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Data Analysis for Infiltration Modeling: Technical Evaluation of Previous Soil Depth Estimation Methods and Development of Alternate Parameter Values

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ACKNOWLEDGMENTS

This document was developed through the contributions of Terry A. Grant who performed the analysis, created the spreadsheets, and wrote nearly all of the original drafts of the analysis. Tim Vogt provided assistance with creation of many of the maps presented in this analysis. Sharad Khamamkar provided assistance with the checking of the data sets presented in this analysis.

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BSC	SCIENTIFIC ANALYSIS SIGNATURE PAGE/ CHANGE HISTORY *Complete only applicable items.*	Page v 1. Total Pages: 120

2. Scientific Analysis Title			
Data Analysis for Infiltration Modeling: Technical Evaluation of Previous Soil Depth Estimation Methods and Development of Alternate Parameter Values			
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9. Remarks			
Appendix B includes one compact disc containing spreadsheets and workbooks with worksheets used to summarize data in their native format for this analysis.			

Change History

10. Revision No.	11. Description of Change
Rev. 00	Initial Issue
Rev. 01	Revised to address DOE comments (DRF 47473) and CR 9047 to provide additional statistical information on soil-depth class distributions in Table 6-10. Expanded the discussion on the use of the results of this analysis for infiltration modeling in Section 6.2.3.

CONTENTS

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FIGURES

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TABLES

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ACRONYMS

DTN	data tracking number
GFM	geologic framework model
RIS	Records Information System
TDMS	Technical Data Management System

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1. PURPOSE

The purpose of this analysis is to evaluate the reasonableness of the approach and the results used to generate surficial deposits (soil) depth information in input file *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6).

In this analysis, soil refers to unconsolidated surficial deposits that range in composition from talus accumulations of cobbles and boulders to fine-grained eolian deposits. *SOILMAP6.INP* data were used in support of the infiltration model (BSC 2004 [DIRS 170007], Sections 6.6.2, 6.6.3, and 6.7.1, and Appendices B, F, and G). The evaluation also considers the utility of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) for use in a future version of the infiltration model. *SOILMAP6.INP* assigns a soil type and depth to each 30 × 30 m grid cell in the model area. Soil type data are used to assign hydrologic and physical properties to surficial deposits for each grid cell. Soil depth data are used directly in the infiltration model for the Yucca Mountain repository.

Through this analysis, *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) data are reviewed herein and alternate soil depth parameter values are recommended as part of the analysis for future infiltration modeling described in *Technical Work Plan for: Infiltration Model Assessment, Revision, and Analyses of Downstream Impacts* (BSC 2006 [DIRS 177492]). Alternate soil depth parameter values are intended for the limited purpose of supporting these revised infiltration modeling calculations. The evaluation of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) represents a work scope element of the technical work plan (BSC 2006 [DIRS 177492], Section 1.1.2, Task 1). Objectives of the work scope element are to:

- Address issues related to technical inadequacies in data and references associated with data collection or reduction that were used in the infiltration model report (BSC 2004 [DIRS 170007])
- Evaluate the technical adequacy of the data and their references (BSC 2004 [DIRS 170007]), and compile a list of issues that require updating or correction
- Evaluate data and records, found to have issues, to identify a resolution plan and to identify, as necessary, other potential sources of data, qualify existing data, and reperform data reduction steps, and to document the evaluation and resolution in accordance with LP-SIII.9Q-BSC, *Scientific Analysis*.

This analysis does not deviate from the applicable technical work plan and work scope elements (BSC 2006 [DIRS 177492], Section 1.1.2, Task 1). The principal criteria related to the evaluation of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) are:

- Review the transparency and traceability of the methods used to generate the file and review the adequacy of these methods

- Review the adequacy and qualification status of the source data used to generate the file
- Review any corroborating or contrary data that might exist that were not used in developing the file.

2. QUALITY ASSURANCE

Development of this analysis and its supporting calculation activities are subject to the Yucca Mountain Project quality assurance program, as indicated in the technical work plan (BSC 2006 [DIRS 177492], Section 8.1), using approved quality assurance procedures (BSC 2006 [DIRS 177492], Section 4.1) to conduct and document the activities. The technical work plan also identifies the methods used to control the electronic management of data (BSC 2006 [DIRS 177492], Section 8.4). Calculations herein were conducted and documented following LP-SIII.9Q-BSC.

This analysis examines the properties of the upper natural barrier – surficial soils, classified as "Safety Category" in *Q-List* (BSC 2005 [DIRS 175539], Appendix A), because they are important to waste isolation as defined in LS-PRO-0203, *Q-List and Classification of Structures, Systems, Components and Barriers*. This analysis contributes to the evaluation and modeling data used to support postclosure performance assessment. It is possible that a future postclosure performance-assessment modeling report will use the conclusions of this analysis and the report could produce results that might affect a design or engineered feature. Such a modeling report would then address any potentially affected feature, structure, system, or component.

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3. USE OF SOFTWARE

Digital comparisons were conducted using the baseline version of ARCINFO (ARCINFO V.7.2.1. STN: 10033-7.2.1-00 [DIRS 157019]) running on a Silicon Graphics, Inc. machine (CRWMS M&O 2000 [DIRS 150920]). This geographic information system software is specifically designed for the intended use of graphically displaying the content of the files discussed herein and for comparing or compiling information for individual cells in the files. ARCINFO is the standard software used for geographic information system processing by the Technical Data Management System (TDMS) and it is appropriate for use in this analysis. This software is used within the range of validation. Some figures in Section 6 (Figures 6-1, 6-2, 6-3, 6-6, 6-8, 6-9, and 6-12) were created using ARCINFO software and using the data listed as the source for each figure.

Data compilation, sorting, and calculations presented in text, tables, and graphs in this analysis were conducted using standard mathematical and statistical functions in Microsoft® 2000 Excel® running on a Dell® personal computer using the Microsoft® 2000 Windows® professional operating system. This software is exempt from the requirements of IT-PRO-0011, *Software Management*, Sections 1.4.2 and 1.4.6. Spreadsheets and workbooks with worksheets used for these processes are described in Appendix B, which also includes the electronic format on compact disc to meet the requirements for documentation and reproducibility per LP-SIII.9Q-BSC, Section 3 of Attachment 2.

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4. INPUTS

4.1 DIRECT INPUTS

This analysis does not use direct inputs to evaluate the technical adequacy (Section 6.1) of existing soil depth data provided in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6). The data used in Section 6.1, some of which are qualified and some unqualified, are used for comparison with the values in *SOILMAP6.INP*, and thereby determine whether the methods and values used for and in *SOILMAP6.INP* are corroborated.

Direct inputs used in the development of the alternate soil depth data summary (Section 6.2) are listed in Table 4-1. To define the ranges of soil depths found in each class discussed in Section 6.2.1, this analysis uses the following soil mapping sources, which have been catalogued in the TDMS by data tracking numbers (DTNs) and ACCs (accession numbers):

- GS940108315142.004 [DIRS 160344], ACCs: MOL.20021001.0238 and MOL.20021001.0239
- GS940108315142.005 [DIRS 160345], ACCs: MOL.20021203.0409 and MOL.20021203.0410
- GS940708315142.008 [DIRS 160346], ACCs: MOL.20021001.0260 and MOL.20021001.0261
- GS950408315142.004 [DIRS 160347], ACC: MOL.20020827.0355.

The analysis also uses a composite soils map (DTN: GS960408312212.005 [DIRS 146299], ACCs: JOL.19961118.0098 and MOL.1996 1118.0100), which was compiled from the sources just listed.

The composite soils map (DTN: GS960408312212.005 [DIRS 146299], ACCs: JOL.19961118.0098 and MOL.19961118.0100) is used to define soil depth classes (Section 6.2.1). The sources used are the current qualified and verified sources for soils mapping in the area covered in this analysis. The appropriateness of the composite soils map (DTN: GS960408312212.005 [DIRS 146299], ACCs: JOL.19961118.0098 and MOL.19961118.0100) has been evaluated separate from this analysis (BSC 2006 [DIRS 176335], Section 6).

Field surface measurements of soil depth are used as the primary source for soil depths in the shallow soil class (Table 4-1). The source DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, provides better data on this depth range than do borehole data. Uncertainties associated with using borehole data in shallow soils are discussed in Section 6.2.

The direct inputs listed under the Borehole Soil Depth and Borehole Location data types are compiled in Table A-1. The data in Table A-1 include both qualified and unqualified inputs that are used in Sections 6-1 and 6-2.

Table 4-1. Direct Input Data

Data Type	Input Description	Input Document Identification Number
Soil Mapping	Preliminary Surficial Materials Properties Map: Soils of the Yucca Mountain Area, NV. Submittal date: 04/18/1996.	DTN: GS960408312212.005 [DIRS 146299], ACCs: JOL.19961118.0098 and MOL.19961118.0100
	Draft Surficial Deposits Map of the Northeast Quarter of the Busted Butte 7.5-Minute Quadrangle. Submittal date: 12/22/1993.	DTN: GS940108315142.004 [DIRS 160344], ACCs: MOL.20021001.0238 and MOL.20021001.0239
	Draft Surficial Deposits Map of the Southern Half of the Topopah Spring NW 7.5-Minute Quadrangle. Submittal date: 12/22/1993.	DTN: GS940108315142.005 [DIRS 160345], ACCs: MOL.20021203.0409 and MOL.20021203.0410
	Draft Surficial Deposits Map of the Northwest Quarter of the Busted Butte 7.5-Minute Quadrangle, Nye County, Nevada. Submittal date: 07/27/1994.	DTN: GS940708315142.008 [DIRS 160346], ACCs: MOL.20021001.0260 and MOL.20021001.0261
	Draft Map of the Surficial Deposits of the Southern Half of the Busted Butte 7.5' Quadrangle, Nye County, Nevada. Submittal date: 04/03/1995.	DTN: GS950408315142.004 [DIRS 160347], ACC: MOL.20020827.0355
Field Surface Measurement of Soil Depth	SN-USGS-SCI-113 V1: Empirical Calculation of Soil Thickness Based on Field Measurements. Submittal date: 01/24/2002.	DTN: GS011208312212.004 [DIRS 176317], Table S02086_001
Borehole Soil Depth	UE-25 RF#13 Borehole Log of Soil and Other Materials Above Bedrock. Submittal date: 03/05/1999.	DTN: MO9903BLOGSOIL.000 [DIRS 103790], Table S99142_001
	Graphical Lithologic Log of Borehole UE-25 UZ#16. Submittal date: 11/22/1993.	DTN: GS931208314211.047 [DIRS 110313] ACC: NNA.19940411.0054 (partially superseded DTN)
	Table of Contacts in Boreholes USW UZ-N57, UZ-N58, UZ-N59, and UZ-N61. Submittal date: 02/10/1994.	DTN: GS940208314211.008 [DIRS 145581], ACC: NNA.19940323.0344
	Table of Contacts for the Tiva Canyon Tuff in Borehole USW UZ-N38. Submittal date: 03/10/1994.	DTN: GS940308314211.011 [DIRS 145588], ACC: MOL.19941101.0063
	Graphical Lithologic Log of Borehole NRG-2 (UE-25 NRG#2), Yucca Mountain, Nevada. Submittal date: 10/07/1993.	DTN: GS931008314211.039 [DIRS 150009], ACC: NNA.19940105.0085
	Graphical Lithologic Log of Bore Hole USW NRG-6. Submittal date: 10/07/1993.	DTN: GS931008314211.045 [DIRS 150010], ACC: NNA.19940608.0248
	Lithostratigraphic Contacts from MO9811MWDGFM03.000 to be Qualified Under the Data Qualification Plan, TDP-NBS-GS-000001. Submittal date: 04/04/2000.	DTN: MO0004QGFMPICK.000 [DIRS 152554], Table S00214_001
	Table of Contacts in Boreholes USW UZ-N33 and USW UZ-N34. Submittal date: 02/10/1994.	DTN: GS940208314211.006 [DIRS 152555], ACC: NNA.19940414.0074 (partially superseded DTN)
	Table of Contacts in Boreholes USW UZ-N31, UZ-N32, UZ-N37. Submittal date: 02/10/1994.	DTN: GS940208314211.005 [DIRS 152563], ACC: NNA.19940323.0348 (partially superseded DTN)
	Table of Contacts in Boreholes USW UZ-N53, USW UZ-N54, and USW UZ-N55. Submittal date: 02/01/1994.	DTN: GS940208314211.003 [DIRS 152565], ACC: NNA.19940323.0355 (partially superseded DTN)
	Table of Contacts in Borehole USW UZ-N35. Submittal date: 02/10/1994.	DTN: GS940208314211.007 [DIRS 155533], ACC: NNA.19940414.0078

Table 4-1. Direct Input Data (Continued)

Data Type	Input Description	Input Document Identification Number
Borehole Soil Depth (Continued)	Table of Contacts for the Tiva Canyon Tuff in Borehole UE-25 UZN#63. Submittal date: 03/28/1994.	DTN: GS940308314211.017 [DIRS 155534], ACC: MOL.19941101.0064
	Generalized Lithologic Log for Test Well USW H-1. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.028 [DIRS 155589], ACC: NNA.19870519.0103
	Lithologic Log for Drill-Hole UE-25 P#1. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.029 [DIRS 155590], ACC: HQS.19880517.2633
	Lithologic Log of Drill-Hole USW G-1. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.030 [DIRS 155591], ACC: NNA.19870406.0222
	Litologic Description of Exploratory Drill Hole USW G-2. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.031 [DIRS 155592], ACC: NNA.19870506.0143
	Geotechnical Borehole Logs for the Waste Handling Building, Yucca Mountain Project, Nevada Test Site, Nevada, Version 7/16/03. Submittal date: 07/23/2003.	DTN: GS030783114233.001 [DIRS 164561], Tables S03299_001 through S03299_016
	Yucca Mountain Site Characterization Project Geology and Rock Structure Log for Drillhole USW NRG-7/7A, Rev. 1. Submittal date: 02/06/1995.	DTN: SNF29041993002.042 [DIRS 166437], Table S97096_001
	Sample Management Facility Geologic Logs for Nye County Early Warning Drilling Program (EWDP) Phase III. Submittal date: 10/08/2002.	DTN: MO0210SMFGLOG3.000 [DIRS 175917], Table S02293_001
	Yucca Mountain Site Characterization Project Geology and Rock Structure Log for Drillhole UE25 NRG-2A, Rev. 1. Submittal date: 02/06/1995.	DTN: SNF29041993002.036 [DIRS 175928], ACC: MOL.19950327.0071
	Sample Management & Drilling Department Records Package for Borehole Records (Geologic Logs) from the "Geotechnical Field Investigation for the Waste Handling Building," FWP-SB-00-003. Submittal date: 01/10/2001.	DTN: MO0101SEPBGLOG.000 [DIRS 157481], ACCs: MOL.20010125.0206, MOL.20010125.0212, MOL.20010125.0194, MOL.20010125.0188, MOL.20010125.0182, MOL.20010125.0221, MOL.20010125.0200, MOL.20010125.0224, MOL.20010125.0191
	Graphical Lithologic Log of Borehole NRG-2B (UE-25 NRG#2B), Yucca Mountain, Nevada. Submittal date: 10/07/1993.	DTN: GS931108314211.041 [DIRS 150011], ACC: NNA.19940217.0156 (partially superseded DTN)
Borehole Location	As-Built Location of UE-25 RF#13 Borehole. Submittal date: 02/23/1999.	DTN: MO9902ASBUBOLC.000 [DIRS 103793], */pub3/gis/baseline/test/mo9902asbubolc.zip*
	Yucca Mountain Project (YMP) Borehole Locations. Submittal date: 06/23/1999.	DTN: MO9906GPS98410.000 [DIRS 109059], */pub3/gis/baseline/test/g98410.zip*
	Generalized Lithologic Log for Test Well USW H-1. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.028 [DIRS 155589], ACC: NNA.19870519.0103
	Lithologic Log for Drill-Hole UE-25 P#1. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.029 [DIRS 155590]; ACC: HQS.19880517.2633
	Lithologic Log of Drill-Hole USW G-1. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.030 [DIRS 155591], ACC: NNA.19870406.0222
	Lithologic Description of Exploratory Drill Hole USW G-2. Submittal date: 06/27/2001.	DTN: MO0106STRATHFM.031 [DIRS 155592], ACC: NNA.19870506.0143
	As-Built Borehole Locations Waste Handling Building WHB Site Investigation. Submittal date: 03/07/2001.	DTN: MO0103GSC01031.000 [DIRS 157304], */pub3/gis/baseline/test/mo0103gsc01031.zip*

Table 4-1. Direct Input Data (Continued)

Data Type	Input Description	Input Document Identification Number
Borehole Location (Continued)	As-Built Survey of Nye County Early Warning Drilling Program (EWDP) Phase III Boreholes NC-EWDP-10S, NC-EWDP-18P, and NC-EWDP-22S – Partial Phase III List. Submittal date: 03/21/2002.	DTN: MO0203GSC02034.000 [DIRS 168375], */pub3/gis/baseline/test/ncewdp31.zip*
	As-Built Location for Surface Boreholes. Submittal date: 06/20/2005.	DTN: MO0506GSC05047.000 [DIRS 175919], */pub3/gis/baseline/test/g05047.zip* and *Cr-4902-sbh.xls*
Modeled Alluvial Depth	Geologic Framework Model (GFM2000). Submittal date: 12/18/2000.	DTN: MO0012MWDGFM02.002 [DIRS 153777], model file
	Geologic Framework Model (GFM2000).	BSC 2004 [DIRS 170029], Figure 6-10

ACC = accession number; DTN = data tracking number.

Direct inputs for borehole soil depth and borehole location (Table 4-1) used in this evaluation are listed in Section 6.2.1, pages 6-34 and 6-38 to 6-41. Data extracted from the direct-use (qualified) and indirect-use (unqualified) sources for borehole alluvial thickness (soil depth) and borehole location are listed in Table A-1. Qualified data that are directly used are listed in Table 4-1 and are separated from unqualified data in the complete listing of all borehole data in Table A-1. Data from the qualified sources are used to estimate the distribution of soil depths and are appropriate for determining soil depth in thicker soil depth classes. These sources were identified through a search of available data on borehole lithology in the Records Information System (RIS) and in the TDMS. These sources represent available data that have been qualified and verified and are considered appropriate for the use described in Section 6.2.

Other sources of soil depth information, such as test pit data, were reviewed but were not directly used. Test pit data that are qualified and verified are located around the Waste Handling Building location and do not intersect bedrock. There are several boreholes in this area that do intersect bedrock and provide a better estimate of soil depth at this location. Other test pit and trench sources are not qualified or verified, and the test pits in this category do not intersect soil-bedrock contact. Some trenches that do intersect the soil-bedrock contact were not directly used because of their qualification status. Data sources for some boreholes are identified as superseded in the TDMS. These sources are documented in the following DTNs:

- GS931108314211.041 [DIRS 150011], ACC: NNA.19940217.0156 (partially superseded DTN)
- GS931208314211.047 [DIRS 110313], ACC: NNA.19940411.0054 (partially superseded DTN)
- GS940208314211.003 [DIRS 152565], ACC: NNA.19940323.0355 (partially superseded DTN)

- GS940208314211.005 [DIRS 152563], ACC: NNA.19940323.0348 (partially superseded DTN)
- GS940208314211.006 [DIRS 152555], ACC: NNA.19940414.0074 (partially superseded DTN).

As noted in the description and comment fields on the Technical Data Information Form, the data in these DTNs are partially superseded and only a small section of the borehole log is superseded by another DTN. The superseding DTNs only provide revised data for the bedded tuff section between the Tiva Canyon and Topopah Springs tuffs and data on the rest of the section penetrated by the boreholes remains in the partially superseded DTNs. From these sources, only the data that were not superseded were used in this analysis. Therefore, the data used from these sources are not superseded, are qualified, and are appropriate for use in this analysis.

Sources for modeled alluvial depth (Table 4-1) were used in this analysis (Section 6.2.1) as sources for depth information on the deeper alluvial section; these sources are from the current version of the geologic framework model (BSC 2004 [DIRS 170029]) and in its output product DTN: MO0012MWDGFM02.002 [DIRS 153777], both hereafter referred to as the GFM. This model represents a synthesis of available geologic information on the site area and is appropriate for this purpose.

Equations that calculate standard statistical test values and tables of standard values (Gilbert 1987 [DIRS 163705]) were used to interpret the test results. The standard textbook used is an appropriate source for this type of information and is the type of source that scientists and engineers would use in their standard work practices to retrieve information of this type. This textbook and the methods taken from this textbook that are used in this analysis have also been recognized and recommended as sources for use in regulatory actions by the U.S. Environmental Protection Agency (EPA 2002 [DIRS 176873], p. 8-11).

4.2 CRITERIA

The technical work plan (BSC 2006 [DIRS 177492], Section 3) identifies the regulatory criteria applicable to infiltration modeling. A subset of these criteria is applicable to data evaluation and summarization for use in infiltration modeling. The activities described in this analysis are subject to regulatory review per the acceptance criteria in *Yucca Mountain Review Plan, Final Report,* NUREG-1804 (NRC 2003 [DIRS 163274], Section 2.2.1.3.5.3); acceptance criteria 2 and 3, related to infiltration data, are as follows:

- Acceptance Criterion 2: Data are sufficient for model justification:

  (1) Climatological and hydrological values used in the license application (e.g., time of onset of climate change, mean annual temperature, mean annual precipitation, mean annual net infiltration, etc.) are adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

(3) The effects of fracture properties, fracture distributions, matrix properties, heterogeneities, time-varying boundary conditions, evapotranspiration, depth of soil cover, and surface-water runoff and runon are considered, such that net infiltration is not underestimated.

(4) Sensitivity or uncertainty analyses are performed to assess data sufficiency and determine the possible need for additional data.

- Acceptance Criterion 3: Data uncertainty is characterized and propagated through the model abstraction:

(1) Models use parameter values, assumed ranges, probability distributions, and bounding assumptions that are technically defensible, reasonably account for uncertainties and variabilities, and do not result in an under-representation of the risk estimate.

(2) The technical bases for the parameter values used in this abstraction are provided.

(3) Possible statistical correlations are established between parameters in this abstraction. An adequate technical basis or bounding argument is provided for neglected correlations.

4.3 CODES, STANDARDS, AND REGULATIONS

Codes, standards, or regulations applicable to this work are defined in the technical work plan (BSC 2006 [DIRS 177492], Section 3). The acceptance criteria in Section 4.2 are primarily derived from 10 CFR 63.114 (a) and (b) [DIRS 176544]. No other codes, standards, or regulations have been identified as being applicable to this analysis.

5. ASSUMPTIONS

No assumptions were used in this analysis that do not have direct confirming data or evidence. Other assumptions that are confirmed or supported by direct-use or corroborating evidence are discussed in Section 6.

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6. SCIENTIFIC ANALYSIS DISCUSSION

SOILMAP6.INP (USGS 2000 [DIRS 175858], folder Soilmap6) is referred to extensively throughout this analysis. *SOILMAP6.INP* is an intermediate product output file that was generated using the SOILMAP6 V1.0 routine within the infiltration model report (BSC 2004 [DIRS 170007], Appendix G). Afterwards, *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) was used as an input file to the infiltration model, which is documented in the infiltration model report (BSC 2004 [DIRS 170007]). *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) was found in the records system without an assigned DTN.

DTN: MO0512SPASURFD.000 [DIRS 175870] was created to contain *SOILMAP6.INP* and to provide a traceable link to the file (Section 7). *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) is an input file that consists of 49 columns and 253,597 rows for the infiltration model. Each row corresponds to a 30 × 30 m cell in the infiltration model area. The columns provide information on cell location, soil type, soil depth, soil depth class, slope, aspect, elevation, geology, and blocking ridge angles.

The term "soil depth" is used herein to denote the thickness of all surficial deposits that overlie the bedrock at Yucca Mountain. Therefore, "soil" may range in composition from talus accumulations of cobbles and boulders to fine-grained eolian deposits.

Native Excel® spreadsheets, and workbooks with worksheets, of calculations used in this evaluation (Sections 6.1 and 6.2) are provided in Appendix B.

6.1 EVALUATION

6.1.1 Background Information and Evaluation of *SOILMAP6.INP*

The construction of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) is discussed in the infiltration model report (BSC 2004 [DIRS 170007]); *SOILMAP6.INP* was not an output or reference of the report. *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) is based on a set of qualified and verified surficial deposits maps, generated by Lundstrom et al., documented in DTNs:

- GS940108315142.004 [DIRS 160344], ACC: MOL.20021001.0239
- GS940108315142.005 [DIRS 160345], ACC: MOL.20021203.0410
- GS940708315142.008 [DIRS 160346], ACC: MOL.20021001.0260
- GS950408315142.004 [DIRS 160347], ACC: MOL.20020827.0355.

These maps were later consolidated and modified using a different soil classification system developed by the U.S. Department of Agriculture (USDA 1994 [DIRS 175859]). The resulting map encompasses the infiltration modeling area (DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098). It was Guertal and Davies who, to develop a new map, used soil descriptions and physical properties measurements from test pits and trenches in the Yucca Mountain area, along with the earlier mapping by Lundstrom et al. as listed in the previous paragraph. Creation of the new map consolidated the areas encompassed by the other maps onto one single map (DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098); the source tree for this map lists twenty-five DTNs. This DTN and its sources are qualified and verified in accordance with procedures that have subsequently been superseded by LP-3.15Q-BSC.

The new map by Guertal and Davies (DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098) and associated data (DTN: GS960508312212.007 [DIRS 124829], ACCs: MOL.20020930.0554 and MOL.20020930.0552), which give preliminary depth to bedrock, were used in the development of the infiltration model (BSC 2004 [DIRS 170007]) to estimate the thickness of surficial deposits by assigning soil depth codes. The preliminary depth to bedrock codes were further modified to remove unrealistically sharp contrasts between adjacent cells, remove inconsistencies between soil depth and bedrock classification, and assign discrete soil thicknesses. The assignment was then further modified by software routine GEOMOD4 V1.0 (BSC 2004 [DIRS 170007], Appendix F) to ensure that any contacts between thin colluvial deposits and deep alluvial deposits were separated by cells with an intermediate surficial deposit thickness. The same routine also ensured that any cells assigned a bedrock classification in the bedrock properties input file *GEOMAP7.INP* (BSC 2004 [DIRS 170007], Appendix F), which indicates a thin colluvial cover and deep alluvial classification based on soils mapping, received an intermediate depth value to reconcile the two classifications (BSC 2004 [DIRS 170007], Appendix F). Finally, a discrete thickness, based on the soil class and topographic slope angle for each 30 × 30 m cell in the model grid, was calculated using the software routine SOILMAP6 V1.0 (BSC 2004 [DIRS 170007], Appendix G).

The calculation resulted in two values related to the soil depth in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) for each of the approximately 250,000 cells that compose the model area. The first soil depth value in the file shows one of six soil depth code numbers, as listed in Table 6-1, assigned to a cell. Soil Depth Codes 3, 5, and 6 represent the same depth range; the depth values, however, were calculated using different methods. The second soil depth value in the file provides an estimated thickness of the surficial deposit based on the soil depth code and topographic slope.

Table 6-1. Explanation of Soil Depth Codes Used in *SOILMAP6.INP*

Soil Depth Code	Depth Range Represented (m)	Comments
1	0.0 to 0.5	Depth based on soil type and topography
2	0.5 to 3.0	Depth based on soil type and topography
3	3.0 to 6.0	Depth based on soil type and topography
4	>6.0	Depth based on soil type and topography
5	3.0 to 6.0	Depth based on GEOMOD4 routine Adds intermediate depth between deep and shallow-soil cells
6	3.0 to 6.0	Depth based on GEOMOD4 routine Adds intermediate depth when cell mapped as bedrock, but has a deep alluvial soil

Source: BSC 2004 [DIRS 170007], Section 6.6.2 and Appendices B and G.

