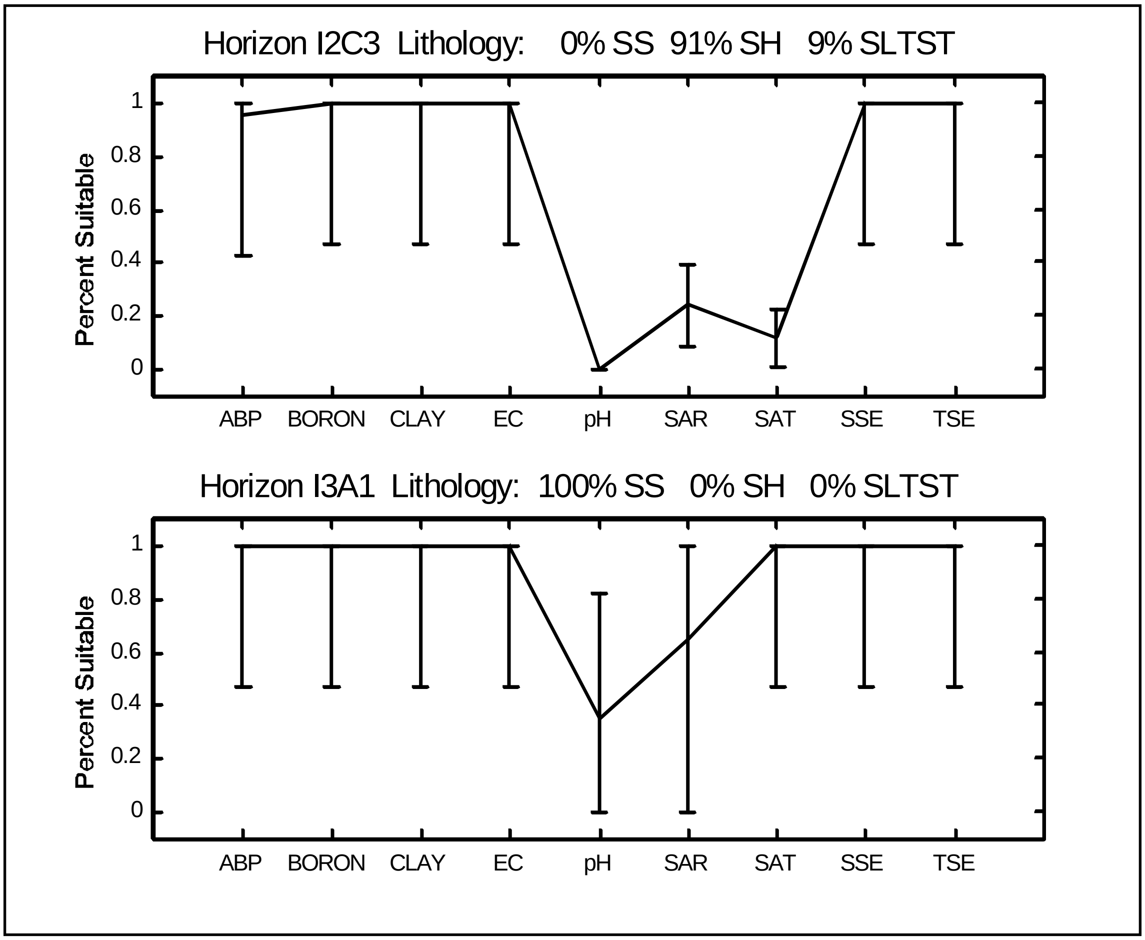

Figure 26. **One-sided 90% confidence intervals on the percent suitable material for the I2C3 and I3A1 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

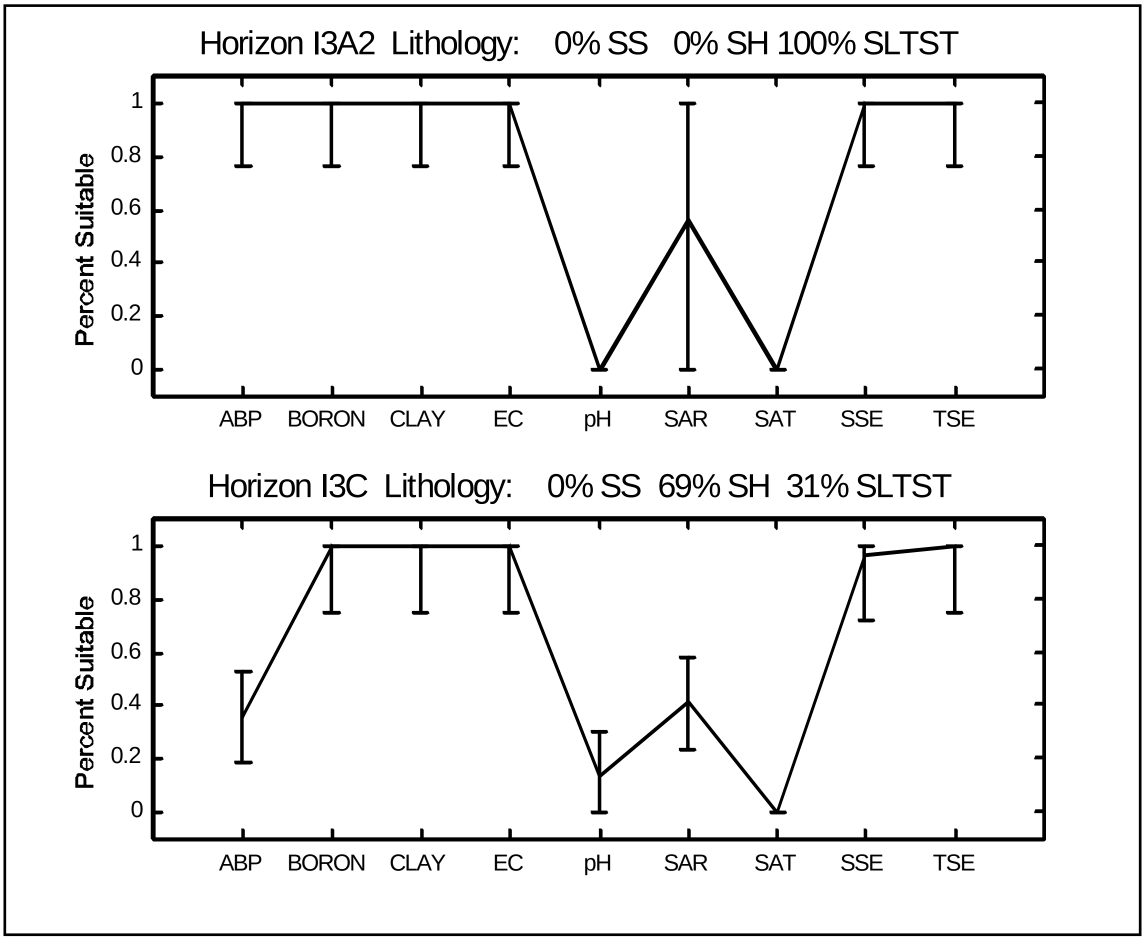

Figure 27. **One-sided 90% confidence intervals on the percent suitable material for the I3A2 and I3C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

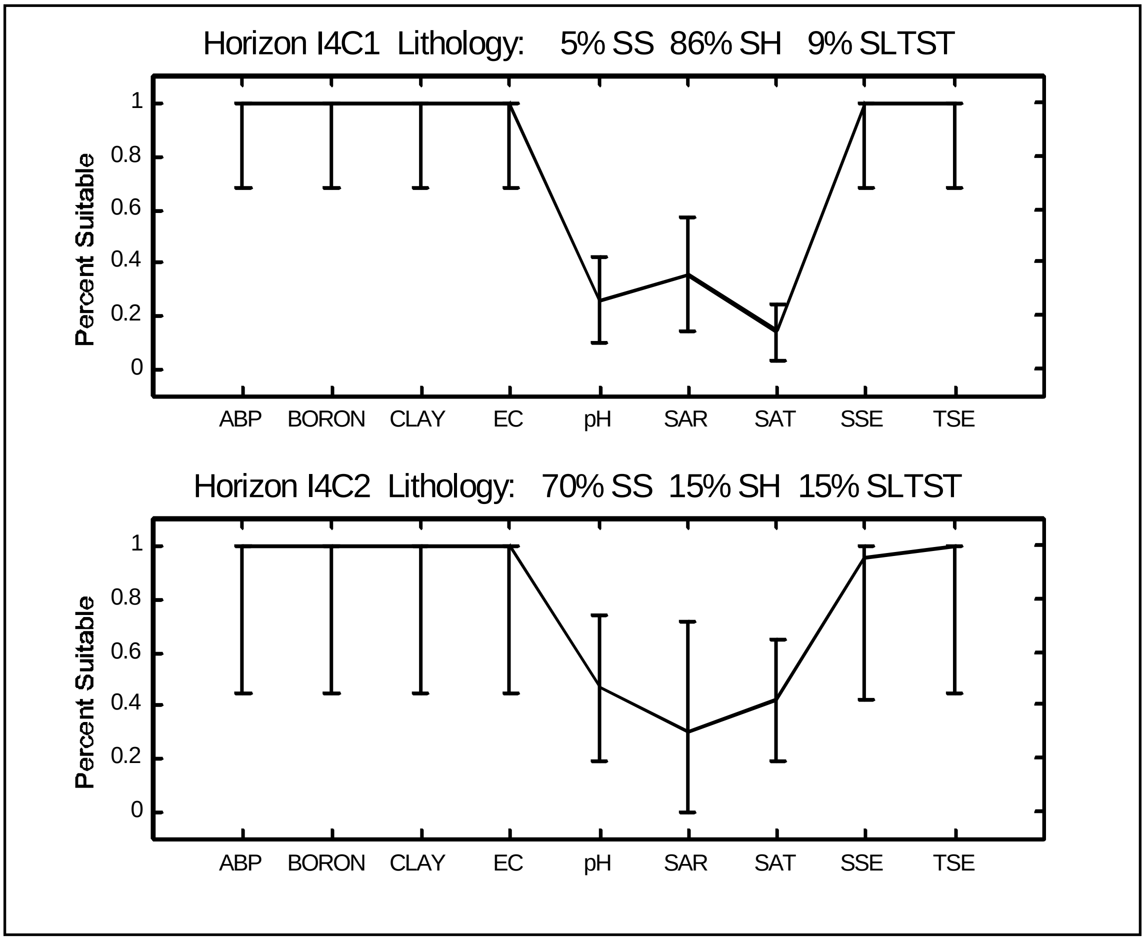

Figure 28. **One-sided 90% confidence intervals on the percent suitable material for the I4C1 and I4C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

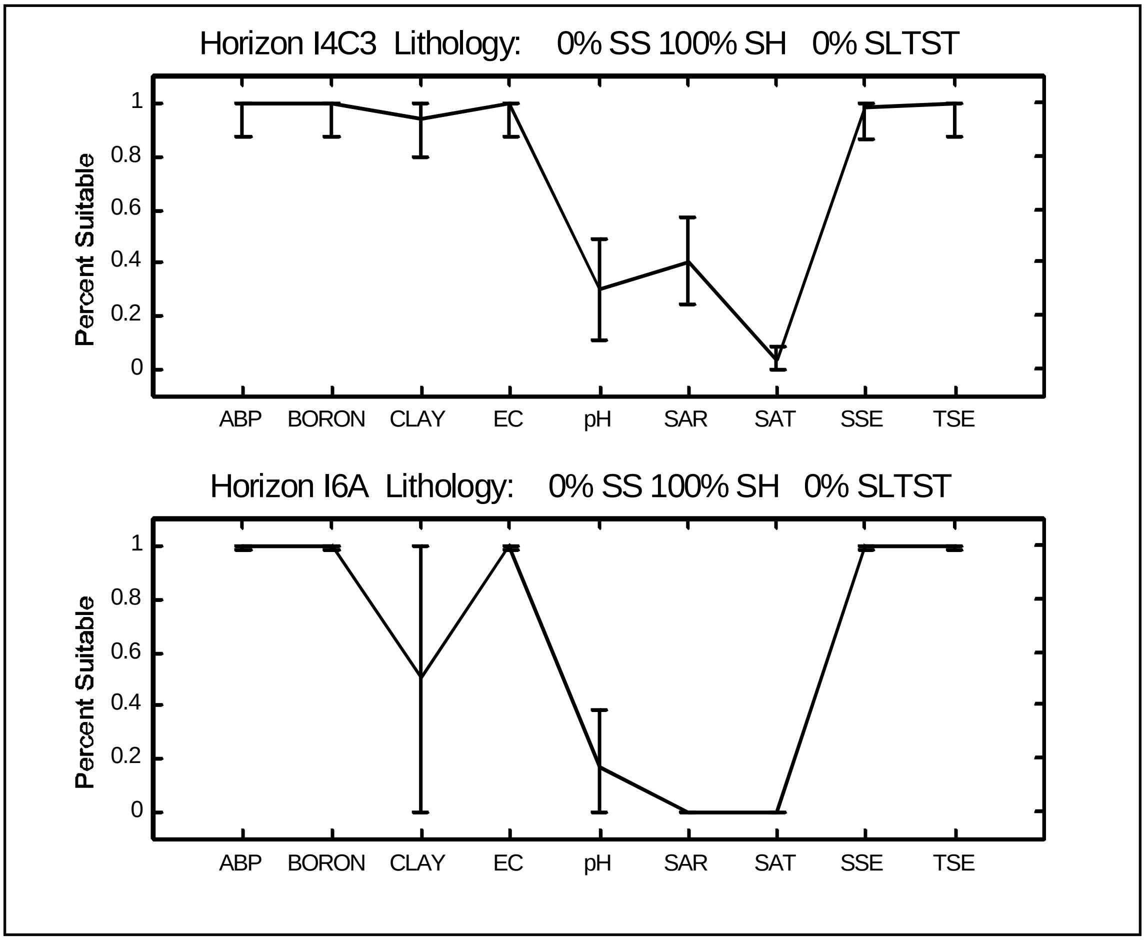

Figure 29. **One-sided 90% confidence intervals on the percent suitable material for the I4C3 and I6A horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

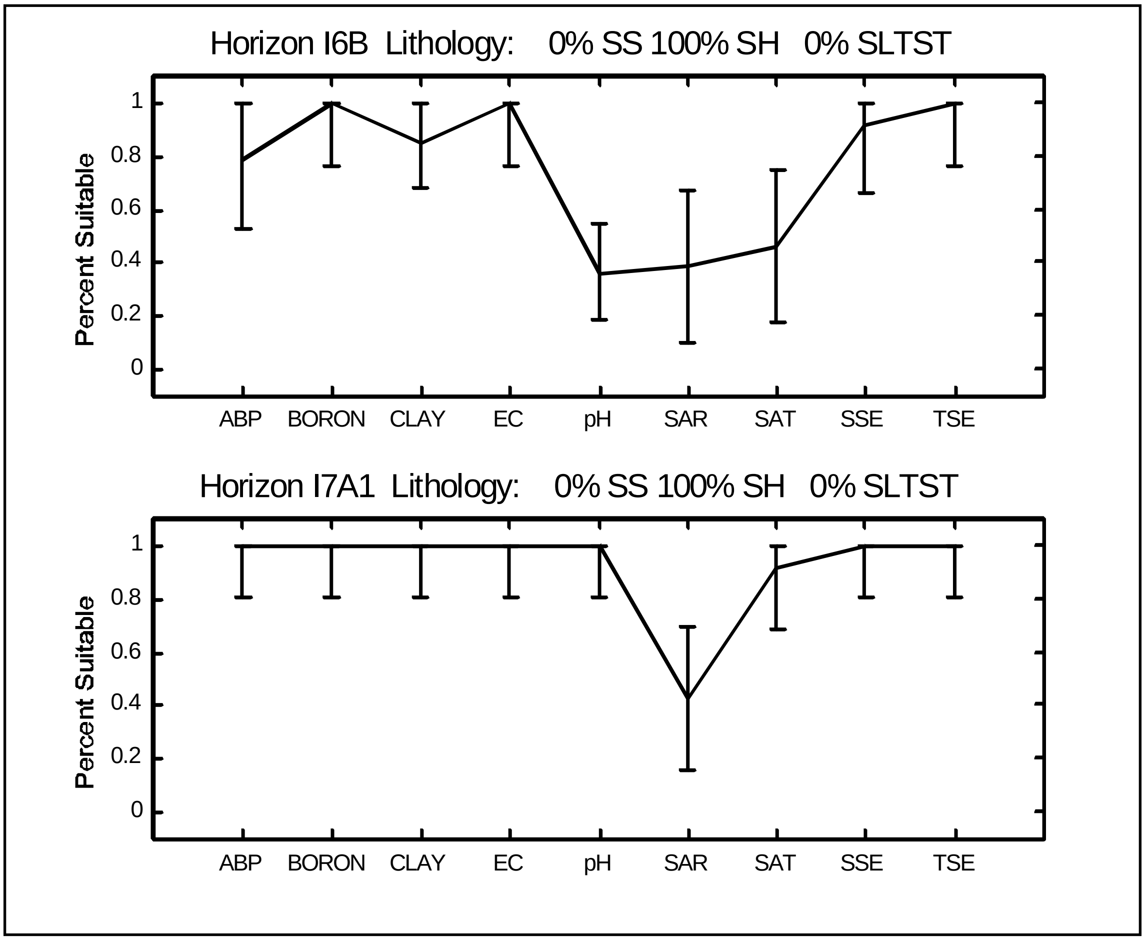

Figure 30. **One-sided 90% confidence intervals on the percent suitable material for the I6B and I7A1 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

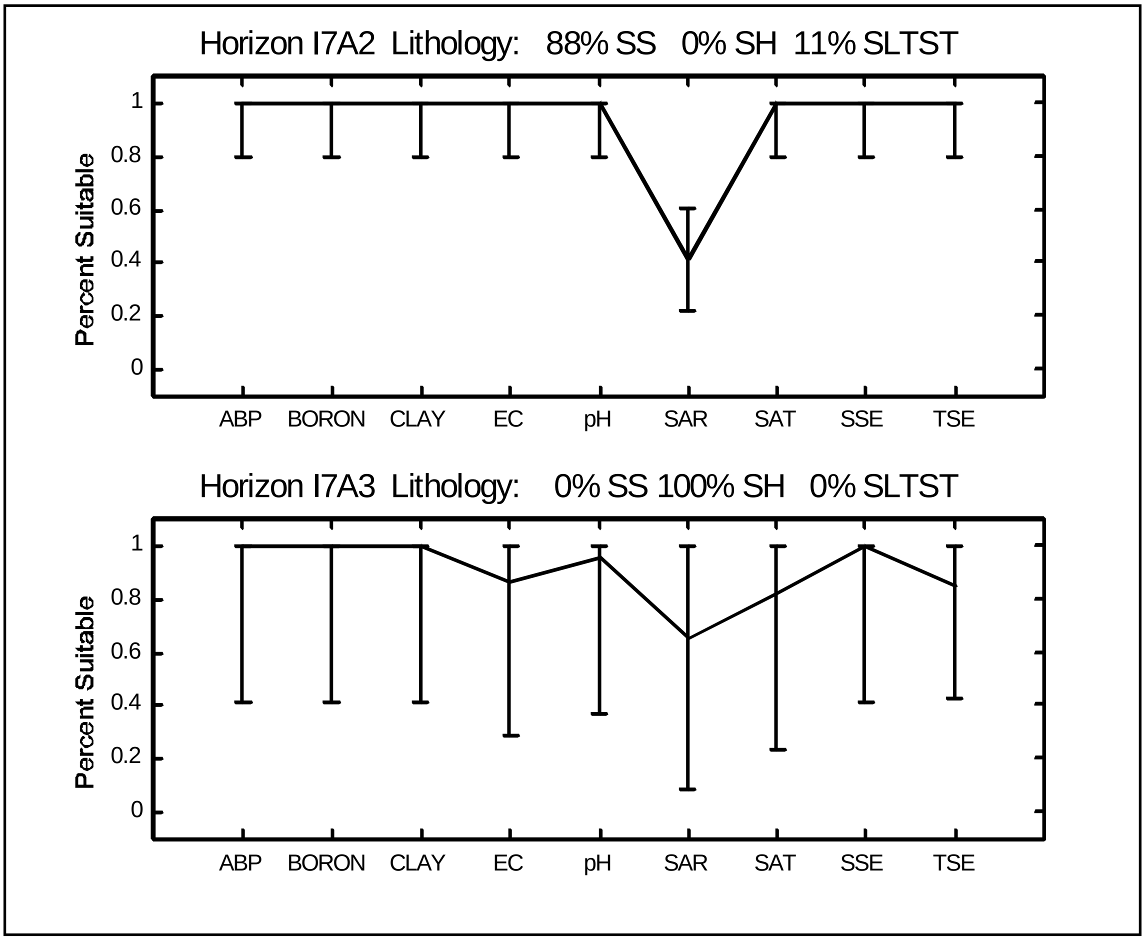

Figure 31. **One-sided 90% confidence intervals on the percent suitable material for the I7A2 and I7A3 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

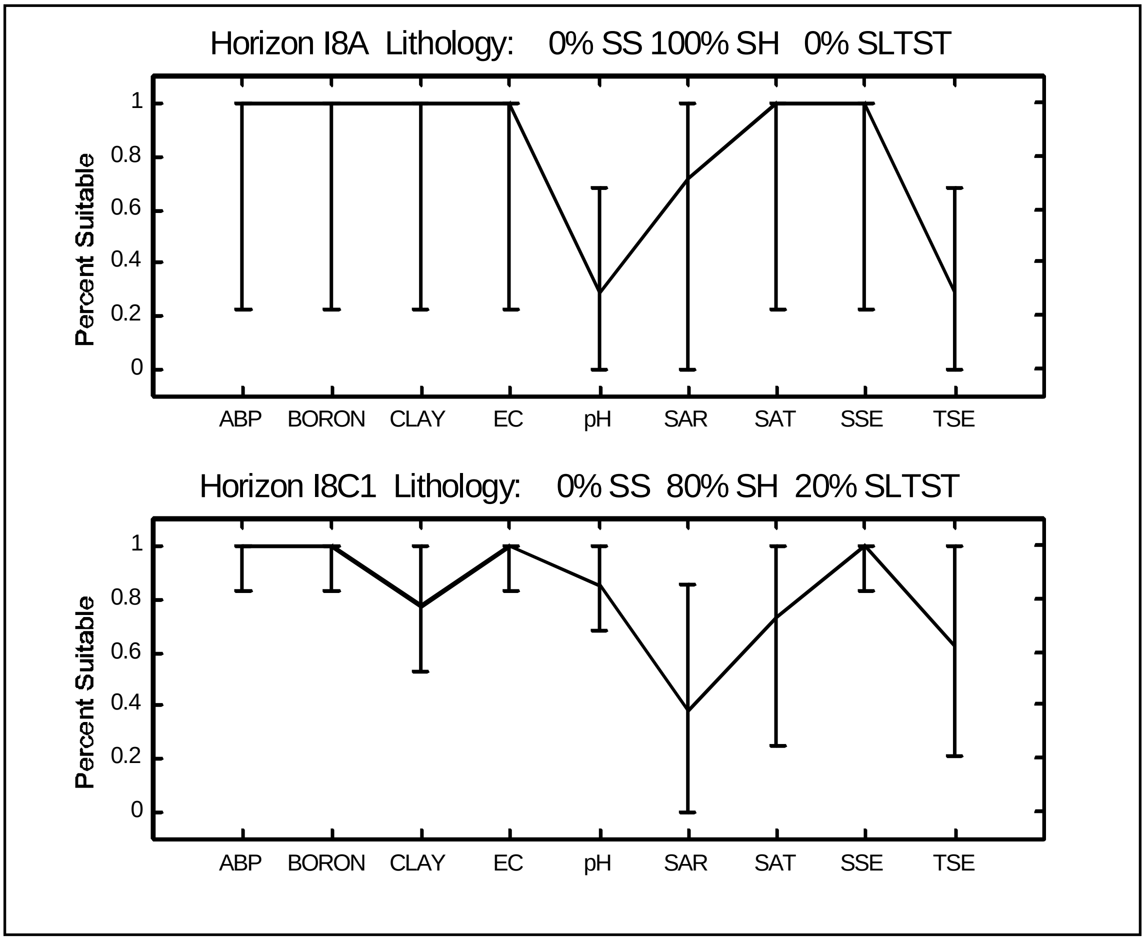

Figure 32. **One-sided 90% confidence intervals on the percent suitable material for the I8A and I8C1 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