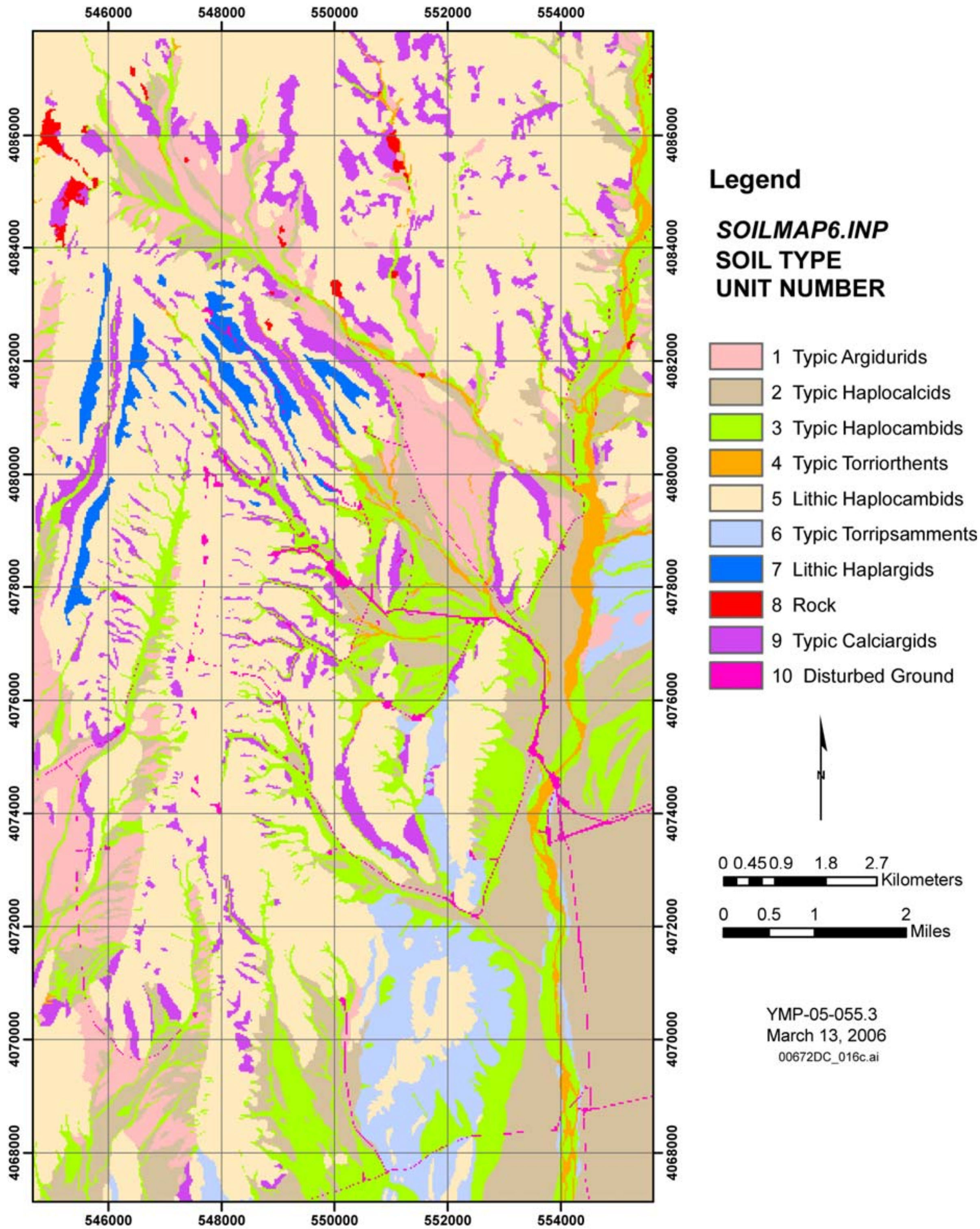
NOTE: Depth ranges and precision are as given in the source.

SOILMAP6.INP (USGS 2000 [DIRS 175858], folder Soilmap6) consists of a compact disc containing one folder, GEOINPUT-1, which contains four secondary folders: Blockr7, Geomap7, Geomod4, and Soilmap6 (USGS 2000 [DIRS 175858]). *SOILMAP6.INP* is included in the secondary folder Soilmap6, along with several other files related to the development of *SOILMAP6.INP*. Although GEOINPUT-1 was intended to be part of an attachment to previous versions of the infiltration model (USGS 2000 [DIRS 123650]; USGS 2001 [DIRS 154674]; USGS 2001 [DIRS 160355]; USGS 2003 [DIRS 166518]), the compact disc containing GEOINPUT-1 was not included in versions located in the Controlled Documents Information System.

6.1.2 Evaluation of *SOILMAP6.INP*

SOILMAP6.INP (USGS 2000 [DIRS 175858], folder Soilmap6) contains a field that identifies the soil type from the original map (DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098) for each cell in the model area, which is the starting point of this evaluation. Soil type is a descriptive classification based upon taxonomy, which is an orderly arrangement for distinguishing soils using observable characteristics (USDA 1994 [DIRS 175859]). Figure 6-1 presents, in map form, the content of the soil type assignments from *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6). The *SOILMAP6.INP* map (Figure 6-1) was compared to the original map (DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098) by overlaying the two maps on a light table, and the *SOILMAP6.INP* file was found to be a good representation of the original map. In addition, the digital version of the soilmap (DTN: MO9903COV96274.000 [DIRS 176571], */pub3/gis/baseline/geol/soils.e00*) was compared to *SOILMAP6.INP* using the ARCINFO IDENTITY command, and all 253,597 cells in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) were found to match the source file (Section B.1.1).

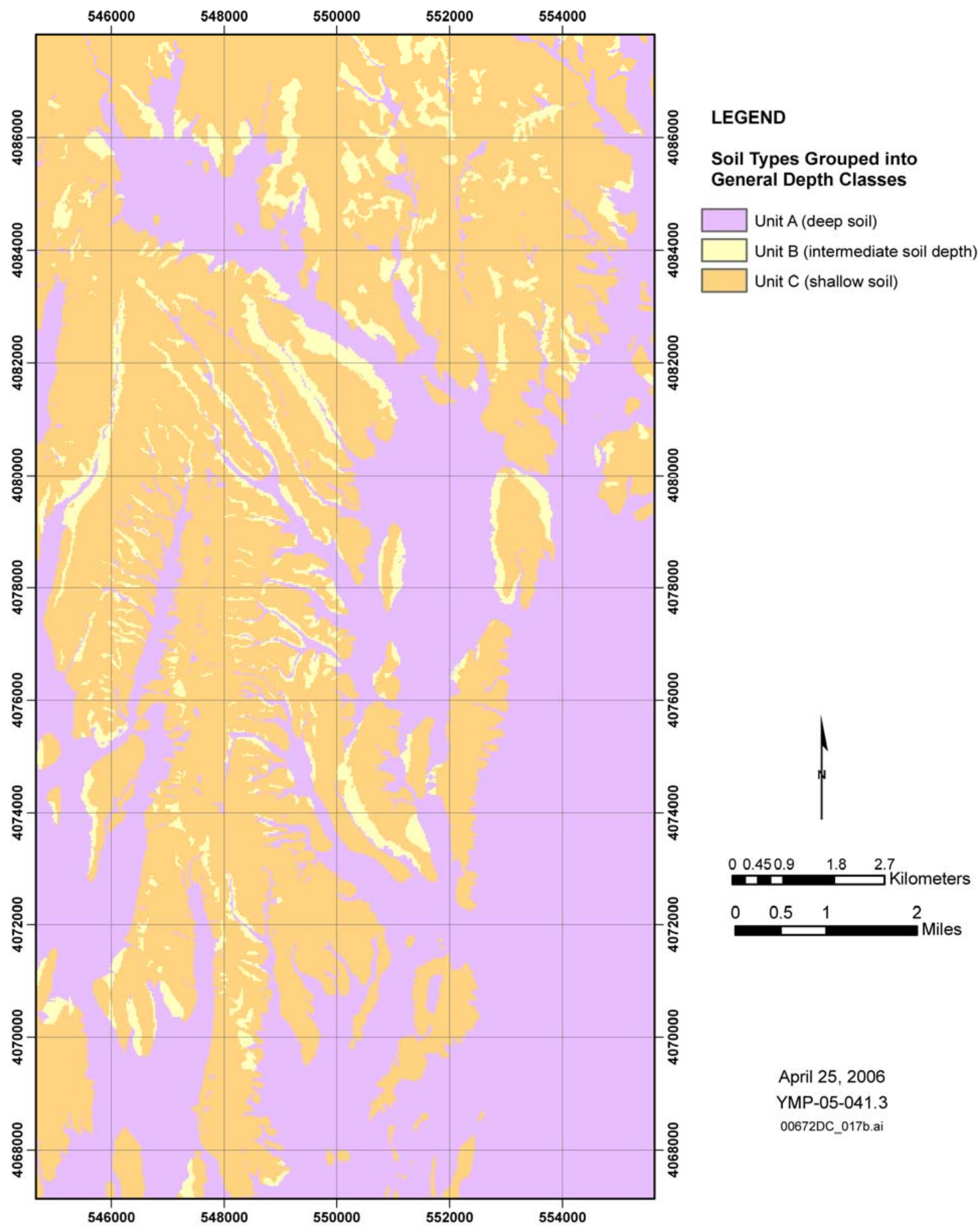
To generate a soil depth file for the entire model area, the soil types (Figure 6-1) were grouped into general soil depth classes (Table 6-2). Three main soil depth classes of soil, those being deep (Unit A), intermediate (Unit B), and shallow (Unit C) (Figure 6-2), were initially selected (DTN: GS960508312212.007 [DIRS 124829], ACCs: MOL.20020930.0554 and MOL.20020930.0552) to produce depth classes based solely on the soil mapping that correspond, respectively, to Soil Depth Codes 3, 2, and 1 (Table 6-1). The resulting soil depth file was then modified based on an estimate using a combination of surficial deposits mapping, topography, field observations, and soil-alluvial depth recorded at borehole sites to produce a final soil depth file. The final soil depth codes from the final file are listed in Table 6-1 and are shown in Figure 6-3. This final step, of combining the various sources of information, used the professional judgment of the author or authors of the infiltration model report (BSC 2004 [DIRS 170007]) who also created the map and soil-depth calculations. This professional judgment is unique to each individual and is not recorded in detail in the report or supporting records, and, thus, cannot be reproduced exactly, but the result has been evaluated against the combined soil map (Figure 6-2).



Sources: DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098; USGS 2000 [DIRS 175858], folder Soilmap6.

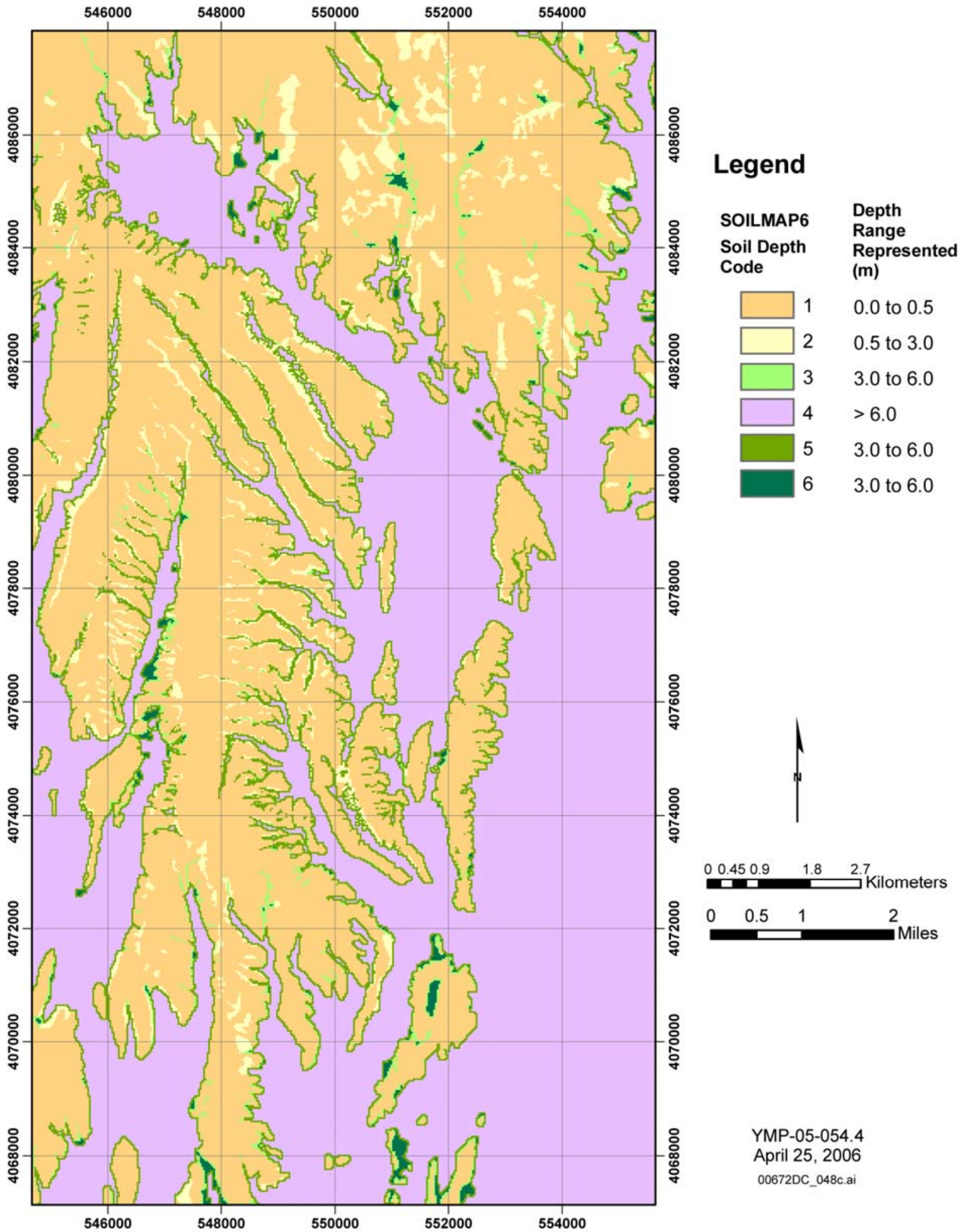
NOTE: Map units are defined in Table 6-2.

Figure 6-1. Representation of the Digital Soil Map Using *SOILMAP6.INP*



Sources: Figure 6-1; Table 6-2; USGS 2000 [DIRS 175858], folder Soilmap6.

Figure 6-2. Surficial Deposit Units Grouped into Depth Classes



Source: USGS 2000 [DIRS 175858], folder Soilmap6.

NOTE: Map units are defined in Table 6-1.

Figure 6-3. Final Soil Depth Codes in *SOILMAP6.INP*

Table 6-2. Classification Scheme Used in the Digital Soil Map for Surficial Deposits Mapping

Soil Type Unit Number[a]	Soil Classification[a]	Corresponding General Soil Depth Classes[b]	Lundstrom Soil Classification[c]
1	Typic Argidurids	Deep Soil–Alluvium	0, 1, 1-3, 2, Tgp
2	Typic Haplocalcids	Deep Soil–Alluvium	3, 3f, 3-4, 4, 4f, 4s, 4/1, 4s-5s, 3-5
3	Typic Haplocambids	Deep Soil–Alluvium	5, 5f, 5s, 5/1, 5-6, 5f-6f, 6, 6f, 5-7
4	Typic Torriorthents	Deep Soil–Alluvium	7, 7f, 6-7, 6f-7f
5	Lithic Haplocambids	Shallow Soil–Colluvium	cu, cs
6	Typic Torripsamments	Deep Soil–Alluvium	e, eo, ey, 1/eo, 3/eo, 1/e, 3/e
7	Lithic Haplargids	Shallow Soil–Colluvium	rc
8	Rock	Exposed Bedrock–No Surficial Deposits	r
9	Typic Calciargids	Intermediate Soil	cf, cf/e
10	Disturbed Ground	Roads and Drill Pads	d

[a] DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098

[b] Grouping of soil classifications into depth classes shown in DTN: GS960508312212.007 [DIRS 124829], ACC: MOL.20020930.0554

[c] DTNs: GS940108315142.004 [DIRS 160344], ACC: MOL.20021001.0238
GS940108315142.005 [DIRS 160345], ACC: MOL.20021203.0409
GS940708315142.008 [DIRS 160346], ACC: MOL.20021001.0261
GS950408315142.004 [DIRS 160347], ACC: MOL.20020827.0355

The final soil depth map (Figure 6-3) reasonably correlates to the consolidated map (Figure 6-2), indicating that the soil depth classes are a good, general representation of depth based on soil mapping. Modifications introduced by the GEOMOD4 routine (BSC 2004 [DIRS 170007], Appendix F) were then incorporated into the soil depth code map. The extent of Soil Depth Codes 5 and 6 resulting from the use of this routine is relatively limited (Figure 6-3), so the effect of adding soil depth codes 5 and 6 will be small with respect to the total infiltration for the entire model area. The soil depths in meters from *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) were then calculated using a soil depth model that relies on soil depth code and topographic slope. The principal assumption in this calculation is that soil-colluvial depth varies with topography; for example, flatter ridge crests and areas at the base of steep slopes tend to have thicker accumulations of surficial deposits than the deposits found on steep hillside slopes.

The following formulae were used to calculate soil depth in meters (D) (BSC 2004 [DIRS 170007], Section 6.7.1):

Soil Depth Code 1
$D = 0.03*S + 0.1$ for slope angles (S) less than or equal to 10 degrees
$D = 0.013*(10-S) + 0.4$ for slope angles between 10 and 40 degrees
$D = 0.01$ for slope angles equal to or greater than 40 degrees.

Soil Depth Code 2
$D = 2 - (0.05*S)$ for slope angles less than 32 degrees
$D = 0.4$ for slope angles equal to or greater than 32 degrees.

Soil Depth Code 3
$D = 6 - (0.16*S)$ for slope angles less than 25 degrees
$D = 2.0$ for slope angles equal to or greater than 25 degrees.

Soil depth for Soil Depth Code 4 was uniformly set at 6 m for all cells, even though most actual depths are greater than this value. This was established because the infiltration model assumes that soil thicknesses exceeding 6 m eliminate the infiltration of water to the soil-bedrock contact, except in some stream channels (BSC 2004 [DIRS 170007], Section 6.1.2), and because the root zone depth is considered to not exceed 6 m, so depth calculations are not required for this code.

A check conducted on the first 65,536 rows in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), using Excel® (Section B.1.2), found that the depth values in the file could be reproduced using the equations in the infiltration model report (BSC 2004 [DIRS 170007], Section G4) and by using the soil depth codes assigned in the file. The only problem noted was a typographical error in the equation for depth class 3 (BSC 2004 [DIRS 170007], Appendix B), which indicates that the first equation for this class should be used for slope angles less than or equal to 25 degrees. Contrary to this range, the infiltration model report (BSC 2004 [DIRS 170007], Section 6.7.1) and *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) indicate that the equation should be used for slope angles less than 25 degrees and that the constant value of 2.00 should be used for slope angles greater than or equal to 25 degrees.

The infiltration model report (BSC 2004 [DIRS 170007]) and its predecessor reports (USGS 2003 [DIRS 166518]; USGS 2001 [DIRS 160355]; USGS 2000 [DIRS 123650]) do not indicate how these depth relationships were derived, so the accuracy of these relationships cannot be verified directly. The equations appear to be linear fits between certain points in the range of slope angles. For example, for the Soil Depth Code 1 equations just given, the ranges are defined by 0 to 10 degrees, between 10 and 40 degrees, and 40 degrees and greater. It is unclear as to how these ranges were chosen or how the constants used in each equation were determined.

The depth equations also define different end points for the soil depth codes than are identified in the infiltration model report (BSC 2004 [DIRS 170007]). For example, the infiltration model report (BSC 2004 [DIRS 170007], Section 6.6.2) gives the depth range for Soil Depth Code 1 as 0 to 0.5 m. The formulae discussed herein, however, define a depth range of 0.01 to 0.4 m. Similarly, the depth range given in the infiltration model report (BSC 2004 [DIRS 170007]) for Soil Depth Code 2 is 0.5 to 3.0 m, while the formulae define a range between 0.4 and 2.0 m. Soil Depth Code 3 is also at variance with a range of 3.0 to 6.0 m (BSC 2004 [DIRS 170007]); the formulae define a range between 2.0 and 6.0 m. This variance calls into question either the soil-depth-code definitions or the depth calculation formulae. Whichever rationale is used to calculate the depth value of cells, the result can be evaluated using other lines of evidence as discussed herein.

One set of data contains field measurements that provide soil depth and a corresponding slope value (DTN: GS011208312212.004 [DIRS 176317], Table S02086_001). The formulae can be evaluated by using the formulae to calculate depth from the measured slope value and then comparing the result to the measured depth value at that point. This can be done for two equations by assuming that the data, classed as having an underlying material of “Tpc” and “stone stripe” (DTN: GS011208312212.004 [DIRS 176317], Table S02086_001), correspond to Soil Depth Code 1 (DTN: MO0512SPASURFD.000 [DIRS 175870]).

The results from calculating depths using the equation for slopes of less than or equal to 10 degrees (Table 6-3, Figure 6-5) show a moderate degree of correlation between the calculated and measured values (correlation coefficient; $r = 0.71$, $r^2 = 0.50$). Depths calculated using the equation for slopes between 10 and 40 degrees show a poor degree of correlation between the calculated and measured values (correlation coefficient; $r = 0.24$, $r^2 = 0.06$). Three outlying points may affect the comparison (Figure 6-4). A test with these points removed, however, still indicates a poor correlation (correlation coefficient; $r = 0.50$, $r^2 = 0.25$).

The scatter of points resulting from this comparison (Figures 6-4 and 6-5) indicates that, at the detailed level, the correlation of topographic slope to soil depth is subject to uncertainty. This measured soil depth and slope data are not discussed in the infiltration model report (BSC 2004 [DIRS 170007]), even though a principal infiltration investigator participated in the data collection effort and the purpose of the data collection effort is stated as being to develop an empirical relationship to calculate soil thickness for modeling recharge in the unsaturated zone at Yucca Mountain (Taylor 2001 [DIRS 176601], RIS p. 5).

The soil depth file in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) can also be evaluated on a more general level. Figure 6-6 shows the soil depth values from *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) for a small part of the infiltration model area around The Prow at the north end of Yucca Mountain.

As expected from the equations used, the map mimics the topography in the area (Figures 6-6 and 6-7). Depth values on ridge crests are thin and grade to near zero on steep slopes surrounding the ridge crests. At the base of the steep slopes, the shallower slopes leading down to major drainages show increasing surficial deposit thickness. Thick alluvial deposits exist in the vicinities of major drainages, such as Windy Wash and Yucca Wash. This general pattern is reasonable and consistent with field observations (Sanchez 2006 [DIRS 176569], pp. 62 to 68).

While the general pattern is consistent and reasonable, the assignments to individual grid cells cannot be verified directly and may be more variable than the input file indicates. At a more detailed level, soil depth might be highly variable, even within a 30×30 m grid cell. Soil depths can range from small patches of bare rock to 0.5 m or more within a cell (Sanchez 2006 [DIRS 176569], photographs; Taylor 2001 [DIRS 176601], photographs). The methods used to estimate soil depths in a grid cell in the infiltration model report (BSC 2004 [DIRS 170007]) cannot account for this local variability. Thus, users of these depth estimates should be aware of this scale-dependent uncertainty when using these depth estimates.

Another check was performed by comparing surficial deposit depth information in boreholes to the predictions of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6). Table A-1 shows the boreholes, values, and data sources used for this comparison. The use of borehole data to verify surficial deposit depth is subject to some caveats that must be considered in making such a comparison. One consideration is the effect from drill pad construction on the measurement. In uneven terrain, the construction of a level pad for the drill rig may require significant cutting or filling, or both. If a borehole is shown as starting directly in bedrock, then this may indicate that surficial deposits were removed down to the bedrock as part of pad construction. This factor is apparent (Sanchez 2006 [DIRS 176569]) where the depth of surficial deposits, removed by pad construction, is indicated for some boreholes.

Table 6-3. Comparison of Measured Soil Thickness with Calculated Thickness

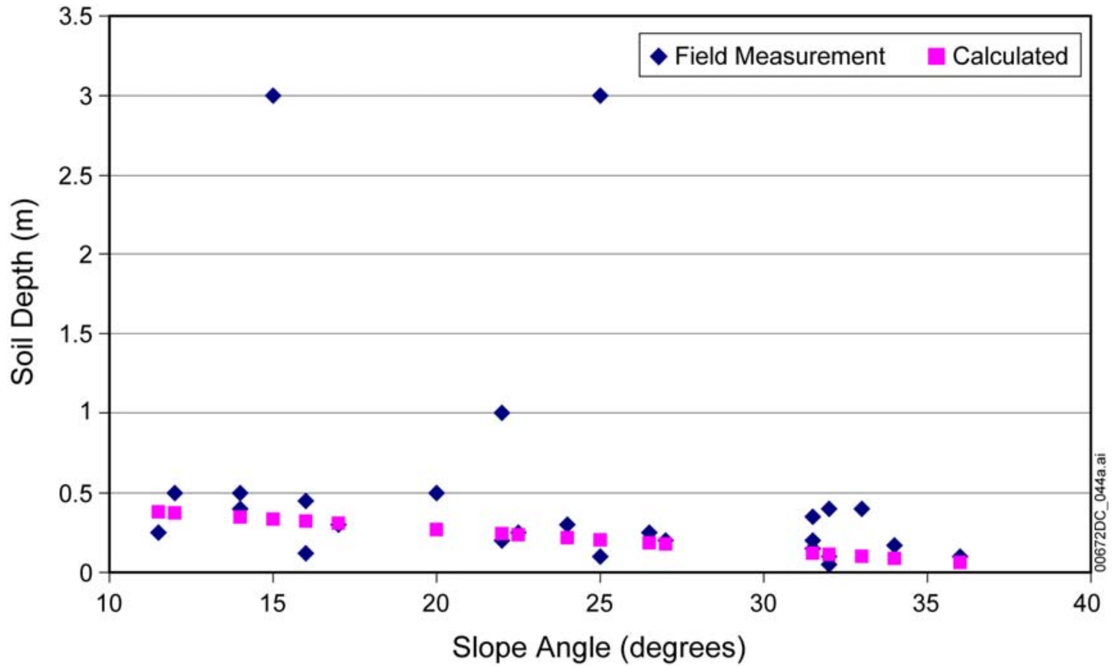
Slope Magnitude (degrees)[a]	Measured Soil Thickness (m)[a]	Calculated Soil Thickness using Slope (m)[b]	Difference Between Calculated and Measured Value
1.5	0.10	0.145	0.045
2.5	0.10	0.175	0.075
2.5	0.20	0.175	−0.025
4.0	0.20	0.22	0.020
5.0	0.20	0.25	0.050
7.0	0.20	0.31	0.110
10.0	0.75	0.4	−0.350
10.0	0.25	0.4	0.150
11.5	0.25	0.381	0.131
12.0	0.50	0.374	−0.126
14.0	0.40	0.348	−0.052
14.0	0.50	0.348	−0.152
15.0	3.00	0.335	−2.665
16.0	0.12	0.322	0.202
16.0	0.45	0.322	−0.128
17.0	0.30	0.309	0.009
20.0	0.50	0.270	−0.230
22.0	0.20	0.244	0.044
22.0	1.00	0.244	−0.756
22.5	0.25	0.238	−0.013
24.0	0.30	0.218	−0.082
25.0	0.10	0.205	0.105
25.0	3.00	0.205	−2.795
26.5	0.25	0.186	−0.065
27.0	0.20	0.179	−0.021
31.5	0.15	0.121	−0.029
31.5	0.20	0.121	−0.080
31.5	0.35	0.121	−0.230
32.0	0.05	0.114	0.064
32.0	0.10	0.114	0.014
32.0	0.40	0.114	−0.286
33.0	0.40	0.101	−0.299
34.0	0.17	0.088	−0.082
36.0	0.10	0.062	−0.038
43.0	0.40	0.010	−0.390

Source: Appendix B, Section B.1.3.

[a] Values from DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, for Deposit Units “Tpc” and “stone st”.

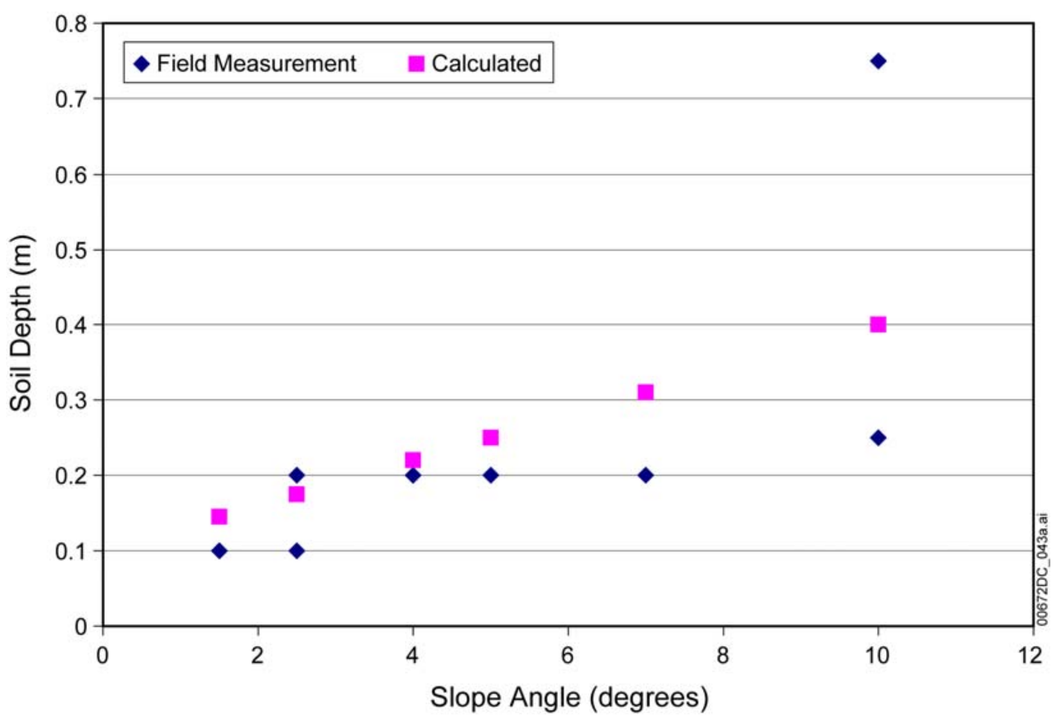
[b] Value calculated from slope value using the equations $D = 0.03 \times S + 0.1$ for $S \leq 10$; $D = 0.013 \times (10-S) + 0.4$ for $10 < S < 40$; and $D = 0.01$ for $S > 40$ degrees.