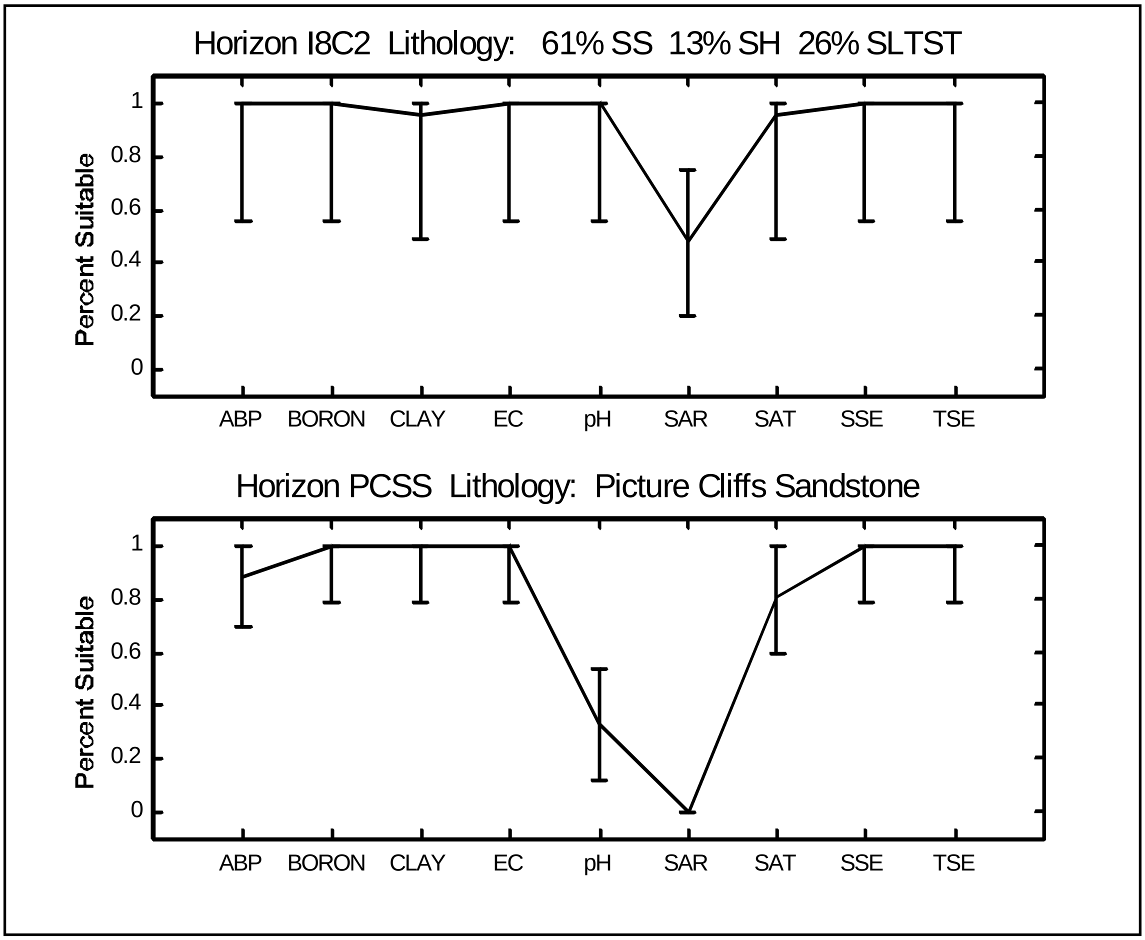

Figure 33. **One-sided 90% confidence intervals on the percent suitable material for the I8C2 and PCSS horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

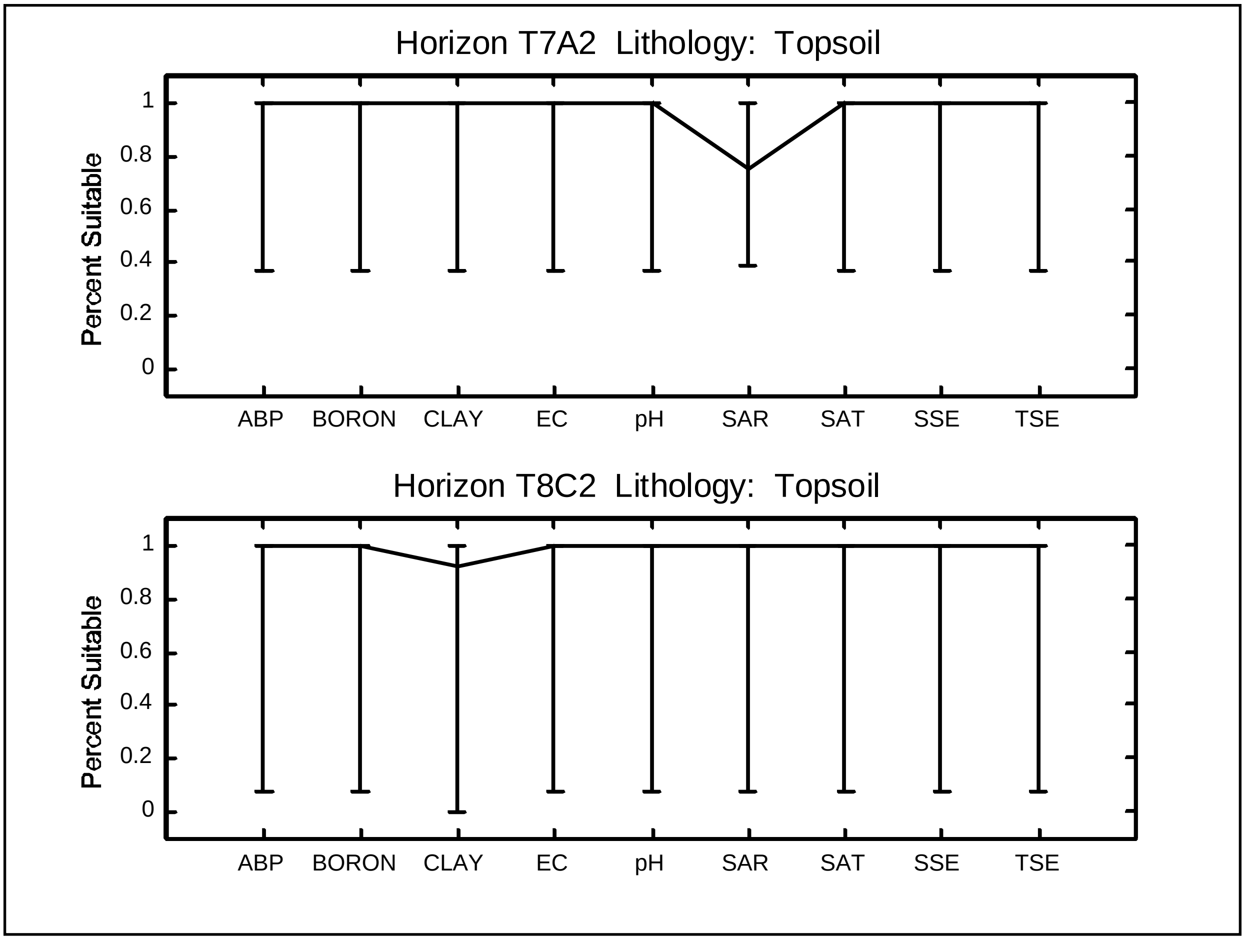

Figure 34. **One-sided 90% confidence intervals on the percent suitable material for the T73A2 and T8C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

Appendix 17.E

Statistical Analysis of Overburden/Interburden Sampling from
1998 and 2007 Drilling Programs

APPENDIX 17.E

STATISTICAL ANALYSIS OF OVERBURDEN/INTERBURDEN SAMPLING FROM 1998 AND 2007 DRILLING PROGRAMS

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APPENDIX 17.E

STATISTICAL ANALYSIS OF OVERBURDEN/INTERBURDEN SAMPLING FROM 1998 AND 2007 DRILLING PROGRAMS

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I. INTRODUCTION

A statistical analysis study on overburden samples collected from 26 drill holes has been prepared. The first phase of drilling to sample overburden in Area 4 South took place in 1998 and consisted of 10 continuous core drill holes. The second phase of drilling in Area 4 South and Area 5 took place in 2007 and consisted of 16 additional continuous core drill holes. The details of this first phase are contained in "No Name Permit Statistical Analysis of Phase I Interburden Sampling" prepared by John W. Kern, Ph.D. of Western EcoSystems Technology Inc. on 3 Aug 1998. This report is included as a separate appendix to Section 17. The objective of the "Kern study" was to assess the adequacy of the drilling program, estimate the volume of suitable material available for reclamation, determine what interburden layers contain high proportions of materials not suitable for reclamation, investigate spatial patterns in material suitability, and estimate the total volume of suitable material in the overburden/interburden layers most likely to be used for reclamation. This study builds on the findings of the "Kern study" and expands the analysis area to the lease extents of Area 4 South and Area 5. The objectives of the study presented in this report are to characterize the interburden layers and spatial patterns, estimate the total volume of root zone suitable material in the interburden layers most likely to be used for reclamation, and characterize mixed material (spoil) suitability and spatial patterns.

The in-situ physical and chemical characteristics of each overburden/interburden horizon or geologic layer have been analyzed for each of the 26 drill holes within Area 4 South and Area 5. Each horizon was sampled at varying intervals during the core logging process and analyzed for the suite of physical parameters and chemical analytes listed in Table 17.E-1. The data for each discrete sample were averaged, as described below in the Approach and Calculation Methods section, to provide a single value for each horizon in each drill hole. This characterization was used to identify interburden layers that contain proportions of unsuitable material or potentially acid- or toxic-forming material (PATFM). In addition, the characterization of interburdens from each drill hole are mathematically composited, as described in the Approach and Calculation Methods section, to model spoil quality and to determine if there are any areas (based on drill hole location) in the mined-out pit that contain proportions of unsuitable material or PATFM. When characterizing the suitability of overburden/interburden layers and spoil material, two potential criteria limits were used: (1) Office of Surface Mining Reclamation and Enforcement (OSM) Southwestern U.S. criteria limits and (2) Navajo Mine site-specific criteria limits (Table 17.E-2).

II. LITHOLOGY AND NAMING CONVENTIONS

There are eight primary coal seams and eight corresponding overburden/interburden horizons within the permit area. The Pictured Cliffs Sandstone (PCS) is the deepest unit described in these investigations, as it conformably underlies the coal-bearing units of the Fruitland Formation. Comprehensive geologic cross-sections and a detailed geologic description of the permit area are included in Section 17. Throughout this report, each interburden layer is designated using the name of the coal seam directly below the interburden layer. Coal seams are numbered from deepest to shallowest. For example, the deepest coal seam to be mined is the No. 2 coal seam (S2) and the interburden above it and below the No. 3 coal seam (S3) is referred to as No. 2 interburden (I2). Similarly, a parting in S2 would be referred to as P2. In situations where the coal seam splits, the coal seam number is followed by an alphabetic designation (e.g., S2A and S2B). For example, interburden and parting layers between splits in the No. 2 coal seam are referred to as I2A and I2B or P2A and P2B. Further, if interburden layers are composed of horizons of differing rock strata (e.g., sandstone and shale), the interburden number will be followed by numeric designation (e.g., I2-1 or I2A-1). For example, if the bottom horizon in I2 is primarily sandstone and the upper primarily shale, then the bottom horizon within this interburden would be labeled I2-1 and the next horizon above would be I2-2. Interburden name and the number of observations during the 1998 and 2007 drilling program are provided in Table 17.E-3. Stratigraphic columns and geologic model cross-sections are presented in Section 17.

III. APPROACH AND CALCULATION METHODS

The results from analysis of the in-situ characteristics of core samples are the basis for all discussions and calculations that follow. As noted in Table 17.E-1, percent sulfate, percent organic sulfur, percent pyritic sulfur, pyritic sulfur acid-base, and pyritic sulfur acid-base potential were determined only for samples with total sulfur acid-base potential (ABP) less than zero. Total sulfur ABP value greater than zero indicates the pyritic sulfur ABP value is greater than zero. The criteria limit presented in Table 17.E-2 is for pyritic sulfur ABP. In this way, total sulfur ABP is used as a screening method to determine if further analysis is needed to characterize the acid-forming potential of the sample.

In-situ Overburden/Interburden Characteristics

Data resulting from the physical and chemical analysis of discrete samples from continuous core drilling provide the basis for calculations used to characterize the in-situ overburden/interburden (interburden) layers. Analysis of the in-situ interburden required simplification of the data set through the calculation of an average value for each analyte for every interburden layer identified in the drill holes. This average value is calculated as the weighted mean . For purposes of calculation, values reported as below the detection limit were assigned values at one half the detection limit. In some cases, a core length could not be recovered during drilling, thus no analytical values were determined. The approach to fill the data gap and maintain the thickness of the interburden layer was to calculate the values for the missing core as a weighted mean of the two adjacent core samples. The weighted mean was calculated as a function of thickness for each core length sampled. The formula for weighted mean calculations follows:

Equation 1: ,

where is the analyte value and is the thickness weighting factor for the sample

This approach simplifies the data set for each drill hole and addresses the variations in analyte values within each set of interburden samples. The weighted mean values are representative of each interburden layer within that drill hole and are used to compare interburden layer characteristics between holes across the permit area.

When evaluating the variability of a particular interburden layer across the permit area, the arithmetic mean and standard deviation along with the range maximum and minimum were computed for each parameter. The formula for and calculations follows:

Equation 2: and

Equation 3:

where is the analyte value and is the number of values in the data set

In this approach, each weighted mean value for the interburden layer is treated as a discrete data point across the permit area and each weighted mean value has the same influence on the calculated values. In conclusion, the weighted mean is used to calculate a representative value from analyte values for interburden samples taken within the same drill hole. Arithmetic mean and standard deviation are used to determine the variability of interburdens between drill holes across the permit area.

Suitable Root Zone Material

The volume of suitable root zone material available within each mining area was estimated using the overburden/interburden above the uppermost coal seam to be mined. This material can be practically handled and stockpiled for use in reclamation, if required. Unlike in the "Kern report", the volume does not come from any single interburden layer. The weighted mean for the analytes of interest from uppermost interburden layer from each drill hole was calculated using the formula above. In some cases, the entire thickness of the overburden was not used in the calculation if the lower samples negatively impacted material suitability. This approach of neglecting the lower, less suitable material is in line with how the material would be recovered in the field. The thickness was adjusted accordingly to reduce the potential depth of recovery from the surface and the weighted mean was recalculated. Spatial Analyst in ArcGIS software was used to develop both a volume of in-situ suitable root zone material and an isopleth of suitable material thickness for each mining area. The Spatial Analyst computations utilized the Spline method of interpolation, which estimates values using a mathematical function that results in a smooth surface that passes through the input points with a minimized overall surface curvature. The Regularized method of Spline was used to extrapolate values out to the mining area boundary.

The continuous core samples included material from the surface or very near the surface that could be salvaged as suitable topdressing. Consequently, the volume of suitable root zone material estimated for each mining area was adjusted to account for the volume of topdressing to be salvaged. The thickness and volume of available topdressing are discussed in Section 14. Volume adjustments were based on the following equation:

Equation 4:

Modeled Spoil Characteristics

The in-situ overburden/interburden characteristics were used to model spoil characteristics by mathematically compositing all interburden layers within each drill hole. This was done by calculating the weighted mean of the values for each interburden layer. In this manner, all core samples within the drill hole are treated as a single mixed or composite sample, resulting in 26 modeled spoil samples. The weighted mean was calculated as a function of thickness for each interburden layer within the drill hole. The formula for weighted mean calculations follows:

Equation 5: ,

where is the weighted mean for the analyte for each interburden layer and

is the thickness weighting factor for the interburden layer

As stated above, it is difficult to predict the thickness of topdressing to be removed at each drill hole location. The topdressing material cannot be addressed in the same manner as used for determining the volume of suitable root zone material. The approach taken in this case was to neglect sample data from the top 5 ft of the uppermost core in each drill hole. This approach is appropriate because it removes the maximum depth of material that would be removed as topdressing. As stated in Section 16, soil classification and suitability of the baseline soils survey are limited to the upper 5 ft of unconsolidated material. In addition, this approach adds a degree of conservatism since the uppermost layers of the overburden are typically suitable for use as root zone material as a result of weathering.

Equation 2 and Equation 3 were used to calculate the arithmetic average of the weighted mean for each analyte for spoil and the corresponding standard deviation . The range limits for the values were also determined. These descriptive statistics are used to compare the variability of the 26 modeled spoil samples across the permit area.

IV. RESULTS

Characterization of In-situ Overburden/Interburden Layers

The physical and chemical characteristics of each overburden/interburden layer are compared to OSM and Navajo Mine root zone suitability criteria listed in Table 17.E-2. Results for all interburden layers above the major coal seam (e.g., S8) are presented and discussed together (e.g., I8A, I8B, etc.). The various interburden layers between major coal seams were not delineated by lithology for the purposes of this analysis since the objective was to understand average physicochemical properties by overburden/interburden layer. The weighted mean , maximum value, and minimum value for each analyte by interburden layer along with arithmetic mean and standard deviation of weighted values for interburden layers I8, I7, I6, I4, I3, and I2 are shown in Table 17.E-4, Table 17.E-5, Table 17.E-6, Table 17.E-7, Table 17.E-8, and Table 17.E-9, respectively.

Interburden Above Number 8 Coal Seam

The I8 interburden in Area 4 South is characterized by 17 layers (Table 17.E-4). The pH values for I8 are within the Navajo Mine criteria, with the lower-range value being slightly below the OSM limit. Average saturation percent is within OSM and Navajo Mine limits. Only 2 of the 17 layer values exceeded limits for both OSM and Navajo Mine, with values in the middle to upper 90% range. Average clay percent value is within both OSM and Navajo Mine limits, with 2 of 17 layer values exceeding the criteria limits by less than 3%. Total sulfur ABP values are above both criteria limits, indicating the pyritic sulfur ABP is also above both criteria limits, suggesting alkaline or neutralizing rock strata. Average soluble selenium (SSe) concentration for I8 is below OSM and Navajo Mine criteria levels. One layer exceeded OSM criteria limits by 0.142 parts per million (ppm) but was below Navajo Mine limits. Values for all other parameters, including boron and total selenium (TSe) are within the appropriate criteria ranges for suitable root zone material.

The I8 interburden in Area 5 is characterized by five layers (Table 17.E-4). Average conductivity is below both criteria limits with one sample value exceeding OSM limits by 0.2 millimohs per centimeter (mmhos/cm). Sodium adsorption ration (SAR) values vary with only one value exceeding Navajo Mine criteria. Average total sulfur ABP is above OSM and Navajo Mine limits by 26.6 tons per 1000 tons (t/kt), indicating the pyritic sulfur ABP is also above both criteria limits. Two individual layer values are below criteria limits. Layer I8A from drill hole 507-01 is a 2-ft-thick carbonaceous shale/coal interburden layer between S4A and S4B coal seams, represents less than 2% of the in-situ interburden thickness for that drill hole, and is characterized by one sample (Table 17.E-10). The pyritic sulfur ABP increased to -19.1 t/kt, but is still below the criteria limit. The other layer, I8A from drill hole 507-02, is characterized by four samples, one of which meets the ABP criteria limit (Table 17.E-10). Together these three layers have a thickness of about 5% of the in-situ interburden thickness for the drill hole. The pyritic sulfur ABP for two of the three samples is above criteria limits, while the pyritic sulfur ABP for the third sample is 8.7 t/kt below the criteria limit. Average TSe concentration exceeds OSM criteria but is within Navajo Mine criteria. Two of five values exceed OSM limits for TSe. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

Interburden Above Number 7 Coal Seam

The I7 is characterized by 18 layers in Area 4 South (Table 17.E-5). SAR values vary widely, with average SAR being within OSM and Navajo Mine criteria limits. Clay percent values are within Navajo Mine limits with one value exceeding the OSM criteria limit by 5%. Total sulfur ABP values are above criteria limits with an average value of 90 t/kt, indicating the pyritic sulfur ABP is also above both criteria limits. Average TSe concentration is below criteria limits for both OSM and Navajo Mine. One of 18 layer values exceeds the OSM limit by approximately 0.5 ppm but is below the Navajo Mine limit. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

The I7 in Area 5 is characterized by eight layers (Table 17.E-5). The majority of pH values are within criteria limits, with one layer value exceeding limits by 0.3 units. Average saturation percent is within criteria limits, even though three of the eight layer values exceed OSM criteria limits. Two of those values exceed Navajo Mine criteria limits. SAR values vary widely with average SAR being within criteria limits. Total sulfur ABP values are above criteria limits with an average value of 75.2 t/kt, indicating the pyritic sulfur ABP is also above both criteria limits. Average TSe concentration is below both OSM and Navajo Mine limits with two samples exceeding OSM limits by up to approximately 0.4 ppm. Average SSe concentration is below both criteria limits with one layer value exceeding OSM limits by approximately 0.06 ppm. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

Interburden Above Number 6 Coal Seam

In Area 4 South, I6 is characterized by 21 layers (Table 17.E-6). The range of pH values is outside the limits for both OSM and Navajo Mine criteria. Three layer values are below criteria limits and five values are above criteria limits. Average conductivity is below both criteria limits. Two of 21 samples slightly exceed OSM criteria by up to 0.4 mmhos/cm. The majority of saturation percent values, including the average, in Area 4 South exceed both OSM and Navajo Mine criteria limits. SAR values vary widely but the average SAR value is below OSM and Navajo Mine limits. Average clay percent is below both criteria limits. Three of 21 samples exceed OSM criteria limits up to 6%, with 2 exceeding Navajo Mine limits by 1%. The majority of total sulfur ABP values, including the average, are below criteria limits. Average ABP is below criteria limits by 1.2 t/kt. The I6 in Area 4 South is characterized by 36 samples, 16 of which contain total sulfur ABP below the criteria limit. These 16 samples were taken among 11 of the 26 drill holes. The pyritic sulfur ABP for five of the samples is above criteria limits (Table 17.E-10). This indicates that only 11 of 36 samples contain pyritic sulfur ABP below criteria limits. These 11 samples are from 8 drill holes. These samples represent core lengths less than 5 ft or 5% of the in-situ interburden thickness for the respective drill holes. These thin representative thicknesses coupled with the small amount by which the average total sulfur ABP is below the criteria limit suggest that the average pyritic sulfur ABP for I6 would be above criteria limits. Boron concentrations for I6 in Area 4 South are below OSM criteria limits. Average TSe value is below OSM and Navajo Mine limits. Eight of 21 values exceed OSM criteria limits but are below Navajo Mine limits. Average SSe is below both criteria limits. Seven of 21 layers exceed OSM limits, with 1 also exceeding the Navajo Mine limit by approximately 0.1 ppm.

The I6 is characterized in Area 5 by nine layers (Table 17.E-6). The upper range of pH values of I6 in Area 5 exceeds criteria limits by up to 0.3 units. Average saturation percent exceeds Navajo Mine criteria but is below OSM criteria. The majority of sample values exceed Navajo Mine criteria limits. Average SAR and a majority of sample values exceed both OSM and Navajo Mine criteria limits. Average total sulfur ABP and a majority of values are above criteria limits with one value below limits, indicating the pyritic sulfur ABP is also above both criteria limits. The pyritic sulfur ABP for this layer, I6 in drill hole 507-01, is below criteria limits by 3.94 t/kt and represents a core length of 3.5 ft, approximately 3% of the in-situ interburden thickness for the drill hole (Table 17.E-10). Average TSe concentration is below criteria limits, with one value exceeding OSM limits by 0.06 ppm. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

Interburden Above Number 4 Coal Seam

In Area 4 South, I4 is characterized by 20 layers (Table 17.E-7). The majority of pH values exceed criteria limits by as much as 1.0 unit. The majority of values for saturation percent, including the average, exceed criteria limits. The majority of SAR values, including the average, exceed both OSM and Navajo Mine criteria limits. Average clay percent is within both criteria limits with one layer exceeding OSM limits by 5%. Average TSe concentration is below criteria limits with one sample value exceeding OSM limits. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

The I4 in Area 5 is characterized by 12 layers (Table 17.E-7). The majority of pH values exceed criteria limits by as much as 0.5 units. The majority of saturation percent values, including the average, exceed both OSM and Navajo Mine criteria limits. SAR values vary widely with the majority exceeding both criteria limits. All clay percent values are below both criteria limits. Average total sulfur ABP and the majority of values are above the criteria limit with one layer value slightly less than the limit, indicating the pyritic sulfur ABP is also above both criteria limits. This layer, I4A in drill hole 507-02, is characterized by one sample and is represented by a core length that was less than 2.5% of the in-situ interburden thickness for the drill hole. The pyritic sulfur ABP for the layer, however, is above criteria limits (Table 17.E-10). Average TSe concentration is below both criteria limits with two sample values exceeding OSM limits. Average SSe concentration is below both OSM and Navajo Mine criteria limits with one sample value exceeding both limits. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

Interburden Above Number 3 Coal Seam

The I3 is characterized by 21 layers in Area 4 South (Table 17.E-8). The majority of pH values, including the average, exceed criteria limits by up to 0.6 units. The majority of saturation percent values, including the average, exceed criteria limits. The majority of SAR values, including the average, exceed both OSM and Navajo Mine limits. Total sulfur ABP values vary widely, with the average value below the criteria limit by 2.0 t/kt. The I3 in Area 4 South is characterized by 65 samples, 33 of which contain total sulfur ABP below the criteria limit. These 33 samples were collected among 13 of the 26 drill holes. The pyritic sulfur ABP of two samples is above the criteria limits. The pyritic sulfur ABP for the remainder of the samples ranges from -6.27 to -71.5 t/kt (Table 17.E-10). The length of core represented by the remainder of samples with pyritic sulfur ABP values less than criteria limits ranges from 3.2 to 18.5 ft, or 3.5 % to 14.1% of the in-situ interburden thickness for the respective drill holes (Table 17.E-10). Average TSe concentration is below both OSM and Navajo Mine limits with 2 of 21 layer values exceeding OSM limits. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

In Area 5, I3 is characterized by 10 layers (Table 17.E-8). The majority of pH values exceed criteria limits, by up to 0.4 units. The majority of values for saturation percent are below both OSM and Navajo Mine criteria limits but the average exceeds the Navajo Mine limit. All SAR sample values exceed both OSM and Navajo Mine criteria limits. Average clay percent is below both criteria limits with one sample value exceeding OSM limits by 3%. Total sulfur ABP values vary widely with average and majority of values within criteria limits, indicating the pyritic sulfur ABP is also above criteria limits. Four of the 10 layers have total sulfur ABP that is below criteria limits. These layers are located in drill holes 507-02, 507-06, 507-07, and 507-09 and are represented by eight samples. The pyritic sulfur ABP for seven of the samples is greater than the criteria limits. The remaining sample has pyritic sulfur ABP of approximately 2 t/kt below the criteria limit and represents a core length of 2.8% of the in-situ interburden thickness for the respective drill hole. Average TSe concentration is below both OSM and Navajo Mine limits. Three of 10 sample values exceed OSM limits but are below Navajo Mine limits. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

Interburden Above Number 2 Coal Seam

In Area 4 South, I2 is characterized by 17 layers (Table 17.E-9). All pH values exceed criteria limits, by as much as 0.6 units. All conductivity values are below both criteria limits. The majority of saturation percent values exceed the criteria limits, including the average value. The majority of SAR values, including the average, exceed both criteria limits. Average clay percent is below OSM and Navajo Mine criteria limits with 3 of 17 values exceeding OSM limits by 3%. Average total sulfur ABP value is above the criteria limit with 2 of 17 layer values (I2B/2A and I2B1) below the limit, indicating average pyritic sulfur ABP is above criteria limits as well. Layer I2B/2A from drill hole 498-06 is a shale layer less than 2 ft thick characterized by one sample (Table 17.E-10). The pyritic sulfur ABP is below criteria limits by 5.1 t/kt. The other, layer I2B1 from drill hole 407-32, is coal and carbonaceous shale 2.3 ft thick characterized by two samples (Table 17.E-10). The pyritic sulfur ABP of the carbonaceous shale layer is above criteria limits, while the pyritic sulfur ABP of the coal seam is below limits. The coal seam S2B2 is 0.6 ft thick and represents 0.5% of the in-situ interburden thickness for the respective drill hole. Boron concentrations are below OSM criteria limits. Average TSe concentration is below both criteria limits with one sample value exceeding OSM limits by approximately 0.2 ppm. Average SSe concentration is below both OSM and Navajo Mine criteria limits. Three of 17 sample values exceed OSM criteria limits with 1 of those exceeding the Navajo Mine limit.

I2 is characterized by 12 layers in Area 5 (Table 17.E-9). Less than half of the pH sample values exceed criteria limits, by up to 0.6 units. The majority of saturation percent values exceed the criteria limits with the average being below the OSM limit. The majority of SAR values, including the average, exceed both OSM and Navajo Mine criteria limits. All values for clay percent are below both limits. Average total sulfur ABP is above the criteria limit with 2 of 12 layer values below the limit. Layer I2A in drill hole 507-02 and layer I2A in drill hole 507-06 are each characterized by one sample. The pyritic sulfur ABP of these layers is above criteria limits, indicating the average pyritic sulfur ABP is above criteria limits (Table 17.E-10). Average TSe concentration is below both OSM and Navajo Mine criteria limits with 1 of 12 values exceeding OSM limits. Values for all other parameters are within the appropriate criteria ranges for suitable root zone material.

Estimated Volume of Suitable Root Zone Material

If needed, suitable root zone material is available from overburden strata above the first seam to be mined. Suitable root zone thickness for each drill hole was determined by comparing the of analytical results to both OSM and Navajo Mine criteria. In cases where the of the entire core above the uppermost seam was not suitable, the thickness was mathematically reduced by removing core sample data from the lowest portion of the core until met the criteria limits. The results of suitable thickness calculations are summarized in Table 17.E-11. The suitable thickness ranges from 10.0 ft to 76.7 ft in Area 4 South and from 20.0 ft to 81.7 ft in Area 5. The average thickness over the permit area, based on drill holes, is 37.8 ft. This thickness is almost an order of magnitude larger than the thickness of root zone material that would be replaced during reclamation of mined areas.

The volume of suitable root zone material available, based on the average thickness over the No Name Permit area is approximately 760,579,900 bcy.

Characterization of Spoil Material

Spoil material quality was modeled by computing the weighted mean of all layers for each analyte within each drill hole. These data are used to characterize spoil at each drill hole location and estimate spoil variability within and among each operational area. The results of these computations are included in Table 17.E.12. The saturation percent values at drill holes in Area 4 South range from 66.6% to 127.9%, with an average that is below OSM criteria limits and exceeds Navajo Mine limits by 0.4%. The saturation percent values in Area 5 are lower, ranging from 62.6% to 95.8%, with an average that is below both criteria limits. The majority of SAR values for spoils in Area 4 South and Area 5, including the average, are below Navajo Mine criteria limits. SAR values for five modeled spoils in Area 4 South and three modeled spoils in Area 5 are above Navajo Mine criteria limits from 0.6% to 14.4%. Total sulfur ABP values for the modeled spoils range from 26.5 to 70.8 t/kt in Area 4 South and from 46.5 to 78.6 t/kt in Area 5. The level of total sulfur ABP indicates the pyritic sulfur ABP will also be above criteria limits, suggesting the modeled spoils represent alkaline or neutralizing rock strata. One drill hole had a minor exceedance of the OSM limit for total selenium by 0.01 ppm. In summary, the modeled spoils meet all Navajo Mine suitable root zone criteria with the exception of saturation percent and SAR.

V. CONCLUSIONS

In conclusion, there is no widespread occurrence of PATFM within Area 4 South or Area 5. Characterization of the in-situ interburden above each coal seam suggests that the materials present in I7 and I6 in Area 4 South possess TSe values that are outside OSM criteria limits, but below Navajo Mine criteria limits and thus are of limited concern. Acid-base potential characterization suggests a net alkaline environment across the geologic column in both Area 4 South and Area 5. Two layers in Area 4 South, I6 and I3, possess pyritic sulfur APB values that are outside criteria limits for several samples. These layers are thin compared to the total thickness of interburden to be excavated during mining, constituting less than 5% and 14%, respectively, of the in-situ interburden thickness at each drill hole location. Characterization of the in-situ interburden also suggests that the materials present in I6, I4, I3, and I2 in Area 4 South and Area 5 possess saturation percent (>85%), SAR (>18), and pH (>9.0) values that are outside criteria limits established by OSM and Navajo Mine for root zone suitability. These characteristics are common of alkaline subsurface environments where weathering has not altered the rock strata.

However, when analyzed as a composite to model mine spoil conditions, the influence of these layer characteristics is attenuated and the overall values for physical and chemical analytes, with the exception of saturation percent and SAR, for the spoil are within suitability limits and PATFM is not a concern. Despite containing these thin layers of low pyritic sulfur ABP interburden, all modeled spoil columns have net alkaline values.

VI. REFERENCES

Navajo Transitional Energy Company (NTEC). 2024. Navajo Mine Permit Application Package. OSM Permit No. NM-0003I. On file at Office of Surface Mining Reclamation and Enforcement- Western Region Technical Office. Denver, Colorado

Table 17.E-1 Physical and Chemical Properties Analyzed or Calculated for Overburden/Interburden Samples from 1998 and 2007 Drilling Program

pH (s.u.)
Conductivity (mmhos/cm)
Saturation (%)
Calcium (meq/L)
Magnesium (meq/L)
Sodium (meq/L)
SAR
Sand (%), Silt (%), Clay (%)
USDA Soil Texture Class
$CaCO_3$ (%)
Total Sulfur (%)
Total Sulfur Acid Potential (t/kt)
Neutralization Potential (t/kt)
Total Sulfur Acid-Base Potential (t/kt)
Sulfate (%) *
Organic Sulfur (%) *
Pyritic Sulfur (%) *
Pyritic Sulfur Acid-Base (t/kt) *
Pyritic Sulfur Acid-Base Potential (t/kt) *
Boron (ppm)
Total Selenium (ppm)
Soluble Selenium (ppm)

* analysis performed when total sulfur acid-base potential is less than zero.

Table 17.E-2 Potential Root Zone Suitability Criteria and PATFM Characteristic Analytes

Characteristic Analytes	OSM Southwestern U. S. Criteria	Navajo Mine Site Specific Criteria[3]
Boron	≤10 ppm	na
Total Selenium	≤0.8 ppm	≤2.5 ppm
Soluble Selenium	≤0.15 ppm	≤0.26 ppm
pH	≥5.5 and ≤9.0	≥5.0 and ≤9.0
Acid-Base Account (Acid-Base Potential[1])	>-5 t $CaCO_3$/1000 t	≥-5 t $CaCO_3$/1000 t
Saturation	≥ 20% and ≤90%	≤85% OR ≤100% only if EC≥4 mmhos/cm
EC	≤12 mmhos/cm	≤16 mmhos/cm
SAR	sandy loam ≤20 loam, clay loam ≤16 40% clay ≤14	≤18 OR ≤40 only if EC ≥4 mmhos/cm
Texture	≤45% clay	≤50% clay
$CaCO_3$	%	No Criteria
Neutralization Potential	t $CaCO_3$/1000 t	No Criteria
Total Sulfur	%	No Criteria
Total Sulfur Acid Potential	t $CaCO_3$/1000 t	No Criteria
Sulfate[2]	%	No Criteria
Organic Sulfur[2]	%	No Criteria
Pyritic Sulfur[2]	%	No Criteria
Acid-Base Pyritic Sulfur[2]	t $CaCO_3$/1000 t	No Criteria

1 Total sulfur and pyritic sulfur acid-base potential are considered under this criteria.
2 These analytes including pyritic sulfur acid-base potential are analyzed when total sulfur acid-base potential is less than zero.
3 Navajo Mine site specific criteria are found in Pinabete Permit – NM-0042B.

Table 17.E-3 Interburden Name and Number of Layer Observations from 1998 and 2007 Drilling Programs

Interburden name	Number of observations Area 4 South	Number of observations Area 5
I8	2	1
I8A	3	2
I8A1	1	-
I8A2	5	-
I8A2/8A1	1	-
I8B	3	2
I8B1	1	-
I8B2	1	-
I7	17	4
I7A	-	2
I7B	-	2
I7-Z	1	-
I6	11	6
I6A	4	1
I6B	6	1
I6-Z	-	1
I4	5	3
I4A	3	4
I4B	10	5
I4B/4A	2	-
I3	11	6
I3A	3	2
I3B	3	2
I3B/3A	1	-
I3C	1	-
I3-Z	1	-
P3B	1	-
I2	4	7
I2A	-	2
I2B	4	2
I2B/2A	1	-
I2B1	1	-
I2B1/2A	3	-
I2B2	4	-
I2-Z	-	1

Table 17.E-4 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I8

Drill hole	Interburden layer	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
407-33	I8A1	8.5	2.0	83.8	0.52	0.13	17.51	30.8	13	53
407-33	I8A2	8.6	2.0	72.8	0.40	0.16	16.81	31.7	24	45
407-33	I8B	8.7	2.4	98.3	2.28	0.64	19.11	15.8	32	42
407-34	I8A	8.8	1.4	95.2	0.24	0.09	13.31	32.8	16	57
407-34	I8B	7.5	5.1	96.8	5.54	2.81	45.33	22.2	24	44
407-38	I8A2	8.9	1.8	59.0	0.52	0.19	17.58	29.4	18	52
407-38	I8B	8.4	3.2	41.7	5.61	2.26	27.45	13.8	69	13
407-41	I8	8.2	5.0	57.9	2.64	1.04	47.05	34.7	25	47
407-43	I8A	8.1	3.9	63.7	9.65	3.86	29.91	11.5	14	57
407-44	I8A2	7.1	7.9	67.8	8.02	9.87	67.24	22.5	11	60
498-04	I8A	7.5	3.7	63.9	18.38	7.45	24.11	6.7	50	23
498-06	I8	6.8	4.2	44.1	24.58	13.49	9.27	2.1	51	26
498-09	I8A2	6.7	9.1	93.6	15.02	7.06	66.58	20.0	21	28
498-10	I8A2	8.2	1.8	56.0	0.51	0.24	20.69	33.9	29	39
498-10	I8B1	5.4	6.9	84.6	15.51	7.35	53.84	15.9	11	30
498-10	I8B2	7.8	4.5	90.1	9.35	3.18	38.46	15.4	27	36
498-12	I8A2/8A1	8.2	6.1	36.5	4.21	4.41	48.52	23.4	46	33
Minimum		5.4	1.4	36.5	0.24	0.09	9.27	2.1	11	13
Maximum		8.9	9.1	98.3	24.58	13.49	67.24	34.7	69	60
Arithmetic mean*		-	4.2	70.9	7.23	3.78	33.10	14.1	28	40
Standard dev		-	2.2	19.8	7.10	3.87	18.00	-	16	13
507-01	I8A	8.1	2.7	56.0	5.84	2.05	20.18	10.2	56	20
507-01	I8B	7.4	2.7	46.0	5.43	5.71	18.60	7.9	53	27
507-02	I8A	8.7	2.6	96.0	0.29	0.12	24.81	54.7	40	33
507-02	I8B	7.8	12.2	69.0	10.3	8.37	102.7	33.6	17	51
507-09	I8	7.5	4.4	54.5	10.7	5.25	38.51	13.6	13	50
Minimum		7.4	2.6	46.0	0.29	0.12	18.60	7.9	13	20
Maximum		8.7	12.2	96.0	10.7	8.37	102.7	54.7	56	51
Arithmetic mean*		-	4.9	64.3	6.52	4.30	40.97	17.6	36	36
Standard dev		-	3.7	17.5	3.81	2.90	31.67		18	13

* Arithmetic mean of the weighted mean values for parameters for each interburden layer except SAR. Arithmetic mean of SAR is calculated from the arithmetic mean values for calcium, magnesium, and sodium.

Table 17.E-4 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I8

Drill hole	Clay (%)	CaCO3 (%)	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
407-33	34	7.48	0.896	28.0	74.8	46.8	2.20	0.942	0.188
407-33	30	10.11	0.627	19.6	101.1	81.6	1.80	0.653	0.116
407-33	26	8.58	0.212	6.6	85.8	79.2	1.22	0.276	0.057
407-34	28	8.39	0.377	11.8	83.9	72.1	1.19	0.423	0.083
407-34	32	4.76	0.218	6.8	47.6	40.7	1.15	0.262	0.086
407-38	30	4.97	0.347	10.8	49.7	38.9	1.28	0.699	0.127
407-38	18	3.80	0.057	1.8	38.0	36.2	1.47	0.642	0.015
407-41	28	3.60	0.339	10.6	36.0	25.4	1.60	0.653	0.091
407-43	29	3.54	0.218	6.8	35.4	28.6	1.12	0.674	0.079
407-44	29	5.79	0.310	9.7	57.9	48.2	1.37	0.421	0.053
498-04	27	7.23	0.170	5.4	71.7	66.4	0.61	0.075	0.013
498-06	23	6.26	0.462	14.5	64.6	50.2	0.54	0.461	0.019
498-09	51	37.91	0.744	23.2	49.1	26.0	0.55	0.713	0.090
498-10	30	5.49	0.220	6.9	53.1	46.2	0.52	0.445	0.021
498-10	53	1.80	0.346	10.9	20.4	10.1	0.74	0.581	0.030
498-10	36	7.00	0.150	4.7	67.5	62.8	0.36	0.252	0.041
498-12	21	8.84	0.055	1.7	86.9	85.3	0.33	0.113	0.037
Minimum	18	1.80	0.055	1.7	20.4	10.1	0.33	0.075	0.013
Maximum	53	37.91	0.896	28.0	101.1	85.3	2.20	0.942	0.188
Arithmetic mean*	31	7.97	0.338	10.6	60.2	49.7	1.06	0.487	0.067
Standard dev	9	7.79	0.225	7.0	21.3	21.2	0.52	0.230	0.046

507-01	24	0.09	1.472	46.0	0.9	-45.1	0.95	2.750	0.084
507-01	21	4.17	0.220	6.9	41.7	34.8	1.09	0.551	0.024
507-02	27	1.13	0.843	26.3	11.3	-15.0	2.04	0.919	0.141
507-02	32	7.58	0.351	11.0	75.8	64.8	0.76	0.652	0.091
507-09	37	6.09	0.074	2.3	60.9	58.6	1.62	0.348	0.018
Minimum	21	0.09	0.074	2.3	0.9	-45.1	0.76	0.348	0.018
Maximum	37	7.58	1.472	46.0	75.8	64.8	2.04	2.750	0.141
Arithmetic mean*	28	3.81	0.592	18.5	38.1	19.6	1.29	1.044	0.072
Standard dev	6	2.85	0.510	15.9	28.5	42.9	0.47	0.873	0.046

Table 17.E-5 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I7

Drill hole	Interburden layer	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
407-32	I7	8.2	2.5	35.4	2.77	1.43	22.49	15.5	59	26
407-33	I7	9.0	2.0	61.4	0.15	0.07	17.51	52.1	31	45
407-34	I7	8.9	2.0	78.4	0.23	0.13	20.08	47.0	25	51
407-38	I7	9.0	1.4	61.6	0.16	0.08	13.84	39.6	20	52
407-41	I7	8.9	2.4	35.6	0.28	0.13	21.73	48.2	57	32
407-43	I7	8.8	1.9	71.9	0.30	0.14	19.55	41.8	30	49
407-44	I7	8.9	1.8	47.0	0.22	0.11	16.10	39.7	47	37
498-01	I7	7.3	4.1	34.9	10.55	27.83	15.00	3.4	41	31
498-03	I7	7.4	4.7	46.4	21.80	14.24	27.00	6.4	26	39
498-04	I7	7.5	2.8	46.3	6.40	6.20	19.92	7.9	37	36
498-05	I7	7.2	5.5	49.8	9.54	11.60	45.82	14.1	29	33
498-06	I7	6.9	8.3	41.3	29.36	49.91	33.48	5.3	44	28
498-07	I7	7.8	10.1	53.8	11.63	13.19	97.32	27.6	33	37
498-08	I7	7.2	8.2	45.4	27.53	13.72	57.08	12.6	41	30
498-09	I7	8.4	1.9	47.3	0.55	0.43	23.63	33.9	36	36
498-09	I7-Z	8.8	1.7	83.0	0.55	0.57	19.00	25.4	19	31
498-10	I7	8.5	1.5	47.6	0.33	0.15	17.36	35.6	38	36
498-12	I7	8.4	1.7	67.7	0.67	0.26	20.08	29.5	37	34
Minimum		6.9	1.4	34.9	0.15	0.07	13.84	3.4	19	26
Maximum		9.0	10.1	83.0	29.36	49.91	97.32	52.1	59	52
Arithmetic mean*		-	3.6	53.0	6.83	7.79	28.17	10.4	36	37
Standard dev		-	2.6	14.1	9.55	12.72	19.95		11	7
507-01	I7A	9.3	1.6	95.9	0.17	0.16	15.40	37.9	9	54
507-01	I7B	8.7	2.2	54.7	0.39	0.27	20.52	35.7	30	42
507-02	I7	8.9	2.0	54.4	0.20	0.10	19.53	50.8	33	42
507-04	I7	8.1	4.8	55.4	10.72	5.26	35.90	12.7	14	51
507-05	I7	7.8	3.6	61.7	23.62	2.38	12.80	3.5	20	40
507-06	I7	8.1	7.4	94.8	6.42	2.67	63.40	29.7	5	53
507-09	I7A	8.8	1.6	101.6	0.34	0.10	17.49	37.3	10	58
507-09	I7B	8.4	2.7	67.2	0.65	0.26	29.96	44.6	24	45
Minimum		7.8	1.6	54.4	0.17	0.10	12.80	3.5	5	40
Maximum		9.3	7.4	101.6	23.62	5.26	63.40	50.8	33	58
Arithmetic mean*		-	3.2	73.2	5.31	1.40	26.88	14.7	18	48
Standard dev		-	1.9	19.3	7.82	1.77	15.56		10	6

* Arithmetic mean of the weighted mean values for parameters for each interburden layer except SAR. Arithmetic mean of SAR is calculated from the arithmetic mean values for calcium, magnesium, and sodium.

Table 17.E-5 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I7

Drill hole	Clay (%)	CaCO3 (%)	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
407-32	14	12.95	0.225	7.0	129.5	122.5	0.82	0.676	0.061
407-33	24	16.16	0.542	16.9	161.6	144.7	1.62	0.620	0.092
407-34	23	9.38	0.590	18.4	93.8	75.4	1.28	0.509	0.076
407-38	28	9.32	0.251	7.8	93.2	85.4	1.29	0.487	0.061
407-41	11	5.94	0.067	2.1	59.4	57.3	0.55	0.148	0.029
407-43	22	12.01	0.306	9.6	120.1	110.6	1.44	0.457	0.041
407-44	16	9.16	0.089	2.8	91.6	88.8	1.00	0.083	0.028
498-01	27	11.88	0.329	10.4	138.7	128.3	0.10	0.364	0.034
498-03	35	9.30	0.386	12.2	98.0	85.7	0.42	0.245	0.010
498-04	27	10.82	0.151	4.8	100.1	95.3	0.62	0.277	0.029
498-05	31	9.26	0.296	9.2	95.0	85.9	0.41	0.321	0.050
498-06	28	8.32	0.424	13.1	76.6	63.4	0.54	0.227	0.066
498-07	30	7.17	0.503	15.8	75.8	60.3	2.86	0.040	0.039
498-08	29	6.50	0.768	24.0	65.1	41.0	0.82	1.374	0.035
498-09	29	11.22	0.191	6.0	111.7	105.9	0.56	0.289	0.023
498-09	50	8.80	0.740	23.0	82.0	58.7	0.80	0.500	0.010
498-10	26	10.49	0.177	5.5	130.5	125.1	0.56	0.267	0.015
498-12	28	8.21	0.237	7.4	93.1	85.6	0.79	0.268	0.010
Minimum	11	5.94	0.067	2.1	59.4	41.0	0.10	0.040	0.010
Maximum	50	16.16	0.768	24.0	161.6	144.7	2.86	1.374	0.092
Arithmetic mean*	27	9.83	0.348	10.9	100.9	90.0	0.91	0.397	0.039
Standard dev	8	2.39	0.203	6.3	26.0	27.7	0.61	0.291	0.023

507-01	36	11.36	0.268	8.4	113.6	105.2	1.25	0.619	0.088
507-01	28	10.11	0.530	16.6	101.1	84.5	1.74	0.657	0.049
507-02	25	19.35	0.504	15.7	193.5	177.8	1.48	0.400	0.054
507-04	30	0.00	0.000	0.0	0.0	68.7	3.28	1.193	0.213
507-05	40	0.49	0.223	7.0	4.9	-2.0	1.56	0.977	0.040
507-06	42	4.74	0.383	12.0	47.4	35.4	0.92	0.772	0.105
507-09	32	1.55	0.448	14.0	15.5	1.5	1.07	0.428	0.079
507-09	31	14.71	0.522	16.3	147.1	130.8	1.43	0.430	0.045
Minimum	25	0.00	0.000	0.0	0.0	-2.0	0.92	0.400	0.040
Maximum	42	19.35	0.530	16.6	193.5	177.8	3.28	1.193	0.213
Arithmetic mean*	33	7.79	0.360	11.2	77.9	75.2	1.59	0.684	0.084
Standard dev	5	6.73	0.174	5.4	67.3	58.8	0.69	0.267	0.053