NOTE: Correlation Coefficient: $r = 0.71$ for $S \leq 10$ and $r = 0.24$ for $10 < S < 40$.



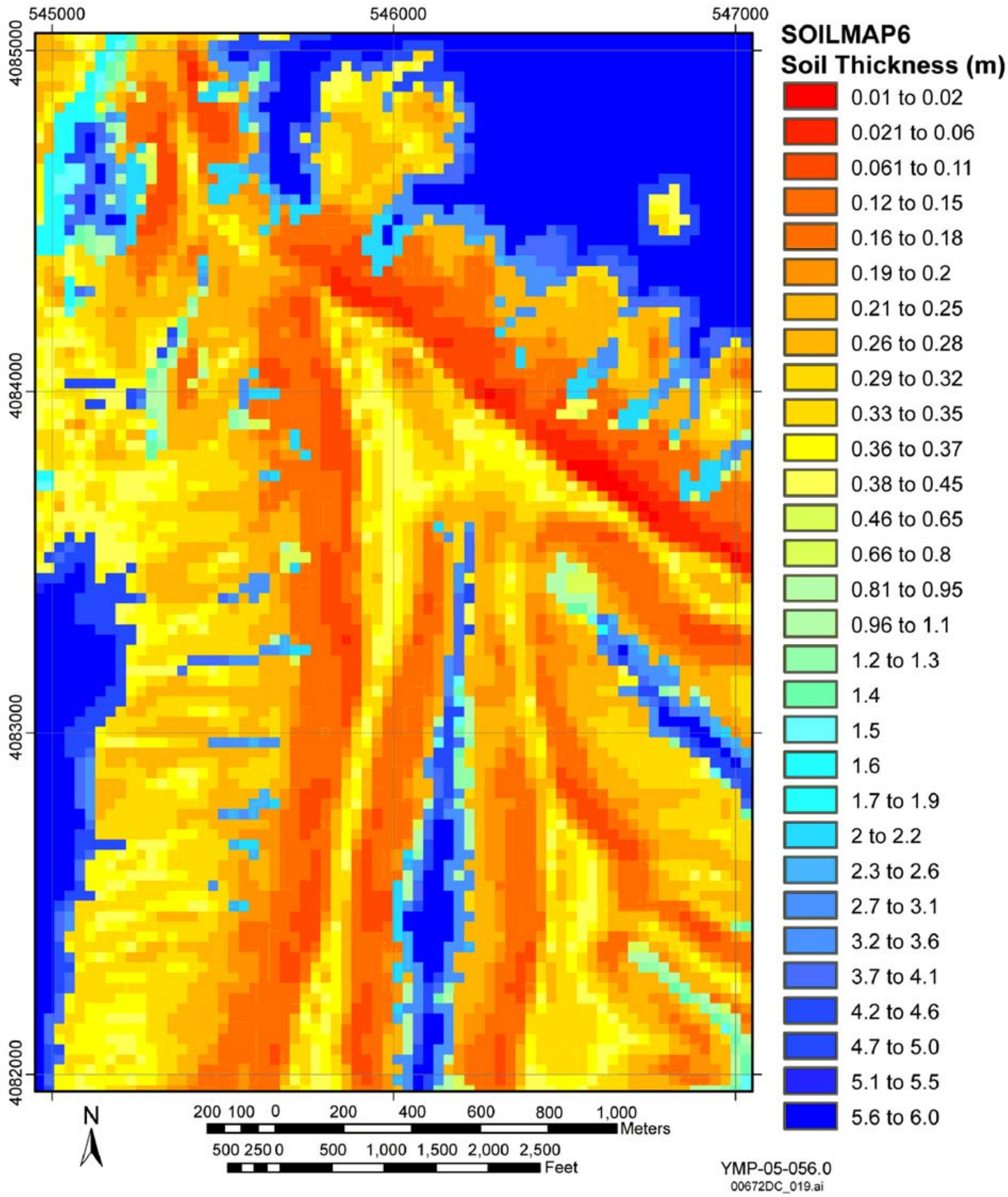
Source: Table 6-3; Appendix B, Section B.1.3 and Section B.2, *Taylor soil depth-Rev 01.xls*, worksheet 'Final calc'.

Figure 6-4. Comparison of Field Measurements to Depths Calculated Using Equation $D = 0.013 \times (10-S) + 0.4$ for $10 < S < 40$ Degrees



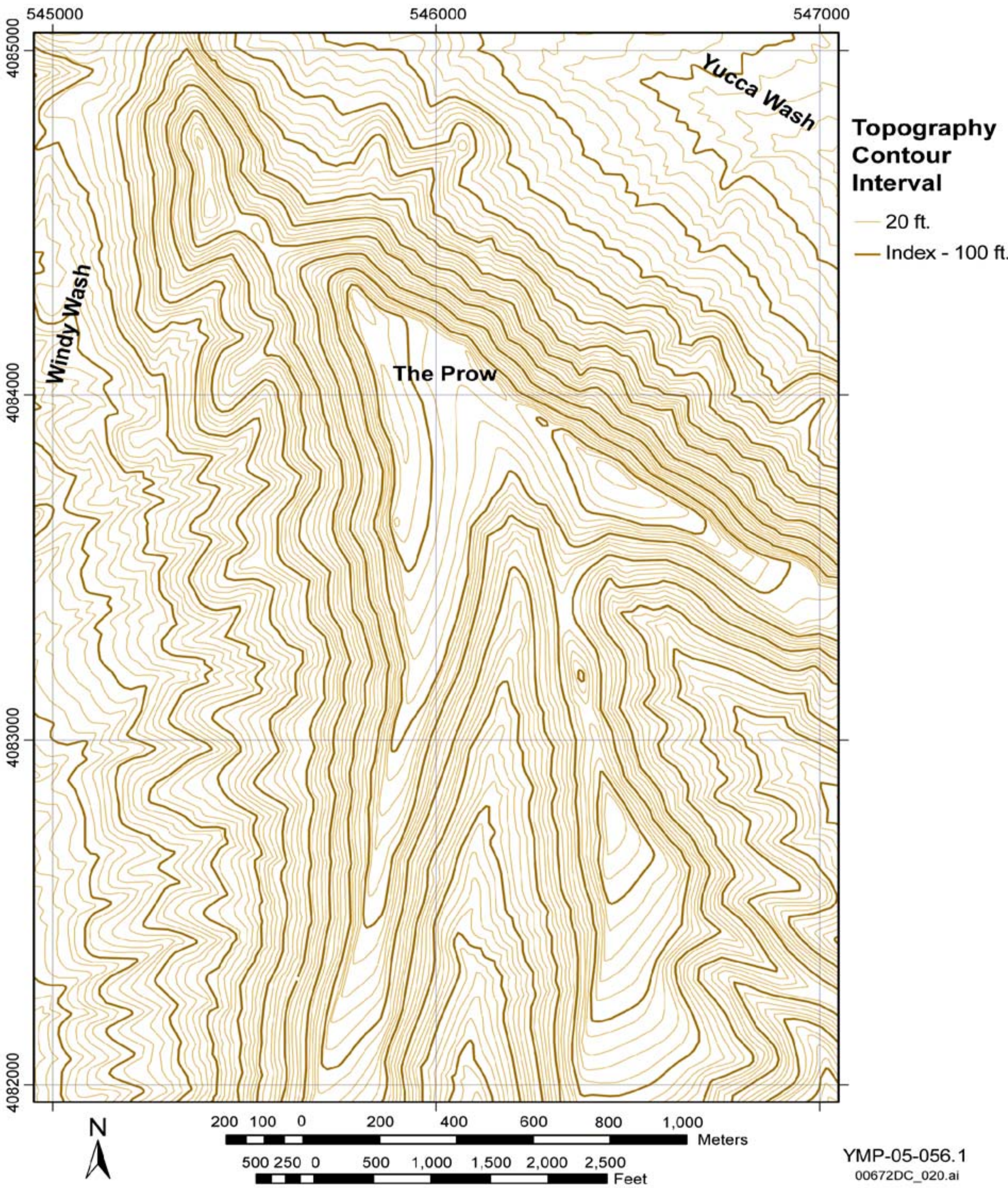
Source: Table 6-3; Appendix B, Section B.1.3 and Section B.2, *Taylor soil depth-Rev 01.xls,* worksheet 'Final calc'.

Figure 6-5. Comparison of Field Measurements to Depths Calculated Using Equation $D = 0.03 \times S + 0.1$ for $S \leq 10$ Degrees



Source: USGS 2000 [DIRS 175858], folder Soilmap6.

Figure 6-6. Enlargement of the Area around the Prow Showing Soil Depth Values from *SOILMAP6.INP*



Source: DTN: MO9811COV98591.000 [DIRS 109060], */pub3/gis/baseline/topo/topo20s.e00*.

Figure 6-7. Topographic Map for the Area Covered in Figure 6-6

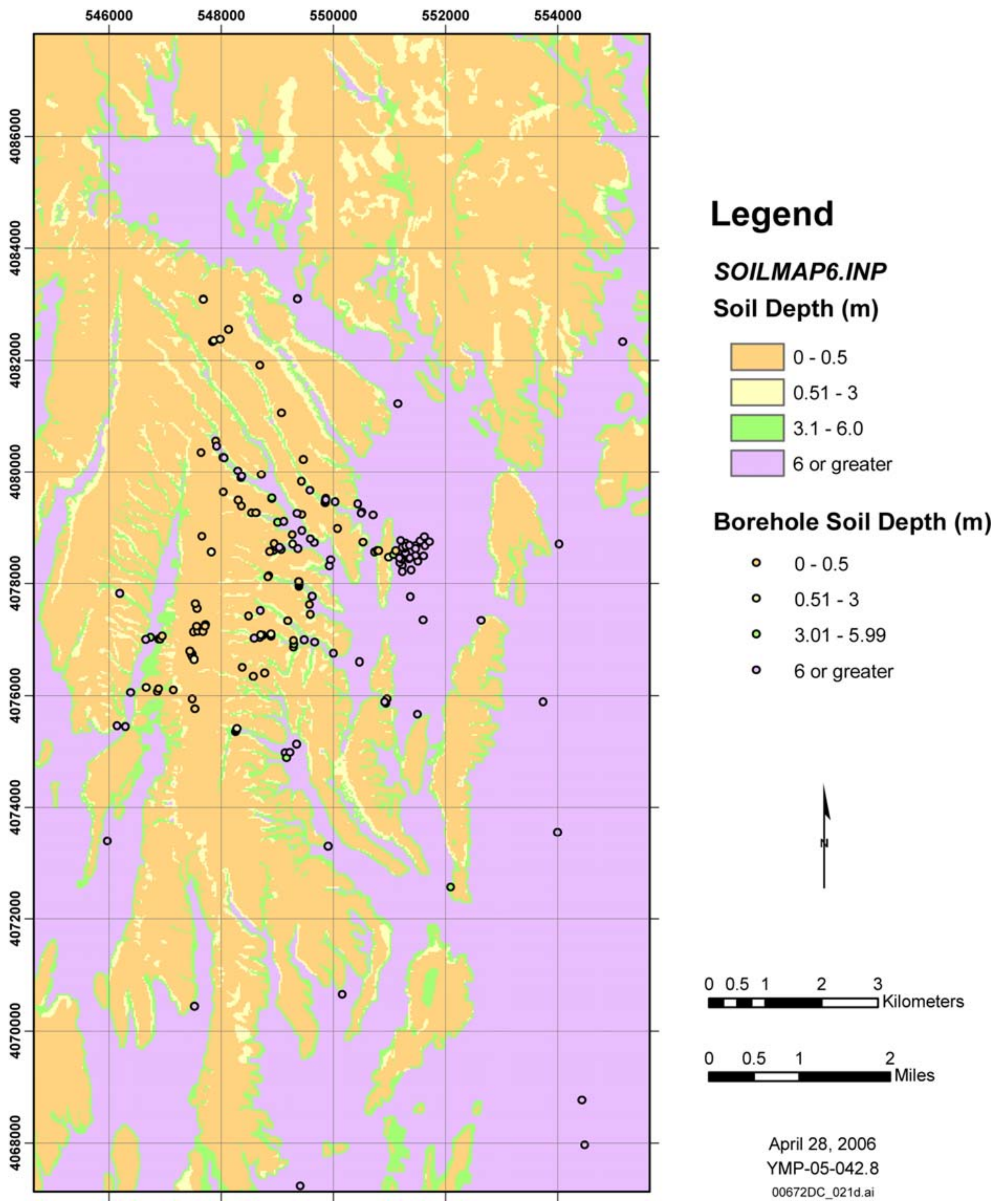
Examples of boreholes with a zero thickness (Table A-1) due to drill pad construction are:

- UE-25 NRG#3: 0.3 to 0.5 m soil thickness around cut (Sanchez 2006 [DIRS 176569], pp. 62 and 63)
- UE-25 NRG#5: 0.5 to 3 m soil thickness around cut (Sanchez 2006 [DIRS 176569], pp. 48 and 50)
- USW SD-9: 0.0 to 0.9 m soil thickness around cut (Sanchez 2006 [DIRS 176569], p. 66)
- USW WT-24: 0.2 m soil thickness around cut (Sanchez 2006 [DIRS 176569], p. 67)
- USW H-5: 0.3 to 0.5 m soil thickness around cut (Sanchez 2006 [DIRS 176569], pp. 59 and 67).

Conversely, some boreholes may penetrate significant thicknesses of artificial fill before entering naturally occurring deposits. When borehole logs differentiate between pad fill and natural alluvium, only the alluvial thickness is shown in Table A-1. It is uncertain that such distinctions were always made, because the primary interest in most borehole logging was determining bedrock geology and not the details of the alluvial section. There are also a limited number of boreholes available with which to make a comparison. With the exception of the Waste Handling Building area in Midway Valley, boreholes are widely scattered. Some areas, such as the area north of Yucca Wash, have no borehole information. In addition, borehole logs give a value only at a specific point and, with a limited number of boreholes they provide minimal information on how the variability in depth of surficial deposits across the entire model area should be modeled. Therefore, boreholes provide a limited number of spot checks that can be used to corroborate an area-wide model.

The depth of surficial deposits in boreholes is compared graphically (Figure 6-8) to soil depth codes (Figure 6-3). Given the limitations of borehole measurements, as previously discussed, the correlation between the two sources is good. Nearly all of the boreholes match the applicable soil depth code generated from the surficial deposits mapping (Figure 6-9). On the ridge crests, there are only minor variances between the two shallowest soil depth codes. In other areas, variances observed near the contacts with different soil depth codes occur in areas of rapid depth change and are usually only off by a single soil depth code.

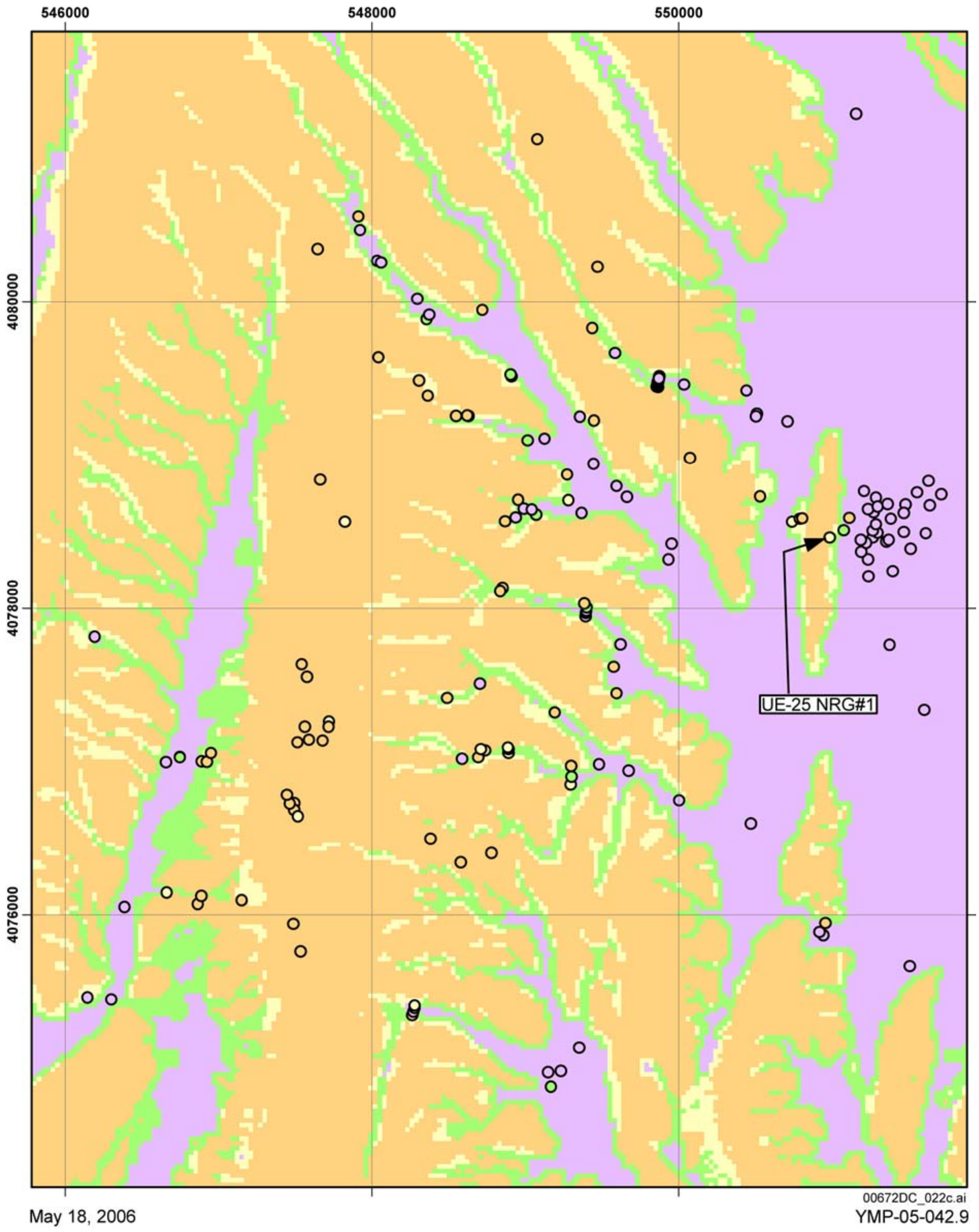
Table 6-4 provides a comparison of the calculated depth for the cell in which the borehole occurs against the value obtained from the borehole. It also shows the correlation between the two approaches for the shallowest Soil Depth Codes 1 and 2. The data, however, also indicate that the average difference between the observed and estimated soil depth is 0.38 m for Soil Depth Code 1 and 2.4 m for Soil Depth Code 2 (See Section B.1.5 for details of the calculation). The average difference in both cases is relatively large because of a small number of well locations where the observed thickness is larger than is typical for most locations in the respective soil depth code. Figure 6-10 illustrates the correlation between soil depth indicated by borehole data and the value for the corresponding cell predicted by *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) for Soil Depth Codes 1 and 2.



Sources: Table A-1; USGS 2000 [DIRS 175858], folder Soilmap6.

NOTE: Depth ranges have been changed from those in Table 6-1 to eliminate overlapping ranges, for the purpose of calculating depth ranges from the original file.

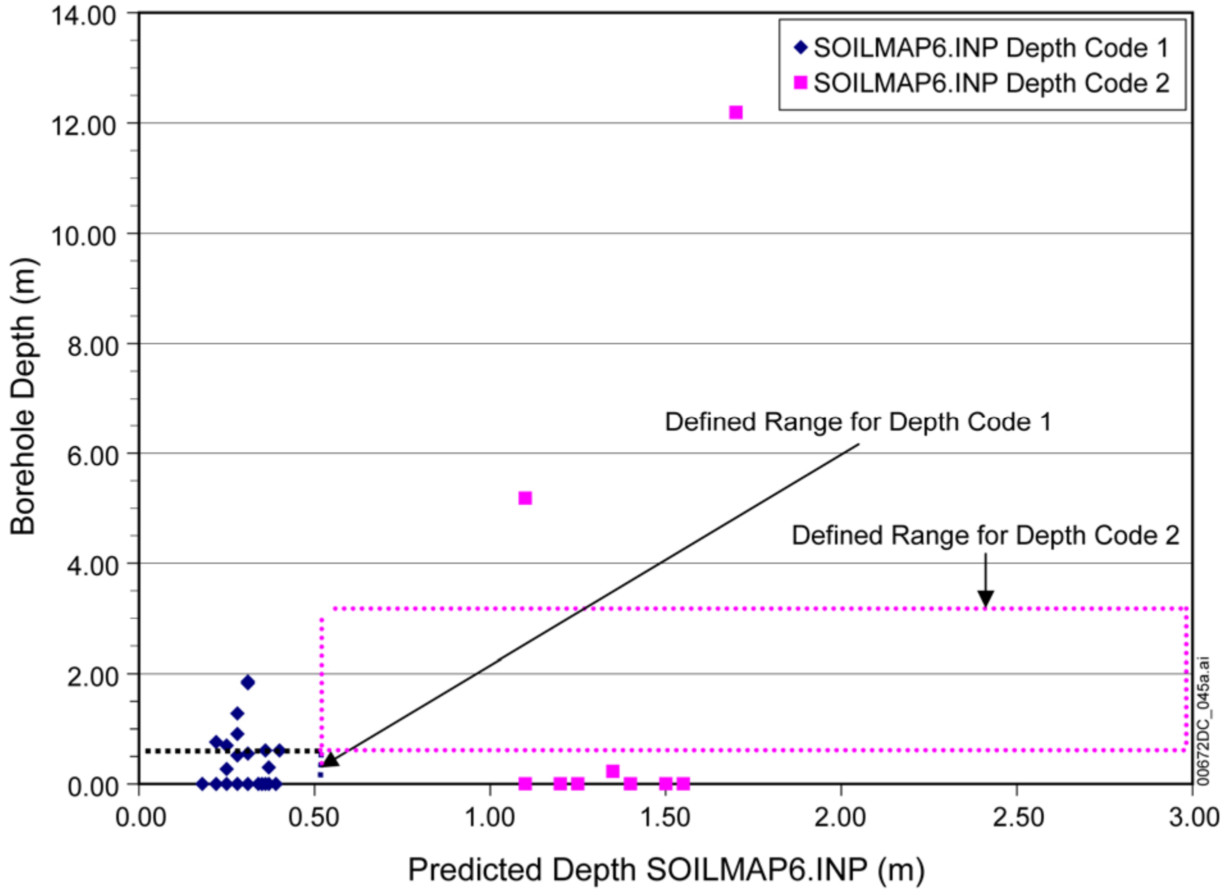
Figure 6-8. Comparison of *SOILMAP6.INP* Calculated Depths to Borehole Actual Measured Depths



Source: Figure 6-8.

NOTE: Figure 6-8 provides an explanation of symbols.

Figure 6-9. Area of Densest Borehole Coverage (Enlarged)



Source: Table 6-4; Appendix B, Section B.1.5 and Section B.2, *Final calcs. for report-Rev 01.xls*, worksheet 'Soilmap BH diff'.

Figure 6-10. Plot Showing the Relationship between the Soil Depth Measured in Boreholes and the Predicted Soil Depth for the Corresponding Grid Cell in *SOILMAP6.INP*

Table 6-4. Comparison between Surficial Deposits Thickness Measured in Boreholes and Those Calculated by *SOILMAP6.INP*

Borehole Identification Number	Actual Borehole Alluvium Thickness (m)	*SOILMAP6.INP* Depth Code	Estimated *SOILMAP6.INP* Soil Depth (m)	Estimated Soil Depth Minus Actual Borehole Thickness (m)[a]
USW G-3	0.00	1	0.18	0.18
USW UZ-N27	0.00	1	0.22	0.22
USW UZ-N17	0.76	1	0.22	−0.54
USW UZ-N36	0.27	1	0.25	−0.02
USW WT-24	0.00[b]	1	0.25	0.25
USW UZ-N15	0.70	1	0.25	−0.45
USW G-2	0.00	1	0.25	0.25
USW UZ-N16	1.28	1	0.28	−1.00

Table 6-4. Comparison between Surficial Deposits Thickness Measured in Boreholes and Those Calculated by *SOILMAP6.INP* (Continued)

Borehole Identification Number	Actual Borehole Alluvium Thickness (m)	*SOILMAP6.INP* Depth Code	Estimated *SOILMAP6.INP* Soil Depth (m)	Estimated Soil Depth Minus Actual Borehole Thickness (m)[a]
USW UZ-N11	0.52	1	0.28	−0.24
USW H-3	0.00	1	0.28	0.28
USW UZ-6	0.00	1	0.28	0.28
UE-25 UZ#5	0.91	1	0.28	−0.63
UE-25 NRG#1	1.86	1	0.31	−1.55
USW UZ-N64	0.55	1	0.31	−0.24
UE-25 NRG#5	0.00[b]	1	0.31	0.31
USW SD-7	0.00	1	0.34	0.34
USW SD-6	0.00	1	0.34	0.34
USW H-5	0.00[b]	1	0.34	0.34
UE-25 WT#18	0.00	1	0.36	0.36
USW UZ-N55	0.00	1	0.37	0.37
USW SD-9	0.00[b]	1	0.37	0.37
USW UZ-N62	0.30	1	0.37	0.07
UE-25 NRG#4	0.00	1	0.39	0.39
USW UZ-N49	0.61	1	0.36	−0.25
USW UZ-N65	0.00	1	0.28	0.28
USW UZ-N66	0.00	1	0.37	0.37
USW UZ-N70	0.00	1	0.31	0.31
USW UZ-N71	0.00	1	0.28	0.28
USW UZ-N72	0.00	1	0.35	0.35
USW UZ-N73	0.00	1	0.34	0.34
USW UZ-N74	0.00	1	0.37	0.37
USW UZ-N75	0.61	1	0.40	−0.21
USW UZ-N76	0.00	1	0.37	0.37
USW UZ-N78	0.00	1	0.39	0.39
USW UZ-N79	0.00	1	0.37	0.37
USW UZ-N81	1.83	1	0.31	−1.52
USW UZ-N93	0.00	1	0.25	0.25
USW UZ-N94	0.00	1	0.28	0.28
USW UZ-N95	0.00	1	0.31	0.31
USW UZ-N96	0.61	1	0.40	−0.21
UE-25 UZN#2	0.00	1	0.28	0.28
UE-25 UZN#10	0.00	1	0.28	0.28
USW UZ-N32	0.00	2	1.10	1.10
USW NRG-7a	5.18	2	1.10	−4.08
UE-25 NRG#2c	NA	2	1.50	—
UE-25 NRG#2b	0.00	2	1.50	1.50
UE-25 NRG#2	0.00	2	1.55	1.55
UE-25 NRG#2d	NA	2	1.55	—
UE-25 NRG#3	0.00[b]	2	1.55	1.55

Table 6-4. Comparison between Surficial Deposits Thickness Measured in Boreholes and Those Calculated by *SOILMAP6.INP* (Continued)