Table 17.E-6 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I6

Drill hole	Interburden layer	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
407-32	I6	9.1	1.5	95.9	0.19	0.19	18.39	42.3	8	57
407-33	I6	9.3	1.8	85.0	0.13	0.05	15.31	51.2	6	60
407-34	I6	8.9	1.2	94.9	0.20	0.12	12.22	30.6	15	55
407-38	I6A	9.0	1.2	110.3	0.11	0.12	12.18	35.9	19	43
407-38	I6B	9.0	1.3	80.0	0.13	0.05	12.77	42.9	19	51
407-41	I6A	8.7	2.4	97.1	0.26	0.10	21.31	50.0	15	45
407-41	I6B	9.2	2.0	96.8	0.19	0.06	18.15	50.5	14	58
407-43	I6	8.9	2.8	90.6	0.23	0.09	27.62	68.5	13	56
407-44	I6	9.2	1.4	72.2	0.13	0.08	13.72	42.1	9	59
498-01	I6B	4.0	12.4	66.4	20.00	61.05	88.64	13.9	17	33
498-03	I6	5.1	12.3	50.1	20.55	38.30	91.24	16.8	21	32
498-04	I6	9.0	1.5	139.0	0.28	0.16	17.00	19.3	13	45
498-05	I6	8.7	2.0	104.0	0.55	0.42	24.00	35.0	13	42
498-06	I6	4.8	10.5	80.0	22.00	37.00	50.00	9.2	22	38
498-07	I6	9.0	1.3	124.0	0.37	0.16	21.60	41.9	16	42
498-08	I6	9.0	1.7	110.0	0.42	0.32	20.00	32.0	15	44
498-09	I6B	8.9	1.4	102.0	0.27	0.23	16.00	32.0	17	45
498-10	I6A	9.0	1.3	115.0	0.47	0.52	14.67	20.9	13	44
498-10	I6B	9.1	1.0	113.4	0.24	0.37	13.00	23.4	13	52
498-12	I6A	9.0	1.3	120.0	0.48	0.72	14.00	19.0	13	36
498-12	I6B	8.7	1.5	95.1	0.51	0.33	17.08	26.3	22	41
Minimum		4.0	1.0	50.1	0.11	0.05	12.18	9.2	6	32
Maximum		9.3	12.4	139.0	22.00	61.05	91.24	68.5	22	60
Arithmetic mean*		-	3.0	97.2	3.22	6.69	25.66	11.5	15	47
Standard dev		-	3.6	20.2	7.20	16.37	22.34		4	8

Drill hole	Interburden layer	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
507-01	I6	9.3	1.9	100.7	0.15	0.07	18.53	56.4	1	55
507-02	I6	9.2	1.3	101.7	0.10	0.05	13.02	48.7	10	55
507-04	I6	9.1	2.0	107.9	0.18	0.09	20.25	54.6	7	54
507-05	I6	8.2	6.8	54.9	16.94	7.37	49.02	14.1	21	46
507-06	I6	6.6	3.1	68.8	0.38	0.13	28.71	57.1	32	41
507-07	I6A	9.2	1.2	98.2	0.15	0.06	12.74	39.8	5	64
507-07	I6B	7.7	1.3	75.9	0.19	0.07	12.80	35.4	13	47
507-07	I6-Z	7.9	8.0	84.2	7.50	2.99	74.29	32.4	18	49
507-09	I6	8.6	2.7	86.8	0.55	0.17	28.51	47.3	37	39
Minimum		6.6	1.2	54.9	0.10	0.05	12.74	14.1	1	39
Maximum		9.3	8.0	107.9	16.94	7.37	74.29	57.1	37	64
Arithmetic mean*		-	3.2	86.6	2.90	1.22	28.65	20.0	16	50
Standard dev		-	2.4	16.5	5.45	2.35	19.49		12	7

Table 17.E-6 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I6

Drill hole	Clay (%)	CaCO3 (%)	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
407-32	35	0.55	0.883	27.6	5.5	-22.1	1.91	0.839	0.198
407-33	34	0.64	1.125	35.1	6.4	-28.8	1.90	1.000	0.210
407-34	30	0.66	1.423	44.5	6.6	-37.8	1.95	0.875	0.195
407-38	38	0.53	0.566	17.7	5.3	-12.4	1.42	1.342	0.225
407-38	31	4.08	1.016	31.7	40.8	9.1	1.78	0.964	0.128
407-41	40	0.44	0.904	28.2	4.4	-23.8	1.35	1.125	0.225
407-41	29	4.63	1.087	34.0	46.3	12.4	1.59	0.816	0.100
407-43	31	1.34	1.073	33.5	13.4	-20.2	2.00	0.900	0.063
407-44	32	1.86	0.845	26.4	18.6	-7.8	1.42	0.330	0.086
498-01	51	0.00	0.623	19.5	0.5	-19.2	0.30	0.450	0.035
498-03	46	0.57	0.608	18.8	5.2	-13.6	0.65	0.621	0.035
498-04	42	1.10	0.910	28.0	13.0	-15.9	1.20	0.650	0.010
498-05	45	1.20	1.260	39.0	9.0	-30.2	0.90	0.650	0.010
498-06	40	0.61	0.380	12.0	7.0	-5.3	0.90	0.450	0.360
498-07	42	1.64	0.660	20.6	15.8	-5.1	1.02	0.013	0.010
498-08	41	1.50	0.600	19.0	18.0	-1.2	1.30	0.700	0.010
498-09	38	3.40	0.400	13.0	33.0	20.8	1.00	0.450	0.010
498-10	43	4.33	0.283	8.9	46.0	37.0	1.67	0.450	0.037
498-10	35	1.72	0.256	8.0	13.6	6.0	1.20	0.341	0.014
498-12	51	0.93	0.200	6.3	10.0	3.8	1.50	0.400	0.000
498-12	37	3.66	0.386	12.2	36.4	24.3	1.12	0.331	0.010
Minimum	29	0.00	0.200	6.3	0.5	-37.8	0.30	0.013	0.000
Maximum	51	4.63	1.423	44.5	46.3	37.0	2.00	1.342	0.360
Arithmetic mean*	39	1.69	0.738	23.0	16.9	-6.2	1.34	0.652	0.094
Standard dev	6	1.40	0.343	10.6	14.2	19.0	0.44	0.311	0.100
507-01	44	0.18	0.441	13.8	1.8	-11.9	1.30	0.775	0.119
507-02	34	2.73	0.192	6.0	27.3	21.3	1.43	0.394	0.104
507-04	39	5.77	0.388	12.1	57.7	45.6	1.48	0.603	0.077
507-05	33	14.03	0.486	15.2	140.3	125.2	1.91	0.860	0.050
507-06	27	9.13	0.572	17.9	91.3	73.4	1.06	0.517	0.053
507-07	31	1.54	0.320	10.0	15.4	5.4	0.90	0.474	0.071
507-07	25	6.39	0.238	7.4	63.9	56.5	0.77	0.328	0.052
507-07	33	5.22	0.257	8.0	52.2	44.1	0.59	0.505	0.087
507-09	24	4.24	0.288	9.0	42.4	33.3	1.06	0.258	0.046
Minimum	24	0.18	0.192	6.0	1.8	-11.9	0.59	0.258	0.046
Maximum	44	14.03	0.572	17.9	140.3	125.2	1.91	0.860	0.119
Arithmetic mean*	32	5.47	0.353	11.0	54.7	43.7	1.17	0.524	0.073
Standard dev	6	3.95	0.119	3.7	39.5	37.8	0.38	0.186	0.024

Table 17.E-7 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I4

Drill hole	Interburden layer	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
407-32	I4	9.3	1.1	79.1	0.18	0.20	11.49	26.4	50	32
407-33	I4	9.2	1.5	61.3	0.14	0.08	12.64	37.5	42	40
407-34	I4	9.0	1.1	111.8	0.14	0.07	11.11	35.0	12	55
407-38	I4B	9.3	1.0	105.1	0.13	0.12	10.62	30.0	22	48
407-41	I4B	9.3	1.3	91.1	0.12	0.07	12.23	40.0	17	53
407-43	I4B	9.2	1.3	83.9	0.13	0.06	12.43	39.5	18	52
407-44	I4B	9.2	1.2	95.3	0.12	0.06	11.80	39.3	16	55
498-01	I4A	9.6	0.9	262.0	0.50	0.38	13.00	19.6	33	32
498-01	I4B	9.4	0.7	151.4	0.40	0.28	7.56	13.0	56	24
498-03	I4A	10.0	0.7	353.0	0.26	0.12	7.80	18.0	20	30
498-03	I4B	8.7	0.9	131.1	0.44	0.20	11.00	19.4	24	41
498-04	I4A	9.1	1.2	122.8	0.30	0.15	15.30	31.9	20	46
498-04	I4B	9.3	1.3	125.1	0.33	0.22	15.00	28.5	18	42
498-05	I4	9.2	1.0	125.5	0.33	0.38	14.47	24.4	23	42
498-06	I4	8.1	4.7	94.0	3.16	1.51	51.21	33.5	27	39
498-07	I4B/4A	9.1	1.2	105.0	0.50	0.53	14.84	20.7	27	36
498-08	I4B	9.1	1.5	90.9	0.45	0.39	16.54	25.4	38	32
498-09	I4B	9.2	1.3	105.1	0.24	0.75	12.77	18.2	28	34
498-10	I4B	8.9	0.9	111.5	0.17	0.23	11.54	25.9	20	43
498-12	I4B/4A	9.0	1.0	101.6	0.44	0.53	11.81	16.9	26	41
Minimum		8.1	0.7	61.3	0.12	0.06	7.56	13.0	12	24
Maximum		10.0	4.7	353.0	3.16	1.51	51.21	40.0	56	55
Arithmetic mean*		-	1.3	125.3	0.42	0.32	14.26	23.4	27	41
Standard dev		-	0.8	65.4	0.64	0.33	8.76		11	9
507-01	I4	9.3	2.3	61.0	0.22	0.08	22.34	57.2	33	44
507-02	I4A	9.5	1.4	109.8	0.14	0.07	11.79	35.6	8	65
507-02	I4B	9.3	2.0	170.0	0.14	0.07	20.31	63.4	10	53
507-03	I4	7.8	4.1	60.2	24.95	12.09	13.30	3.1	12	45
507-04	I4	9.2	2.0	95.8	0.18	0.09	20.01	55.1	22	50
507-05	I4B	9.1	2.3	96.4	0.65	0.19	21.08	32.5	31	43
507-06	I4A	9.2	1.3	60.6	0.15	0.08	11.70	34.2	47	35
507-06	I4B	9.2	1.9	107.6	0.12	0.07	17.82	57.7	15	53
507-07	I4A	9.5	0.9	71.1	0.17	0.11	9.48	25.3	40	26
507-07	I4B	9.2	1.1	110.0	0.18	0.08	11.92	33.4	12	59
507-08	I4B	8.4	5.5	100.6	6.68	4.69	47.94	20.1	23	50
507-09	I4A	8.9	1.1	102.9	0.26	0.09	12.21	29.1	15	52
Minimum		7.8	0.9	60.2	0.12	0.07	9.48	3.1	8	26
Maximum		9.5	5.5	170.0	24.95	12.09	47.94	63.4	47	65
Arithmetic mean*		-	2.2	95.5	2.82	1.47	18.32	12.5	22	48
Standard dev		-	1.3	29.5	6.90	3.44	9.90		12	10

* Arithmetic mean of the weighted mean values for parameters for each interburden layer except SAR. Arithmetic mean of SAR is calculated from the arithmetic mean values for calcium, magnesium, and sodium.

Table 17.E-7 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I4

Drill hole	Clay (%)	CaCO3 (%)	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total sulfur (t/kt)	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
407-32	18	7.74	0.096	3.0	77.4	74.4	0.62	0.148	0.029
407-33	19	7.61	0.139	4.3	76.1	71.8	0.96	0.211	0.087
407-34	34	7.11	0.317	9.9	71.1	61.2	1.42	0.394	0.109
407-38	30	5.68	0.349	10.9	56.8	46.0	1.62	0.578	0.099
407-41	30	7.12	0.222	6.9	71.2	64.3	1.39	0.399	0.075
407-43	31	8.69	0.397	12.4	86.9	74.5	1.50	0.504	0.070
407-44	29	7.55	0.287	9.0	75.5	66.5	1.30	0.292	0.060
498-01	35	2.40	0.050	1.6	20.0	18.7	0.60	0.900	0.080
498-01	21	4.15	0.064	2.0	44.4	42.2	0.14	0.077	0.016
498-03	50	2.00	0.030	0.9	21.0	20.5	2.50	0.650	0.090
498-03	35	6.43	0.176	5.5	71.9	66.5	0.91	0.317	0.047
498-04	34	8.88	0.150	4.7	67.4	62.8	1.03	0.321	0.047
498-04	40	1.33	0.180	5.6	12.6	7.3	1.16	0.366	0.054
498-05	35	5.50	0.194	6.1	52.4	46.3	1.24	0.274	0.085
498-06	34	4.50	0.091	2.9	44.8	41.9	0.26	0.198	0.049
498-07	37	5.17	0.195	6.1	50.0	44.2	0.78	0.103	0.041
498-08	30	3.84	0.204	6.5	35.8	29.5	0.76	0.299	0.062
498-09	37	5.05	0.169	5.3	57.5	52.3	1.07	0.247	0.070
498-10	37	5.63	0.089	2.8	53.3	50.5	1.25	0.269	0.039
498-12	33	6.42	0.246	7.8	66.5	58.9	1.13	0.378	0.066
Minimum	18	1.33	0.030	0.9	12.6	7.3	0.14	0.077	0.016
Maximum	50	8.88	0.397	12.4	86.9	74.5	2.50	0.900	0.109
Arithmetic mean*	32	5.64	0.182	5.7	55.6	50.0	1.08	0.346	0.064
Standard dev	7	2.09	0.098	3.1	20.3	18.8	0.50	0.190	0.023

507-01	23	5.31	0.115	3.6	53.1	49.5	0.94	0.321	0.036
507-02	28	0.84	0.505	15.8	8.4	-7.4	2.25	1.175	0.270
507-02	38	1.14	0.378	11.8	11.4	-0.5	2.35	0.675	0.129
507-03	43	5.13	0.334	10.4	51.3	40.9	2.64	0.596	0.143
507-04	28	4.79	0.098	3.1	47.9	44.8	1.23	0.443	0.060
507-05	26	4.15	0.119	3.7	41.5	37.8	0.88	0.341	0.042
507-06	17	6.54	0.051	1.6	65.4	63.8	0.73	0.200	0.049
507-06	32	1.15	0.323	10.1	11.5	1.4	1.29	0.595	0.112
507-07	34	2.98	0.511	16.0	29.8	13.9	1.35	1.225	0.065
507-07	28	11.74	0.059	1.9	117.4	115.5	0.87	0.206	0.026
507-08	27	8.63	0.259	8.1	86.3	78.2	1.79	0.664	0.058
507-09	33	12.14	0.107	3.4	121.4	118.1	1.23	0.299	0.038
Minimum	17	0.84	0.051	1.6	8.4	-7.4	0.73	0.200	0.026
Maximum	43	12.14	0.511	16.0	121.4	118.1	2.64	1.225	0.270
Arithmetic mean*	30	5.38	0.238	7.4	53.8	46.3	1.46	0.562	0.086
Standard dev	6	3.68	0.162	5.1	36.8	40.3	0.62	0.328	0.067

Table 17.E-8 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I3

Drill hole	Interburden layer	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
407-32	I3	9.6	0.8	109.2	0.08	0.05	9.16	35.6	19	48
407-33	I3	9.4	1.0	96.2	0.13	0.21	8.50	20.5	27	39
407-34	I3	9.4	1.1	99.8	0.12	0.10	11.28	34.1	20	49
407-38	I3	9.2	1.8	111.5	0.17	0.14	17.86	45.8	13	57
407-41	I3	9.4	1.8	104.7	0.17	0.08	16.62	46.9	10	61
407-41	I3-Z	9.6	1.2	138.0	0.08	0.04	11.09	44.5	25	51
407-43	I3	9.3	1.2	100.7	0.10	0.12	11.61	34.9	11	62
407-44	I3	9.3	1.9	100.1	0.15	0.07	17.48	53.7	13	59
498-01	I3A	9.4	1.0	77.1	0.46	0.58	12.58	17.4	40	33
498-01	I3B	9.5	0.9	154.4	0.40	0.64	11.47	15.9	21	34
498-01	P3B	8.6	1.0	71.0	0.20	0.11	13.00	33.0	63	24
498-03	I3B/3A	9.6	0.7	138.0	0.51	0.23	8.30	13.6	20	35
498-04	I3A	9.1	1.0	112.0	0.26	0.17	12.00	26.2	27	41
498-04	I3B	9.1	1.1	130.8	0.25	0.29	11.74	22.6	21	42
498-05	I3	9.3	1.1	134.2	0.45	0.66	14.48	19.4	21	41
498-06	I3A	9.2	1.0	104.0	0.62	1.10	13.00	14.0	30	38
498-06	I3B	7.9	5.8	123.7	7.49	3.80	57.27	24.1	26	43
498-07	I3	9.1	1.4	128.0	0.38	0.47	16.00	24.0	21	41
498-08	I3	9.6	1.2	118.0	0.44	0.88	14.00	17.0	29	28
498-10	I3C	9.2	1.3	127.0	0.14	0.08	15.00	45.0	20	43
498-12	I3	9.4	1.3	115.2	0.38	0.41	15.07	24.0	27	33
Minimum		7.9	0.7	71.0	0.08	0.04	8.30	13.6	10	24
Maximum		9.6	5.8	154.4	7.49	3.80	57.27	53.7	63	62
Arithmetic mean*		-	1.4	114.0	0.62	0.49	15.12	20.3	24	43
Standard dev		-	1.0	19.8	1.54	0.80	9.79		11	10

507-02	I3A	9.3	1.2	70.9	0.06	0.07	10.40	40.7	18	50
507-02	I3B	9.2	1.2	57.0	0.09	0.08	13.29	45.4	29	45
507-03	I3	9.1	1.7	78.3	0.18	0.09	16.80	45.5	26	47
507-04	I3	8.8	1.8	78.0	0.22	0.09	18.04	46.0	11	57
507-05	I3	9.0	1.3	110.2	0.19	0.08	11.74	32.2	5	48
507-06	I3A	9.4	1.2	82.1	0.10	0.05	11.22	40.4	25	47
507-06	I3B	9.2	1.4	126.3	0.11	0.06	13.69	47.2	26	47
507-07	I3	9.3	1.7	56.3	0.21	0.12	17.69	43.7	12	57
507-08	I3	9.1	1.8	113.3	0.20	0.07	17.75	47.5	28	39
507-09	I3	8.9	1.2	120.1	0.25	0.16	12.72	28.2	10	54
Minimum		8.8	1.2	56.3	0.06	0.05	10.40	28.2	5	39
Maximum		9.4	1.8	126.3	0.25	0.16	18.04	47.5	29	57
Arithmetic mean*		-	1.4	89.3	0.16	0.09	14.33	40.7	19	49
Standard dev		-	0.2	24.7	0.06	0.03	2.81		8	5

* Arithmetic mean of the weighted mean values for parameters for each interburden layer except SAR. Arithmetic mean of SAR is calculated from the arithmetic mean values for calcium, magnesium, and sodium.

Table 17.E-8 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I3

Drill hole	Clay (%)	CaCO3 (%)	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
407-32	34	3.06	1.547	48.3	30.6	-17.7	1.61	0.703	0.051
407-33	34	3.56	1.685	52.6	35.6	-17.0	1.60	0.900	0.036
407-34	31	2.62	1.540	48.1	26.2	-21.9	1.87	0.609	0.074
407-38	30	1.38	1.128	35.2	13.8	-21.5	1.57	0.721	0.087
407-41	29	1.35	1.216	38.0	13.5	-24.5	1.48	0.708	0.086
407-41	24	0.89	0.567	17.7	8.9	-8.8	1.56	0.666	0.109
407-43	28	3.58	1.183	36.9	35.8	-1.1	1.77	0.657	0.042
407-44	28	1.86	1.370	42.8	18.6	-24.2	1.65	0.552	0.056
498-01	27	1.28	0.056	1.8	12.9	11.2	0.24	0.333	0.053
498-01	44	4.19	0.584	18.0	40.1	22.0	0.33	0.376	0.008
498-01	13	5.00	0.250	7.8	54.0	46.7	0.30	1.200	0.040
498-03	45	1.30	1.180	37.0	13.0	-23.8	1.20	0.550	0.000
498-04	33	1.65	0.160	5.0	16.5	11.6	1.10	0.675	0.100
498-04	37	2.29	0.962	30.2	21.5	-8.6	1.52	0.584	0.053
498-05	38	2.03	0.813	25.6	17.3	-8.2	1.30	0.491	0.109
498-06	32	1.60	0.280	8.8	14.0	5.7	1.40	0.600	0.120
498-06	31	2.86	1.001	31.4	27.1	-4.2	0.60	0.299	0.010
498-07	38	2.90	1.200	37.0	28.0	-9.6	0.85	0.300	0.000
498-08	43	1.40	1.080	34.0	12.0	-21.8	1.20	0.400	0.010
498-10	37	2.80	0.980	31.0	25.0	-5.7	1.30	0.400	0.030
498-12	40	1.69	1.267	39.5	14.3	-25.6	1.30	0.545	0.010
Minimum	13	0.89	0.056	1.8	8.9	-25.6	0.24	0.299	0.000
Maximum	45	5.00	1.685	52.6	54.0	46.7	1.87	1.200	0.120
Arithmetic mean*	33	2.35	0.955	29.8	22.8	-7.0	1.23	0.584	0.052
Standard dev	7	1.06	0.462	14.4	11.2	17.9	0.48	0.207	0.038

507-02	33	0.94	0.620	19.4	9.4	-10.0	1.75	0.500	0.114
507-02	26	13.65	0.141	4.4	136.5	132.1	1.66	0.424	0.053
507-03	27	0.79	0.090	2.8	7.9	5.0	1.34	0.233	0.041
507-04	32	9.24	0.087	2.7	92.4	89.7	1.49	0.436	0.053
507-05	48	0.38	0.178	5.6	3.8	-1.7	1.94	0.875	0.114
507-06	28	9.79	0.093	2.9	97.9	95.0	1.65	0.355	0.040
507-06	27	1.24	0.701	21.9	12.4	-9.5	2.17	0.978	0.079
507-07	31	2.92	1.464	45.7	29.2	-16.6	1.12	0.623	0.037
507-08	34	1.67	0.317	9.9	16.7	6.8	3.15	1.000	0.090
507-09	36	2.13	1.173	36.6	21.3	-15.3	1.45	0.633	0.054
Minimum	26	0.38	0.087	2.7	3.8	-16.6	1.12	0.233	0.037
Maximum	48	13.65	1.464	45.7	136.5	132.1	3.15	1.000	0.114
Arithmetic mean*	32	4.27	0.487	15.2	42.7	27.5	1.77	0.606	0.067
Standard dev	6	4.52	0.470	14.7	45.2	52.6	0.54	0.254	0.028

Table 17.E-9 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I2

Drill hole	Interburden layer	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
407-32	I2B1	9.3	0.9	115.6	0.08	0.05	10.67	40.7	24	42
407-33	I2	9.3	0.9	82.8	0.12	0.06	11.00	37.0	18	53
407-34	I2	9.3	1.0	95.8	0.08	0.07	9.92	36.1	10	58
407-43	I2B2	9.3	1.0	62.4	0.07	0.04	9.69	40.7	25	51
498-01	I2B	9.6	1.0	143.3	0.47	0.64	12.30	16.5	19	38
498-03	I2B	9.5	0.8	72.4	0.37	0.15	9.81	19.3	57	26
498-04	I2B1/2A	9.4	0.9	152.0	0.20	0.16	11.00	25.9	23	35
498-04	I2B2	9.4	1.0	160.1	0.21	0.22	13.70	29.7	15	37
498-05	I2B1/2A	9.6	1.0	179.0	0.17	0.33	13.00	27.0	18	34
498-05	I2B2	9.3	1.0	63.7	0.30	0.29	13.97	25.7	54	30
498-06	I2B/2A	9.3	1.4	132.0	0.38	0.41	17.00	27.0	28	24
498-07	I2B1/2A	9.4	1.3	126.0	0.24	0.39	16.00	29.0	14	50
498-07	I2B2	9.3	1.2	109.2	0.36	0.71	14.26	19.5	20	45
498-08	I2B	9.6	1.4	110.6	0.36	0.42	16.58	26.5	32	38
498-09	I2B	9.4	1.1	93.7	0.43	0.46	13.69	20.5	23	44
498-10	I2	9.3	1.2	137.5	0.09	0.14	15.49	45.8	16	43
498-12	I2	9.3	1.4	71.6	0.25	0.16	16.51	36.6	34	41
Minimum		9.3	0.8	62.4	0.07	0.04	9.69	16.5	10	24
Maximum		9.6	1.4	179.0	0.47	0.71	17.00	45.8	57	58
Arithmetic mean*		-	1.1	112.2	0.25	0.28	13.21	25.8	25	40
Standard dev		-	0.2	34.4	0.13	0.20	2.47		13	9
507-01	I2	9.0	2.7	61.9	0.58	0.22	25.71	40.6	45	33
507-02	I2A	8.9	1.1	121.9	0.08	0.03	10.57	43.6	6	56
507-02	I2B	8.9	1.4	64.7	0.14	0.09	13.53	40.4	34	39
507-03	I2	8.9	2.2	66.4	2.21	0.34	20.06	17.8	53	29
507-04	I2	8.7	1.8	79.4	0.33	0.12	16.98	35.5	13	52
507-05	I2	8.8	1.9	79.9	0.47	0.12	17.64	32.3	10	49
507-06	I2A	9.3	1.3	121.4	0.08	0.04	12.48	49.7	8	55
507-06	I2B	9.4	1.2	82.1	0.10	0.05	11.22	40.4	25	47
507-06	I2-Z	9.2	1.0	79.3	0.11	0.06	10.40	35.9	8	58
507-07	I2	9.6	1.8	105.3	0.14	0.05	18.94	61.6	8	56
507-08	I2	9.0	2.8	78.9	0.50	0.17	26.80	46.1	33	40
507-09	I2	9.2	1.3	125.5	0.22	0.09	13.17	33.8	6	52
Minimum		8.7	1.0	61.9	0.08	0.03	10.40	17.8	6	29
Maximum		9.6	2.8	125.5	2.21	0.34	26.80	61.6	53	58
Arithmetic mean*		-	1.7	88.9	0.41	0.12	16.46	32.0	21	47
Standard dev		-	0.6	22.3	0.57	0.09	5.38		16	9

* Arithmetic mean of the weighted mean values for parameters for each interburden layer except SAR. Arithmetic mean of SAR is calculated from the arithmetic mean values for calcium, magnesium, and sodium.

Table 17.E-9 Weighted Mean of Physical and Chemical Properties by Interburden Layer for I2

Drill hole	Clay (%)	CaCO3 (%)	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total sulfur (t/kt)	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
407-32	34	0.93	0.496	15.5	9.3	-6.2	2.33	1.013	0.189
407-33	30	0.58	0.208	6.5	5.8	-0.7	1.35	0.700	0.017
407-34	33	0.66	0.141	4.4	6.6	2.2	1.20	0.550	0.210
407-43	24	3.56	0.095	3.0	35.6	32.6	1.58	0.241	0.049
498-01	43	1.15	0.333	10.4	12.5	2.2	0.60	0.575	0.008
498-03	17	3.12	0.051	1.6	29.7	28.1	0.61	0.139	0.028
498-04	42	1.30	0.260	8.1	12.0	3.5	2.10	0.600	0.140
498-04	48	0.98	0.415	13.3	8.3	-4.6	1.95	0.591	0.016
498-05	48	1.20	0.260	8.1	12.0	3.9	2.60	0.500	0.450
498-05	16	2.42	0.034	1.1	23.6	22.5	0.65	0.013	0.036
498-06	48	1.00	0.680	21.0	8.0	-13.2	1.50	0.700	0.010
498-07	36	1.30	0.150	4.7	12.0	7.4	1.10	0.250	0.040
498-07	35	4.22	0.087	2.8	41.4	38.6	0.94	0.094	0.047
498-08	30	2.62	0.048	1.5	24.7	23.2	1.17	0.232	0.077
498-09	34	4.91	0.051	1.6	48.1	46.5	1.49	0.146	0.104
498-10	41	1.50	0.356	11.2	12.5	1.3	2.10	0.499	0.065
498-12	25	4.60	0.034	1.1	43.7	43.0	1.11	0.166	0.050
Minimum	16	0.58	0.034	1.1	5.8	-13.2	0.60	0.013	0.008
Maximum	48	4.91	0.680	21.0	48.1	46.5	2.60	1.013	0.450
Arithmetic mean*	34	2.12	0.218	6.8	20.3	13.6	1.43	0.412	0.090
Standard dev	10	1.41	0.182	5.7	13.8	18.2	0.59	0.267	0.107

507-01	22	4.97	0.158	4.9	49.7	44.8	1.12	0.326	0.051
507-02	38	0.54	0.368	11.5	5.4	-6.1	2.00	0.725	0.093
507-02	27	5.56	0.275	8.6	55.6	47.0	1.93	0.512	0.055
507-03	18	7.65	0.113	3.5	76.5	73.0	0.71	0.100	0.017
507-04	35	7.08	0.172	5.4	70.8	65.4	1.73	0.577	0.053
507-05	41	11.70	0.392	12.3	117.0	104.7	1.48	0.604	0.059
507-06	38	0.68	0.507	15.8	6.8	-9.1	2.15	0.925	0.140
507-06	28	9.79	0.093	2.9	97.9	95.0	1.65	0.355	0.040
507-06	35	0.58	0.031	1.0	5.8	4.9	1.55	0.425	0.060
507-07	36	2.14	0.344	10.7	21.4	10.7	1.32	0.425	0.074
507-08	26	9.11	0.153	4.8	91.1	86.3	1.61	0.228	0.040
507-09	43	0.99	0.403	12.6	9.9	-2.7	1.98	0.613	0.129
Minimum	18	0.54	0.031	1.0	5.4	-9.1	0.71	0.100	0.017
Maximum	43	11.70	0.507	15.8	117.0	104.7	2.15	0.925	0.140
Arithmetic mean*	32	5.07	0.251	7.8	50.7	42.8	1.60	0.485	0.068
Standard dev	7	3.86	0.144	4.5	38.6	40.3	0.39	0.215	0.035

Interburden name	Sample ID	Date sampled	Thickness (ft)	OB core thickness (ft)	Sample of OB core (%)	Rock type	pH (s.u.)	Total Sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total sulfur (t/kt)	Sulfate (%)	Organic sulfur (%)	Pyritic sulfur (%)	Acid-base pyritic sulfur (t/kt)	Acid-base potential pyritic sulfur (t/kt)
I8A	507-01 S-1092	10/4/2007	2.0	111.6	1.8%	CSH/CO/ASH	8.14	1.472	46.0	0.85	-45.1	0.194	0.621	0.657	20.5	-19.7
I8A	507-02 S-1129	10/6/2007	1.1	117.1	0.9%	CSH	8.17	0.636	19.9	4.79	-15.1	0.136	0.500	0.000	0.00	4.79
I8A	507-02 S-1131	10/6/2007	4.0	117.1	3.4%	SH	8.42	1.231	38.5	13.3	-25.1	0.045	0.322	0.864	27.0	-13.7
I8A	507-02 S-1131A	10/6/2007	0.9	117.1	0.8%	CSH/CO	8.20	1.915	59.8	9.38	-50.4	0.830	0.716	0.369	11.5	-2.15
Average			2.0		1.7%						-33.9					-7.7
Minimum			0.9		0.8%						-50.4					-19.7
Maximum			4.0		3.4%						-15.1					4.8
I6	498-03 #03	4/5/1998	4.7	81.0	5.8%	SH	6.6	0.84	26	0	-26.2	0.8	0.05	0.01	0.3	-0.3
I6	498-04 #12	4/9/1998	4.1	87.2	4.7%	SH	9.0	0.91	28	13	-15.9	0	0.08	0.86	26.9	-14.3
I6	498-06 #14	4/17/1998	4.1	110.8	3.7%	SH	4.8	0.38	12	7	-5.3	0.3	0.06	0.07	2.2	4.4
I6	407-32 S-546	4/14/2007	0.85	113.8	0.7%	CSH	8.65	1.686	52.7	6.38	-46.3	0.015	0.566	1.105	34.5	-28.1
I6	407-32 S-547	4/14/2007	3.15	113.8	2.8%	SH/ST	9.26	0.666	20.8	5.26	-15.6	<0.001	0.176	0.510	15.9	-10.7
I6	407-33 S-606	4/16/2007	3.9	190.3	2.0%	SH	9.29	1.125	35.1	6.38	-28.8	0.101	0.192	0.832	26.0	-19.6
I6	407-34 S-669	4/18/2007	2.9	185.8	1.6%	CSH/SH	8.87	1.423	44.5	6.63	-37.8	0.029	0.220	1.175	36.7	-30.1
I6	407-43 S-789	5/9/2007	4.08	100.8	4.0%	CSH/SH/CO	8.88	1.073	33.5	13.4	-20.2	<0.001	0.232	0.86	26.9	-13.5
I6	407-44 S-828	5/10/2007	2	112.0	1.8%	CSH	9.18	0.981	30.6	11.6	-19.1	<0.001	0.250	0.743	23.2	-11.6
I6	407-44 S-830	5/10/2007	1.4	112.0	1.2%	CSH	9.31	1.346	42.0	6.35	-35.7	<0.001	0.152	1.270	39.7	-33.3
I6B	498-01 #04	4/2/1998	2.8	77.3	3.6%	SH	3.9	0.54	17	0	-16.9	0.5	0.06	0.01	0.3	-0.3
I6B	498-01 #05	4/2/1998	2.7	77.3	3.5%	SH	4.1	0.71	22	1	-21.5	0.6	0.02	0.07	2.2	-1.5
I6A	407-38 S-712	4/28/2007	0.6	151.0	0.4%	CSH	8.57	0.501	15.6	6.63	-9.00	0.044	0.417	0.040	1.25	5.38
I6A	407-38 S-713	4/28/2007	2.5	151.0	1.7%	SH	9.14	0.447	14.0	4.39	-9.58	<0.001	0.105	0.382	11.9	-7.54
I6A	407-38 S-714	4/28/2007	1.15	151.0	0.8%	CSH	8.79	0.860	26.9	6.63	-20.2	0.009	0.019	0.832	26.0	-19.4
I6A	407-41 S-758	5/2/2007	3.0	157.4	1.9%	SH/CSH	8.65	0.904	28.2	4.39	-23.8	<0.001	0.258	0.682	21.3	-16.9
I6	507-01 S-1105	10/4/2007	3.5	111.6	3.1%	SH/CSH	9.29	0.441	13.8	1.84	-11.9	0.002	0.095	0.345	10.8	-8.94
Average			2.8		2.6%						-21.4					-12.1
Minimum			0.6		0.4%						-46.3					-33.3
Maximum			4.7		5.8%						-5.3					5.4
I4A	507-02 S-1144	10/6/2007	2.8	117.1	2.4%	CSH	9.51	0.505	15.8	8.40	-7.38	0.051	0.141	0.313	9.78	-1.38
I3	498-08 #12	4/18/1998	3.2	76.8	4.2%	SH	9.6	1.08	34	12	-21.8	0	0.08	1.1	34.4	-22.4
I3	498-07 #14	4/17/1998	5.4	67.5	8.0%	SH	9.1	1.2	37	28	-9.6	0	0.13	1.1	0	27.9
I3	498-05 #14	4/13/1998	3.6	67.5	5.3%	SH	9.4	0.64	20	14	-6.4	0	0.07	0.67	20.9	-7.4
I3	498-05 #15	4/13/1998	2.1	67.5	3.1%	SH	9.4	1.56	49	13	-35.9	0	0.14	1.58	49.4	-36.6
I3	498-12 #21	4/25/1998	2.7	89.4	3.0%	SH	9.4	0.97	30	16	-14.6	0	0.09	0.9	28.1	-12.4
I3	498-12 #25	4/25/1998	1.9	89.4	2.1%	SH	9.5	1.69	53	12	-41.2	0	0.15	1.53	47.8	-36.2
I3	407-32 S-561	4/14/2007	2.7	113.8	2.4%	SH	9.99	1.632	51.0	13.1	-37.9	<0.001	0.220	1.479	46.2	-33.1
I3	407-32 S-562	4/14/2007	4	113.8	3.5%	SH	9.54	1.690	52.8	19.8	-33.0	0.060	0.183	1.447	45.2	-25.4
I3	407-32 S-563	4/14/2007	2.45	113.8	2.2%	SH	9.58	1.530	47.8	19.8	-28.0	<0.001	0.186	1.425	44.5	-24.7
I3	407-32 S-564	4/14/2007	0.9	113.8	0.8%	CSH	8.81	2.643	82.6	5.26	-77.3	<0.001	0.416	2.457	76.8	-71.5
I3	407-33 S-619	4/16/2007	5.3	190.3	2.8%	SH/ASH	9.59	1.807	56.5	24.0	-32.5	0.108	0.183	1.516	47.4	-23.4
I3	407-33 S-620	4/16/2007	4.8	190.3	2.5%	SH	9.39	1.793	56.0	25.1	-30.9	0.112	0.197	1.484	46.4	-21.3
I3	407-33 S-623	4/16/2007	2.3	190.3	1.2%	CSH	9.10	1.961	61.3	7.50	-53.8	0.203	0.329	1.430	44.7	-37.2
I3	407-34 S-676	4/18/2007	4.8	185.8	2.6%	SH/CSH	9.60	1.658	51.8	32.3	-19.5	<0.001	0.227	1.486	46.4	-14.1
I3	407-34 S-677	4/18/2007	3.9	185.8	2.1%	SH	9.52	1.651	51.6	22.2	-29.3	<0.001	0.182	1.506	47.0	-24.8
I3	407-34 S-678	4/18/2007	4.0	185.8	2.2%	SH	9.17	1.205	37.6	29.1	-8.58	<0.001	0.167	1.131	35.3	-6.27
I3	407-34 S-679	4/18/2007	4.4	185.8	2.4%	SH/ST	9.35	1.442	45.0	24.6	-20.5	0.067	0.161	1.214	37.9	-13.3
I3	407-34 S-680	4/18/2007	1.3	185.8	0.7%	CSH	9.17	2.107	65.8	12.2	-53.6	<0.001	0.285	1.944	60.7	-48.5
S4A	407-38 S-721	4/28/2007	1.25	151.0	0.8%	CSH/CO	9.22	0.849	26.5	5.51	-21.0	0.561	0.204	0.084	2.62	2.89
I3	407-38 S-724	4/28/2007	3.65	151.0	2.4%	CSH/SH/CO	8.79	1.353	42.3	8.88	-33.4	0.068	0.348	0.938	29.3	-20.4
I3	407-38 S-725	4/28/2007	4	151.0	2.6%	SH	9.43	1.099	34.3	10.0	-24.3	<0.001	0.154	0.993	31.0	-21.0
I3	407-38 S-726	4/28/2007	1.5	151.0	1.0%	CSH	8.77	2.420	75.6	6.63	-69.0	<0.001	0.316	2.105	65.8	-59.1
Z-S4A-I3	407-41 S-767	5/2/2007	2.6	157.4	1.7%	SH/CO	9.75	0.679	21.2	8.88	-12.3	<0.001	0.124	0.604	18.9	-9.99
I3	407-41 S-769	5/2/2007	3.7	157.4	2.4%	SH/CSH	9.01	1.904	59.5	14.5	-45.0	0.042	0.319	1.543	48.2	-33.7
I3	407-41 S-770	5/2/2007	4.9	157.4	3.1%	SH	9.62	1.257	39.3	12.2	-27.0	<0.001	0.163	1.215	38.0	-25.7
I3	407-41 S-771	5/2/2007	1.5	157.4	0.9%	CSH	8.96	2.577	80.5	7.75	-72.8	<0.001	0.409	2.424	75.7	-68.0
I3	407-44 S-838	5/10/2007	5	122.0	4.1%	SH	9.39	1.532	47.9	13.1	-34.8	0.064	0.209	1.259	39.3	-26.2
I3	407-44 S-839	5/10/2007	5	122.0	4.1%	SH	9.10	1.294	40.4	22.8	-17.6	<0.001	0.161	1.188	37.1	-14.3
I3	407-44 S-840	5/10/2007	5.5	122.0	4.5%	SH	9.33	1.159	36.2	22.1	-14.2	<0.001	0.152	1.072	33.5	-11.4
I3	407-44 S-841	5/10/2007	1.68	122.0	1.4%	CSH	9.12	1.804	56.4	10.8	-45.5	0.310	0.335	1.159	36.2	-25.4
I3C	498-10 #40	4/22/1998	5.1	144.1	3.5%	SH	9.2	0.98	31	25	-5.7	0	0.13	1.01	31.6	-6.6
I3B	498-04 #23	4/9/1998	3.6	87.2	4.1%	SLTS	9.2	1.16	36	18	-18.3	0	0.11	1.17	36.6	-18.7
I3B/3A	498-03 #15	4/5/1998	4.5	81.0	5.6%	SH	9.6	1.18	37	13	-23.8	0	0.14	1.08	33.7	-20.7
I3	507-07 S-1375	10/17/2007	3.8	196.1	2.0%	SH	9.04	1.366	42.7	36.6	-6.10	0.062	1.304	0.000	0.00	36.6
I3	507-07 S-1376	10/17/2007	2.5	196.1	1.2%	SH	9.58	1.618	50.5	17.6	-32.9	0.000	1.469	0.149	4.65	13.0
I3	507-09 S-1443	10/19/2007	3.8	104.1	3.6%	SH	9.04	1.192	37.2	14.0	-23.2	0.012	1.180	0.000	0.00	14.0
I3	507-09 S-1444	10/19/2007	4.1	104.1	3.9%	SH	8.83	1.155	36.1	28.0	-8.04	0.000	1.124	0.031	0.97	27.1
I3B	507-06 S-1308	10/16/2007	1.8	147.5	1.2%	BNCO	9.06	0.226	7.06	5.05	-2.01	0.044	0.158	0.024	0.75	4.30
I3B	507-06 S-1309	10/16/2007	1.0	147.5	0.7%	CSH	8.74	0.564	17.6	4.06	-13.6	0.002	0.329	0.233	7.28	-3.22

Table 17.E-5 Summary of Sulfur Analysis for Interburden Samples with Total Sulfur Acid-Base Potential Values Less Than Zero t/kt.

Interburden name	Sample ID	Date sampled	Thickness (ft)	OB core thickness (ft)	Sample of OB core (%)	Rock type	pH (s.u.)	Total Sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total sulfur (t/kt)	Sulfate (%)	Organic sulfur (%)	Pyritic sulfur (%)	Acid-base pyritic sulfur (t/kt)	Acid-base potential pyritic sulfur (t/kt)
I3B	507-06 S-1310	10/16/2007	4.2	147.5	2.8%	SH	9.34	0.941	29.4	17.6	-11.8	0.000	0.155	0.786	24.6	-6.98
I3A	507-02 S-1148	10/6/2007	2.1	117.1	1.8%	ST/SH	9.32	0.620	19.4	9.38	-9.99	0.053	0.192	0.375	11.7	-2.33
Average			3.3		2.7%						-27.5					-17.2
Minimum			0.9		0.7%						-77.3					-71.5
Maximum			5.5		8.0%						-2.0					36.6
I2B/2A	498-06 #30	4/17/1998	1.8	110.8	1.6%	SH	9.3	0.68	21	8	-13.2	0	0.11	0.58	18.1	-10.1
S2B2	407-32 S-567	4/14/2007	0.6	113.8	0.5%	CO	8.12	1.416	44.2	6.38	-37.9	<0.001	0.761	1.354	42.3	-35.9
I2B1	407-32 S-568	4/14/2007	1.7	113.8	1.4%	CSH	9.30	0.870	27.2	17.6	-9.58	0.059	0.248	0.563	17.6	0.01
I2A	507-06 S-1322	10/16/2007	2.8	147.5	1.9%	SH	9.25	0.507	15.8	6.75	-9.09	0.000	0.206	0.301	9.40	-2.65
I2A	507-02 S-1158	10/6/2007	2.3	117.1	2.0%	CSH	8.94	0.368	11.5	5.44	-6.06	0.063	0.120	0.185	5.78	-0.34
Average			1.8		1.5%						-15.2					-9.8
Minimum			0.6		0.5%						-37.9					-35.9
Maximum			2.8		2.0%						-6.1					0.0

Table 17.E-11 Summary of Suitable Root Zone Thickness by Drill Hole for Area 4 South and Area 5

Drill hole	Thickness (ft)	Interburden name	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)
498-01	11.5	I7	7.49	3.52	32.2	8.0	20.9	15.4	4.0	44.4	30.4	25.2	12.72
498-03	10.0	I7	4.30	2.45	25.5	11.6	7.2	14.0	4.5	17.6	21.7	19.1	6.07
498-04	22.9	I8A	6.98	2.86	53.7	13.6	5.5	19.3	6.2	48.8	20.0	23.6	7.379
498-05	17.6	I7	7.85	5.63	56.7	9.7	9.0	49.2	16.1	30.6	34.7	34.7	8.962
498-06	42.6	I8	6.92	3.86	42.1	23.0	12.6	8.8	2.1	53.9	24.9	21.2	6.847
498-07	22.8	I7	7.30	11.53	51.7	13.4	14.4	118.3	31.8	31.5	32.5	29.9	5.984
498-08	25.8	I7	7.25	8.07	46.5	30.4	11.7	56.1	12.2	37.8	29.4	21.1	6.257
498-09	23.6	I8A2	6.94	9.30	93.7	16.0	6.9	68.3	20.2	21.3	28.3	50.5	43.898
498-10	28.0	I8B2	7.82	4.40	85.7	9.2	3.1	38.0	15.3	29.9	34.6	35.5	6.589
498-12	42.6	I8A2/8A1	8.18	6.50	36.3	5.3	5.4	50.4	21.8	46.2	32.4	21.4	8.592
407-32	44.6	I7	7.91	2.26	34.0	2.4	1.2	20.7	15.3	58.9	23.6	13.5	11.862
407-33	37.6	I8B	8.26	3.40	83.7	5.7	1.3	26.6	14.3	54.9	25.9	19.2	9.339
407-34	52.3	I8B	6.66	4.54	80	5.6	2.4	39.8	19.9	24.6	37.5	26.8	4.40
407-38	38.4	I8B	8.36	3.07	40	5.5	2.1	26.1	13.5	71.2	11.7	17.1	3.48
407-41	76.7	I8A2/Z	8.23	4.76	56	2.5	1.0	44.3	33.5	29.1	44.2	26.6	3.45
407-43	33.5	I8A	8.10	4.61	59	10.7	3.9	36.7	13.6	23.8	50.0	26.2	4.72
407-44	44.8	I8A2/Z	7.20	9.23	70	8.9	8.9	80.1	26.9	11.8	57.1	31.1	5.26
Minimum thickness	10.0												
Maximum thickness	76.7												
507-01	34.3	I8B	7.53	3.00	45	8.4	6.4	19.0	7.0	54.7	25.8	19.6	4.45
507-02	31.3	I8B	7.90	12.25	69.4	11.3	7.8	104.6	33.9	16.9	54.6	28.5	7.39
507-03	31.8	I4	7.82	4.18	57.2	25.1	11.6	14.8	3.4	15.1	43.0	41.9	7.06
507-04	57.7	I7	8.10	4.68	54.3	10.9	5.3	34.5	12.1	17.5	49.8	28.5	7.878
507-05	20.0	I7	7.87	3.73	59	24.3	2.8	14.0	3.8	23.8	36.3	39.9	1.28
507-06	69.6	I7	8.05	7.81	93	7.1	2.7	66.2	29.9	6.2	52.5	41.3	4.508
507-07	58.8	IZ	7.91	7.76	82	7.5	2.8	72.2	31.8	20.6	46.2	33.3	5.091
507-08	81.7	I4B	8.40	5.73	96	7.6	5.0	49.8	19.8	24.3	49.8	25.9	9.983
507-09	22.0	I8	7.61	4.45	56	10.7	4.9	39.7	14.2	12.1	50.4	37.5	6.452
Minimum thickness	20.0												
Maximum thickness	81.7												
Average thickness	37.8												

Table 17.E-11 Summary of Suitable Root Zone Thickness by Drill Hole for Area 4 South and Area 5

Drill hole	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
498-01	0.197	6.2	149	143	0.09	0.285	0.026
498-03	0.194	6.15	62	56.0	0.21	0.123	0.005
498-04	0.119	3.8	71.0	67.4	0.46	0.058	0.010
498-05	0.566	18.0	88.9	71.4	0.43	0.364	0.041
498-06	0.389	12.2	70.8	58.7	0.51	0.393	0.017
498-07	0.799	25.2	63.0	38.1	2.89	0.157	0.050
498-08	0.676	21.08	62.9	41.7	0.66	1.180	0.033
498-09	0.747	23.3	54.9	31.7	0.52	0.701	0.093
498-10	0.147	4.6	63.3	58.7	0.34	0.246	0.038
498-12	0.061	1.92	84.9	83.1	0.31	0.120	0.036
407-32	0.203	6.33	118.6	112	0.79	0.582	0.055
407-33	0.102	3.20	93.4	90.2	1.09	0.098	0.019
407-34	0.174	5.45	44	38.5	0.95	0.227	0.068
407-38	0.054	1.69	35	33.1	1.43	0.568	0.014
407-41	0.318	9.94	35	24.6	1.51	0.615	0.085
407-43	0.247	7.70	47	39.5	1.03	0.675	0.068
407-44	0.419	13.09	53	37.7	1.51	0.555	0.155
Minimum thickness							
Maximum thickness							
507-01	0.202	6.31	45	38.2	1.10	0.514	0.022
507-02	0.405	12.66	74	61.2	0.86	0.603	0.081
507-03	0.320	9.99	71	60.6	2.49	0.554	0.122
507-04	0.408	12.76	78.8	66.0	3.15	1.109	0.195
507-05	0.189	5.91	13	6.90	1.60	0.826	0.032
507-06	0.447	13.96	45.1	31.1	1.01	0.805	0.104
507-07	0.243	7.6	50.9	43.3	0.62	0.485	0.080
507-08	0.313	9.8	99.8	90.1	1.85	0.662	0.055
507-09	0.093	2.9	64.5	61.6	1.78	0.351	0.016
Minimum thickness							
Maximum thickness							
Average thickness							