Borehole Identification Number	Actual Borehole Alluvium Thickness (m)	*SOILMAP6.INP* Depth Code	Estimated *SOILMAP6.INP* Soil Depth (m)	Estimated Soil Depth Minus Actual Borehole Thickness (m)[a]
USW WT-7	12.19	2	1.70	−10.49
USW UZ-N44	0.00	2	1.20	1.20
USW UZ-N80	0.00	2	1.20	1.20
USW UZ-N88	0.23	2	1.35	1.12
USW UZ-N25	0.00	2	1.40	1.40
USW UZ-N26	0.00	2	1.25	1.25
USW UZ-N86	0.00	3	4.56	4.56
NC-EWDP-18P	13.72	4	6.00	—
USW UZ-N59	3.99	4	6.00	2.01
UE-25 ONC #1	29.87	4	6.00	—
USW UZ-N54	5.79	4	6.00	0.21
UE-25 UZ#16	10.27	4	6.00	—
UE-25 RF#13	26.06	4	6.00	—
UE-25 RF#22	24.38	4	6.00	—
UE-25 RF#24	6.10	4	6.00	—
USW UZ-N37	11.06	4	6.00	—
UE-25 UZ#4	11.89	4	6.00	—
USW UZ-N34	15.27	4	6.00	—
USW UZ-14	12.10	4	6.00	—
UE-25 RF#18	18.29	4	6.00	—
UE-25 RF#16	16.25	4	6.00	—
UE-25 RF#26	21.64	4	6.00	—
UE-25 RF#14	31.03	4	6.00	—
UE-25 RF#23	19.51	4	6.00	—
UE-25 RF#28	3.05	4	6.00	2.95
UE-25 RF#20	21.34	4	6.00	—
UE-25 RF#15	0.00	4	6.00	6.00
UE-25 RF#19	36.58	4	6.00	—
UE-25 RF#21	33.53	4	6.00	—
UE-25 RF#25	18.29	4	6.00	—
UE-25 RF#29	25.91	4	6.00	—
UE-25 RF#17	28.16	4	6.00	—
USW G-1	18.29	4	6.00	—
UE-25 p#1	39.01	4	6.00	—
UE-25 J#13	132.59	4	6.00	—
USW a#1	9.14	4	6.00	—
UE-25 a#5	27.43	4	6.00	—
UE-25 a#6	6.10	4	6.00	—
UE-25 a#7	50.29	4	6.00	—
UE-25 b#1	47.55	4	6.00	—

Table 6-4. Comparison between Surficial Deposits Thickness Measured in Boreholes and Those Calculated by *SOILMAP6.INP* (Continued)

Borehole Identification Number	Actual Borehole Alluvium Thickness (m)	*SOILMAP6.INP* Depth Code	Estimated *SOILMAP6.INP* Soil Depth (m)	Estimated Soil Depth Minus Actual Borehole Thickness (m)[a]
UE-25 c#2	21.31	4	6.00	—
UE-25 c#3	24.41	4	6.00	—
USW UZ-1	12.19	4	6.00	—
USW WT-1	9.14	4	6.00	—
UE-25 WT#6	51.82	4	6.00	—
USW WT-10	18.29	4	6.00	—
USW WT-11	12.19	4	6.00	—
UE-25 WT#12	18.29	4	6.00	—
UE-25 WT#13	67.06	4	6.00	—
UE-25 WT#14	32.61	4	6.00	—
UE-25 WT#15	64.01	4	6.00	—
UE-25 WT#16	41.76	4	6.00	—
UE-25 WT#17	9.14	4	6.00	—
UE-25 J#12	156.97	4	6.00	—
UE-25 JF #3	148.44	4	6.00	—
USW UZ-N45	10.67	4	6.00	—
USW UZ-N47	10.06	4	6.00	—
USW UZ-N67	5.79	4	6.00	0.21
USW UZ-N68	15.24	4	6.00	—
USW UZ-N69	8.23	4	6.00	—
USW UZ-N82	6.70	4	6.00	—
USW UZ-N84	6.09	4	6.00	—
USW UZ-N87	5.79	4	6.00	0.21
USW UZ-N89	10.06	4	6.00	—
USW UZ-N90	9.91	4	6.00	—
UE-25 UZN#1	8.32	4	6.00	—
UE-25 UZN#7	12.34	4	6.00	—
UE-25 UZN#8	12.19	4	6.00	—
UE-25 UZN#9	10.67	4	6.00	—
UE-25 UZN#12	13.72	4	6.00	—
UE-25 UZN#13	13.41	4	6.00	—
UE-25 UZN#14	13.41	4	6.00	—
UE-25 UZN#18	17.07	4	6.00	—
UE-25 UZN#21	8.38	4	6.00	—
UE-25 UZN#22	5.94	4	6.00	0.06
UE-25 UZN#56	17.07	4	6.00	—
UE-25 UZN#97	17.68	4	6.00	—
UE-29 UZN#92	17.68	4	6.00	—
USW UZ-N61	2.99	5	3.92	0.93
USW NRG-7	0.00	5	3.92	3.92
USW UZ-N33	3.99	5	4.08	0.09

Table 6-4. Comparison between Surficial Deposits Thickness Measured in Boreholes and Those Calculated by *SOILMAP6.INP* (Continued)

Borehole Identification Number	Actual Borehole Alluvium Thickness (m)	*SOILMAP6.INP* Depth Code	Estimated *SOILMAP6.INP* Soil Depth (m)	Estimated Soil Depth Minus Actual Borehole Thickness (m)[a]
USW UZN#63	2.62	5	4.24	1.62
USW UZ-7a	0.00	5	4.40	4.40
USW SD-12	0.00	5	4.40	4.40
UE-25 a#4	9.14	5	4.40	−4.74
USW UZ-N35	3.60	5	4.56	0.96
USW NRG-6	0.00	5	4.56	4.56
USW UZ-N38	5.46	5	4.56	−0.90
USW UZ- N53	0.64	5	4.88	4.24
USW G-4	9.14	5	4.88	−4.26
USW H-6	9.11	5	4.88	−4.23
USW WT-2	18.29	5	4.88	−13.41
USW H-1	0.00	5	5.04	5.04
USW H-4	0.00	5	5.04	5.04
UE-25 NRG#2a	2.07	5	5.20	3.13
USW UZ-N31	0.00	5	5.20	5.20
UE-25 WT#3	3.35	5	5.36	2.01
UE-25 WT#4	15.54	5	5.36	−10.18
USW UZ-N57	0.37	5	5.52	5.15
USW UZ-N58	6.74	5	5.52	−1.22
UE-25 c#1	0.00	5	5.68	5.68
USW UZ-N40	0.88	5	4.72	3.84
USW UZ-N41	4.88	5	5.52	0.64
USW UZ-N42	0.00	5	4.40	4.40
USW UZ-N43	8.23	5	4.72	−3.51
USW UZ-N46	0.00	5	4.88	4.88
USW UZ-N48	0.00	5	4.72	4.72
USW UZ-N50	2.74	5	3.44	0.70
USW UZ-N51	4.27	5	4.88	0.61
USW UZ-N52	2.13	5	4.88	2.75
USW UZ-N77	11.58	5	5.52	−6.06
USW UZ-N83	0.00	5	4.72	4.72
USW UZ-N98	0.30	5	4.08	3.78
USW UZ-N24	0.15	5	4.08	3.93
UE-25 UZN#3	2.74	5	4.40	1.66
UE-25 UZN#4	7.47	5	4.40	−3.07
UE-25 UZN#5	13.56	5	4.40	−9.16
UE-25 UZN#6	12.04	5	4.40	−7.64
UE-25 UZN#19	6.86	5	4.56	−2.30
UE-25 UZN#20	11.89	5	5.36	−6.53
UE-25 UZN#23	0.00	5	4.56	4.56
UE-25 UZN#29	0.30	5	4.88	4.58

Table 6-4. Comparison between Surficial Deposits Thickness Measured in Boreholes and Those Calculated by *SOILMAP6.INP* (Continued)

Borehole Identification Number	Actual Borehole Alluvium Thickness (m)	*SOILMAP6.INP* Depth Code	Estimated *SOILMAP6.INP* Soil Depth (m)	Estimated Soil Depth Minus Actual Borehole Thickness (m)[a]
UE-25 UZN#30	0.38	5	4.24	3.86
UE-25 UZN#60	8.08	5	5.36	−2.72

Sources: Table A-1; USGS 2000 [DIRS 175858], folder Soilmap6; Appendix B, Section B.1.5 for Excel® calculation.

[a] A dash (—) in the last column indicates that either the actual borehole alluvial thickness was not provided or both the actual and estimated soil thickness (depth) are not less than 6 m.

[b] Zero values are shown on the borehole log, but inspection of the pad cut indicated that soil was present (Section 6.1.2).

NA = not applicable.

All the data for Soil Depth Codes 1 and 2 are presented in Figure 6-10, but the number of symbols is less than the number of data points because many data points overlap. Only one data point is available for Soil Depth Code 3 and no data points fall into Soil Depth Code 6; thus there was no need to plot them. Soil Depth Codes 4 and 5 are discussed in the following paragraphs.

Several boreholes fall into Soil Depth Code 5 (Table 6-4), which has the greatest soil depth variation. Soil Depth Code 5 was created using the software routines GEOMOD4 V1.0 and SOILMAP6 V1.0 (BSC 2004 [DIRS 170007], Appendices F and G) to provide an intermediate-depth buffer cell between cells that were classed as shallow soils and deep alluvium on the basis of soil type. Therefore, the locations of these intermediate depth cells represent an area of rapid depth change by definition. This is also the type of terrain where drill pad construction practices may affect the comparison. The large depth variation in this code, with an average difference of about plus or minus 4 m, indicates that the methods used to create the file result in larger errors where soil depths change over small horizontal distances.

Because depths are not calculated for depths greater than 6 m in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), and all cells in Soil Depth Code 4 are assigned a uniform value of 6 m, the only comparison that can be made for Soil Depth Code 4 is whether a borehole indicates a depth greater than 6 m. Only seven of the 71 boreholes in Soil Depth Code 4 indicate depths shallower than 6 m. These seven boreholes are located near the contact with shallower soil depth codes and are probably indicative of the difficulty in precisely defining contacts between soil depth codes.

6.2 ALTERNATE SOIL DEPTH EVALUATION

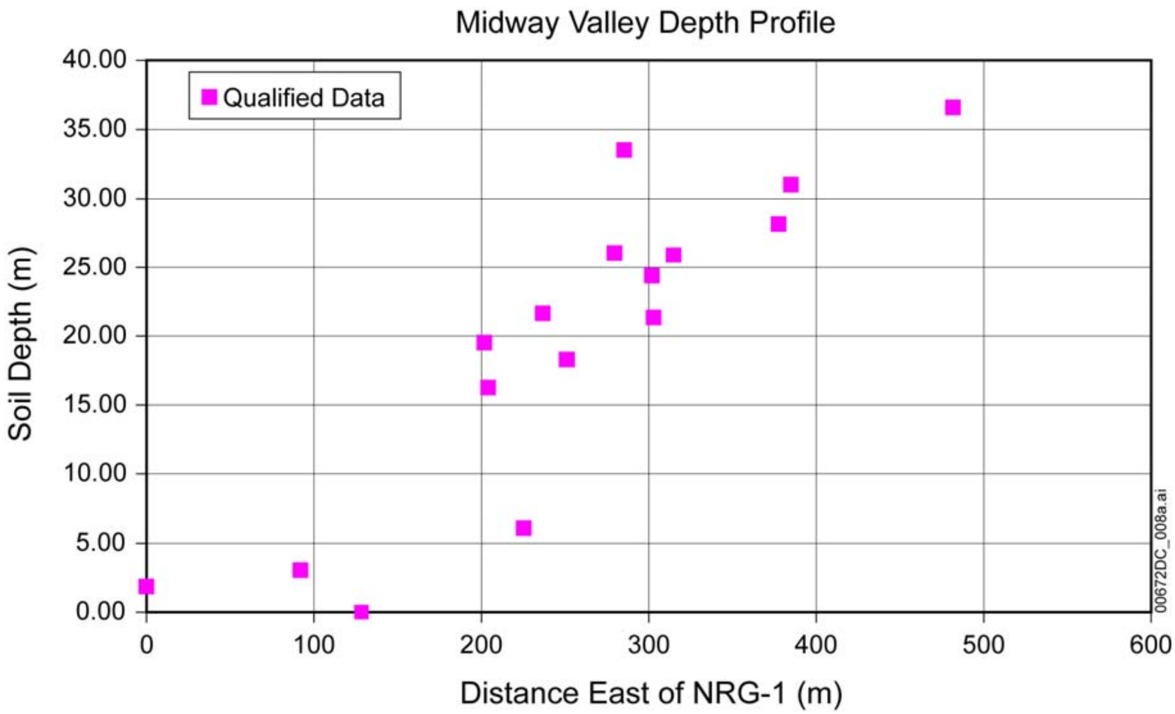
Upon review (Section 6.1.2), it was determined that an alternate soil depth file, other than *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), should be generated and documented for use in future infiltration modeling. This alternate approach was taken because of transparency and traceability issues raised by the uncertainty in how the equations for calculating depth were derived, by questions about how end points of the depth classes correspond to ranges calculated by depth equations in the infiltration model report (BSC 2004 [DIRS 170007]), and because of poor corroboration by available data sets of the soil depth calculations. Therefore, an alternate soil depth file has been created, based on a different and simplified approach compared to that used in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6). This alternate soil depth file is based on the same soil map (Figure 6-1) used to prepare *SOILMAP6.INP*.

6.2.1 Summary and Evaluation of Soil Depth Data

The grouping of soil types used in DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098 (Figure 6-1 and Table 6-2) are used as a starting point for evaluation. The general soil depth classes interpreted to correspond to these soil types (Table 6-2) were used to generate the three combined soil depth classes illustrated on Figure 6-2. For this grouping, cells belonging to the Disturbed Ground classification, such as for roads and drill pads, were assigned to the same general depth class as surrounding, undisturbed cells, on the assumption that the soil depth under these features would not differ greatly from the surrounding area. Roads and drill pads are a small percentage of the total area, are often located over thicker alluvial areas, and are generally not much higher or lower than the surrounding area.

For this evaluation, two additional soil depth classes were added to the three that are shown on Figure 6-2. As discussed in the following paragraphs, the deep soil class shown on Figure 6-2 contains soils that can range in depth from a few meters to over 150 m. The subdivision of the deep soil class into two soil depth classes provides better definition of the shallower part of this range. This is desirable because previous versions of the infiltration model (BSC 2004 [DIRS 170007]); USGS 2000 [DIRS 123650]; USGS 2001 [DIRS 154674]; USGS 2001 [DIRS 160355]; USGS 2003 [DIRS 166518]) have indicated that shallow soils may transmit water to the soil-bedrock interface, whereas deeper soils may not (BSC 2004 [DIRS 170007], pp. 5-2 and 6-2). Other estimates of percolation also indicate little or no deep percolation below depths of about 6 to 8 m; for example, estimates of percolation depths based on chloride accumulation beneath native vegetation in the Amargosa Desert south of Yucca Mountain (Stonestrom et al. 2003 [DIRS 165862], p. 16). Therefore, a fourth class was added by subdividing the deep soil class into a moderately deep soil class and a very deep soil class to add more definition to the deep soils that may be significant in future modeling.

The boundaries for the moderately deep soil class were based on a review of the large number of boreholes in the vicinity of the proposed Waste Handling Building in Midway Valley, as shown in Figure 6-11. Boreholes were projected to an east-west line, perpendicular to the strike of the structural trend in the area, to evaluate soil depth trends in this area. Distances (Figure 6-11) were measured eastward from the location of UE-25 NRG#1 (Figure 6-9) at the portal of the Exploratory Studies Facility on Exile Hill. Boreholes within about 200 m of this point are located in the shallow and intermediate depth classes. Boreholes at a greater distance are in alluvium that would be assigned to the newly defined moderately deep soil class or to the very deep soil class. Figure 6-11 shows that depth generally increases in a linear fashion with distance beyond 200 m, which is the approximate boundary between the shallow or intermediate depth classes and the moderately deep soil class. Given that there is no natural break in the depth-distance trend to define a subdivision, the moderately deep soil class was defined by arbitrarily setting an upper limit that extends 10 cells, or 300 m, out from the boundaries of the shallow or intermediate depth classes using ARCINFO (Figure 6-12). This definition creates a zone of sufficient lateral dimensions to be significant in modeling and was deliberately defined to include depths that are expected to range from near zero meters to about 40 m.

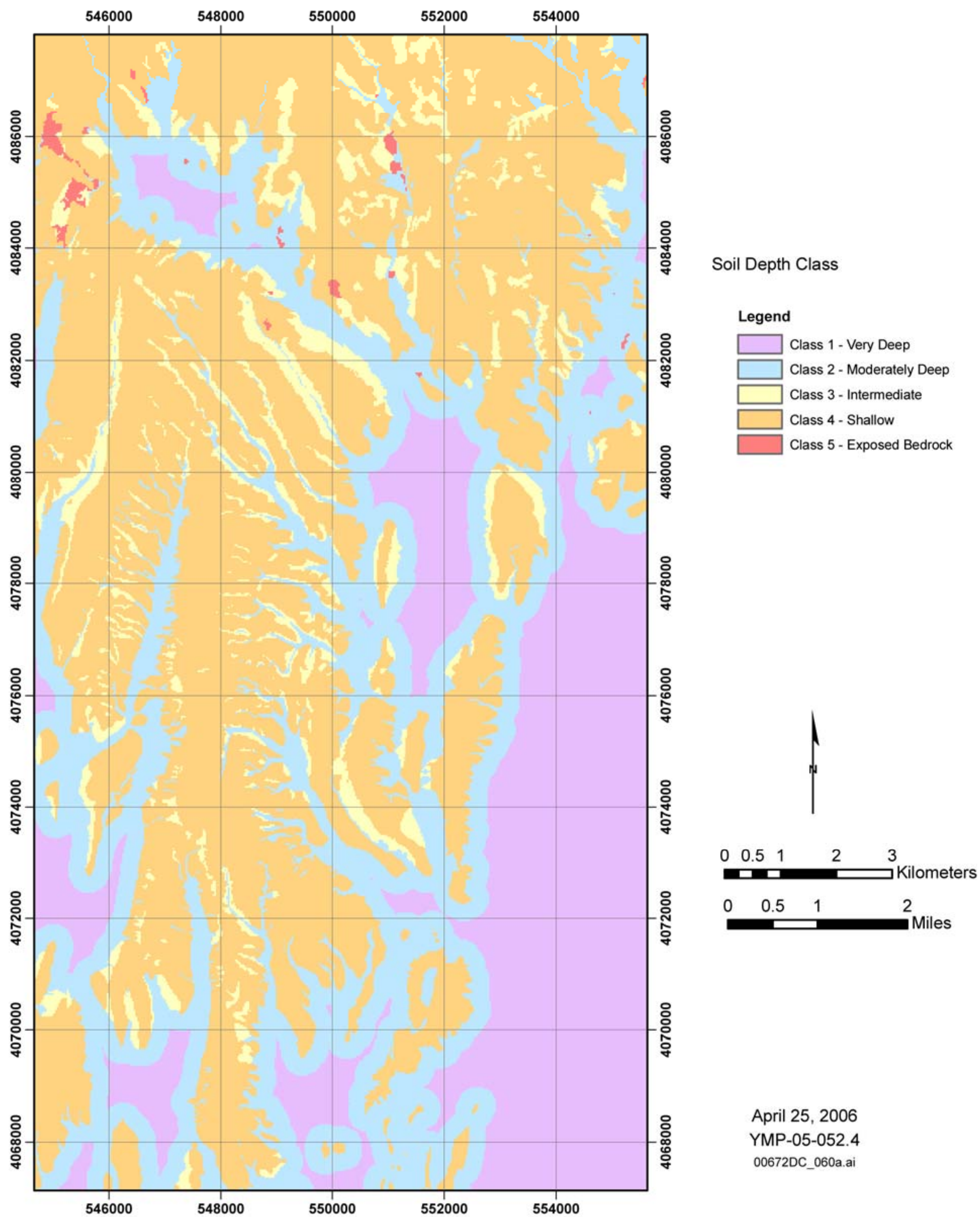


Sources: Table A-1; Appendix B, Section B.1.7 and Section B.2, *Final calcs. for report-Rev 01.xls*, worksheet 'Midway Valley depth'.

Figure 6-11. Data of Borehole Soil Depth Near the Proposed Waste Handling Building (Midway Valley); Projected to an East-West Line

The depth range was selected to include the soil depth limit for infiltration defined by previous models. Previous infiltration models were based on an assumption that soils deeper than 6 m do not permit infiltration of water to the soil-bedrock contact, except in some channels, because the soils have sufficient storage capacity to retain precipitation in the root zone where it is subject to evapotranspiration. Therefore, previous models had assigned a constant depth of 6 m to all soils of greater depth (BSC 2004 [DIRS 170007], pp. 5-2 and 6-2). For this evaluation, a somewhat broader potential depth range was selected to incorporate the uncertainties inherent in assigning an areal distribution to the moderately deep soil class and any uncertainties in the infiltration depth limit.

The fifth soil depth class was added (Figure 6-12) to create a separate class for the exposed bedrock shown as Soil Type Unit 8 (Figure 6-1), making it possible to differentiate between areas with some soil thickness, such as the shallow soils-colluvium class, and areas devoid of surficial deposits of sufficient size to be mapped. Depth classes (Figure 6-12) are included in the alternate soil depth file, output DTN: MO0608SPASDFIM.006. This soil depth file uses the same map area and soil groupings based on the soil types given in DTN: GS960408312212.005 [DIRS 146299], ACC: MOL.19961118.0100, and the same 30×30 m grid system used in previous versions of the infiltration model (BSC 2004 [DIRS 170007]); USGS 2000 [DIRS 123650]; USGS 2001 [DIRS 154674]; USGS 2001 [DIRS 160355]; USGS 2003 [DIRS 166518]).



Source: Output DTN: MO0608SPASDFIM.006.

NOTE: Very deep, intermediate, and shallow class data are from Figure 6-2.

Figure 6-12. Graphical Representation of Depth Classes Used for Alternate Soil Depth Evaluation

Each grid cell in the model area is assigned a soil depth class. For ease in implementing the model, a numerical designator is used in the file, rather than a name to identify the soil depth class. The five numerical designators are:

1. Very deep alluvium
2. Moderately deep alluvium
3. Intermediate depth soils
4. Shallow soils-colluvium
5. Exposed bedrock.

Depth ranges were then assigned to the five soil depth classes and then soil depth distributions were developed for each class; general depth ranges for the shallow and intermediate depth classes were given in reports, as discussed in the following paragraphs, that accompany soil maps by Lundstrom et al., as noted in Table 6-5.

Table 6-5. Interpreted Soil Thickness Ranges

Class	Soil Type Unit Number[a]	Soil Classification[a]	Soil Type [b, c, d, e]	Soil Name [b, c, d, e]	Minimum Thickness (m)	Maximum Thickness (m)
Soil Depth Class 4 – Shallow Soil/Colluvium	5	Lithic Haplocambids	cu	Undivided Colluvium	0.1[f]	1[b, c, d, e]
Soil Depth Class 4 – Shallow Soil/Colluvium	7	Lithic Haplargids	rc	Summit Colluvium	0.1[f]	1[c, d]
Soil Depth Class 3 – Intermediate Depth Soils	9	Typic Calciargids	cf	Footslope Colluvium and Alluvium	0.5[b, c, d, e]	>3[e]

[a] DTN: GS960408312212.005 [DIRS 146299], ACC: JOL.19961118.0098
[b] DTN: GS940108315142.004 [DIRS 160344], ACC: MOL.20021001.0238, RIS p. 13
[c] DTN: GS940108315142.005 [DIRS 160345], ACC: MOL.20021203.0409, RIS pp. 20 and 22
[d] DTN: GS940708315142.008 [DIRS 160346], ACC: MOL.20021001.0261, RIS pp. 17 and 19
[e] DTN: GS950408315142.004 [DIRS 160347], ACC: MOL.20020827.0355, RIS pp. 27 and 29
[f] This is the minimum thickness inferred from maps (footnotes b to e) that show nearly all upland surfaces to be soil covered (i.e., non-zero) rather than bare rock (Soil Type r). Minimum thickness is also determined by measurements in DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, for soil depth in the “Tpc” and “stone st” deposit units, and corroborated by soil depth measurements on side slopes and ridge crests (Sanchez 2006 [DIRS 176569], pp. 59 and 62 to 68).

Direct field measurements of soil depth are given in DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, and are used for the shallow soil classes (Table 6-5). Other sources of qualified information are borehole data listed in Section 6.2, Tables 6-7, 6-8, and 6-9.

For this evaluation, a distribution was used to characterize the depth variability in all but the exposed bedrock soil depth class. This approach was used because of the limited data available on soil depth. This approach differs from the previous approach used in the infiltration model (BSC 2004 [DIRS 170007]) in that the evaluation does not attempt to provide a numerical correlation of soil depth with other factors, such as topographic slope. Such schemes were not employed because of the absence of qualified and verified data that directly tie soil depth values to topographic slope. This approach, however, does include the influence of topography on soil depth via the mapped soil depth classes as presented (Figure 6-2), which are based in part on topography and soil type.

Because the depth values for a soil depth class are presented as a distribution rather than being based on the attributes of a particular cell, such as slope, as was done in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), this evaluation is not intended to predict the actual depth values within specific grid cells based on their properties. Use of the distribution is intended to characterize the general range of depths that might be encountered within a soil depth class covering a large area of many cells. With this approach, cell values may be assigned using various methods, such as sampling from the distribution or a mean value based on the distribution, so that an area of many cells is representative of the variation seen in the point measurements found in the data sources. These larger areas should then represent the variation seen in the distribution in the model.

This approach is considered adequate for modeling purposes when the uncertainty in any estimate of this type is considered. In this case, the uncertainty consists of two components: the measurement uncertainty resulting from the small number of direct measurements, such as from boreholes, and the inherent variability in the soil thickness across the area where the actual thickness may vary significantly, even within a single grid cell.

The exposed bedrock of Soil Depth Class 5 is described as volcanic bedrock with small areas of thin colluvium in the original surficial deposits mapping; listed as Lundstrom Soil Classification “r” on Table 6-2 (DTN: GS940108315142.004 [DIRS 160344], ACC: MOL.20021001.0238). Based on this description, cells in this depth class should be assigned a zero soil depth.

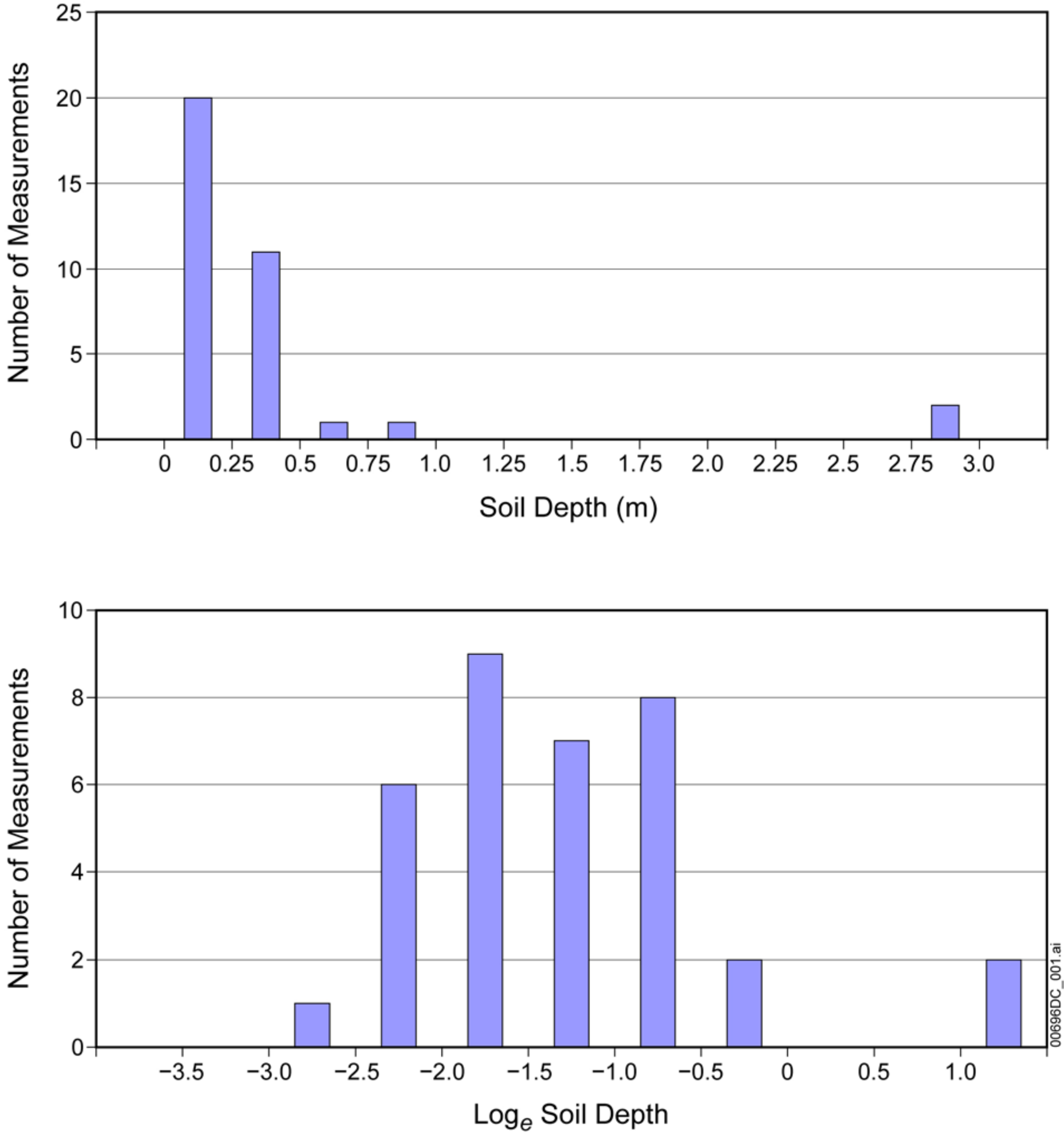
The distribution for the shallow soils of Soil Depth Class 4 is based on the direct field measurements in DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, and is corroborated by the range of 0.1 to 1 m estimated from soil mapping (Table 6-5) and the qualified data for boreholes located in cells assigned to this class. A lognormal distribution was selected to represent Soil Depth Class 4 because DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, indicates that the soil depth for this class is better described by a lognormal distribution (Section B.1.8). This data set represents field measurements of soil depth from natural and artificial exposures in the infiltration model area. Values with “Deposit Unit” designations of “Tpc” and “stone st” in DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, are interpreted as belonging to Soil Depth Class 4 (Table 6-6). The distribution of these data is illustrated (Figure 6-13) in both linear and $\log_e$ transformed format.