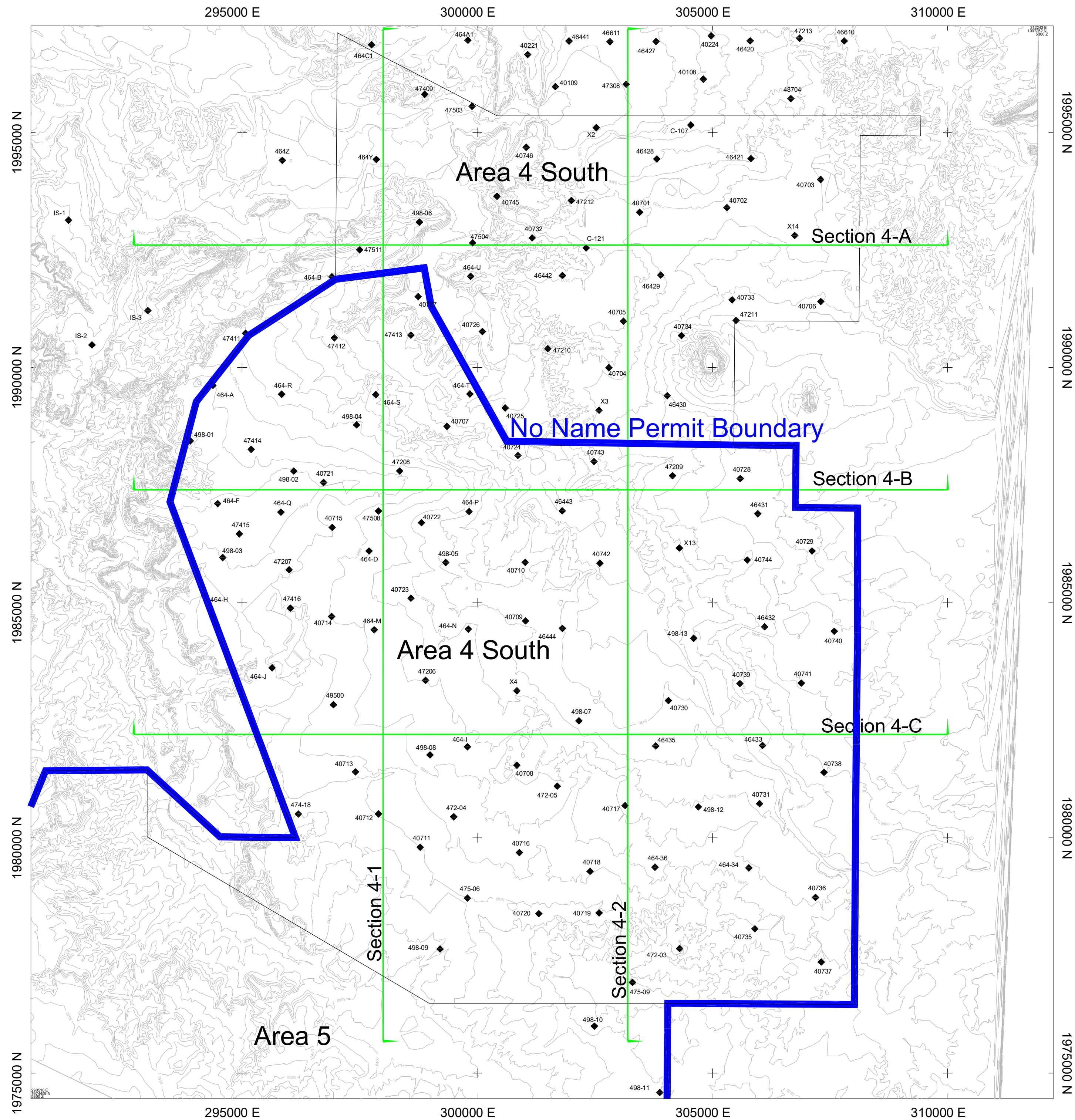
Table 17.E-12 Weighted Mean of Physical and Chemical Properties by Drill Hole for Mixed Material (Spoil)

Drill hole	Thickness (ft)	pH (s.u.)	Conductivity (mmhos/cm)	Saturation (%)	Calcium (meq/L)	Magnesium (meq/L)	Sodium (meq/L)	SAR	Sand (%)	Silt (%)
498-01	77.3	8.9	1.9	127.9	2.66	7.03	15.53	7.1	42	29
498-03	81.0	8.6	2.5	95.9	4.14	5.61	20.95	9.5	36	34
498-04	87.2	8.4	2.1	97.5	5.36	3.02	17.43	8.5	30	37
498-05	67.5	8.9	1.9	93.5	2.06	2.48	20.43	13.6	33	36
498-06	110.8	7.5	5.2	77.7	14.39	12.54	34.95	9.5	37	34
498-07	67.5	8.8	3.6	96.5	3.38	3.86	37.23	19.6	26	39
498-08	76.8	8.8	3.3	88.3	7.74	4.03	27.58	11.4	35	34
498-09	86.1	8.6	3.0	87.8	3.56	1.93	26.89	16.2	25	37
498-10	144.1	8.2	2.5	85.9	3.48	1.48	24.39	15.5	24	39
498-12	89.4	8.6	3.3	69.4	2.04	2.09	29.20	20.3	35	36
407-32	113.8	9.0	1.5	70.7	1.06	0.60	15.21	16.7	46	33
407-33	190.3	8.9	1.9	81.5	0.96	0.31	15.82	19.9	31	43
407-34	185.8	8.6	2.4	96.1	1.56	0.78	21.75	20.1	18	52
407-38	151.0	8.9	1.9	69.8	1.46	0.60	17.76	17.5	30	43
407-41	157.4	8.7	3.3	66.6	1.31	0.53	31.02	32.4	29	46
407-43	100.8	8.8	2.2	77.2	2.85	1.16	19.19	13.5	18	54
407-44	122.0	8.4	3.7	70.3	2.73	3.28	32.16	18.6	24	51
Minimum	67.5	7.5	1.5	66.6	0.96	0.31	15.21	7.1	18	29
Maximum	190.3	9.0	5.2	127.9	14.39	12.54	37.23	32.4	46	54
Arithmetic mean*		-	2.7	85.4	3.57	3.02	23.97	13.2	31	40
Standard dev		-	0.9	15.0	3.18	3.01	6.89	-	7	7
507-01	111.6	8.6	2.4	62.6	1.81	1.67	21.02	15.9	38	37
507-02	117.1	8.7	4.0	80.0	2.43	1.94	35.26	23.9	23	47
507-03	87.8	8.6	2.7	66.0	8.91	3.90	17.59	7.0	37	36
507-04	123.2	8.6	3.1	73.6	4.73	2.31	25.90	13.8	13	53
507-05	122.6	8.7	2.9	84.2	5.45	1.34	22.52	26.6	23	44
507-06	147.5	8.6	4.1	88.2	2.89	1.21	35.69	24.9	19	48
507-07	196.1	8.2	3.1	85.4	2.19	0.87	29.91	24.2	14	51
507-08	102.5	8.6	4.8	95.8	5.12	3.55	42.44	20.4	26	47
507-09	104.1	8.6	2.3	90.7	2.08	0.98	22.83	18.5	18	49
Minimum	87.8	8.2	2.3	62.6	1.81	0.87	17.59	7.0	13	36
Maximum	196.1	8.7	4.8	95.8	8.91	3.90	42.44	26.6	38	53
Arithmetic mean*		-	3.3	80.7	3.96	1.97	28.13	16.3	23	46
Standard dev		-	0.8	10.6	2.19	1.03	7.76	-	8	5

* Arithmetic mean of the weighted mean values for parameters for each interburden layer except SAR. Arithmetic mean of SAR is calculated from the arithmetic mean values for calcium, magnesium, and sodium.

Table 17.E-12 Weighted Mean of Physical and Chemical Properties by Drill Hole for Mixed Material (Spoil)

Drill hole	Clay (%)	CaCO3 (%)	Total sulfur (%)	Acid potential total sulfur (t/kt)	Neutralization potential (t/kt)	Acid-base potential total	Boron (ppm)	Total selenium (ppm)	Soluble selenium (ppm)
498-01	29	3.82	0.210	6.5	41.4	34.8	0.24	0.27	0.021
498-03	30	4.28	0.246	7.7	45.3	37.7	0.76	0.30	0.034
498-04	33	6.31	0.289	9.1	56.6	47.5	1.01	0.35	0.010
498-05	30	4.55	0.272	8.5	44.4	36.0	0.93	0.24	0.073
498-06	29	4.91	0.439	13.7	48.6	34.9	0.52	0.33	0.047
498-07	35	4.89	0.378	11.8	49.1	37.4	1.39	0.10	0.036
498-08	31	3.87	0.352	11.1	37.6	26.5	0.98	0.59	0.056
498-09	38	13.18	0.275	8.6	61.2	52.6	1.01	0.33	0.075
498-10	36	5.22	0.236	7.4	52.7	45.3	0.84	0.38	0.032
498-12	28	6.80	0.207	6.5	68.8	62.4	0.78	0.24	0.036
407-32	20	8.26	0.378	11.8	82.6	70.8	0.97	0.48	0.060
407-33	27	8.33	0.483	15.1	83.3	68.2	1.38	0.46	0.082
407-34	29	6.30	0.499	15.6	63.0	47.4	1.29	0.41	0.103
407-38	27	5.05	0.388	12.1	50.5	38.3	1.43	0.67	0.085
407-41	25	4.30	0.396	12.4	43.0	30.7	1.32	0.53	0.078
407-43	27	6.36	0.472	14.7	63.6	48.8	1.45	0.57	0.059
407-44	25	6.46	0.406	12.7	64.6	51.9	1.28	0.30	0.048
Minimum	20	3.82	0.207	6.5	37.6	26.5	0.24	0.10	0.010
Maximum	38	13.18	0.499	15.6	83.3	70.8	1.45	0.67	0.103
Arithmetic mean*	29	6.05	0.349	10.9	56.2	45.4	1.04	0.39	0.055
Standard dev	4	2.23	0.094	2.9	13.1	12.4	0.33	0.14	0.025
507-01	25	6.14	0.267	8.3	61.4	53.0	1.20	0.53	0.050
507-02	30	6.84	0.361	11.3	68.4	57.1	1.54	0.56	0.089
507-03	27	6.04	0.178	5.6	60.4	54.8	1.38	0.27	0.058
507-04	32	3.97	0.099	3.1	39.7	66.0	2.28	0.81	0.125
507-05	33	6.30	0.235	7.3	63.0	55.7	1.25	0.56	0.049
507-06	33	5.55	0.290	9.1	55.5	46.5	1.16	0.58	0.080
507-07	29	6.39	0.265	8.3	63.9	55.6	0.79	0.39	0.059
507-08	27	8.60	0.236	7.4	86.0	78.6	1.78	0.57	0.054
507-09	33	7.00	0.344	10.7	70.0	59.3	1.39	0.39	0.054
Minimum	25	3.97	0.099	3.1	39.7	46.5	0.79	0.27	0.049
Maximum	33	8.60	0.361	11.3	86.0	78.6	2.28	0.81	0.125
Arithmetic mean*	30	6.31	0.253	7.9	63.1	58.5	1.42	0.52	0.069
Standard dev	3	1.16	0.076	2.4	11.6	8.6	0.40	0.14	0.024



LEGEND

NO NAME PERMIT BOUNDARY

CROSS-SECTION LOCATION

REGISTERED PROFESSIONAL GEOLOGIST
MS 0901
JOSHUA M. JOHNS

Joshua M Johns

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EXHIBIT 17.1-1

Navajo Transitional Energy Company

NAVAJO MINE
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PHONE (505) 278-8625

NO NAME PERMIT
DRILL HOLE & CROSS-SECTION LOCATIONS
(SHEET 1 OF 2)

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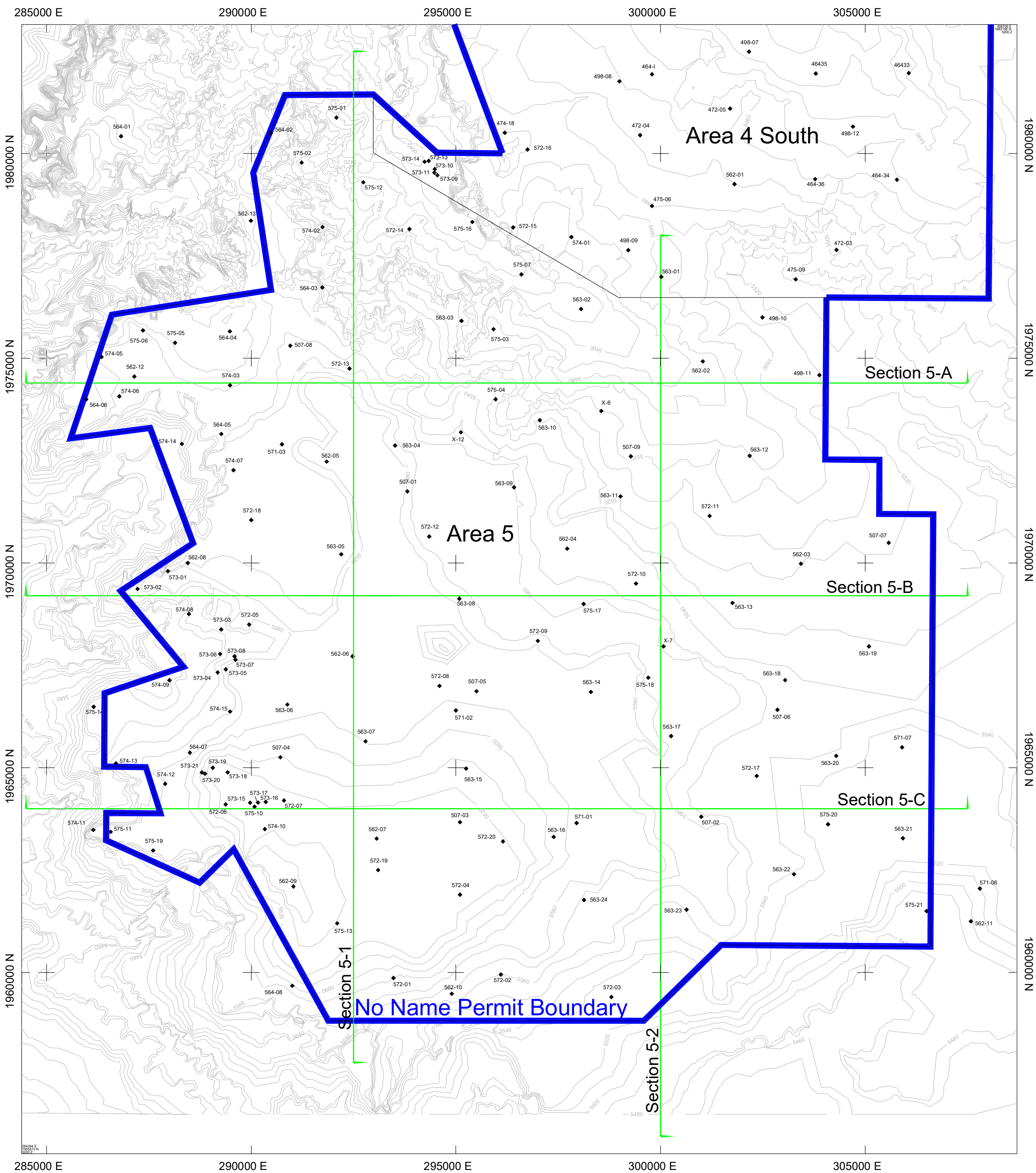

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NO NAME PERMIT
DRILL HOLE & CROSS-SECTION LOCATIONS
(SHEET 2 of 2)

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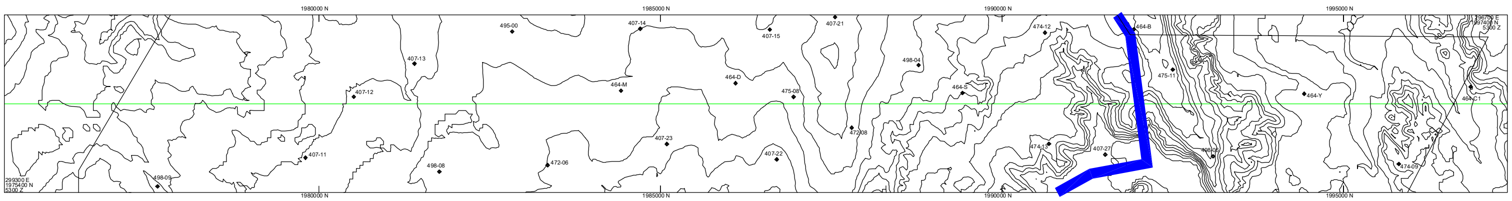

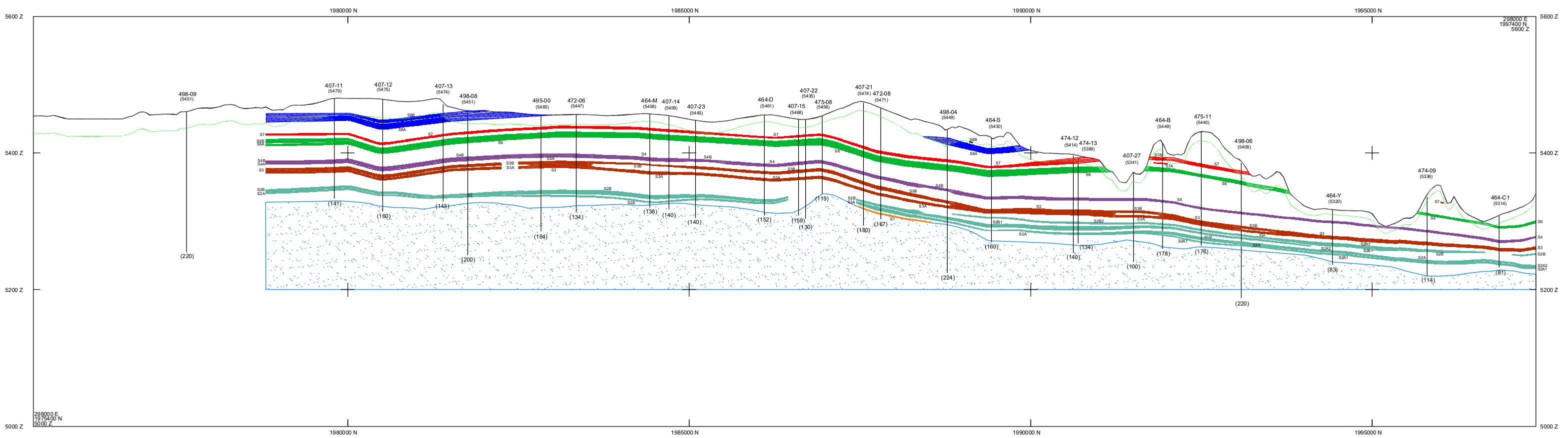

LEGEND

Topography

575-13 (5629) Drillhole # (Collar Elevation)

Depth of Weathering

(210) Drillhole Trace (Total Depth of Drillhole)

No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

Seam 8 — Weathered

SEAM 7 INTERBURDEN

Seam 7 — Weathered

SEAM 6 INTERBURDEN

Seam 6 — Weathered

SEAM 4 INTERBURDEN

Seam 4 — Weathered

SEAM 3 INTERBURDEN

Seam 3 — Weathered

SEAM 2 INTERBURDEN

Seam 2 — Weathered

SEAM 1 INTERBURDEN

Seam 1

Pictured Cliffs Sandstone (PCF)

1000 0 1000 2000

CONTOUR INTERVAL: 10'

VERTICAL SCALE 100 0 100 FEET

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	APPROVED DATE
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EXHIBIT 17.1-2

Navajo Transitional Energy Company

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PHONE (505) 278-8625

NO NAME PERMIT

GEOLOGIC CROSS-SECTION 4-1

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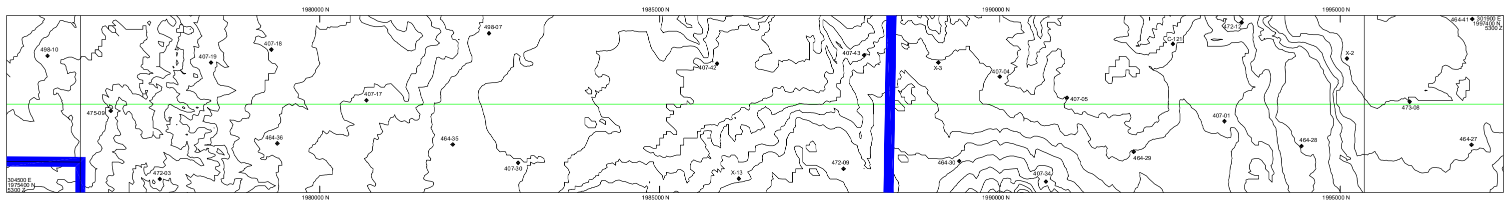

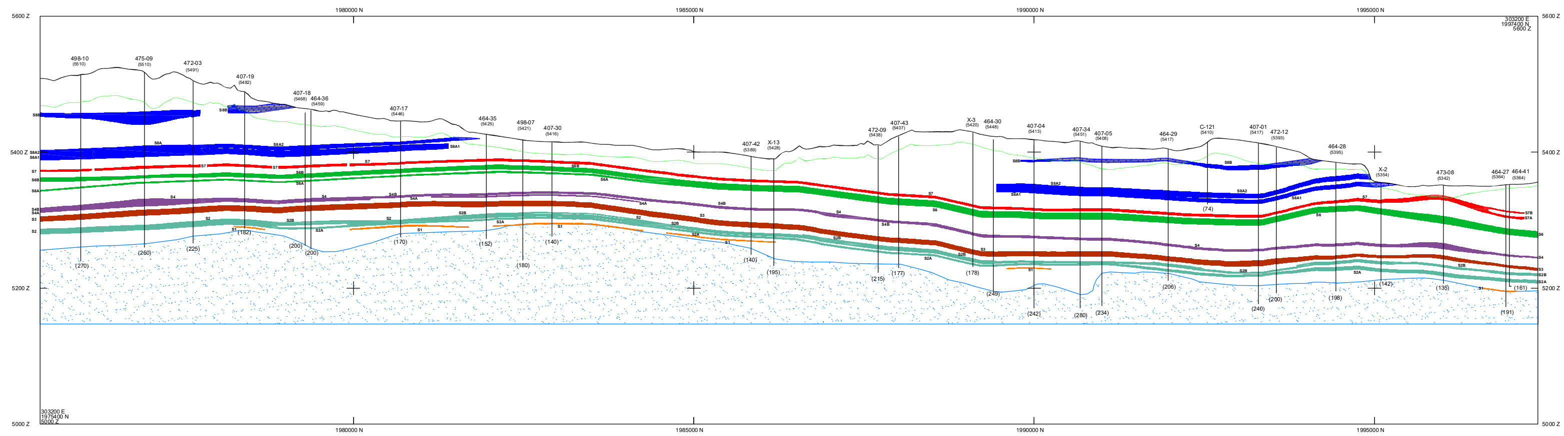

LEGEND

Topography

575-13 (5629) Drillhole # (Collar Elevation)

Depth of Weathering

(210) Drillhole Trace (Total Depth of Drillhole)

No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

Seam 8 — Weathered

SEAM 7 INTERBURDEN

Seam 7 — Weathered

SEAM 6 INTERBURDEN

Seam 6 — Weathered

SEAM 4 INTERBURDEN

Seam 4 — Weathered

SEAM 3 INTERBURDEN

Seam 3 — Weathered

SEAM 2 INTERBURDEN

Seam 2 — Weathered

SEAM 1 INTERBURDEN

Seam 1

Pictured Cliffs Sandstone (PCF)

1000 0 1000 2000

CONTOUR INTERVAL: 10'

VERTICAL SCALE FEET 100 0 100

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	APPROVED DATE
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EXHIBIT 17.1-3

Navajo Transitional Energy Company

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NO NAME PERMIT

GEOLOGIC CROSS-SECTION 4-2

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Joshua M Johns

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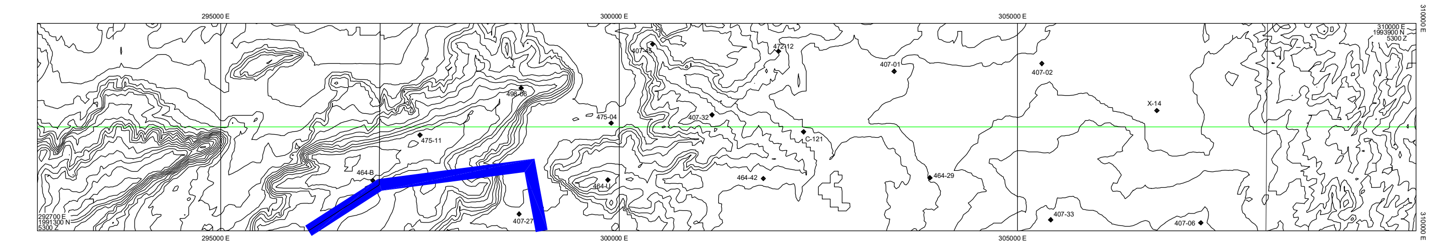