Table 6-6. Field Measurements of Soil Depth for Soil Depth Class 4

General Location	Soil Depth (m)	LN Depth (m)
Mile High Mesa	0.05	−2.99573
Mile High Mesa	0.10	−2.30259
Alice Crest	0.10	−2.30259
Mile High Mesa	0.10	−2.30259
UZ-14	0.10	−2.30259
Fran Ridge	0.10	−2.30259
Alice	0.12	−2.12026
Yucca Wash	0.15	−1.89712
ESF South Portal	0.17	−1.77196
Isolation Ridge	0.20	−1.60944
Alice	0.20	−1.60944
Drill Hole Wash	0.20	−1.60944
Mile High Mesa	0.20	−1.60944
Split Wash	0.20	−1.60944
Pagany Wash	0.20	−1.60944
Mile High Mesa	0.20	−1.60944
Split Wash	0.25	−1.38629
Split Wash	0.25	−1.38629
Bleach Bone Ridge	0.25	−1.38629
Yucca Wash	0.25	−1.38629
Drill Hole Wash	0.30	−1.20397
Antler Ridge Trench 5	0.30	−1.20397
Yucca Wash	0.35	−1.04982
Alice	0.40	−0.91629
Fran Ridge	0.40	−0.91629
Bow Ridge	0.40	−0.91629
Trench 14	0.40	−0.91629
Antler Ridge Trench 5	0.45	−0.79851
ESF south portal	0.50	−0.69315
UZ-7A	0.50	−0.69315
NRG-5	0.50	−0.69315
Alice	0.75	−0.28768
UZ-7A	1.00	0.00000
Split Wash	3.00	1.09861
Yucca Wash	3.00	1.09861
Sample Statistics		
LN Mean (m)		−1.29
LN Standard Deviation (m)		0.88
Median (m) (not log transformed)		0.25

Sources: DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, ACC: MOL.20060823.0126, and ACC: MOL.20020320.0367; Appendix B, Section B.1.8 for Excel® calculations.

LN = natural logarithm.

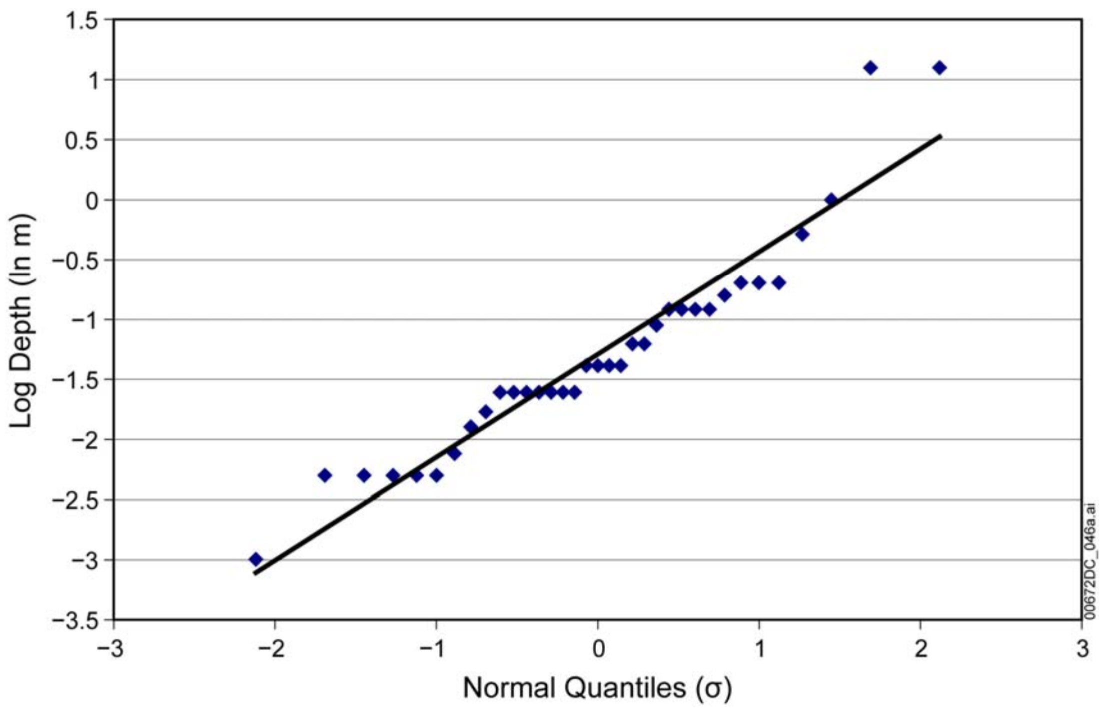


Sources: Table 6-6; Appendix B, Section B.1.8 and Section B.2, *Taylor soil depth-Rev 01.xls*, worksheet 'Wtest'.

NOTE: Soil Depth (m) shows field measurements, while Log$_e$ Soil Depth shows transformed measurements.

Figure 6-13. Distribution of Soil Depths from Surface Field Measurements for Soil Depth Class 4 (Shallow Soils)

These data have been subjected to a "W test" (Gilbert 1987 [DIRS 163705], pp. 158 to 162; Tables A6, A7, and A8). The test results support the hypothesis that the data are lognormally distributed at the 0.02 significance level, but not at the 0.05 significance level. The test produced W = 0.925. Values greater than 0.920 are required to accept a lognormal distribution hypothesis at the 0.02 level, and values greater than 0.934 are required to accept the hypothesis at the 0.05 level. A similar test for the alternate hypothesis, that the data are normally distributed, shows that this hypothesis should be rejected. This test produced W = 0.49. Values greater than 0.92 are required to accept the normal distribution hypothesis. The fit to a lognormal distribution is illustrated on Figure 6-14 as a probability plot. This result and the general observation that depths in this class should be non-zero, because the soil mapping indicates that some cover was present but that soil depths generally fall at the shallow end of the range, result in the selection of a lognormal distribution as the preferred option for describing depth in Soil Depth Class 4. The calculated lognormal distribution (Section B.1.8) from field exposure measurements in DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, has a $\log_e$ transformed mean of −1.29 m (0.27 m) and a $\log_e$ transformed standard deviation of 0.88 m.



Sources: Table 6-6; Appendix B, Section B.1.8 and Section B.2, *Taylor soil depth-Rev 01.xls*, worksheet 'Wtest'.

Figure 6-14. Probability Plot of the Log_e Transformed Data Shown in Figure 6-13

Borehole data (Table A-1) are also available for Soil Depth Class 4. These data were not used, however, in the evaluation of this class, because of significant uncertainties in any soil depths reported for boreholes located on shallow soils. These uncertainties result from borehole and drill pad construction practices and environmental permit requirements that were in effect when the holes were drilled. Soil Depth Class 4 consists of upland areas that can have steep slopes. The construction of drill pads in these areas requires considerable cutting and filling that will remove the native soil before drilling begins. Drill pad construction records for the following boreholes in Soil Depth Class 4 also indicate that soil was present and removed prior to drilling, because of environmental permit stipulations on all land-disturbing activities that required the removal and storage of the top 0.30 to 0.35 m of topsoil at the start of construction for use in post-activity site reclamation:

- USW SD-7: "Stripped & stacked topsoil" on first day of drill pad construction (YMP 1994 [DIRS 176589], RIS p. 1) followed by considerable cutting and filling for the drill pad (YMP 1994 [DIRS 176590], RIS p. 16)
- USW UZ-7A: "Site preparation will include topsoil removal and storage, excavation of rock material, and installation of fill material…Topsoil shall be salvaged down to 14 inches or until bedrock is reached" (YMP 1994 [DIRS 176591], RIS pp. 4 and 28)
- UE–25 NRG#4: "Topsoil, down to bedrock or 30 centimeters, whichever is shallowest, shall be salvaged wherever topsoil disturbance (i.e., movement) will occur…Salvaged topsoil at the drill pad shall be stored adjacent to the drill pad at a location opposite the access road" (YMP 1993 [DIRS 176592], RIS p. 23).

In addition, the inspection of four of the drillpads in Soil Depth Class 4, those being UE-25 NRG#3, UE25 NRG#5, USW WT-24, and USW SD-9, show that these drillpads are cuts. The soils surrounding these cuts have average depths of about 0.7 m (Section 6.1.2) (Sanchez 2006 [DIRS 176569], pp. 48 to 67), while borehole logs show a zero depth. These factors make the use of borehole data in these areas suspect.

The distribution of intermediate depth soils that are assigned to Soil Depth Class 3 is based on the depth range from soil mapping of 0.5 m to greater than 3 m (Table 6-5), and on qualified data from field measurements and for boreholes located in cells assigned to this class. Field measurements represent locations of natural and artificial exposures measured at the surface where soil depth was recorded. Because there were only five field measurements, the field measurements and borehole data were combined for the analysis of this class. The field measurements with "Deposit Unit" designations of "coll" (DTN: GS011208312212.004 [DIRS 176317], Table S02086_001) were interpreted to correspond to Soil Depth Class 3. These measurements range between 2 and 3 m. Borehole location data (Table A-1) were used in conjunction with the soil depth class assignments from output DTN: MO0608SPASDFIM.006 (Figure 6-12) to determine which boreholes are located in Soil Depth Class 3.

Qualified boreholes belonging to Soil Depth Class 3 with their associated soil depth are listed in Table 6-7, along with the data from the field measurements. Depths from qualified boreholes, shown in Figure 6-15, range from 0 to 20 m with all but one borehole in the 0 to 6 m range.

A significant number of boreholes show a zero depth for the soils. As discussed, for Soil Depth Class 4, these values are interpreted to be the result of drill pad construction operations and environmental requirements for removing and stockpiling soil in disturbed areas. Soil mapping shows that these locations are in areas of footslope colluvium and alluvium that should be thicker and more continuous than Soil Depth Class 4. Therefore, for the purposes of calculating the distribution, zero values were assigned a value of 0.5 m to correspond with the minimum value shown for the range estimated from soil mapping (Table 6-5).

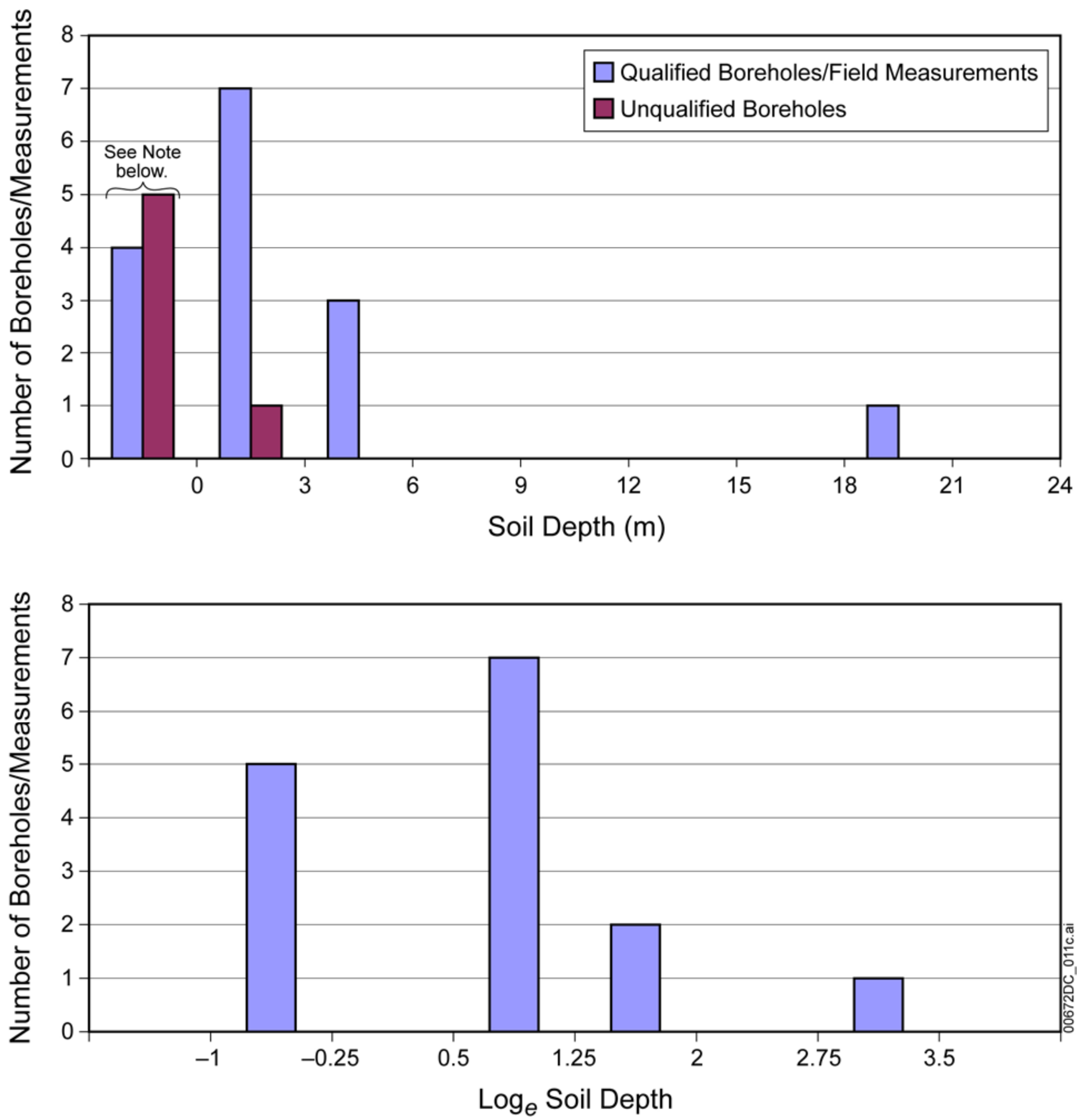
Table 6-7. Field Measurements and Qualified Borehole Depths Used to Calculate Depth Distributions and Unqualified Borehole Depths Used for Corroboration for Soil Depth Class 3

Borehole ID	Soil Depth (m)	LN Depth (m)
Qualified Data		
USW UZ-N32	0.00	−0.69315
UE-25 RF#28	3.05	1.11449
UE-25 RF#15	0.00	−0.69315
UE-25 RF#23	19.51	2.97078
UE-25 NRG#2	0.00	−0.69315
USW NRG-6	0.00	−0.69315
USW NRG-7a	5.18	1.64511
USW UZ-N33	3.99	1.38451
UE-25 NRG#2a	2.07	0.72882
UE-25 NRG#2b	0.67	−0.40048
Field Measurement	2.00	0.69315
Field Measurement	3.00	1.09861
Field Measurement	2.50	0.91629
Field Measurement	2.00	0.69315
Field Measurement	3.00	1.09861
Sample Statistics for Qualified Data		
LN Mean (m)		0.61
LN Standard Deviation (m)		1.07
Median (m) (not log transformed)		2.07
Unqualified Data		
USW NRG-7	0.00	NA
USW UZ-N80	0.00	NA
USW UZ-N25	0.00	NA
USW UZ-N26	0.00	NA
UE-25 UZN#23	0.00	NA
UE-25 UZN#30	0.38	NA

Sources: Table 4-1; Table A-1; DTN: GS011208312212.004 [DIRS 176317], Table S02086_001; Appendix B, Section B.1.6 for Excel® calculations.

NOTE: Depths of 0.00 m changed to 0.5 m to calculate LN depth. LN depths were not calculated for the unqualified data.

LN = natural logarithm; NA = not applicable.



Sources: Table 6-7; Appendix B, Section B.1.6 and B.2; *Final calcs. for report-Rev 01.xls*, worksheet 'Class 3'.

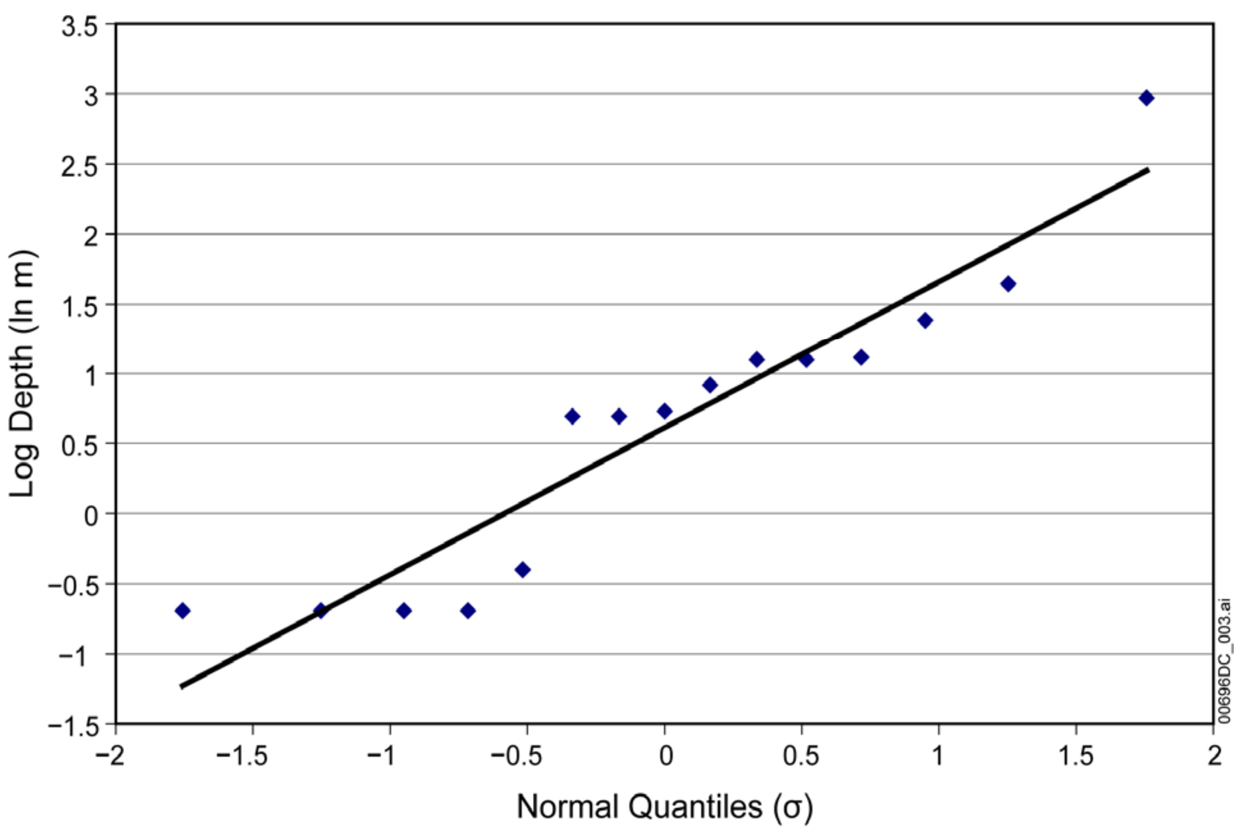
NOTE: In the top figure, soil depths less than 0 represent observed soil depth equal to zero. All other soil depths fall within the ranges as presented.

NOTE: Soil Depth (m) shows linear depths, while Log $_e$ Soil Depth shows log transformed measurements.

Figure 6-15. Distribution of Soil Depths from Boreholes and Surface Field Measurements for Soil Depth Class 3 (Intermediate Depth Soils)

A lognormal distribution was selected to represent depth distribution for Soil Depth Class 3. The lognormal hypothesis is shown by a W test (Section B.1.10) to be accepted at the 0.05 significance level for the qualified data (Table 6-7). This W test, however, is based on a small number of data points and the uncertainty in the depth values for the qualified boreholes in the class must be considered. A probability plot for these data is illustrated on

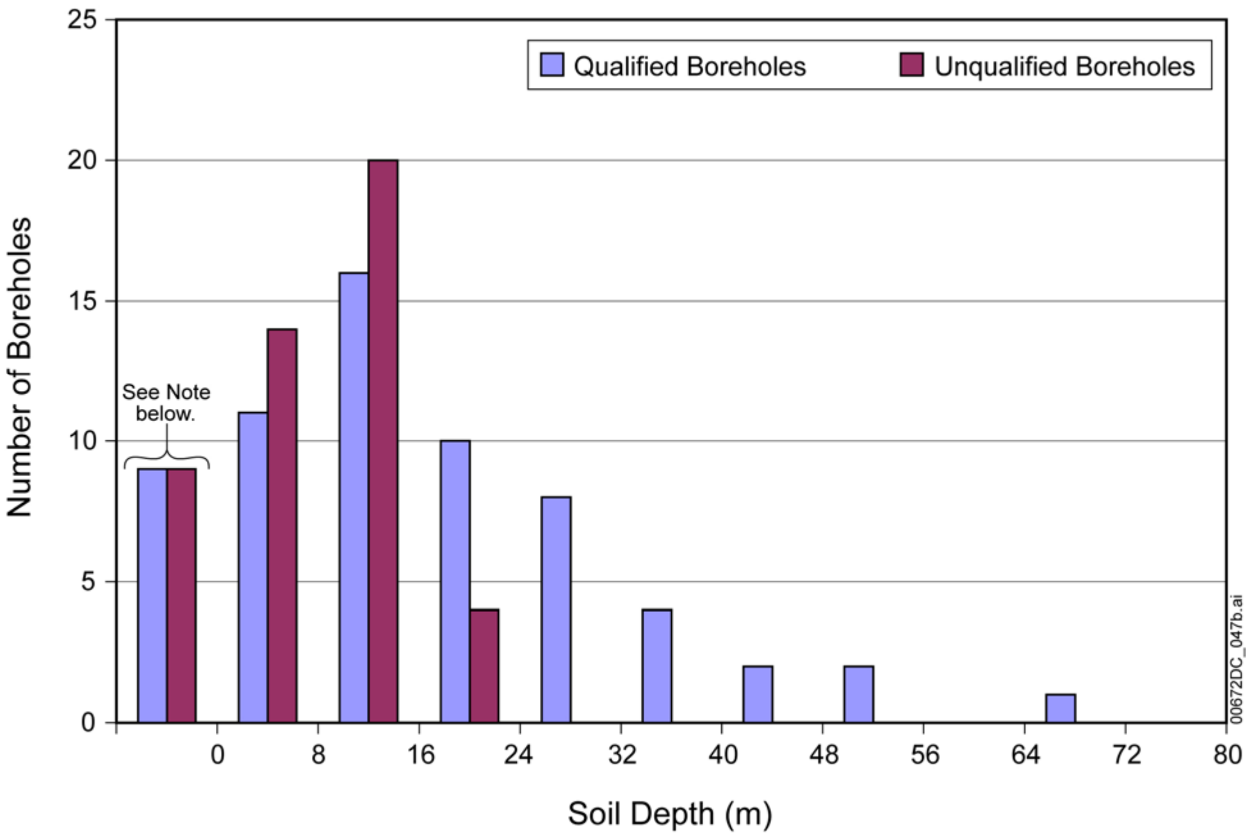
Figure 6-16. The selection of a lognormal distribution is also based on the description of the soil unit in this class, which indicates that soil is gradational into the soils of Soil Depth Class 4 and are generally thick enough to obscure underlying bedrock (DTNs: GS940108315142.004 [DIRS 160344], ACC: MOL.20021001.0238; GS940108315142.005 [DIRS 160345], ACC: MOL.20021203.0409; GS940708315142.008 [DIRS 160346], ACC: MOL.20021001.0261; and GS950408315142.004 [DIRS 160347], ACC: MOL.20020827.0355). These descriptions, and the indication from borehole data that the majority of points should fall in the shallow end of the range, led to selecting a distribution that would skew the depths toward the shallow end the range. The calculated values describing the distribution are listed in Table 6-7. The distribution is considered reasonable because it preserves the bias toward the low end of the range indicated by borehole data and it generally corresponds to the range derived from surface mapping. Qualified borehole values are also corroborated by unqualified borehole depth values (Figure 6-15).



Sources: Table 6-7; Appendix B, Section B.1.10 and Section B.2, *Final calcs. for report-Rev 01.xls* , worksheet 'W-testC3'.

Figure 6-16. Probability Plot of the Data Listed in Table 6-7

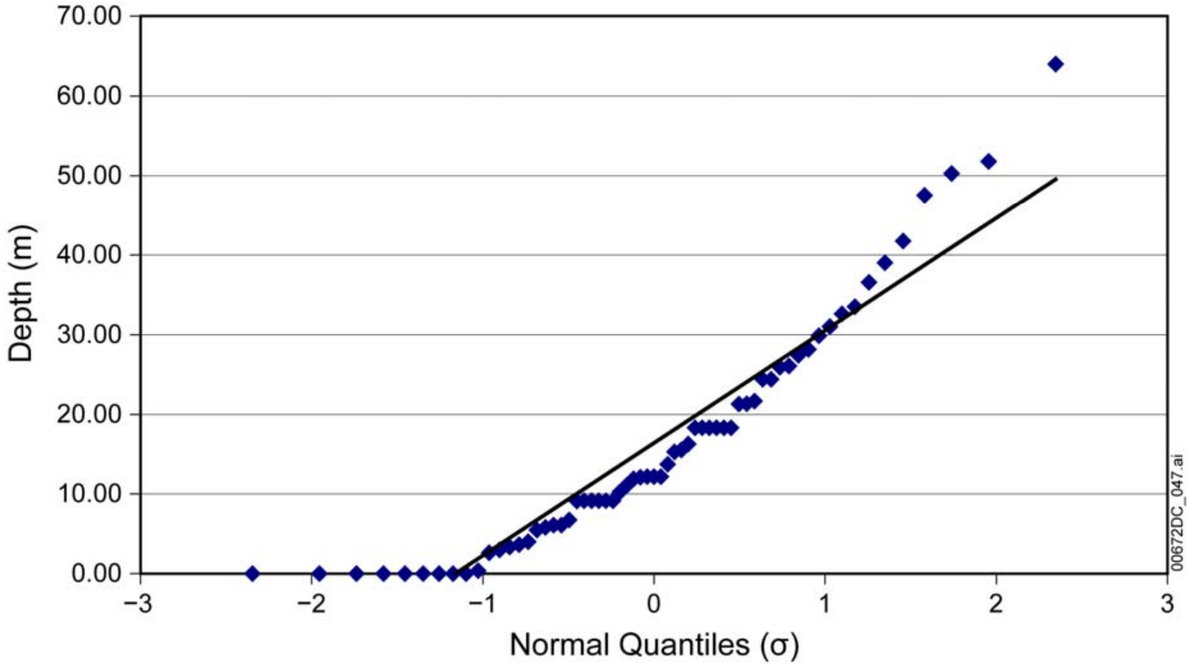
The distribution of moderately deep soils, assigned to Soil Depth Class 2, is based on qualified data for boreholes located in cells assigned to this class. Borehole location data (Table A-1) were used in conjunction with soil depth class assignments (Figure 6-12) from output DTN: MO0608SPASDFIM.006 to determine which boreholes are located in Soil Depth Class 2. Qualified boreholes in Soil Depth Class 2 with their associated soil depth are listed in Table 6-8. Borehole soil depths in this class, shown in Figure 6-17, range from 0 to 65 m. This class includes the greatest number of borehole data points. The distribution of data (Figure 6-17) indicates that a normal distribution is most appropriate for characterizing soil depths in this class. The selection of a normal distribution was tested using D'Agostino's Test (Gilbert 1987 [DIRS 163705]), which supports the hypothesis that data are normally distributed at the 0.02 significance level, but not at the 0.05 significance level. As illustrated by the probability plot in Figure 6-18, this lower degree of confidence is the result of the truncation of the distribution at the zero value (Figure 6-17) and the number of points with the same value of zero. The parameters for a normal distribution based on qualified borehole data are listed in Table 6-8.



Source: Appendix B, Section B.1.6 and Section B.2, *Final calcs. for report-Rev 01.xls*, worksheet 'Class 2'.

NOTES: Qualified and unqualified data are listed in Table 6-8. Soil depths less than 0 represent observed soil depth equal to zero. All other soil depths fall within the ranges as presented.

Figure 6-17. Distribution of Soil Depths in Qualified and Unqualified Boreholes for Soil Depth Class 2 (Moderately Deep Soils)



Source: Appendix B, Section B.1.11 and Section B.2, *Final calcs. for report-Rev 01.xls*, worksheet 'DAgtest'.

Figure 6-18. Probability Plot of the Qualified Data Shown in Figure 6-17

Table 6-8. Qualified Borehole Depths Used to Calculate Depth Distribution and Unqualified Borehole Depths Used for Corroboration for Soil Depth Class 2

Borehole Identification	Soil Depth (m)
Qualified Data	
UE-25 RF#13	26.06
UE-25 RF#22	24.38
UE-25 UZ#4	11.89
UE-25 RF#18	18.29
UE-25 RF#14	31.03
UE-25 RF#19	36.58
UE-25 RF#29	25.91
UE-25 RF#17	28.16
USW G-1	18.29
USW G-2	0.00
USW H-1	0.00
UE-25p#1	39.01
USW G-4	9.14
USW a#1	9.14
UE-25 a#4	9.14
UE-25 a#5	27.43
UE-25 a#6	6.10
UE-25 a#7	50.29
UE-25 b#1	47.55

Table 6-8. Qualified Borehole Depths Used to Calculate Depth Distribution and Unqualified Borehole Depths Used for Corroboration for Soil Depth Class 2 (Continued)

Borehole Identification	Soil Depth (m)
Qualified Data (Continued)	
UE-25 c#1	0.00
UE-25 c#2	21.31
UE-25 c#3	24.41
USW H-3	0.00
USW H-4	0.00
USW H-5	0.00
USW H-6	9.11
USW UZ-1	12.19
USW UZ-6	0.00
USW WT-1	9.14
USW WT-2	18.29
UE-25 WT#3	3.35
UE-25 WT#4	15.54
UE-25 WT#6	51.82
USW WT-7	12.19
USW WT-10	18.29
USW WT-11	12.19
UE-25 WT#12	18.29
UE-25 WT#14	32.61
UE-25 WT#15	64.01
UE-25 WT#16	41.76
UE-25 WT#17	9.14
UE-25 WT#18	0.00
UE-25 RF#26	21.64
UE-25 RF#16	16.25
NC-EWDP-18P	13.72
UE-25 RF#20	21.34
UE-25 RF#24	6.10
UE-25 RF#25	18.29
UE-25 RF#21	33.53
USW UZ-N57	0.37
USW UZ-N58	6.74
USW UZ-N59	3.99
USW UZ-N61	2.99
USW UZ-N54	5.79
USW UZ-N35	3.63
USW UZ-N37	11.06
USW UZN#63	2.62
USW UZ-N34	15.27
USW UZ-N31	0.00
UE-25 UZ#16	10.27
UE-25 ONC #1	29.87

Table 6-8. Qualified Borehole Depths Used to Calculate Depth Distribution and Unqualified Borehole Depths Used for Corroboration for Soil Depth Class 2 (Continued)

Borehole Identification	Soil Depth (m)
Qualified Data (Continued)	
USW UZ-N38	5.46
USW UZ-14	12.10
Sample Statistics for Qualified Data (lower bound set at 0.5 m)	
Mean	16.47
Standard Deviation	14.61
Median	12.19
Unqualified Data	
USW SD-12	0.00
USW UZ-N40	0.88
USW UZ-N41	4.88
USW UZ-N42	0.00
USW UZ-N43	8.23
USW UZ-N45	10.67
USW UZ-N46	0.00
USW UZ-N47	10.06
USW UZ-N48	0.00
USW UZ-N50	2.74
USW UZ-N51	4.27
USW UZ-N52	2.13
USW UZ-N67	5.79
USW UZ-N68	15.24
USW UZ-N69	8.23
USW UZ-N77	11.58
USW UZ-N82	6.70
USW UZ-N83	0.00
USW UZ-N84	6.09
USW UZ-N86	0.00
USW UZ-N87	5.79
USW UZ-N89	10.06
USW UZ-N90	9.91
USW UZ-N93	0.00
USW UZ-N94	0.00
USW UZ-N95	0.00
USW UZ-N98	0.30
USW UZ-N24	0.15
UE-25 UZN #1	8.32
UE-25 UZN #3	2.74
UE-25 UZN #4	7.47
UE-25 UZN #5	13.56
UE-25 UZN #6	12.04
UE-25 UZN #7	12.34
UE-25 UZN #8	12.19

Table 6-8. Qualified Borehole Depths Used to Calculate Depth Distribution and Unqualified Borehole Depths Used for Corroboration for Soil Depth Class 2 (Continued)

Unqualified Data (Continued)	
UE-25 UZN #9	10.67
UE-25 UZN #12	13.72
UE-25 UZN #13	13.41
UE-25 UZN #14	13.41
UE-25 UZN #18	17.07
UE-25 UZN #20	11.89
UE-25 UZN #21	8.38
UE-25 UZN #22	5.94
UE-25 UZN #56	17.07
UE-25 UZN #60	8.08
UE-25 UZN #97	17.68
UE-29 UZN #92	17.68

Sources: Table 4-1; Table A-1; Appendix B, Section B.1.6 for Excel® calculations.

This distribution should be implemented as a left-truncated normal distribution with a point of truncation at 0.5 m because negative values are not possible and a spike at the zero value would be undesirable because this class is mapped as alluvial covered valley floors and should not have bedrock exposures. As was seen with the shallower soil depth classes, a few borehole logs indicate zero soil depth. These boreholes are considered to have been affected by drill pad construction practices because the soil mapping indicate the presence of alluvial cover. As illustrated on Figure 6-9, these boreholes are near the contact with shallower classes and at the base of slopes where cuts may have been required to create a drill pad. A truncation point of 0.5 m was selected because the apparent ability of drill pad excavation to remove all soil indicates that some depths in this class must be relatively shallow. In addition, as shown on Figure 6-12, Soil Depth Class 2 may be in contact with either Soil Depth Class 3 or Soil Depth Class 4. Therefore, the depth at the contact could be as small as 0.1 to 0.5 m, depending on the class with which Soil Depth Class 2 is in contact (Table 6-5), and, thus, a minimum value of 0.5 m is reasonable for this class. The distribution is considered reasonable because it closely corresponds to the qualified borehole data. The distribution is also corroborated by the unqualified data from additional boreholes (Figure 6-17). Physically, the class represents shallower alluvial deposits extending outward for 300 m from the contact with thin colluvial deposits. Because buried topography can exist at the alluvial-bedrock contact, the increase in depth is not necessarily uniform so that the random depth pattern created by sampling from the distribution is not necessarily at odds with reality. A distribution of this type that ranges from near zero meters to depths of about 40 m should be an adequate representation of depths in this area (Figure 6-11).

Because of the sparse amount of qualified borehole data for very deep soils, the distribution recommended for Soil Depth Class 1 is based on the alluvial depth range given in output DTN: MO0012MWDGFM02.002 [DIRS 153777], as illustrated in the GFM (BSC 2004 [DIRS 170029], Figure 6-10). The distribution is also based on an extension of the range of depths given by borehole data for Soil Depth Class 2 (Figure 6-17). The qualified data for boreholes located in cells assigned to this class were also used to support the evaluation. Borehole location data (Table A-1) were used in conjunction with soil depth class assignments (Figure 6-12) in output DTN: MO0608SPASDFIM.006 to determine which boreholes are located in Soil Depth Class 1. Qualified and unqualified boreholes in Soil Depth Class 1, with their associated soil depth, are listed in Table 6-9. There are only two qualified boreholes located within this class. The number of unqualified data points is also small. Qualified boreholes (Table 6-9) give a range of soil depths from 67 to 132 m. Unqualified points range from 148 to 157 m in soil depth. The distribution of qualified and unqualified data points is shown on Figure 6-19. Due to the small number of data values, the lower bound for Class 1 is set at 40 m, which corresponds approximately with the upper bound depth of Soil Depth Class 2.

Table 6-9. Qualified Borehole Soil Depths Used to Determine the Depth Distribution Limits and Unqualified Borehole Soil Depths for Corroboration for Soil Depth Class 1

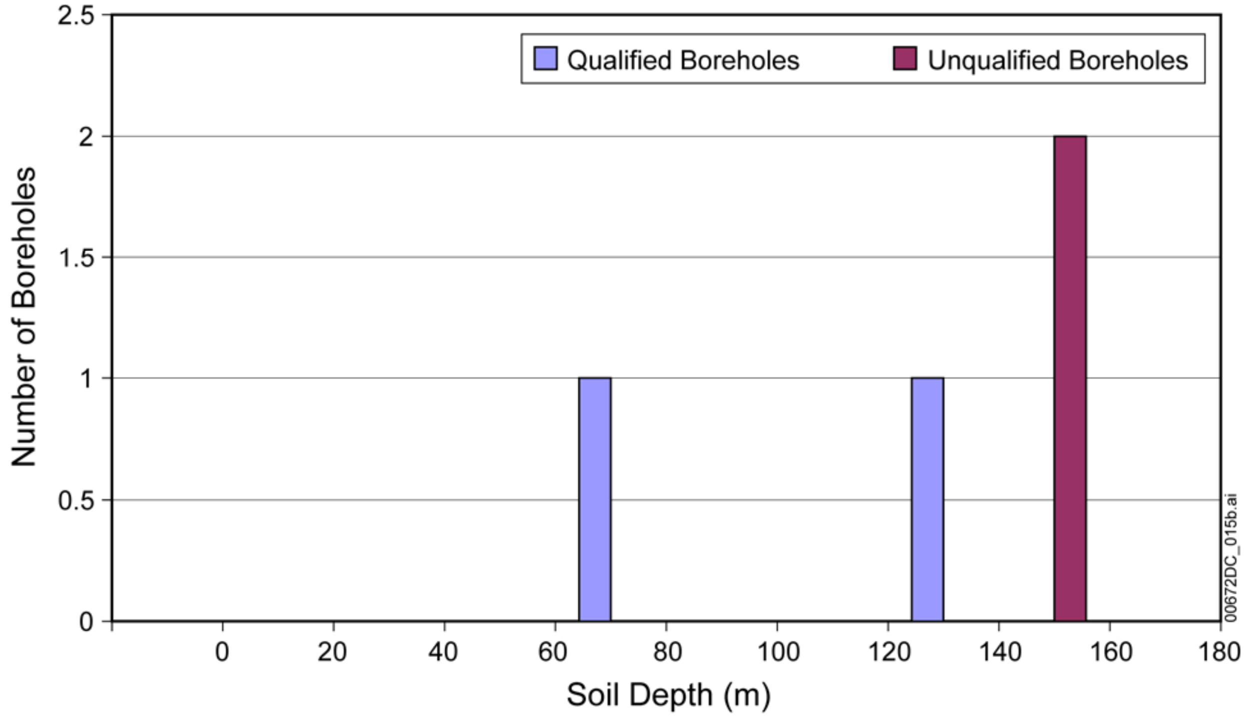
Borehole ID	Soil Depth (m)	Qualification Status
UE-25 J#13	132.59	Qualified - PVAR
UE-25 WT#13	67.06	Qualified - PVAR
UE-25 J#12	156.97	Unqualified
UE-25 JF#3	148.44	Unqualified

Sources: Table 4-1; Table A-1; Appendix B, Section B.1.6 for Excel® calculations.

ID = identification; PVAR = Process Validation and Reengineering.

Data from the GFM (BSC 2004 [DIRS 170029], Figure 6-10) were compared to the outline of the very deep soil depth class (Figure 6-12). The correspondence between the depth contours from the GFM (BSC 2004 [DIRS 170029]; DTN: MO0012MWDGFM02.002 [DIRS 153777]) and the contact between Soil Depth Classes 1 and 2 is reasonable but not exact. The GFM indicates a depth ranging between approximately 25 and 60 m for this contact. The maximum depth indicated by the GFM for this class is somewhat greater than 150 m in the southeast corner of the GFM area. Because Soil Depth Classes 1 and 2 are subdivisions of what is an essentially steadily increasing linear trend (Figure 6-11), the boundary between the two classes should agree or overlap slightly. Based on this information, a simple uniform distribution ranging from 40 to 150 m is recommended for modeling purposes.

The minimum value generally corresponds to the upper bound of the range defined by Soil Depth Class 2 (Figure 6-17) with some slight overlap of the outlying points and falls within the range shown by the GFM (BSC 2004 [DIRS 170029], Figure 6-10). The maximum value represents a rounded value based on the GFM (BSC 2004 [DIRS 170029]; DTN: MO0012MWDGFM02.002 [DIRS 153777]). The depths for the qualified and unqualified boreholes also fall within this range (Figure 6-19). This simplified approach of using a uniform distribution is reasonable because depths in this class are significantly below, by greater than 30 m, the depths where infiltration processes were considered by previous infiltration models to allow water to reach the soil-bedrock contact (BSC 2004 [DIRS 170007], Section 6.1.2). Therefore, a more detailed evaluation of soil depths in this class is not required at this time. This conclusion, however, is subject to confirmation by future modeling efforts. If a more detailed prediction of depth for the cells in Soil Depth Class 1 is required, DTN: MO0012MWDGFM02.002 [DIRS 153777] can be used to generate values, as were generated for the GFM (BSC 2004 [DIRS 170029], Figure 6-10).



Sources: Table 6-9; Appendix B, Section B.1.6 and Section B.2, *Final calcs. for report-Rev 01.xls*, worksheet 'Class 1'.

Figure 6-19. Distribution of Soil Depths in Qualified and Unqualified Boreholes for Soil Depth Class 1 (Very Deep Soils)

6.2.2 Uncertainty in Estimating Soil Depth Parameters for Modeling

The results discussed in this analysis are subject to several types of uncertainty. One type of uncertainty pertains to the natural variability in soil depth that occurs at all scales in the area. This uncertainty is most visible in shallow soil classes where depths can vary considerably within the area defined by a 30 × 30 m grid cell, in addition to the variability in average depths that can occur between grid cells. Although the sample distributions listed in Table 6-10 are intended to be used to estimate the variability in average depth that occurs between grid cells for modeling purposes, they are actually based on point values made at specific locations within a cell. The variability of these point measurements also demonstrate the variability that can occur within an individual grid cell. This local variability is corroborated by trench logs in the area that can provide an illustration of the variability in depth along a continuous exposure. For example, DTN: GS980183117462.001 [DIRS 176939], ACC: MOL.19990706.0190, shows depths ranging from 0.8 to 2.2 m over a distance of 11 m in Soil Depth Class 4 to the east of the Solitario Canyon fault in Trench SCF-T1.

A second type of uncertainty pertains to measurement errors made when determining soil depths at sampling localities. Soil Depth Classes 3 and 4 use data from surface field measurements at natural exposures, such as gullies and stream cuts, as well as from manmade exposures, such as cuts for drill pads and trenches. These soil-depth measurements were made with a tape measure and measurement uncertainty of these values is small. The principal uncertainty in these measurements is the accuracy in defining the soil-bedrock contact at the field exposure.

Table 6-10. Summary of Recommended Distributions for Soil Depth Classes Used in Alternate Evaluation

Soil Depth Class Designator	**1**	**2**	**3**	**4**	**5**
Soil Depth Class	**Very Deep Alluvium**	**Moderately Deep Alluvium**	**Intermediate Depth Soils**	**Shallow Soils–Colluvium**	**Exposed Bedrock**
Sample Distribution Type	Uniform	Left-Truncated Normal (truncated at 0.5 m)	Lognormal	Lognormal	Single Value
Sample Mean	NA	16.47 (m)	3.26 (m)	0.45 (m)	NA
Sample Mean of the Natural Logarithm	NA	NA	0.61 (LN m) (1.84 m)	−1.29 (LN m) (0.27 m)	NA
Sample Standard Deviation	NA	14.61 (m)	4.71 (m)	0.67 (m)	NA
Sample Standard Deviation of the Natural Logarthm	NA	NA	1.07 (LN m)	0.88 (LN m)	NA
Sample Standard Error	NA	1.84 (m)	1.22 (m)	0.11 (m)	NA
Sample Median (also Estimated Population Median)	95 m	12.19 (m)	2.07 (m)	0.25 (m)	NA
Sample Geometric Standard Error for the Median	NA	NA	1.32 (m)	1.16 (m)	NA
Sample Minimum Value (m)	40 (m)	0.5	NA	NA	0
Sample Maximum Value (m)	150 (m)	64.0	NA	NA	0
Number of Data Points	4	63	15	35	NA
Estimated Population Mean	95 (m)	16.47 (m)	3.25 (m)	0.40 (m)	0
Confidence Interval for Population Mean at 80% Limit	—	14.09 to 18.86 (m)	2.21 to 5.73 (m)	0.33 to 0.52 (m)	NA
Confidence Interval for Population Mean at 90% Limit	—	13.40 to 19.54 (m)	2.00 to 7.11 (m)	0.31 to 0.57 (m)	NA
Confidence Interval for Population Median at 80% Limit	NA	NA	1.27 to 2.67 (m)	0.23 to 0.33 (m)	NA
Confidence Interval for Population Median at 90% Limit	NA	NA	1.13 to 2.99 (m)	0.21 to 0.35 (m)	NA

Sources: Output DTN: MO0608SPASDFIM.006; Appendix B.2, *Final calcs. for report-Rev 01.xls*, worksheets ‘Class 2’ and ‘Class 3’; Appendix B.2, *Taylor soil depth-Rev 01.xls*, worksheet ‘Wtest’ (for Class 4).

NOTE: See discussion in Section 6.2.1 related to Table 6-9 for an explanation of the minimum value for Class 1.

LN = natural logarithm; NA = not applicable.

In contrast to the surface field measurements, the uncertainty in the borehole measurements used directly in Soil Depth Classes 1, 2, and 3 is more significant. This uncertainty is related to drill pad construction activities and to determining the alluvial-bedrock contact based on borehole information. Environmental stipulations generally require the removal of the uppermost 0.3 to 0.4 m of topsoil, which is then stored for use in site restoration. In addition, the creation of a level pad for a drill rig and support trailers can result in cuts that remove additional material. Therefore, borehole depth measurements can be low by amounts ranging from zero to three or more meters, because of drill pad construction operations (Sections 6.1.2 and 6.2.1). While this factor affects all boreholes, the most significant effect would occur in areas of shallow soil depth, because the amount of potentially removed soil during drill pad construction represents a large percentage of the total soil depth. To account for this factor in Soil Depth Classes 3 and 4, the zero soil depths have been modified to reflect the minimum values for each class as reported in soil mapping data. All depths determined from boreholes, however, probably represent minimum depths. Because of these concerns, borehole soil depths for Soil Depth Class 4 were not used. Countering this uncertainty factor is the uncertainty that a soil depth may have been increased by the addition of fill to create a level pad. Some borehole logs indicate considerable depths of artificial fill. Wherever fill was indicated in a log, the fill thickness was not included in the soil depth value. It is possible, however, that in all cases the fill was not differentiated from the soil-alluvium.

Another area of uncertainty includes difficulty in determining the soil-bedrock contact in a borehole. For relatively shallow soils, the soil interval is generally augered or drilled, rather than cored, to set casing for subsequent coring operations in bedrock. Even if coring were to take place across the contact, the core recovery in the unconsolidated soils could be poor. Therefore, the contact depth for fill-soil or soil-bedrock contact could be an estimate by the geologist who logged the borehole and subjected the soil to some measure of uncertainty.

A third type of uncertainty is in the statistical estimation of population parameters using a relatively limited sample from the population. For Soil Depth Class 2, the uncertainty is quantified using a standard Student's *t*-distribution (Section B.1.12). The confidence interval for estimating the population mean from the sample values is given in Table 6-10.

Because Soil Depth Classes 3 and 4 are characterized as lognormal distributions, the sample mean is not the estimate of the population mean. The estimated population mean is calculated (Gilbert 1987 [DIRS 163705], Equation 13.7) as are the confidence limits for the population mean (Gilbert 1987 [DIRS 163705], Equations 13.13 and 13.14) (Section B.1.12). These values are shown in Table 6-10. This calculation indicates, for example, that the population mean for Soil Depth Class 4 is expected to be between 0.31 and 0.57 m with a 90% level of confidence. In a similar fashion, the population mean for Soil Depth Class 3 is expected to be between 2.0 and 7.11 m with a 90% level of confidence. Values would occur between 0.57 and 2.0 m for both classes because the distributions about these means overlap in this interval.

The calculated confidence intervals shown on Table 6-10 include the underlying assumptions that the population is normally (or lognormally) distributed and that the sample represents a random sample of the population. Tests for normality are discussed in Section 6.2.1. The field measurements of soil depth for Soil Depth Class 4 probably represent a reasonably random sample because the relatively steep terrain and thin soils create a large number of exposures randomly scattered across the area covered by this class. The field measurements for Soil Depth Class 3 may be more biased because, as the soils are thicker in this class, exposures may tend to preferentially occur in the thinner soils in the class rather than the thicker soils. Borehole locations were selected without regard to soil depth in Soil Depth Classes 3 and 4, but locations that were near roads and on level terrain were preferred when possible for cost and environmental reasons, which could introduce some bias into the sample. Boreholes in Soil Depth Classes 1 and 2 were mostly sited to study foundation conditions in the vicinity of proposed surface facilities in Midway Valley. Therefore, the borehole data points tend to be concentrated at this locality and are not randomly distributed across the area covered by these soil depth classes.

While uncertainties related to sample size can be quantified, the contribution of other types of uncertainty, to the total uncertainty in the estimate, are more difficult to quantify. Uncertainties for Soil Depth Class 4 are most likely to affect net infiltration because these soils are thin and more readily transmit water to the bedrock and because the majority of model cells above the repository block belong to this class. Uncertainties in this class are predominantly related to sample size, because borehole data with their attendant uncertainty were not used to evaluate this class. The principal uncertainty in this class is the natural variation in thickness in the shallow soils in this class. The infiltration model grid will assign a uniform soil depth value to a 30×30 m grid cell and may assign that same depth value to multiple adjacent grids. Actual conditions in the cell will likely vary between small areas of exposed bedrock and areas of soil cover with different depths.

Soil Depth Class 3 is subject to the greatest uncertainty because of a small sample size and because of the uncertainties related to borehole measurements in relatively shallow soils. This class, however, covers a small percentage of the model area (Figure 6-12). Modified values used for boreholes showing zero depth values compensate for some of this uncertainty. Values for the confidence intervals around the estimated population mean (Table 6-10) include the range shown by surface field measurements that are not subject to this uncertainty. For this reason, and because underestimating the thickness would be a conservative bias, the confidence intervals on the population mean (Table 6-10) are considered the best estimate given the available data.

Recommendations herein result in distributions for soil depth classes that overlap. This is a departure from previous evaluations where ranges did not overlap. This is considered a reasonable approach that reflects the uncertainty, as shown by borehole data and observations from surficial deposits mapping, that results from the considerable natural variation in soil depth in the model area. A summary of recommended distributions representing the relevant qualified data for each soil depth class in this alternate evaluation is listed in Table 6-10 and is included in output DTN: MO0608SPASDFIM.006.

6.2.3 Intended Use of Output and Limitations

The analyses in this document are intended as a possible basis for constructing input files for use in infiltration modeling. The following discussion is intended to provide recommendations on the spatial distribution of soil depth classes, type of depth distribution to be used for each depth class, and estimates of the population mean with confidence intervals for the population mean, which are listed in Table 6-10 and included in output DTN: MO0608SPASDFIM.006, *Summary of Recommended Distributions.doc*. It is not intended that this analysis prescribe specific model input values or approaches to be used in addressing soil depth within a model. Modelers will need to consider the requirements of their model, the natural variation in soil thickness across the area, and any uncertainties associated with limited data sets in determining the approach that best meets their needs. Users of this analysis should also note that output DTN: MO0608SPASDFIM.006, *revised soil depth file.csv* and *revised soil depth file.txt*, describes the spatial extent of soil depth classes uses a grid specifically intended for use in an infiltration model. The choice of grid size and soil-depth-class definitions may not be completely suitable for other applications.

The proposed distributions are not based on a correlation between slope and soil depth as used in the infiltration model report (BSC 2004 [DIRS 170007]). While such a correlation may or may not exist, the existing data do not support such a correlation or provide data to quantify such a correlation if it exists. The limited data currently available are best characterized in a simple fashion as a distribution that can be used to characterize the cells in a particular soil depth class. This approach has the limitation of not being capable of predicting the depth value of an individual grid cell, as was done in the previous infiltration model report (BSC 2004 [DIRS 170007], p. 6-45) as a function of slope and depth class. The distribution can only be used to characterize the distribution of depths estimated to occur over a large area, but not the precise geometry of the depths within the area.

There are many approaches that could be taken in implementing the recommended distributions listed in Table 6-10, which are provided for use given several considerations. In assigning depth values to use for modeling, two possible approaches are discussed. The first approach is to assign a value to each cell in a particular soil depth class by sampling, from the distribution for that soil depth class. This would result in the cells in the class having a range of values that follow the distribution and would require careful implementation, because the spatial relationship of soil depth from cell to cell must be taken into consideration. The depth of soil in each cell is not independent of the depth in the adjacent cell. Additionally, the relationship of soil depth cell to cell may also depend on whether the cells are oriented, generally, parallel or perpendicular to bedrock outcrops.

Parallel to outcrops, adjacent cells may have similar soil depths, but perpendicular to outcrops, soil depth may change significantly over a short distance. Therefore, an approach that assigns the depth to a cell, by random sampling from the probability distribution (Table 6-10), then repeats that random sampling for each of the remaining cells would be unlikely to produce a depth distribution that resembles reality. This approach, if spatial correlation among cells is properly incorporated in the analysis, may be useful to assess the effect of the soil depth variability, at a particular location, to the infiltration at that location in the model domain.

Alternatively, if more general information, such as net infiltration over the entire model domain, is sufficient, then an appropriate bulk parameter value may be determined that is applied over the entire set of model cells belonging to a particular soil depth class. Appropriate bulk parameter means that when all cells in a class are assigned the same value, the net infiltration averaged across the entire depth class is the same as if the soil depths in the class were allowed to vary spatially (as occurs in nature) and were then averaged to determine the mean or median infiltration. This bulk parameter is also called an effective uniform value in this section.

The appropriate bulk soil depth value approach would use a further simplification of the model in which a single representative value (that may be uncertain) is used to characterize soil depth for all cells in a soil depth class. This approach would simplify calculations and would be satisfactory if infiltration values from the low end of the depth range tend to be cancelled out by values at the high end of the range, thus producing a trend toward the value predicted by a representative value when a large number of cells are considered. Implementation of this approach also requires a careful assessment because infiltration rates may change dramatically with depth within the depth range, so that cells from one segment of the distribution dominate infiltration and, thus, result in a different total infiltration value compared with infiltration from another segment of the distribution. This possible nonlinear or nonsymmetrical infiltration response implies that a simple arithmetic mean value may not be the appropriate bulk parameter value to assign to all cells in that cell class.

The following paragraphs discuss some considerations when choosing values for soil depth, if the approach used is that of a single, representative value.

Soil Depth Class 1

This depth class represents very thick alluvial soils, described by a uniform distribution with lower and upper bound values of 40 and 150 m, respectively. Because this class represents depths above the threshold where infiltration into the bedrock is expected, using a representative value equal to the mean for the class of 95 m is appropriate. Because soil depths in this class are large and infiltration is expected to be small, the specific value chosen within this range is unlikely to cause a significant change to predicted infiltration.

Soil Depth Class 2

This depth class represents moderately alluvial deep soils that range in depth from 0.5 m to about 50 m. This class is intended to include the value where soil depth is sufficient to prohibit infiltration of water to the soil-bedrock contact, except in some channels, because the soils have sufficient storage capacity to retain precipitation in the root zone where it is subject to evapotranspiration. Therefore, the treatment of soil depth in this class is dependent on the value assumed or calculated by the model for this infiltration threshold related to the climate state of interest. It is expected that infiltration in the Soil Depth Class 2 areas is most likely to occur where soil thickness is small. Consequently, the appropriate bulk parameter value will lie closer to the small soil thickness portion of the distribution (Table 6-10), rather than near the large soil thickness values. A separate analysis may need to be conducted to determine the appropriate bulk soil thickness for Soil Depth Class 2. If no analysis is made, the use of the sample median (approximately 12 m) or the sample mean (approximately 16 m) would be appropriate as an effective uniform value.