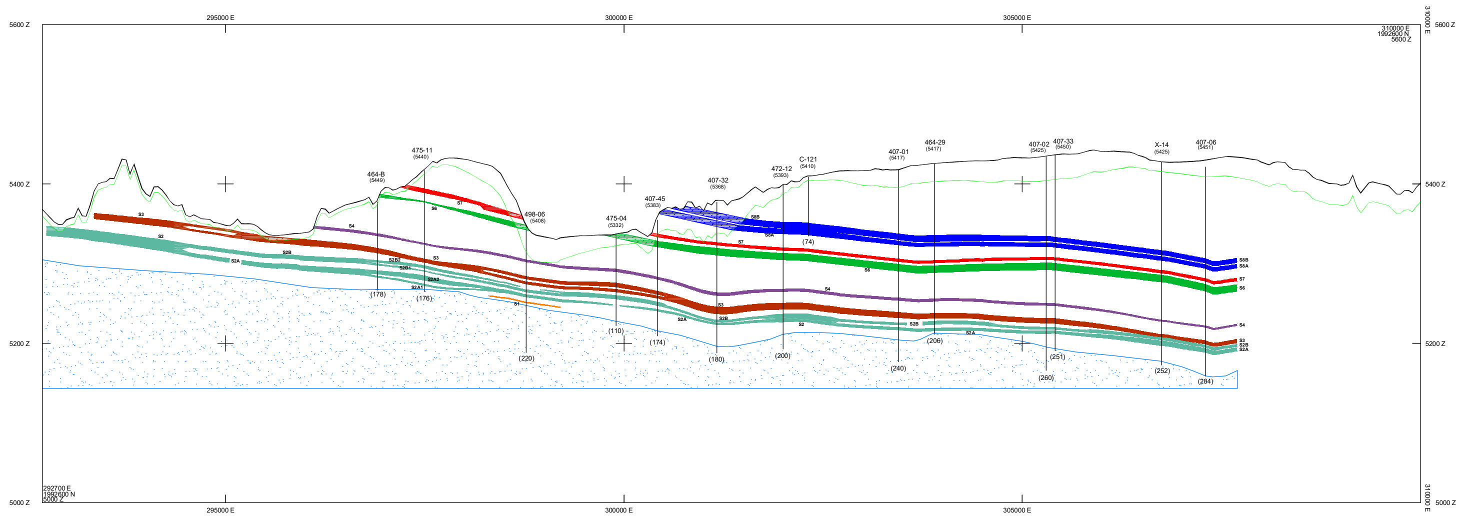

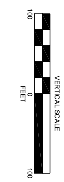

LEGEND

	Topography
575-13 (5629)	Drillhole # (Collar Elevation)
	Depth of Weathering
(210)	Drillhole Trace (Total Depth of Drillhole)
	No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

Seam 8		Weathered
SEAM 7 INTERBURDEN		
Seam 7		Weathered
SEAM 6 INTERBURDEN		
Seam 6		Weathered
SEAM 4 INTERBURDEN		
Seam 4		Weathered
SEAM 3 INTERBURDEN		
Seam 3		Weathered
SEAM 2 INTERBURDEN		
Seam 2		Weathered
SEAM 1 INTERBURDEN		
Seam 1		
Pictured Cliffs Sandstone (PCF)		

1000 0 1000 2000

CONTOUR INTERVAL: 10'

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EXHIBIT 17.1-4

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NO NAME PERMIT

GEOLOGIC CROSS-SECTION 4-A

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Joshua M Johns

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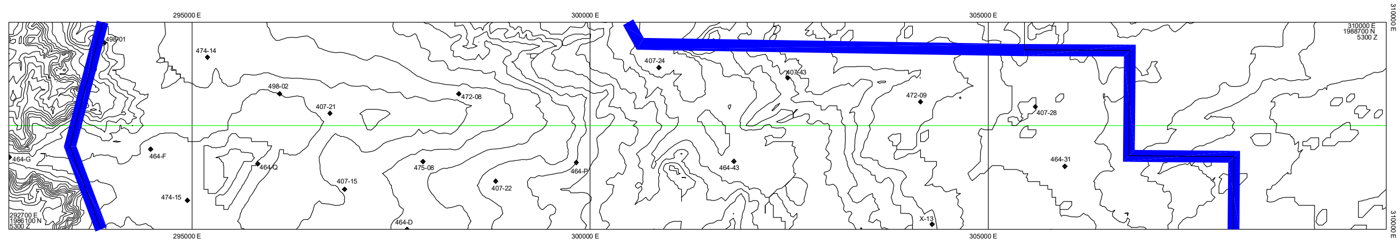

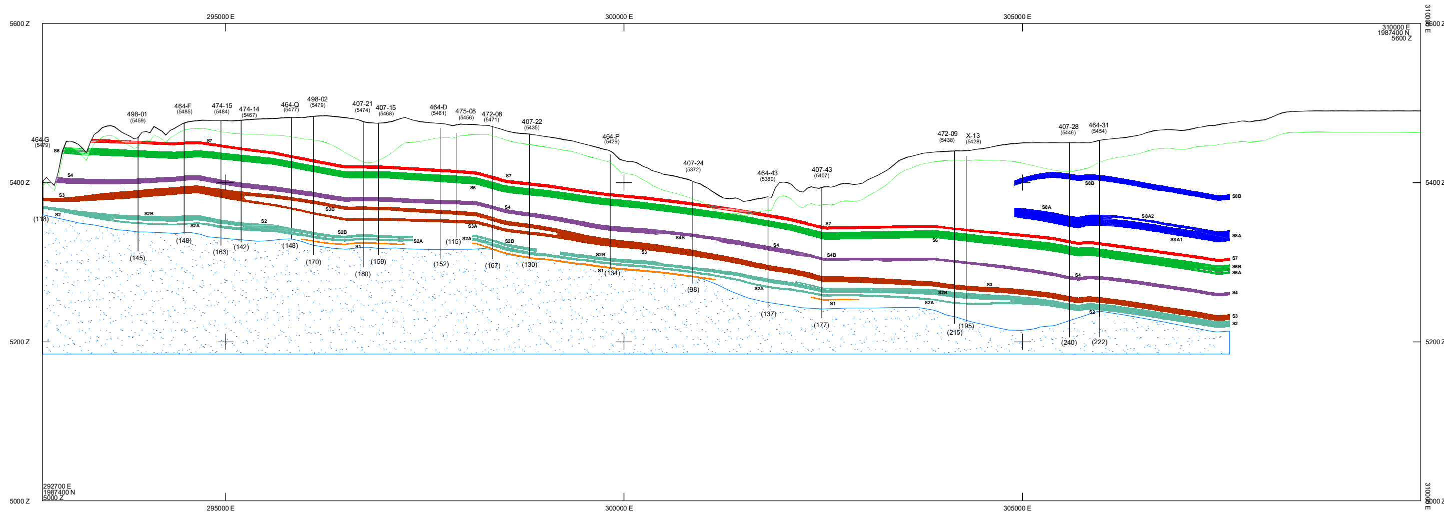

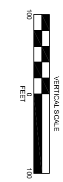

LEGEND

	Topography
575-13 (5629)	Drillhole # (Collar Elevation)
	Depth of Weathering
(210)	Drillhole Trace (Total Depth of Drillhole)
	No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

Seam 8	Weathered	
SEAM 7 INTERBURDEN		
Seam 7	Weathered	
SEAM 6 INTERBURDEN		
Seam 6	Weathered	
SEAM 4 INTERBURDEN		
Seam 4	Weathered	
SEAM 3 INTERBURDEN		
Seam 3	Weathered	
SEAM 2 INTERBURDEN		
Seam 2	Weathered	
SEAM 1 INTERBURDEN		
Seam 1		
Pictured Cliffs Sandstone (PCF)		

1000 0 1000 2000

CONTOUR INTERVAL: 10'

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	APPROVED DATE
				APPROVALS			

EXHIBIT 17.1-5

Navajo Transitional Energy Company

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NO NAME PERMIT

GEOLOGIC CROSS-SECTION 4-B

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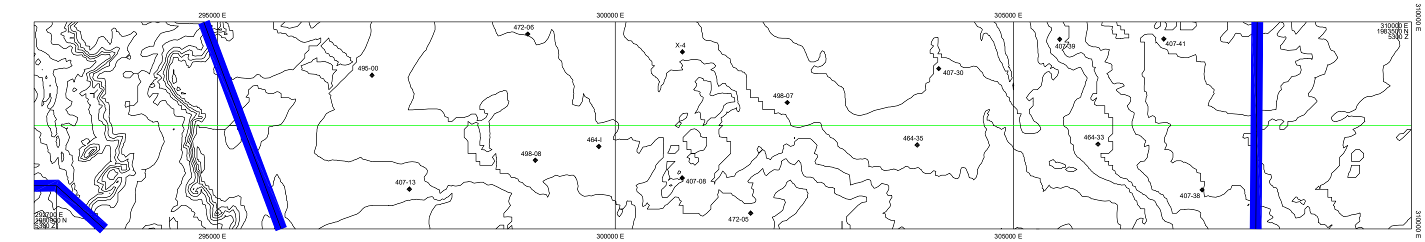

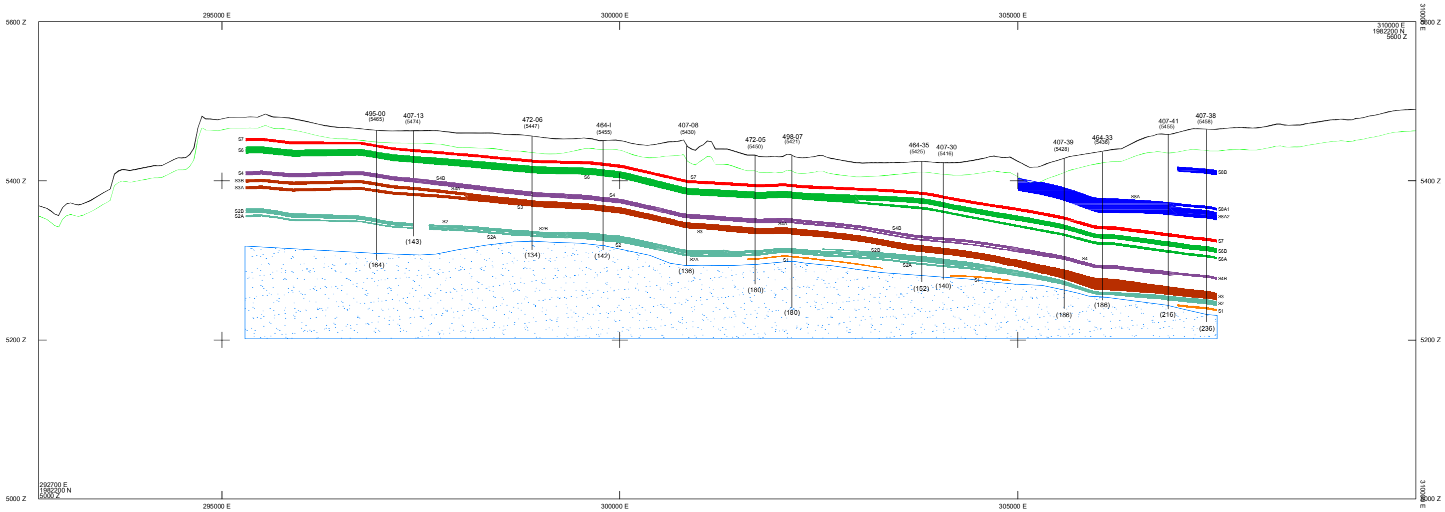

LEGEND

Topography

Drillhole # (Collar Elevation)

Depth of Weathering

Drillhole Trace (Total Depth of Drillhole)

No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

Seam 8 — Weathered

SEAM 7 INTERBURDEN

Seam 7 — Weathered

SEAM 6 INTERBURDEN

Seam 6 — Weathered

SEAM 4 INTERBURDEN

Seam 4 — Weathered

SEAM 3 INTERBURDEN

Seam 3 — Weathered

SEAM 2 INTERBURDEN

Seam 2 — Weathered

SEAM 1 INTERBURDEN

Seam 1

Pictured Cliffs Sandstone (PCF)

1000 0 1000 2000

CONTOUR INTERVAL: 10'

VERTICAL SCALE FEET 100 0 100

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.G.	P.E.	APPROVED DATE

APPROVALS

EXHIBIT 17.1-6

Navajo Transitional Energy Company

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PHONE (505) 278-8625

NO NAME PERMIT

GEOLOGIC CROSS-SECTION 4-C

PREPARED BY	NTEC	DRAWN BY		SCALE:	1" = 1000'
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REGISTERED PROFESSIONAL GEOLOGIST MS 0501 JOSHUA M. JOHNS

Joshua M Johns

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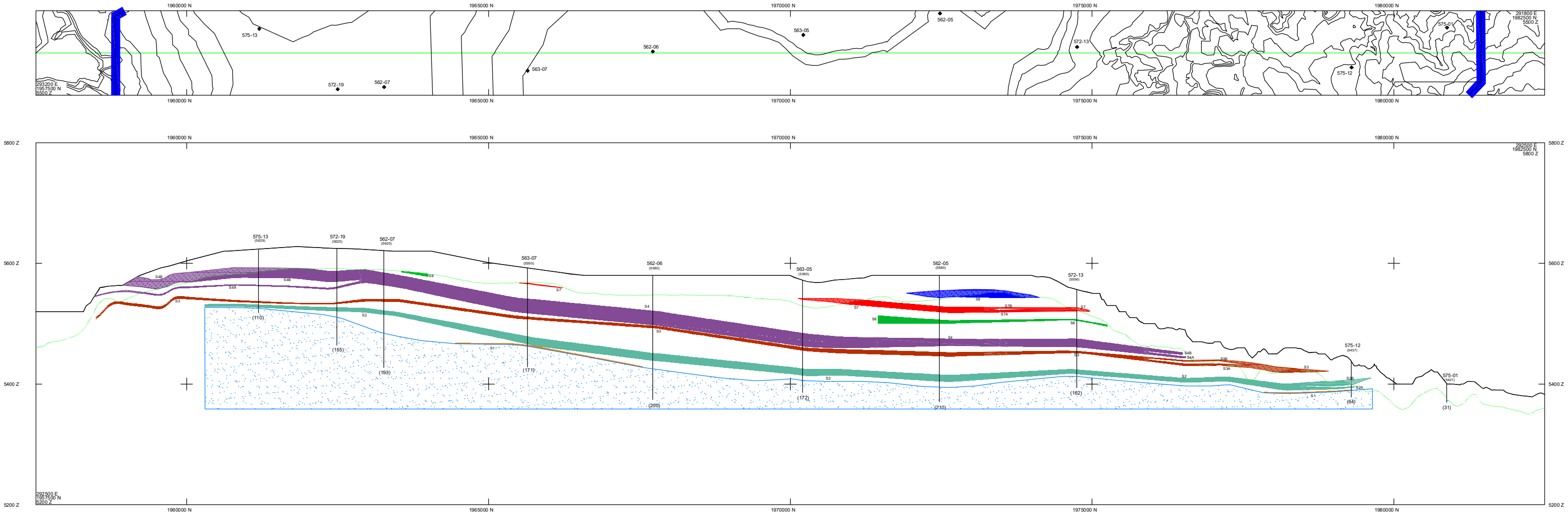

LEGEND

Topography

575-13 (5629) Drillhole # (Collar Elevation)

Depth of Weathering

(210) Drillhole Trace (Total Depth of Drillhole)

No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

Seam 8 — Weathered

SEAM 7 INTERBURDEN

Seam 7 — Weathered

SEAM 6 INTERBURDEN

Seam 6 — Weathered

SEAM 4 INTERBURDEN

Seam 4 — Weathered

SEAM 3 INTERBURDEN

Seam 3 — Weathered

SEAM 2 INTERBURDEN

Seam 2 — Weathered

SEAM 1 INTERBURDEN

Seam 1

Pictured Cliffs Sandstone (PCF)

1000 0 1000 2000

CONTOUR INTERVAL: 10'

VERTICAL SCALE FEET

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	APPROVED DATE
				APPROVALS			

EXHIBIT 17.1-7

Navajo Transitional Energy Company

NAVAJO MINE
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SHIPROCK, NEW MEXICO 87420

PHONE (505) 278-8625

NO NAME PERMIT

GEOLOGIC CROSS-SECTION 5-1

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Joshua M Johns

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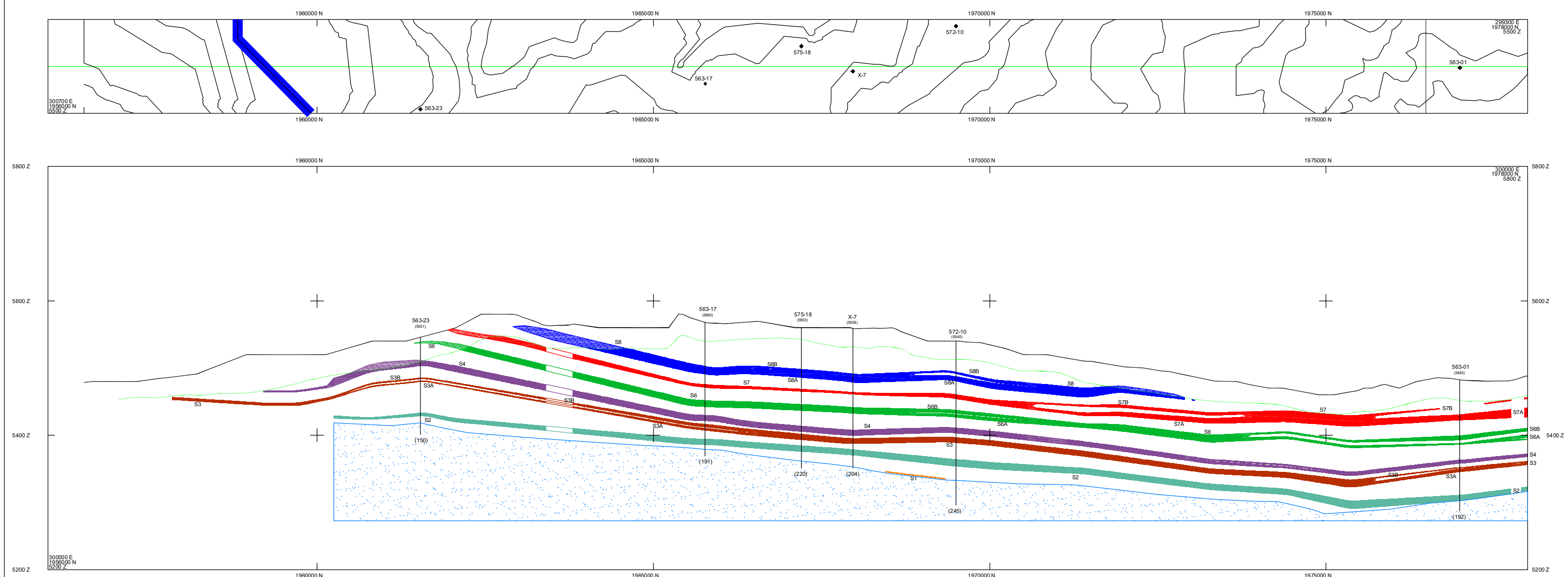

LEGEND

Topography

575-13 (5629) Drillhole # (Collar Elevation)

Depth of Weathering

(210) Drillhole Trace (Total Depth of Drillhole)

No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

Seam 8 — Weathered

SEAM 7 INTERBURDEN

Seam 7 — Weathered

SEAM 6 INTERBURDEN

Seam 6 — Weathered

SEAM 4 INTERBURDEN

Seam 4 — Weathered

SEAM 3 INTERBURDEN

Seam 3 — Weathered

SEAM 2 INTERBURDEN

Seam 2 — Weathered

SEAM 1 INTERBURDEN

Seam 1

Pictured Cliffs Sandstone (PCF)

1000 0 1000 2000

CONTOUR INTERVAL: 10'

VERTICAL SCALE FEET 100 0 100

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PREP'D BY	E.Q.	P.E.	APPROVED DATE

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EXHIBIT 17.1-8

Navajo Transitional Energy Company

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SHIPROCK, NEW MEXICO 87420

PHONE (505) 278-8625

NO NAME PERMIT

GEOLOGIC CROSS-SECTION 5-2

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Joshua M Johns

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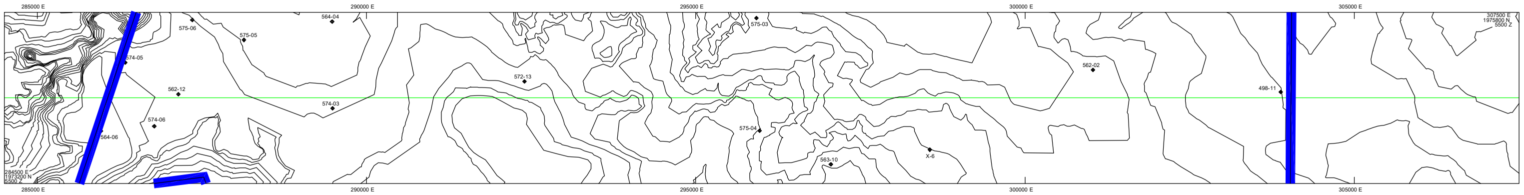
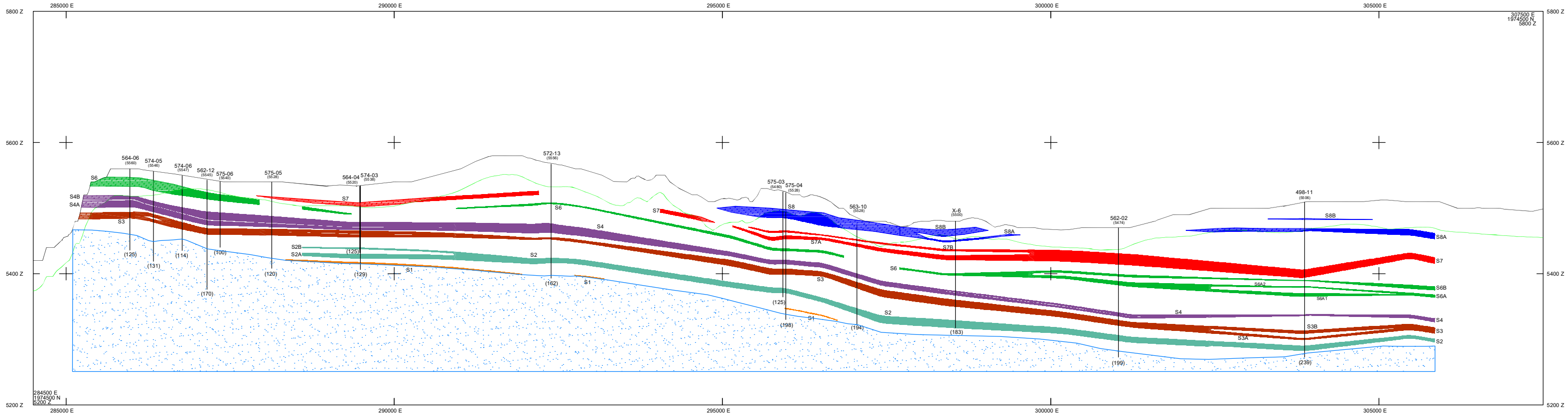




LEGEND

	Topography
575-13 (5629)	Drillhole # (Collar Elevation)
	Depth of Weathering
(210)	Drillhole Trace (Total Depth of Drillhole)
	No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN

	Seam 8	Weathered
SEAM 7 INTERBURDEN		
	Seam 7	Weathered
SEAM 6 INTERBURDEN		
	Seam 6	Weathered
SEAM 4 INTERBURDEN		
	Seam 4	Weathered
SEAM 3 INTERBURDEN		
	Seam 3	Weathered
SEAM 2 INTERBURDEN		
	Seam 2	Weathered
SEAM 1 INTERBURDEN		
	Seam 1	
	Pictured Cliffs Sandstone (PCF)	

1000 0 1000 2000

CONTOUR INTERVAL: 10'