Soil Depth Class 3

This depth class represents areas of thicker footslope colluvium that occur intermittently in the area. The data are represented by a lognormal distribution with a sample mean soil depth of 3.26 m and a sample median of 2.07 m, which is also the estimated population median; only one value is larger than 5.18 m (Figure 6-15 and Table 6-7). The depth in Soil Depth Class 3 will be small where it contacts Soil Depth Class 4, but increases where it contacts other soil depth classes, primarily Soil Depth Class 2. The majority of infiltration through Soil Depth Class 3 will occur where the depth is small. The appropriate effective uniform depth for Soil Depth Class 3 is a value that allows for the same total infiltration, through all of Soil Class 3, as occurs through the spatially variable material that exists in nature. Estimating an effective uniform value for this depth class is especially challenging. There are very few measurements for this depth class (15 measurements, four of which indicate that there is no soil). Many of these measurements may represent disturbed regions where drilling pads were constructed and, thus, may not represent actual soil depth. Although it is common to choose the median of a lognormal distribution as a measure of central tendency, the potential underestimate previously noted suggests that the sample mean is a better measure of central tendency in this case. The 90% confidence interval about the mean ranges from 2 to 7 m, where the lower bound of this range is approximately the median.

Soil Depth Class 4

This shallow depth class represents colluvial-covered upland slopes and plateaus. The data are represented by a lognormal distribution with an estimated population mean of 0.4 m and a sample median of 0.25 m. This depth class is described by only 35 measurements over an area of approximately 71 km^2. Because of the extremely low data density, it is necessary to extend the range of uniform effective soil depth beyond that described by a standard confidence interval. It is proposed here that the uniform effective value be represented by a uniform distribution from 0.1 to 0.5 m. There is no rigorous basis for this range, but rather it is consistent with a range of unqualified and qualified observations made in the field at numerous locations in the upland regions in the Yucca Mountain vicinity. For example, Sanchez (Scientific Notebook 2006, pp. 62-68, ACC: MOL.20060306.0186) made several observation of soil depth in the upland areas of Yucca Mountain. These observations show typical soil depth profiles at locations with outcrop exposures. These observations range from no soil on the tops of some ridges to about 3 m at the bottom of the footslope region. The areas with less than 0.1 m and more than 0.5 m of soil appear to be not as common as areas that fall within the suggested range. When compared to the available 35 data values, 0.1 m is represented by the 10th percentile and 0.5 m is represented by the 80th percentile (Figure 6-14). Given that the relationship between infiltration and soil depth is probably nonlinear, it is appropriate to favor the shallow end of the range over the deeper end.

Soil Depth Class 5

This class represents exposed bedrock in the area that does not have soil cover. Therefore, all cells in this class should be assigned a zero soil depth value.

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7. CONCLUSIONS

7.1 TECHNICAL ADEQUACY OF THE EXISTING SOIL DEPTH FILE

Because of the limited availability of direct surficial deposit thickness measurements, any method of estimating thickness over the model area is subject to uncertainty. Using soil classification as a surrogate for depth information is considered the best approach given the available information. The assessment of the soil depth values in the file *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) identified several inadequacies with the traceability of the development of SOILMAP6.INP. Additionally, the approach used to create SOILMAP6.INP results in values that are subject to uncertainty at a detailed level, such as depth estimate values for specific model cells calculated from equations based on topographic slopes.

While *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) provides a reasonable, generalized model of soil thickness in the vicinity of Yucca Mountain as defined by general soil depth codes (Figures 6-3 and 6-8), the detailed calculations of the depth for each grid cell based on topographic slope are not supported by available data (see Figures 6-4, 6-5, and 6-10, and Table 6-4). The natural variability in soil depth at all scales is too great to allow correlations between slope and soil to be significant. The effect from these detailed slope-based soil depth calculations on the output of previous versions of the infiltration model (BSC 2004 [DIRS 170007]); USGS 2000 [DIRS 123650]; USGS 2001 [DIRS 154674]; USGS 2001 [DIRS 160355]; USGS 2003 [DIRS 166518]) is beyond the scope of this analysis.

Some elements of the production of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) are not fully transparent. The methods used to define the original soil depth codes, and the development of equations used to calculate depth, are considered to be based on author judgment, which is not well documented. There is also a difference between the boundaries of the soil depth codes defined by the depth equations and those defined in the infiltration model report (BSC 2004 [DIRS 170007]). These issues make it difficult to completely assess the process used to develop *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6).

Although the infiltration model report (BSC 2004 [DIRS 170007]) identifies and documents the creation of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), it does not provide the location of the file. DTN: MO0512SPASURFD.000 [DIRS 175870], containing *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), was created as output from the infiltration model report (BSC 2004 [DIRS 170007]) to provide a traceable link to the actual input file. These issues are documented in Condition Report Number 6334.

The file *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) has been shown to be inadequate because the method used is not fully traceable and the resulting site specific depth estimates are not corroborated by observation. As a result, an alternate method based on soil types and soil depth observations was implemented.

7.2 CONCLUSIONS BASED ON THE SUMMARY OF EXISTING DATA

Future infiltration modeling should use a soil depth file that is traceable to data sources available for the model area. This analysis supplies an alternate evaluation of soil depth that can be used as such a source. The evaluation herein relies on a simplified approach that uses qualified data from boreholes, field surficial deposits mapping, and the GFM (BSC 2004 [DIRS 170029], Figure 6-10). The evaluation divides the infiltration model area into five soil depth classes (Figure 6-12) and offers a set of distributions representing available data (Table 6-10) that can be used to estimate soil depths for model grid cells.

The soil depth class for each grid cell in the model area and a listing of the soil depth distributions are included in output DTN: MO0608SPASDFIM.006.

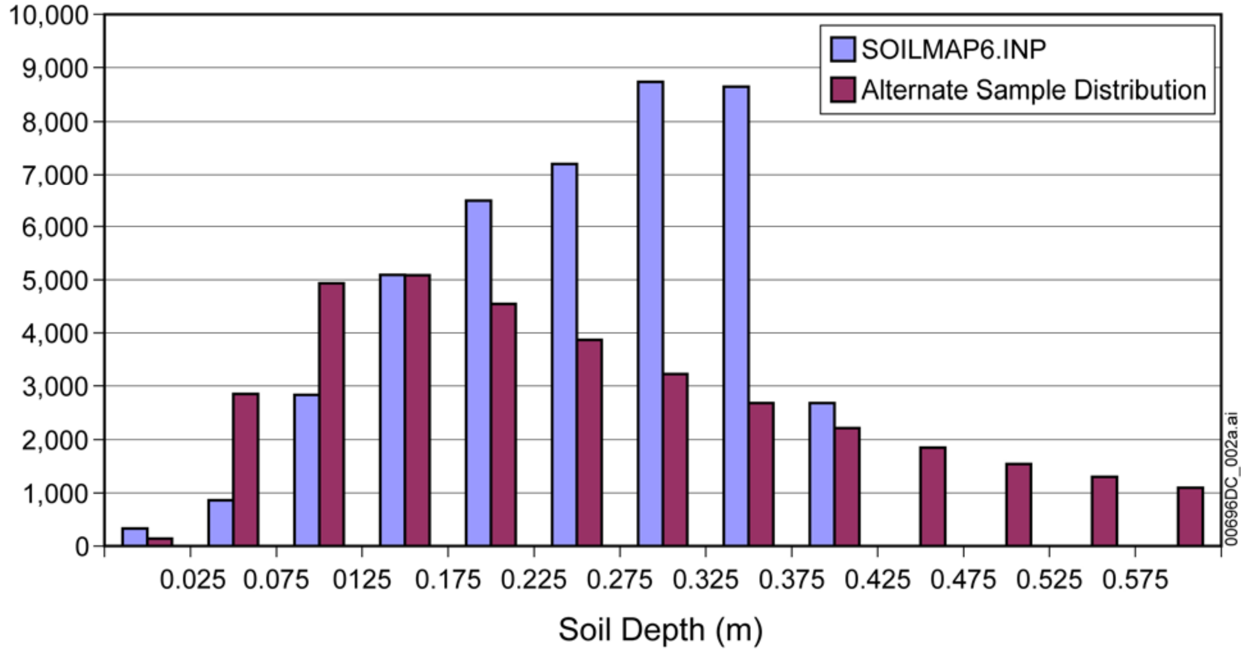
The soil depth data used herein are sufficient to provide input to an infiltration model when data limitations and uncertainties are recognized. Users of output DTN: MO0608SPASDFIM.006 for future infiltration modeling should consider the requirements and sensitivities of their model in determining its utility.

The grid file and distributions in output DTN: MO0608SPASDFIM.006 can be used to randomly sample values from the soil depth classes shown in the file and assign values to particular grid cells.

Output DTN: MO0608SPASDFIM.006 does not attempt to coordinate values used with adjacent cells that were based on slope or other factors. Such an approach can result in a pattern in which adjacent cells may have significantly different soil depth values because of the uncertainty resulting from a limited set of field measurements and because of the known high natural variability of soil depths in shallower depth classes. The output is considered a reasonable representation of soil depth variability across the model area based on currently available data.

Estimates made by *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) and output DTN: MO0608SPASDFIM.006 are compared for the shallow soil class to illustrate the differences between the two approaches. Figure 7-1 shows the distribution of 42,851 grid cell values for Soil Depth Code 1 (Figure 6-3) taken from the portion of the data analyzed (Section 6.1.2) to test the depth calculations. These values are compared to a hypothetical distribution based on the sample mean and the sample standard deviation for Soil Depth Class 4 (Table 6-10), but are scaled up to the same amount of values from *SOILMAP.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) to provide the comparison.

The mean for the *SOILMAP6.INP* sample (0.26 m) (USGS 2000 [DIRS 175858], folder Soilmap6) is similar to the sample median (0.25 m) and the anti-log of the sample mean of the log-depth values (0.27 m) for Soil Depth Class 4; the values, however, are distributed differently.



Sources: Table 6-10; Appendix B, Sections B.1.2 and B.1.13 and Section B.2, *Section 7 comparison.xls*, worksheet 'Figure 7-1'.

NOTE: The hypothetical distribution, based on the sample mean and on the sample standard deviation for Soil Depth Class 4 (Table 6-10), uses the same total number of values as those used in the *SOILMAP.INP* sample (USGS 2000 [DIRS 175858], folder Soilmap6).

Figure 7-1. Comparison of Values Calculated for Soil Depth Code 1 in *SOILMAP6.INP* and Soil Depth Class 4

7.3 SUMMARY OF THIS ANALYSIS

This analysis addresses work scope elements (Section 1) and presents the following findings:

- The technical adequacy of the soil depth file used in the infiltration model report (BSC 2004 [DIRS 170007]) was evaluated through a review of supporting documentation and corroborating data.
- The findings from the evaluation of the existing file are:
  - The method used to calculate soil depths for each grid cell in the model is not well-documented or traceable
  - The general soil depth codes and depth ranges used are reasonable
  - The specific depth calculations for each grid cell based on topographic slope are not corroborated by the existing data.
- After an evaluation of *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), it was determined that an alternate soil depth file should be created. This is consistent with the resolution plan to reperform the preparation of the soil depth file for issues noted in the evaluation, using available data to provide an alternate source for future modeling

- This analysis generated an alternate soil depth file that assigns a soil depth class to each grid cell in the model area (Figure 6-12) and provides distributions characterizing soil depth for each of the classes (Table 6-10). These files are located in output DTN: MO0608SPASDFIM.006.
- There is significant uncertainty involved in soil depth characterizations because of significant natural variability at all scales in soil depth and because of the limited size of data sets that provide soil depth information. Users of the results of this analysis need to carefully consider the uncertainties of the results.
- This analysis addresses the soil depth cover portion of the criteria identified in Section 4.2 as listed in Table 7-1.

Table 7-1. Mapping of Yucca Mountain Review Plan Acceptance Criteria and Soil Depth Summary

Acceptance Criteria	Subcriteria	How Addressed
Acceptance Criterion 2: Data are sufficient for model justification (NRC 2003 [DIRS 163274], Section 2.2.1.3.5.3)	Climatological and hydrological values used in the license application (e.g., time of onset of climate change, mean annual temperature, mean annual precipitation, mean annual net infiltration, etc.) are adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.	Not applicable for soil depth
	The effects of fracture properties, fracture distributions, matrix properties, heterogeneities, time-varying boundary conditions, evapotranspiration, depth of soil cover, and surface-water runoff and run-on are considered, such that net infiltration is not underestimated.	The variation in the soil cover depth establishes a reasonable and realistic estimate, based on available data, for use in modeling. The limited data set used herein does introduce some uncertainty into the estimates, which are discussed and incorporated into the analyses as discussed in Sections 6.2.1 and 6.2.2.
	Sensitivity or uncertainty analyses are performed to assess data sufficiency and determine the possible need for additional data.	Uncertainty in the soil depth values discussed and incorporated in recommendations as discussed in Section 6.2.2.
Acceptance Criterion 3: Data uncertainty is characterized and propagated through the model abstraction (NRC 2003 [DIRS 163274], Section 2.2.1.3.5.3)	Models use parameter values, assumed ranges, probability distributions, and bounding assumptions that are technically defensible, reasonably account for uncertainties and variabilities, and do not result in an under-representation of the risk estimate.	Uncertainties and variability included in derivation of recommended values to provide a reasonable parameter estimate are discussed in Sections 6.2.1 and 6.2.2
	The technical bases for the parameter values used in this abstraction are provided.	Available site-specific data identified and evaluated in the analysis as discussed in Section 4.
	Possible statistical correlations are established between parameters in this abstraction. An adequate technical basis or bounding argument is provided for neglected correlations.	Statistical correlations established and evaluated in generating recommended values. Basis for neglected correlation between slope and depth provided. These correlations and the basis are discussed in Sections 6.2.1 and 6.2.2.

8. INPUTS AND REFERENCES

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176591 YMP 1994. *Construction of Drill Pad and Refurbishment of Access Road for Borehole USW UZ-7a*. Job Package 94-14. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: DRC.19960729.0031.

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IT-PRO-0011, *Software Management*.

LP-3.15Q-BSC, *Managing Technical Product Inputs*.

LP-SIII.9Q-BSC, *Scientific Analyses*.

LS-PRO-0203, *Q-List and Classification of Structures, Systems, Components and Barriers*.

8.3 SOURCE DATA, LISTED BY DATA TRACKING NUMBER

158000 GS000308314211.002. Stratigraphic Contacts for Boreholes UE-25 A#1, UE-25 A#4, USW G-1, USW G-2, USW H-5, USW SD-9, USW SD-12 and USW VH-2. Submittal date: 04/28/2000.

176317 GS011208312212.004. SN-USGS-SCI-113 V1: Empirical Calculation of Soil Thickness Based on Field Measurements. Submittal date: 01/24/2002.

164561 GS030783114233.001. Geotechnical Borehole Logs for the Waste Handling Building, Yucca Mountain Project, Nevada Test Site, Nevada, Version 7/16/03. Submittal date: 07/23/2003.

175972 GS910808312212.001. Geohydrologic Data Collected from Shallow Neutron-Access Boreholes and Resultant Preliminary Geohydrologic Evaluations, Yucca Mountain Area, Nye County, Nevada. Submittal date: 08/09/1991.

150007 GS931008314211.037. Graphical Lithologic Log of Borehole NRG-3 (UE-25 NRG#3), Version 1.0. Submittal date: 10/07/1993.

150009 GS931008314211.039. Graphical Lithologic Log of Borehole NRG-2 (UE-25 NRG#2), Yucca Mountain, Nevada. Submittal date: 10/07/1993.

150010 GS931008314211.045. Graphical Lithologic Log of Bore Hole USW NRG-6. Submittal date: 10/07/1993.

150011 GS931108314211.041. Graphical Lithologic Log of Borehole NRG-2B (UE-25 NRG#2B), Yucca Mountain, Nevada. Submittal date: 10/07/1993.

150012 GS931208314211.046. Graphical Lithologic Log of Borehole UE-25 NRG#1. Submittal date: 11/22/1993.

110313 GS931208314211.047. Graphical Lithologic Log of Borehole UE-25 UZ#16. Submittal date: 11/22/1993.

160344 GS940108315142.004. Draft Surficial Deposits Map of the Northeast Quarter of the Busted Butte 7.5-Minute Quadrangle. Submittal date: 12/22/1993.

160345 GS940108315142.005. Draft Surficial Deposits Map of the Southern Half of the Topopah Spring NW 7.5-Minute Quadrangle. Submittal date: 12/22/1993.

145577 GS940208314211.002. Table of Contacts in Boreholes USW UZ-N62. Submittal date: 02/01/1994.

152565 GS940208314211.003. Table of Contacts in Boreholes USW UZ-N53, USW UZ-N54, and USW UZ-N55. Submittal date: 02/01/1994.

145579 GS940208314211.004. Table of Contacts in Borehole USW UZ-N27. Submittal date: 02/10/1994.

152557 GS941008314211.051. Graphical Lithologic Log for Borehole USW UZ-N31. Submittal Date: 10/19/1994.

152563 GS940208314211.005. Table of Contacts in Boreholes USW UZ-N31, UZ-N32, UZ-N37. Submittal date: 02/10/1994.

152555 GS940208314211.006. Table of Contacts in Boreholes USW UZ-N33 and USW UZ-N34. Submittal date: 02/10/1994.

155533 GS940208314211.007. Table of Contacts in Borehole USW UZ-N35. Submittal date: 02/10/1994.

145581 GS940208314211.008. Table of Contacts in Boreholes USW UZ-N57, UZ-N58, UZ-N59, and UZ-N61. Submittal date: 02/10/1994.

145588 GS940308314211.011. Table of Contacts for the Tiva Canyon Tuff in Borehole USW UZ-N38. Submittal date: 03/10/1994.

146474 GS940308314211.016. Table of Contacts for the Tiva Canyon Tuff in Borehole USW UZ-N64. Submittal date: 03/28/1994.

155534 GS940308314211.017. Table of Contacts for the Tiva Canyon Tuff in Borehole UE-25 UZN#63. Submittal date: 03/28/1994.

145589 GS940308314211.018. Table of Contacts for the Tiva Canyon Tuff in Borehole USW UZ-N36. Submittal date: 03/28/1994.

160346 GS940708315142.008. Draft Surficial Deposits Map of the Northwest Quarter of the Busted Butte 7.5-Minute Quadrangle, Nye County, Nevada. Submittal date: 07/27/1994.

160347 GS950408315142.004. Draft Map of the Surficial Deposits of the Southern Half of the Busted Butte 7.5' Quadrangle, Nye County, Nevada. Submittal date: 04/03/1995.

146299 GS960408312212.005. Preliminary Surficial Materials Properties Map: Soils of the Yucca Mountain Area, NV. Submittal date: 04/18/1996.

124829 GS960508312212.007. Estimated Distribution of Geomorphic Surfaces and Depth to Bedrock for the Southern Half of the Topopah Spring NW 7.5 Minute Quadrangle and the Entire Busted Butte 7.5 Minute Quadrangle. Submittal date: 04/21/1996.

176939 GS980183117462.001. Trench Logs and Unit Descriptions for Solitario Canyon Fault Trenches T8 (TR8), T8A (TR8A), SCF-T1, SCF-T1A, SCF-T2, SCF-T3, and SCF-T4. Submittal date: 01/16/1998.

152562 MO0002GSC00068.000. UE-25 NRG-1 Drill Hole Resurvey for Comparison. Submittal date: 02/10/2000.

152554 MO0004QGFMPICK.000. Lithostratigraphic Contacts from MO9811MWDGFM03.000 to be Qualified Under the Data Qualification Plan, TDP-NBS-GS-000001. Submittal date: 04/04/2000.

153777 MO0012MWDGFM02.002. Geologic Framework Model (GFM2000). Submittal date: 12/18/2000.

157481 MO0101SEPBGLOG.000. Sample Management & Drilling Department Records Package for Borehole Records (Geologic Logs) from the "Geotechnical Field Investigation for the Waste Handling Building," FWP-SB-00-003. Submittal date: 01/10/2001.

157304 MO0103GSC01031.000. As-Built Borehole Locations Waste Handling Building WHB Site Investigation. Submittal date: 03/07/2001.

155539 MO0106STRATHFM.004. Lithologic Description of Drill Hole USW GU-3 and USW G-3. Submittal date: 06/27/2001.

155589 MO0106STRATHFM.028. Generalized Lithologic Log for Test Well USW H-1. Submittal date: 06/27/2001.

155590 MO0106STRATHFM.029. Lithologic Log for Drill-Hole UE-25 P#1. Submittal date: 06/27/2001.

155591 MO0106STRATHFM.030. Lithologic Log of Drill-Hole USW G-1. Submittal date: 06/27/2001.

155592 MO0106STRATHFM.031. Lithologic Description of Exploratory Drill Hole USW G-2. Submittal date: 06/27/2001.

168375 MO0203GSC02034.000. As-Built Survey of Nye County Early Warning Drilling Program (EWDP) Phase III Boreholes NC-EWDP-10S, NC-EWDP-18P, and NC-EWDP-22S—Partial Phase III List. Submittal date: 03/21/2002.

175917 MO0210SMFGLOG3.000. Sample Management Facility Geologic Logs for Nye County Early Warning Drilling Program (EWDP) Phase III. Submittal date: 10/08/2002.

175919 MO0506GSC05047.000. As-Built Location for Surface Boreholes. Submittal date: 06/20/2005.

175870 MO0512SPASURFD.000. Input File on Surficial Deposits Depth for Infiltration Modeling. Submittal date: 12/05/2005.

109060 MO9811COV98591.000. Coverage: TOPO20S. Submittal date: 11/09/1998.

103793 MO9902ASBUBOLC.000. As-Built Location of UE-25 RF#13 Borehole. Submittal date: 02/23/1999.

103790 MO9903BLOGSOIL.000. UE-25 RF#13 Borehole Log of Soil and Other Materials Above Bedrock. Submittal date: 03/05/1999.

176571 MO9903COV96274.000. Coverage: Soils. Submittal date: 03/29/1999.

165921 MO9905LUSWWT24.000. Surveyed Location USW WT-24. Submittal date: 05/07/1999.

109059 MO9906GPS98410.000. Yucca Mountain Project (YMP) Borehole Locations. Submittal date: 06/23/1999.

165922 MO9912GSC99492.000. Surveyed USW SD-6 As-Built Location. Submittal date: 12/21/1999.

175927 SNF29041993002.034. Yucca Mountain Site Characterization Project Geology and Rock Structure Log for Drillhole UE25 NRG-1, Rev. 1. Submittal date: 02/06/1995.

175928 SNF29041993002.036. Yucca Mountain Site Characterization Project Geology and Rock Structure Log For Drillhole UE25 NRG-2A, Rev. 1. Submittal date: 02/06/1995.

175958 SNF29041993002.038. Yucca Mountain Site Characterization Project Geology and Rock Structure for Drillhole UE25 NRG-3, Rev. 1. Submittal date: 02/06/1995.

175959 SNF29041993002.039. Yucca Mountain Site Characterization Project Geology and Rock Structure Log For Drillhole UE25 NRG-4, Rev. 1. Submittal date: 02/06/1995.

175960 SNF29041993002.040. Yucca Mountain Site Characterization Project Geology and Rock Structure Log For Drillhole UE25 NRG-5, Rev. 1. Submittal date: 02/06/1995.

166437 SNF29041993002.042. Yucca Mountain Site Characterization Project Geology and Rock Structure Log for Drillhole USW NRG-7/7A, Rev. 1. Submittal date: 02/06/1995.

107239 SNF40060198001.001. Unsaturated Zone Lithostratigraphic Contacts in Borehole USW WT-24. Submittal date: 10/15/1998.

107372 SNF40060298001.001. Unsaturated Zone Lithostratigraphic Contacts in Borehole USW SD-6. Submittal date: 10/15/1998.

105187 SNT02052794001.003. Geologic Core Logs for USW SD-9, Version 2.0. Submittal date: 01/29/1996.

175971 TM0000000000CL.005. UE-25 JF-3 Composite Borehole Log. Submittal date: 10/13/1995.

175918 TM0000000SD7RS.006. USW SD-7 Video Tapes and Composite Borehole Log To a Total Depth Of 2675.1′. Submittal date: 02/13/1996.

175924 TM000000SD12RS.014. USW SD-7 Composite Borehole Log and Sample Weight Logs. Submittal date: 02/27/1996.

160826 TM000000UZ7ARS.001. USW UZ-7A Shift Drilling Summaries, Lithologic Logs, Structural Logs, Weight Logs, and Composite Borehole Log from 0.0′ to 770.0′. Submittal date: 09/05/1995.

8.4 OUTPUT DATA, LISTED BY DATA TRACKING NUMBER

MO0608SPASDFIM.006. Soil Depth Input File for Use in Infiltration Modeling. Submittal date: 08/31/2006.

8.5 SOFTWARE CODES

157019 2000. *Software Code: ARCINFO.* V.7.2.1. SGI, IRIX 6.5. STN: 10033-7.2.1-00.

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APPENDIX A

BOREHOLES AND SURFICIAL DEPOSIT DEPTH MEASUREMENTS

BOREHOLES AND SURFICIAL DEPOSIT DEPTH MEASUREMENTS

The data listed as direct input for Borehole Soil Depth and Borehole Location (Table 4-1) are compiled into a single table (Table A-1). Table A-1 includes both qualified data used in the analysis and nonqualified data used for corroboration. Columns A through D of Table A-1 include the borehole name, Nevada State Plane coordinate northing and easting (Nevada Central zone, U.S. feet, NAD 27), and the source of the location data. Columns E through H contain the Alluvial thickness (in feet and in meters), the source of the thickness data, and a remarks column that indicates the quality status of the data. The quality status refers to both the location and Alluvial Thickness DTNs unless otherwise indicated. The qualification / verification status does not apply to other RIS records referenced. The sections of the data with qualified and unqualified data are clearly marked.

The reader should note that in some cases, such as the entry for USW UZ-N36, on page A-4, the status of qualified and verified refers to the DTN file listed; not to the record. In these cases, the DTN file does not contain the data, but rather points to the record that does contain the data.