VERTICAL SCALE FEET

REV No.	DATE	DRAFT BY	REVISION DESCRIPTION	PREP BY	E.Q.	P.E.	APPROVED DATE
				APPROVALS			

EXHIBIT 17.1-9

Navajo Transitional Energy Company

NAVAJO MINE
P.O. BOX 958
SHIPROCK, NEW MEXICO 87420

PHONE (505) 278-8625

NO NAME PERMIT

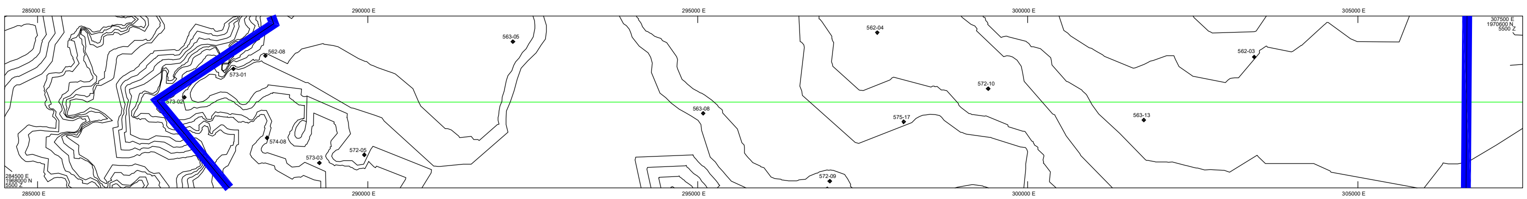
GEOLOGIC CROSS-SECTION 5-A

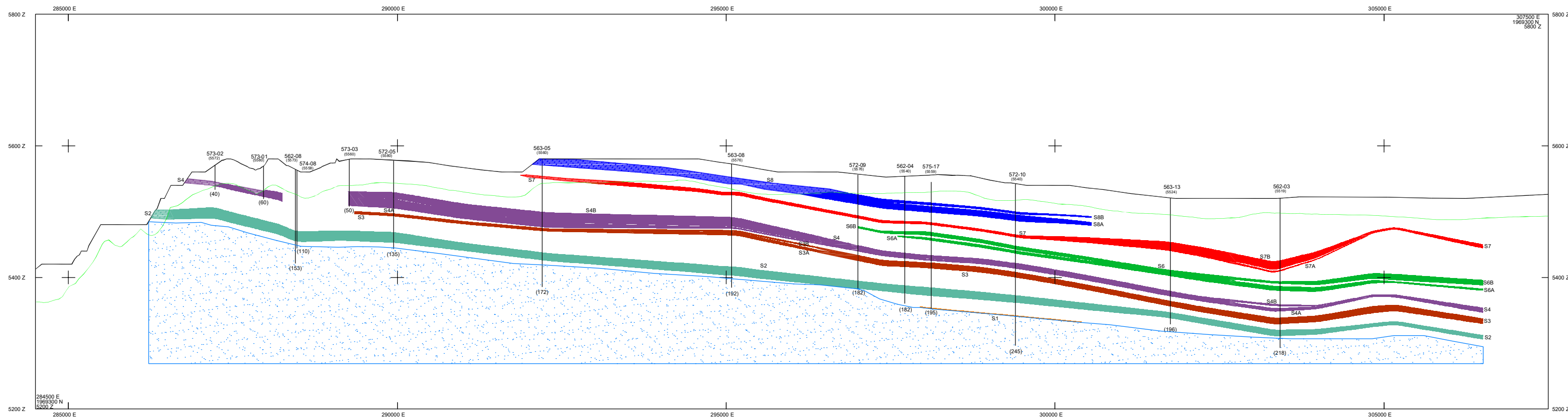
PREPARED BY NTEC	DRAWN BY	SCALE: 1" = 1000'	
APPROVED BY	DATE		

REGISTERED PROFESSIONAL GEOLOGIST MS 0901 JOSHUA M. JOHNS

Joshua M Johns

Digitally signed by Joshua M Johns
DN: CN=Joshua M Johns, E=josh.johns@navenergy.com
Reason: I am approving this document
Location: your signing location here
Date: 2026.03.31 08:33:06-06'00'
Foxit PDF Editor Version: 11.2.12





LEGEND

Topography
Drillhole # (Collar Elevation)
Depth of Weathering
Drillhole Trace (Total Depth of Drillhole)
No Name Permit Boundary

Generalized Stratigraphic Column

OVERBURDEN		
	Seam 8	Weathered
SEAM 7 INTERBURDEN		
	Seam 7	Weathered
SEAM 6 INTERBURDEN		
	Seam 6	Weathered
SEAM 4 INTERBURDEN		
	Seam 4	Weathered
SEAM 3 INTERBURDEN		
	Seam 3	Weathered
SEAM 2 INTERBURDEN		
	Seam 2	Weathered
SEAM 1 INTERBURDEN		
	Seam 1	
	Pictured Cliffs Sandstone (PCF)	

1000 0 1000 2000

CONTOUR INTERVAL: 10'

VERTICAL SCALE FEET

REV No	DATE	DRAFT BY	REVISION DESCRIPTION	PREP'D BY	E.G.	P.E.	APPROVED DATE
				APPROVALS			

EXHIBIT 17.1-10

Navajo Transitional Energy Company

NAVAJO MINE
P.O. BOX 958
SHIPROCK, NEW MEXICO 87420
PHONE (505) 278-8625

NO NAME PERMIT

GEOLOGIC CROSS-SECTION 5-B

PREPARED BY NTEC	DRAWN BY	SCALE: 1" = 1000'	
APPROVED BY	DATE		

REGISTERED PROFESSIONAL GEOLOGIST MS 0901 JOSHUA M. JOHNS

Joshua M Johns

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Date: 2026.03.31 08:33:43-06'00'
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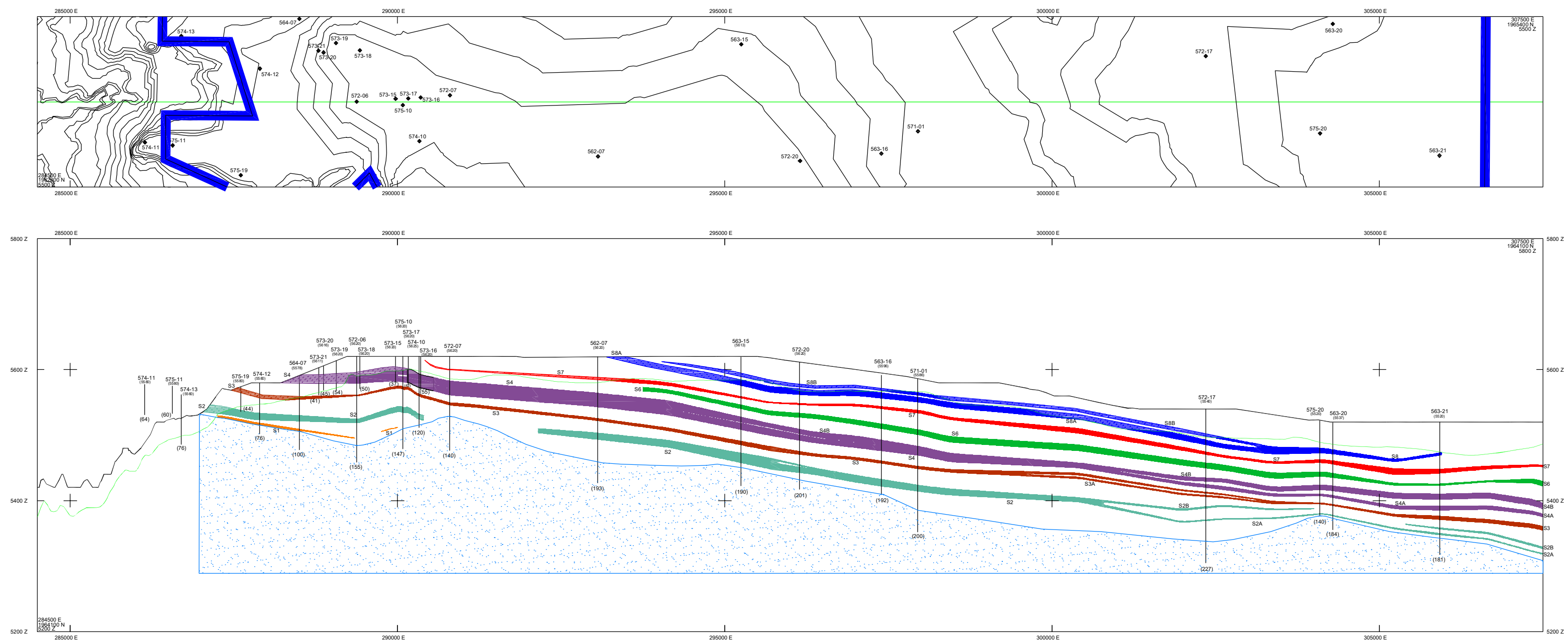

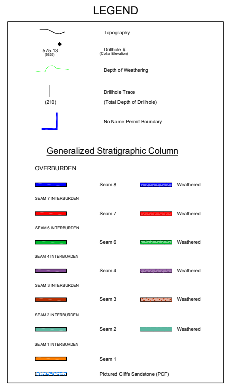

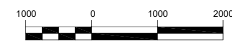

CONTOUR INTERVAL: 10'

REV. No.	DATE	DRAFT BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	APPROVED DATE

APPROVALS

EXHIBIT 17.1-11

Navajo Transitional Energy Company

NAVAJO MINE
P.O. BOX 958
SHIPROCK, NEW MEXICO 87420
PHONE (505) 278-8625

NO NAME PERMIT

GEOLOGIC CROSS-SECTION 5-C

PREPARED BY	NTEC	DRAWN BY		SCALE:	1" = 1000'
APPROVED BY		DATE			

REGISTERED PROFESSIONAL GEOLOGIST MS 0601 JOSHUA M. JOHNS

Joshua M Johns

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E=josh.johns@navenergy.com
Reason: I am approving this document
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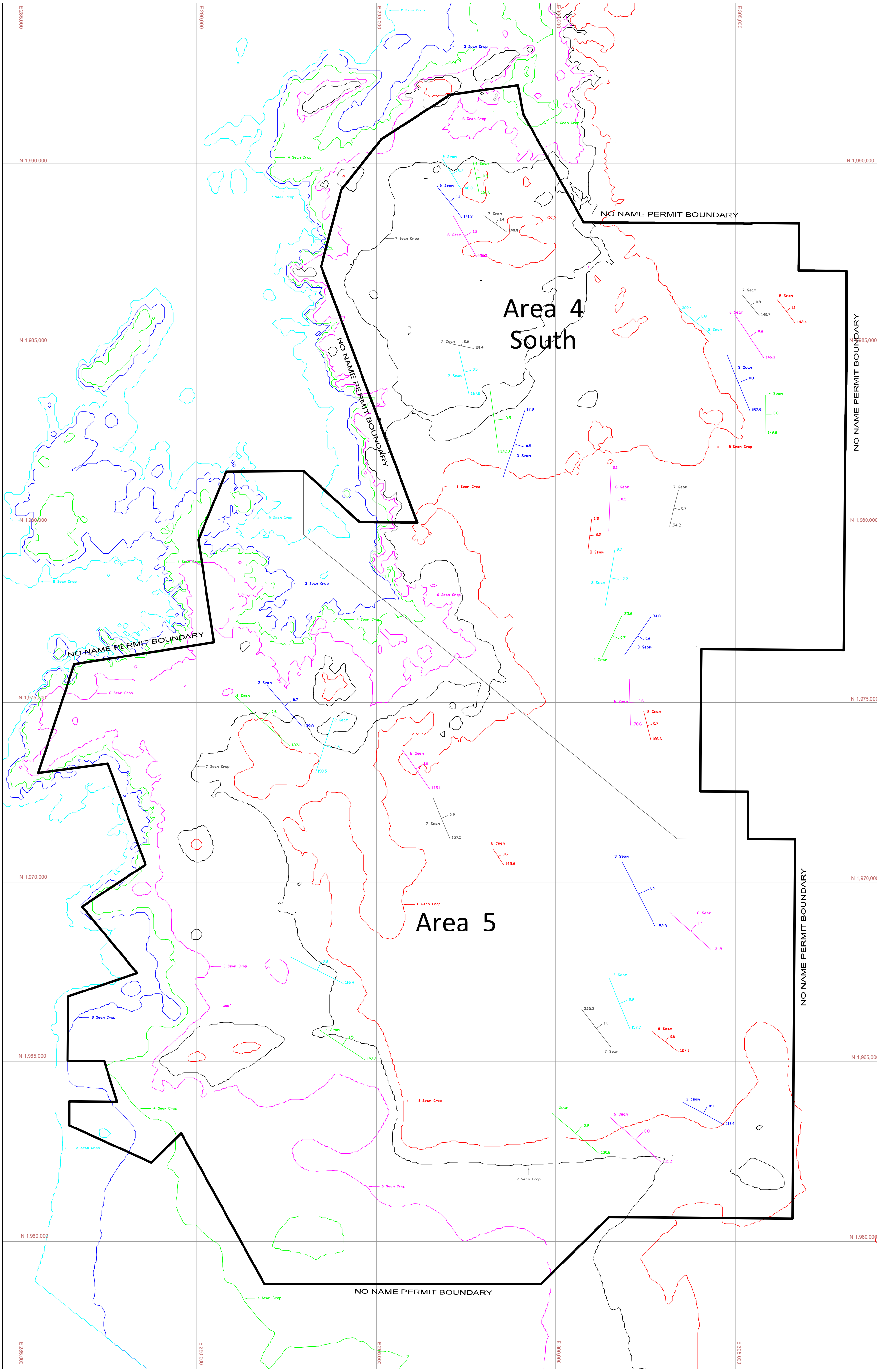
Date: 2026.03.31 08:34:12-06'00'
Foxit PDF Editor Version: 11.2.12



LEGEND

2 SEAM CROP
3 SEAM CROP
4 SEAM CROP
6 SEAM CROP
7 SEAM CROP
8 SEAM CROP
PERMIT BOUNDARY

0.7 DIP
194.2 STRIKE

REGISTERED PROFESSIONAL GEOLOGIST
MS 0901
JOSHUA M. JOHNS

Joshua M Johns
Digitally signed by Joshua M Johns
DN: CN=Joshua M Johns, E=josh.johns@navenergy.com
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Foxit PDF Editor Version: 11.2.12

800 0 800 1600
SCALE 1"=800'

Notes:

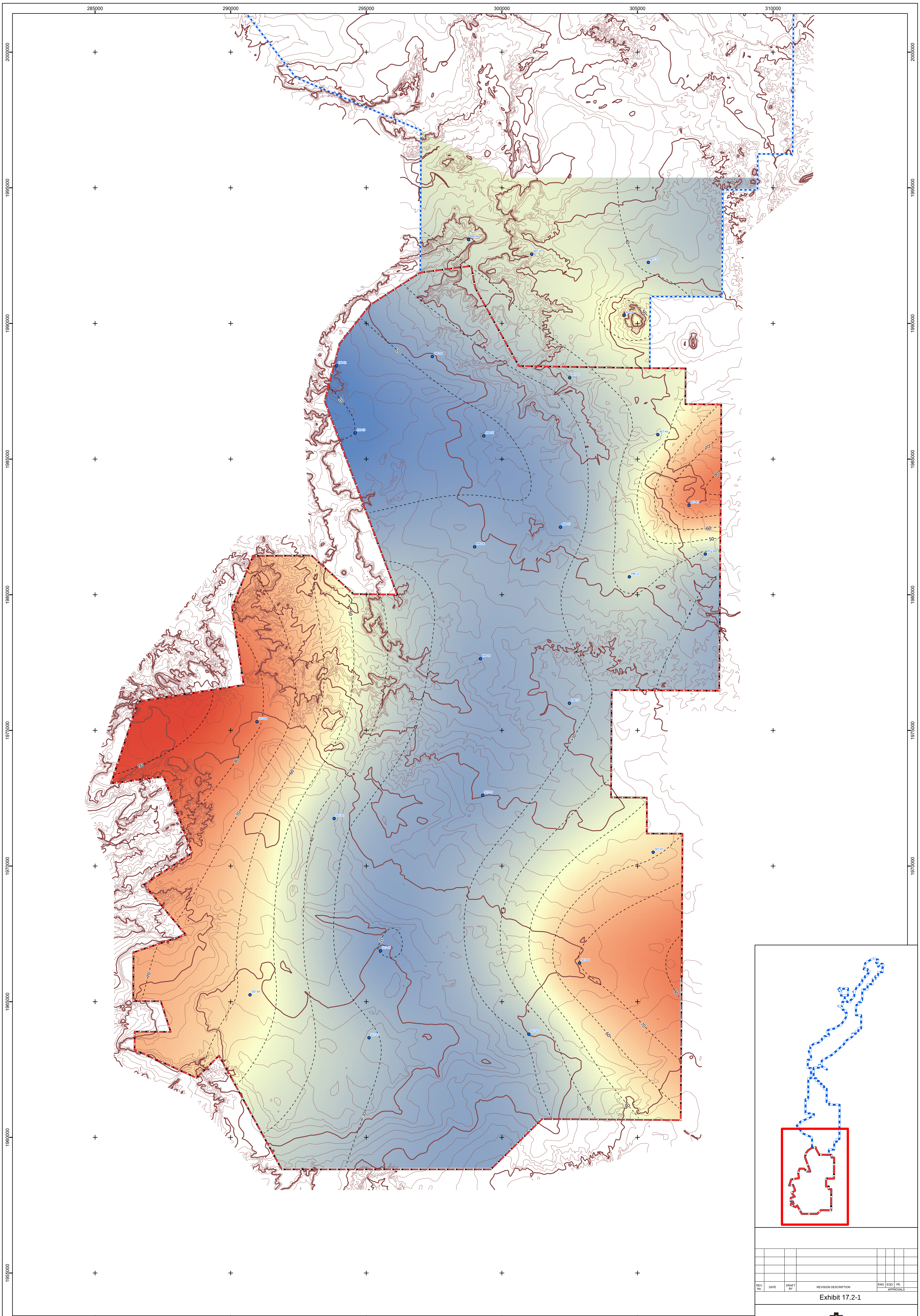
Original certified signed exhibits are maintained at the mine site and at OSM.

Navajo Transitional Energy Company

EXHIBIT 17.1–12

NO NAME
COAL CROP, STRIKE
AND DIP LINES

PREPARED BY JJ | DRAWN BY JJ | SCALE: 1" = 800'
APPROVED BY | DATE 02/02/2026



Coordinate System:
NAD 1927 StatePlane New Mexico West FIPS 3003 Feet
Datum: North American 1927
Units US Feet

0 500 1,000 2,000 3,000 Feet
1:18,000
1 inch equals 1,500 feet

No Name Permit Boundary
NTEC Lease Boundary
Index Contours (50 ft)
Intermediate Contours (10 ft)

Overburden Drill Location
Suitable Overburden Depth Contour

Suitable Overburden Depth (Ft)
92.88
9.36

REV. No.	DATE	DRAFT BY	REVISION DESCRIPTION	ENG.	EQD.	PE.	
				APPROVALS			

Exhibit 17.2-1

Navajo Transitional Energy Company

No Name Permit

Isopleth of Suitable Material Thickness

PREPARED BY: RFB	DRAWN BY: RFB	PAPER SIZE: ARCH D
APPROVED BY: JJ	DATE: 07/11/2025	

Figure 17.1-1 Generalized Stratigraphic Column Showing Overburden/Interburden, Coal Seams, and Pictured Cliffs Sandstone

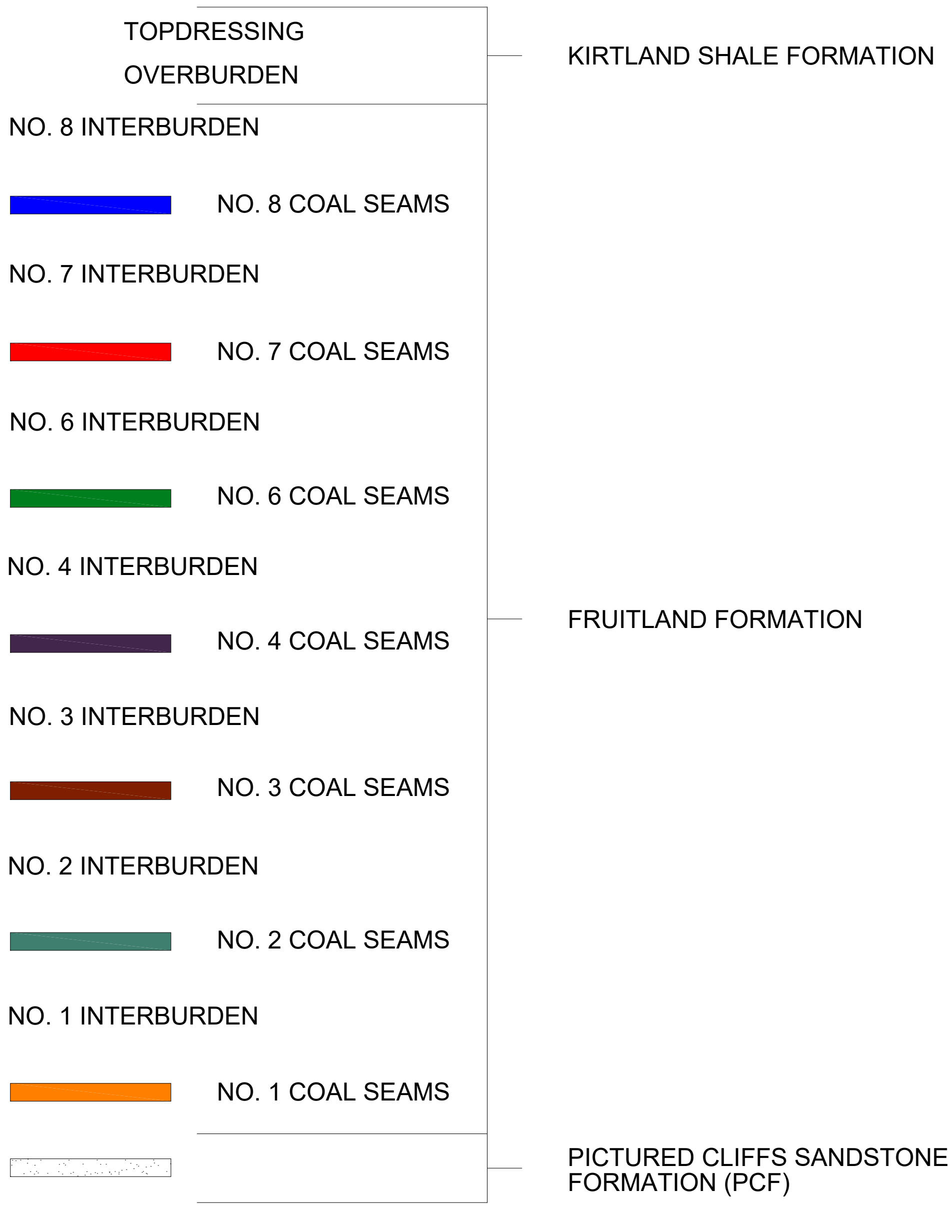


Table 17.2-1 Physical and Chemical Properties Analyzed or Calculated for Overburden/Interburden Samples from 1998 and 2007 Drilling Program

pH (s.u.)
Conductivity (mmhos/cm)
Saturation (%)
Calcium (meq/L)
Magnesium (meq/L)
Sodium (meq/L)
SAR
Sand (%), silt (%), clay (%)
USDA soil texture
CaCO3 (%)
Total sulfur (%)
Acid potential total sulfur (t/kt)
Neutralization potential (t/kt)
Acid-base potential total sulfur (t/kt)
Sulfate (%) *
Organic sulfur (%) *
Pyritic sulfur (%) *
Acid-base pyritic sulfur (t/kt) *
Acid-base potential pyritic sulfur (t/kt) *
Boron (ppm)
Total selenium (ppm)
Soluble selenium (ppm)

* analysis performed only if total sulfur acid-base potential is less than zero t/kt

Table 17.2-28 Potential Root Zone Suitability Criteria and PATFM Characteristic Analytes

Characteristic analytes	OSM southwestern U.S. criteria	Navajo Mine site-specific criteria[3]
Boron	≤10 ppm	na
Total selenium	≤0.8 ppm	≤2.5 ppm
Soluble selenium	≤0.15 ppm	≤0.26 ppm
pH	≥5.5 and ≤9.0	≥5.0 and ≤9.0
Acid-base account (Acid-base potential[1])	>-5 t $CaCO_3$/1000 t	≥-5 t $CaCO_3$/1000 t
Saturation	≥ 20% and ≤90%	≤85% OR ≤100% only if EC≥4 mmhos/cm
EC	≤12 mmhos/cm	≤16 mmhos/cm
SAR	sandy loam ≤20 loam, clay loam ≤16 40% clay ≤14	≤18 OR ≤40 only if EC ≥4 mmhos/cm
Texture	≤45% clay	≤50% clay
$CaCO_3$	%	no criteria
Neutralization potential	t $CaCO_3$/1000 t	no criteria
Total sulfur	%	no criteria
Total sulfur acid potential	t $CaCO_3$/1000 t	no criteria
Sulfate[2]	%	no criteria
Organic sulfur[2]	%	no criteria
Pyritic sulfur[2]	%	no criteria
Acid-base pyritic sulfur[2]	t $CaCO_3$/1000 t	no criteria

[1] Total sulfur and pyritic sulfur acid-base potential are considered under this criteria.

[2] These analytes including pyritic sulfur acid-base potential are analyzed when total sulfur acid-base potential is less than zero.

[3] Navajo Mine site-specific criteria are found in Pinabete Permit NM-0042B.

Table 17.2-29 Volume of Suitable Root Zone Material Available

Permit Area	Volume to 4-ft depth in mining area (bcy)	Volume of suitable material available (bcy)
No Name	74,379,184	760,579,900

Table 17.3-1 Chemical Characteristics for Coal Seams to be Mined

Seam identification	Average total sulfur (%)	Average pyritic sulfur* (%)
No. 8	0.66	-
No. 8B	0.79	0.21
No. 8A	0.78	0.22
No. 7	1.25	0.71
No. 7B	1.11	-
No. 7A	0.60	-
No. 6	0.61	0.10
No. 6B	0.53	0.13
No. 6A	0.63	0.20
No. 4	0.55	0.11
No. 4B	0.60	0.13
No. 4A	0.62	0.23
No. 3	0.74	0.37
No. 3B	0.97	0.29
No. 2	0.91	0.40
No. 2B	0.69	0.34
No. 2A	1.27	0.55

* Pyritic sulfur analyses were not performed on No. 8, No. 7B, and No. 7A coal seams.