Table A-1. Boreholes and Surficial Deposit Depth Measurements

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA							
USW SD-7	758949.87	561240.26	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	MO0004QGFMPICK.000 [DIRS 152554][h]; TM0000000SD7RS.006 [DIRS 175918], ACC: DRC.19960220.0044	DTN: MO0004QGFMPICK.000 is Qualified-PVAR; DTN: TM0000000SD7RS.006 is qualified but not verified and shows that the unconsolidated material is pad fill. This data is not direct input. 50.2 ft of Pad Fill
USW UZ-N57	755164.51	560829.83	MO9906GPS98410.000 [DIRS 109059][a]	1.20	0.37	GS940208314211.008 [DIRS 145581][e]	Qualified and Verified
USW UZ-N58	755240.39	560862.22	MO9906GPS98410.000 [DIRS 109059][a]	22.10	6.74	GS940208314211.008 [DIRS 145581][e]	Qualified and Verified
USW UZ-N59	755321.24	560888.40	MO9906GPS98410.000 [DIRS 109059][a]	13.10	3.99	GS940208314211.008 [DIRS 145581][e]	Qualified and Verified
USW UZ-N61	755375.92	560893.95	MO9906GPS98410.000 [DIRS 109059][a]	9.80	2.99	GS940208314211.008 [DIRS 145581][e]	Qualified and Verified
UE-25 ONC#1	759257.27	568092.85	MO9906GPS98410.000 [DIRS 109059][a]	98.00	29.87	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified and Verified
USW UZ-N53	760096.24	564237.27	MO9906GPS98410.000 [DIRS 109059][a]	2.10	0.64	GS940208314211.003 [DIRS 152565][j]	Qualified and Verified
USW UZ-N54	760272.26	564262.66	MO0506GSC05047.000 [DIRS 175919][b]	19.00	5.79	GS940208314211.003 [DIRS 152565][j]	Qualified and Verified
USW UZ-N55	760503.25	564248.64	MO0506GSC05047.000 [DIRS 175919][b]	0.00	0.00	GS940208314211.003 [DIRS 152565][j]	Qualified and Verified
USW UZ-N35	762264.00	562309.92	MO9906GPS98410.000 [DIRS 109059][a]	11.90	3.60	GS940208314211.007 [DIRS 155533], ACC: NNA.19940414.0078	Qualified and Verified
USW SD-6	762421.40	558607.70	MO9912GSC99492.000 [DIRS 165922][c]	0.00	0.00	SNF40060298001.001 [DIRS 107372], Table S98430_001	Qualified and Verified
USW UZ-N32	764302.62	562799.60	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS940208314211.005 [DIRS 152563][g]	Qualified and Verified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA (Continued)							
UE-25 NRG#1	765358.60	569803.06	MO0002GSC00068.000 [DIRS 152562], */pub3/gis/baseline/test/mo0002gsc00068.zip*	6.10	1.86	SNF29041993002.034 [DIRS 175927], ACC: MOL.19950327.0062; GS931208314211.046 [DIRS 150012], ACC: NNA.19940608.0247	Qualified and Verified
USW UZ-N64	765728.12	559435.53	MO9906GPS98410.000 [DIRS 109059][a]	1.80	0.55	GS940308314211.016 [DIRS 146474], ACC: MOL.19941101.0065	Qualified and Verified
UE-25 NRG#2	765763.71	569162.45	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS931008314211.039 [DIRS 150009], ACC: NNA.19940105.0085	Qualified and Verified
UE-25 NRG#3	766250.60	568316.10	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS931008314211.037 [DIRS 150007], ACC: NNA.19940105.0083; SNF29041993002.038 [DIRS 175958], ACC: MOL.19950327.0079	Qualified and Verified
USW NRG-6	766726.28	564187.17	MO0506GSC05047.000 [DIRS 175919][b]	0.00	0.00	GS931008314211.045 [DIRS 150010], ACC: NNA.19940608.0248	Qualified and verified
UE-25 NRG#4	767080.21	566819.99	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	SNF29041993002.039 [DIRS 175959], ACC: MOL.19950327.0083	Qualified and Verified
USW UZ-N37	767498.87	563713.51	MO0506GSC05047.000 [DIRS 175919][b]	36.30	11.06	GS940208314211.005 [DIRS 152563][g]	Qualified and Verified
UE-25 NRG#5	767889.61	564769.87	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	SNF29041993002.040 [DIRS 175960], MOL.19950327.0087	Qualified and Verified
UE-25 UZN#63	768837.28	566169.64	MO9906GPS98410.000 [DIRS 109059][a]	8.60	2.62	GS940308314211.017 [DIRS 155534], ACC: MOL.19941101.0064	Qualified and Verified
USW NRG-7a	768880.11	562983.99	MO9906GPS98410.000 [DIRS 109059][a]	17.00	5.18	SNF29041993002.042 [DIRS 166437], Table S97096_001	Qualified and Verified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA (Continued)							
USW UZ-N33	770070.14	561192.18	MO9906GPS98410.000 [DIRS 109059][a]	13.10	3.99	GS940208314211.006 [DIRS 152555][k]	Qualified and Verified
USW UZ-N34	770158.78	561251.37	MO9906GPS98410.000 [DIRS 109059][a]	50.10	15.27	GS940208314211.006 [DIRS 152555][k]	Qualified and Verified
USW UZ-N27	771569.36	558871.76	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS940208314211.004 [DIRS 145579], ACC: NNA.19940414.0082	Qualified and Verified
USW UZ-N36	773900.21	563582.90	MO0506GSC05047.000 [DIRS 175919][b]	0.90	0.27	YMP 1992 [DIRS 175965], p. 1; GS940308314211.018 [DIRS 145589], ACC: MOL.19941101.0062	Qualified and Verified Qualification refers to the DTN, not to the record YMP 1992
USW WT-24	776703.06	562329.90	MO9905LUSWWT24.000 [DIRS 165921], */pub3/gis/baseline/test/mo9905luswwt24.zip* and *MO9905LUSWWT24.pdf*	0.00	0.00	SNF40060198001.001 [DIRS 107239], Table S98429_001	Qualified and Verified
USW UZ-N62	757125.18	558302.66	MO9906GPS98410.000 [DIRS 109059][a]	1.00	0.30	GS940208314211.002 [DIRS 145577], ACC: NNA.19940323.0352	Qualified and Verified
USW UZ-N31	764245.65	562751.92	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS941008314211.051 [DIRS 152557], ACC: MOL.19950505.0067 (partially superseded DTN); GS940208314211.005 [DIRS 152563][g]	Qualified and Verified, DTN: GS941008314211.051 is provided as corroboration for the assessment of zero thickness at this location.
UE-25 NRG#2b	765765.24	569214.54	MO9906GPS98410.000 [DIRS 109059][a]	2.20	0.67	GS931108314211.041 [DIRS 150011], ACC: NNA.19940217.0156 (partially superseded DTN)	Qualified and Verified
USW SD-9	767998.49	561818.02	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	SNT02052794001.003 [DIRS 105187], Table S98290_001	Qualified and Verified 52.5 ft of Pad Fill (Some May Be Alluvium)
USW UZ-7a	760692.76	562269.84	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	TM000000UZ7ARS.001 [DIRS 160826], ACC: DRC.19961014.0067	Qualified and Verified 12 ft of Pad Fill

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA (Continued)							
UE-25 UZ#16	760535.13	564857.49	MO9906GPS98410.000 [DIRS 109059][a]	33.70	10.27	YMP 1992 [DIRS 175923], p. 1-2; GS931208314211.047 [DIRS 110313], ACC: NNA.19940411.0054 (partially superseded DTN)	Qualified and Verified 6.0 ft of Pad Fill. Qualification refers to the DTN, not to the record YMP 1992
UE-25 NRG#2a	765699.94	569001.08	MO9906GPS98410.000 [DIRS 109059][a]	6.80	2.07	SNF29041993002.036 [DIRS 175928], ACC: MOL.19950327.0071	Qualified and Verified First 80.6 ft of Cuttings Not Cored
USW UZ-N38	767466.34	563343.87	MO9906GPS98410.000 [DIRS 109059][a]	17.90	5.46	DTN: GS940308314211.011 [DIRS 145588], ACC: MOL.19941101.0063	Qualified and Verified Shown as No Core Recovery, May Not Be Accurate
NC-EWDP-18P	728530.50	564519.85	MO0203GSC02034.000 [DIRS 168375], */pub3/gis/baseline/test/ncewdp31.zip*	45.00	13.72	MO0210SMFGLOG3.000 [DIRS 175917], Table S02293_001	Qualified—PVAR
UE-25 RF#22	766206.20	570793.48	MO0103GSC01031.000 [DIRS 157304][d]	80.00	24.38	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR
UE-25 UZ#4	768715.71	566140.11	MO9906GPS98410.000 [DIRS 109059][a]	39.00	11.89	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW UZ-14	771309.80	560141.57	MO9906GPS98410.000 [DIRS 109059][a]	39.70	12.10	YMP 1995 [DIRS 172113]; MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW UZ-N15	778090.36	559551.85	MO0506GSC05047.000 [DIRS 175919][b]	2.30	0.70	YMP 1992 [DIRS 175967], p. 1; MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR Qualification refers to the DTN, not the record YMP 1992
USW UZ-N16	778150.65	559626.15	MO0506GSC05047.000 [DIRS 175919][b]	4.20	1.28	YMP 1992 [DIRS 176008], ACC: MOL.19980304.0467; MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR Qualification refers to the DTN, not the record YMP 1992
USW UZ-N17	778224.12	559995.10	MO9906GPS98410.000 [DIRS 109059][a]	2.50	0.76	YMP 1992 [DIRS 176010], ACC: MOL.19980304.0469; MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR Qualification refers to the DTN, not the record YMP 1992

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA (Continued)							
USW UZ-N11	780573.74	559020.91	MO0506GSC05047.000 [DIRS 175919][b]	1.70	0.52	Gertz 1992 [DIRS 175968]; MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR Qualification refers to the DTN, not the record Gertz 1992
UE-25 RF#18	764522.34	570626.93	MO0103GSC01031.000 [DIRS 157304][d]	60.00	18.29	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR
UE-25 RF#14	765308.73	571065.44	MO0103GSC01031.000 [DIRS 157304][d]	101.80	31.03	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR
UE-25 RF#19	765880.41	571383.73	MO0103GSC01031.000 [DIRS 157304][d]	120.00	36.58	GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR
UE-25 RF#29	766018.46	570836.04	MO0103GSC01031.000 [DIRS 157304][d]	85.00	25.91	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR
UE-25 RF#17	766075.86	571041.88	MO0103GSC01031.000 [DIRS 157304][d]	92.40	28.16	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR
USW G-1	770500.20	561000.50	MO0106STRATHFM.030 [DIRS 155591][q]	60.00	18.29	MO0106STRATHFM.030 [DIRS 155591][q]	Qualified—PVAR
USW G-2	778822.20	560502.00	MO0106STRATHFM.031 [DIRS 155592][l]	0.00	0.00	MO0106STRATHFM.031 [DIRS 155592][l]	Qualified—PVAR
USW G-3	752780.00	558483.00	MO0106STRATHFM.004 [DIRS 155539][m]	0.00	0.00	MO0106STRATHFM.004 [DIRS 155539][m]	Qualified—PVAR
USW H-1	770254.00	562388.00	MO0106STRATHFM.028 [DIRS 155589][n]	0.00	0.00	MO0106STRATHFM.028 [DIRS 155589][n]	Qualified—PVAR
UE-25 p#1	756171.20	571484.52	MO0106STRATHFM.029 [DIRS 155590][o]	128.00	39.01	MO0106STRATHFM.029 [DIRS 155590][o]	Qualified—PVAR
USW G-4	765807.51	563081.78	MO9906GPS98410.000 [DIRS 109059][a]	30.00	9.14	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 J#13	749201.99	579647.91	MO9906GPS98410.000 [DIRS 109059][a]	435.00	132.59	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA (Continued)							
USW a#1	764900.99	566349.89	MO9906GPS98410.000 [DIRS 109059][a]	30.00	9.14	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 a#4	767972.39	564471.85	MO9906GPS98410.000 [DIRS 109059][a]	30.00	9.14	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 a#5	766956.42	564755.20	MO9906GPS98410.000 [DIRS 109059][a]	90.00	27.43	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 a#6	765899.90	564500.89	MO9906GPS98410.000 [DIRS 109059][a]	20.00	6.10	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 a#7	766250.03	565468.31	MO9906GPS98410.000 [DIRS 109059][a]	165.00	50.29	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 b#1	765244.31	566416.20	MO9906GPS98410.000 [DIRS 109059][a]	156.00	47.55	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 c#1	757096.78	569680.57	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 c#2	756849.64	569633.94	MO9906GPS98410.000 [DIRS 109059][a]	69.90	21.31	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 c#3	756910.88	569554.93	MO9906GPS98410.000 [DIRS 109059][a]	80.10	24.41	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW H-3	756542.01	558451.90	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW H-4	761644.48	563911.40	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW H-5	766634.12	558908.41	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW H-6	763299.43	554074.96	MO9906GPS98410.000 [DIRS 109059][a]	29.90	9.11	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW UZ-1	771277.35	560221.57	MO9906GPS98410.000 [DIRS 109059][a]	40.00	12.19	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW UZ-6	759730.18	558324.98	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 UZ#5	768593.15	566136.13	MO9906GPS98410.000 [DIRS 109059][a]	3.00	0.91	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW WT-1	753942.15	563739.20	MO9906GPS98410.000 [DIRS 109059][a]	30.00	9.14	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA (Continued)							
USW WT-2	760661.55	561924.01	MO9906GPS98410.000 [DIRS 109059][a]	60.00	18.29	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#3	745995.54	573385.20	MO9906GPS98410.000 [DIRS 109059][a]	11.00	3.35	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#4	768511.94	568038.29	MO9906GPS98410.000 [DIRS 109059][a]	51.00	15.54	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#6	780576.15	564523.62	MO9906GPS98410.000 [DIRS 109059][a]	170.00	51.82	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW WT-7	755570.55	553891.65	MO9906GPS98410.000 [DIRS 109059][a]	40.00	12.19	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW WT-10	748771.58	553302.33	MO9906GPS98410.000 [DIRS 109059][a]	60.00	18.29	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
USW WT-11	739071.30	558376.70	MO9906GPS98410.000 [DIRS 109059][a]	40.00	12.19	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#12	739726.71	567011.79	MO9906GPS98410.000 [DIRS 109059][a]	60.00	18.29	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#13	756885.20	578842.27	MO9906GPS98410.000 [DIRS 109059][a]	220.00	67.06	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#14	761651.39	575210.21	MO9906GPS98410.000 [DIRS 109059][a]	107.00	32.61	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#15	766116.98	579806.27	MO9906GPS98410.000 [DIRS 109059][a]	210.00	64.01	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#16	774420.20	570395.13	MO9906GPS98410.000 [DIRS 109059][a]	137.00	41.76	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#17	748421.52	566212.01	MO9906GPS98410.000 [DIRS 109059][a]	30.00	9.14	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 WT#18	771167.22	564854.65	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	MO0004QGFMPICK.000 [DIRS 152554][h]	Qualified—PVAR
UE-25 RF#25	765968.15	570626.38	MO0103GSC01031.000 [DIRS 157304][d]	60.00	18.29	GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 10 ft of Pad Fill
UE-25 RF#23	765311.43	570465.03	MO0103GSC01031.000 [DIRS 157304][d]	64.00	19.51	GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 12 ft of Pad Fill

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
QUALIFIED DATA (Continued)							
UE-25 RF#13	765500.04	570720.12	MO9902ASBUBOLC.000 [DIRS 103793], */pub3/gis/baseline/test/mo9902asbubolc.zip*	85.50	26.06	GS030783114233.001 [DIRS 164561][i]; MO9903BLOGSOIL.000 [DIRS 103790], Table S99142_001	Qualified—PVAR 12.5 ft of Pad Fill
UE-25 RF#26	765247.95	570579.71	MO0103GSC01031.000 [DIRS 157304][d]	71.00	21.64	GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 14 ft of Pad Fill
UE-25 RF#16	765055.54	570472.65	MO0103GSC01031.000 [DIRS 157304][d]	53.30	16.25	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 22.4 ft of Pad Fill
UE-25 RF#20	765637.36	570796.82	MO0103GSC01031.000 [DIRS 157304][d]	70.00	21.34	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 28 ft of Pad Fill
UE-25 RF#28	765510.21	570104.87	MO0103GSC01031.000 [DIRS 157304][d]	10.00	3.05	MO0101SEPBGLOG.000 [DIRS 157481][p], GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 5 ft of Pad Fill
UE-25 RF#21	765898.91	570739.18	MO0103GSC01031.000 [DIRS 157304][d]	110.00	33.53	GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 5 ft of Pad Fill
UE-25 RF#15	765773.64	570224.85	MO0103GSC01031.000 [DIRS 157304][d]	0.00	0.00	GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 5 ft of Pad Fill
UE-25 RF#24	766344.31	570542.26	MO0103GSC01031.000 [DIRS 157304][d]	20.00	6.10	MO0101SEPBGLOG.000 [DIRS 157481][p]; GS030783114233.001 [DIRS 164561][i]	Qualified—PVAR 10 ft of Pad Fill
UNQUALIFIED DATA							
USW SD-12	761956.56	561605.61	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	TM000000SD12RS.014 [DIRS 175924], ACC: DRC.19960926.0174; GS000308314211.002 [DIRS 158000], Table S00274_001	Location is Qualified and Verified; Soil Depth in DIRS 175924 is Qualified and Not Verified; Soil Depth in DIRS 158000 is not qualified. 12.9 ft of Pad Fill

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
UNQUALIFIED DATA (Continued)							
USW NRG-7	768846.23	563004.86	YMP 1993 [DIRS 175962], p. 22C - Proposed Location NRG-7	0.00	0.00	YMP 1993 [DIRS 175963], p. 1	Unqualified
UE-25 NRG#2c	765771.68	569189.78	MO9906GPS98410.000 [DIRS 109059][a]	Not Determined	—	YMP 1994 [DIRS 175930], ACC: MOL.19940719.0031	Location is Qualified and Verified; Soil Depth is Unqualified - Alluvial Section Not Logged
UE-25 NRG#2d	765825.10	569132.29	MO9906GPS98410.000 [DIRS 109059][a]	Not Determined	—	—	Location is Qualified and Verified; Soil Depth is Unqualified – Log Not Available for Alluvial Section
UE-25 J#12	733508.28	581012.07	MO9906GPS98410.000 [DIRS 109059][a]	515.00	156.97	Dixon 1992 [DIRS 175970], ACC: MOL.19980218.0561, p. 24	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 JF#3	730875.40	581179.42	MO9906GPS98410.000 [DIRS 109059] [a]	487.00	148.44	TM0000000000CL.005 [DIRS 175971], ACC: MOL.20011018.0232	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N40	766176.22	564221.41	MO9906GPS98410.000 [DIRS 109059][a]	2.89	0.88	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N41	765867.75	563521.07	MO9906GPS98410.000 [DIRS 109059][a]	16.01	4.88	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N42	765729.13	562858.62	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N43	765997.47	563263.61	MO9906GPS98410.000 [DIRS 109059][a]	27.00	8.23	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N44	766193.00	563139.53	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N45	765977.24	563429.26	MO9906GPS98410.000 [DIRS 109059][a]	35.01	10.67	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
UNQUALIFIED DATA (Continued)							
USW UZ-N46	772262.19	559747.93	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N47	771967.54	559783.74	MO9906GPS98410.000 [DIRS 109059][a]	33.01	10.06	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N48	760835.94	562413.82	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N49	760861.42	562322.06	MO9906GPS98410.000 [DIRS 109059][a]	2.00	0.61	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N50	760776.92	562911.92	MO9906GPS98410.000 [DIRS 109059][a]	8.99	2.74	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N51	760861.75	562909.56	MO9906GPS98410.000 [DIRS 109059][a]	14.01	4.27	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N52	760894.93	562908.95	MO9906GPS98410.000 [DIRS 109059][a]	6.99	2.13	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N65	758627.34	562537.63	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N66	758433.89	561881.67	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N67	753635.58	563799.22	MO9906GPS98410.000 [DIRS 109059][a]	19.00	5.79	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N68	753963.71	564006.12	MO9906GPS98410.000 [DIRS 109059][a]	50.00	15.24	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N69	754462.47	564401.98	MO9906GPS98410.000 [DIRS 109059][a]	27.00	8.23	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
UNQUALIFIED DATA (Continued)							
USW UZ-N70	769250.78	560165.01	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N71	761025.67	558405.94	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N72	761071.61	558645.91	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N73	761052.93	558945.57	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N74	761361.94	558560.11	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N75	761462.24	559076.00	MO9906GPS98410.000 [DIRS 109059][a]	2.00	0.61	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N76	761356.90	559067.41	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N77	755526.90	554397.31	MO9906GPS98410.000 [DIRS 109059][a]	37.99	11.58	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N78	757558.45	556262.68	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N79	757733.70	556334.15	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N80	757635.00	557201.37	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N81	757807.56	555595.39	MO9906GPS98410.000 [DIRS 109059][a]	6.00	1.83	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
UNQUALIFIED DATA (Continued)							
USW UZ-N82	757498.76	554689.93	MO9906GPS98410.000 [DIRS 109059][a]	21.98	6.70	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N83	760624.95	556349.23	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N84	760717.05	555888.00	MO9906GPS98410.000 [DIRS 109059][a]	19.98	6.09	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N86	760615.37	556460.50	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N87	760714.24	555887.25	MO9906GPS98410.000 [DIRS 109059][a]	19.00	5.79	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N88	760797.96	556551.25	MO9906GPS98410.000 [DIRS 109059][a]	0.75	0.23	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N89	760611.22	555588.72	MO9906GPS98410.000 [DIRS 109059][a]	33.01	10.06	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N90	760609.25	555587.46	MO9906GPS98410.000 [DIRS 109059][a]	32.51	9.91	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N93	759584.09	558321.03	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N94	759723.29	558236.66	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N95	759898.73	558172.62	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N96	759445.54	558403.36	MO9906GPS98410.000 [DIRS 109059][a]	2.00	0.61	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
UNQUALIFIED DATA (Continued)							
USW UZ-N98	767996.47	562083.75	MO9906GPS98410.000 [DIRS 109059][a]	0.98	0.30	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N24	768005.60	562054.42	MO9906GPS98410.000 [DIRS 109059][a]	0.49	0.15	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N25	768430.44	561219.10	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
USW UZ-N26	768757.35	561023.24	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#1	769329.75	565224.45	MO9906GPS98410.000 [DIRS 109059][a]	27.30	8.32	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#2	768606.38	566113.70	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#3	768631.42	566119.42	MO9906GPS98410.000 [DIRS 109059][a]	8.99	2.74	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#4	768664.37	566127.14	MO9906GPS98410.000 [DIRS 109059][a]	24.51	7.47	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#5	768690.17	566134.21	MO9906GPS98410.000 [DIRS 109059][a]	44.49	13.56	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#6	768706.49	566136.79	MO9906GPS98410.000 [DIRS 109059][a]	39.50	12.04	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#7	768724.95	566141.35	MO9906GPS98410.000 [DIRS 109059][a]	40.49	12.34	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#8	768743.84	566146.64	MO9906GPS98410.000 [DIRS 109059][a]	39.99	12.19	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
UNQUALIFIED DATA (Continued)							
UE-25 UZN#9	768782.36	566156.06	MO9906GPS98410.000 [DIRS 109059][a]	35.01	10.67	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#10	769869.29	564744.59	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#12	768651.53	566695.21	MO9906GPS98410.000 [DIRS 109059][a]	45.01	13.72	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#13	768025.46	568255.20	MO9906GPS98410.000 [DIRS 109059][a]	44.00	13.41	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#14	767968.00	568233.04	MO9906GPS98410.000 [DIRS 109059][a]	44.00	13.41	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#18	766472.79	565246.63	MO9906GPS98410.000 [DIRS 109059][a]	56.00	17.07	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#19	763689.57	564570.82	MO9906GPS98410.000 [DIRS 109059][a]	22.51	6.86	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#20	763760.60	564579.42	MO9906GPS98410.000 [DIRS 109059][a]	39.01	11.89	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#21	763806.82	564591.36	MO9906GPS98410.000 [DIRS 109059][a]	27.49	8.38	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#22	763881.05	564604.88	MO9906GPS98410.000 [DIRS 109059][a]	19.49	5.94	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#23	763973.76	564545.69	MO9906GPS98410.000 [DIRS 109059][a]	0.00	0.00	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#29	762613.84	565173.32	MO9906GPS98410.000 [DIRS 109059][a]	0.98	0.30	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified

Table A-1. Boreholes and Surficial Deposit Depth Measurements (Continued)

Borehole Name	State Plane Coordinate Northing	State Plane Coordinate Easting	Location Source by Author and Date, or DTN, or Both	Alluvial Thickness (ft)	Alluvial Thickness (m)	Thickness Source by Author and Date, or DTN, or Both	Remarks
UNQUALIFIED DATA (Continued)							
UE-25 UZN#30	762048.20	565232.87	MO9906GPS98410.000 [DIRS 109059][a]	1.25	0.38	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#56	760394.69	565480.10	MO9906GPS98410.000 [DIRS 109059][a]	56.00	17.07	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#60	759757.95	566567.14	MO9906GPS98410.000 [DIRS 109059][a]	26.51	8.08	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-25 UZN#97	763094.58	565320.64	MO9906GPS98410.000 [DIRS 109059][a]	58.01	17.68	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-29 UZN#91	797275.80	585341.38	MO9906GPS98410.000 [DIRS 109059][a]	64.01	19.51	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified
UE-29 UZN#92	778010.13	583558.97	MO9906GPS98410.000 [DIRS 109059][a]	58.01	17.68	GS910808312212.001 [DIRS 175972][f]	Location is Qualified and Verified; Soil Depth is Unqualified

Source: Appendix B, Section B.1.4.

[a] */pub3/gis/baseline/test/g98410.zip*
[b] */pub3/gis/baseline/test/g05047.zip* and *Cr-4902-sbh.xls*
[c] */pub3/gis/baseline/test/mo9912gsc99492.zip*
[d] */pub3/gis/baseline/test/mo0103gsc01031.zip*
[e] ACC: NNA.19940323.0344
[f] Table S96401_001
[g] ACC: NNA.19940323.0348; partially superseded DTN
[h] Table S00214_001
[I] Tables S03299_001 through S03299_016
[j] ACC: NNA.19940323.0355 data; partially superseded DTN
[k] ACC: NNA.19940414.0074; partially superseded DTN
[l] ACC: NNA.19870506.0143
[m] ACC: NNA.19890804.0017
[n] ACC: NNA.19870519.0103
[o] ACC: HQS.19880517.2633
[p] ACCs: MOL.20010125.0206, MOL.20010125.0212, MOL.20010125.0194, MOL.20010125.0188, MOL.20010125.0182, MOL.20010125.0221, MOL.20010125.0200, MOL.20010125.0224, MOL.20010125.0191
[q] ACC: NNA.19870406.0222.

DTN = data tracking number; PVAR = Process Validation and Reengineering; SMF = Sample Management Facility.

APPENDIX B

ELECTRONIC SPREADSHEETS AND WORKBOOK–WORKSHEETS FOR CALCULATIONS PRESENTED IN THE ANALYSIS

B.1 SUPPORTING INFORMATION FOR ELECTRONIC SPREADSHEETS AND WORKBOOK–WORKSHEETS FOR CALCULATIONS PRESENTED IN THE ANALYSIS

Included with this appendix is a compact disc with copies of Excel® spreadsheets and workbooks with worksheets used to create the tables, charts, and values presented in this analysis in their native format. The provision of this information responds to the requirements of LP-SIII.9Q-BSC, Attachment 2, regarding the use of standard functions in exempted software, Excel®, used for this analysis. Several spreadsheets and worksheets were used to carry out operations in Excel®. The following text provides a roadmap and explanation to allow the user to locate the proper spreadsheet or worksheet, and to interpret the material contained in the spreadsheet or worksheet for a particular table, figure, or text. The user can determine the standard function used to calculate a particular value in a cell on a spreadsheet or worksheet by selecting the cell and finding the function on the formula bar. The software ARCINFO was also used to support the comparison of historic and revised map files.

B.1.1 Files for Section 6.1.2 – Comparison of *SOILMAP6.INP* to the Digital Soil Map

A comparison was made (DTN: MO0512SPASURFD.000 [DIRS 175870]) between the version of the soil map in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6) and the digital version of the original source map (DTN: MO9903COV96274.000 [DIRS 176571], */publ3/gis/baseline/geol/soils.e00*). The comparison was performed using the ARCINFO IDENTITY command. The summary statistics for that comparison are given in *Guertal Test.xls*.

B.1.2 Files for Section 6.1.2 – Check of Soil Depth Code Equation Calculation

A check was performed of how well the equations, given to calculate depth from topographic slope, were implemented in *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6). *Depth eq. test.xls* documents the check performed using a single spreadsheet or worksheet containing the Excel® maximum of 65,536 rows. Columns A through K were copied from the first 65,536 rows in *SOILMAP6.INP* and pasted into *Depth eq. test.xls*. The spreadsheet was then sorted on slope angle (column F) and soil depth code (column J) to produce the version of the file displayed in the spreadsheet. The calculated soil depth was then calculated independently in column L using the equations shown in Section 6.1.2. Column M represents the difference between the file value (column K) and the independently calculated value (column L). Column M values were then summed to test for any non-zero differences (cell Q12). The result identifies some differences, those being a series of 0.01 values that result from rounding to two decimal places in the calculation. Row 11,232 provides an example of the rounding issue.

B.1.3 Files for Table 6-3, Figures 6-4 and 6-5, and Associated Text in Section 6.1.2

Table 6-3 and Figures 6-4 and 6-5 compare the soil depth equations to a set of corroborating data (DTN: GS011208312212.004 [DIRS 176317], Table S02086_001) that provide field measurements of the topographic slope and associated soil depth. These items were compiled in *Taylor soil depth-Rev 01.xls* using several worksheets. The original data (DTN: GS011208312212.004 [DIRS 176317], Table S02086_001) are shown in worksheet

'Original Data'. *Taylor soil depth-Rev 01.xls* also includes location information from the scientific notebook associated with DTN: GS011208312212.004 [DIRS 176317], Table S02086_001. The values shown in Table 6-3 and on Figures 6-4 and 6-5, and in text, were derived in worksheet 'Final calc'. Values representing Soil Depth Code 1 were selected and copied from worksheet 'Original Data' and appear in columns A through I. These values were sorted on the slope magnitude value (column F). Values calculated from the field slope measurements using the equations from Section 6.1.2 are given in column J. The difference between the calculated and measured soil depths is given in column K. The correlation coefficient between the predicted depth from the equations and the measured depths is given in cells Q31 and Q65 for the two ranges of slope angles. The correlation coefficient for the range between 10 and 40 degrees with outliers removed is calculated in cell AD80.

B.1.4 Files for Table A-1

Information presented in Table A-1 were compiled in worksheet 'BH compile' located in *Final calcs. for report-Rev 01.xls*. Sources that were reviewed in compiling data for Table A-1 are shown in 'BH compile', while Table A-1 lists values and the sources of those values. Thus, some additional records may appear in 'BH compile' as sources. Data were copied from 'BH compile' for use in other worksheets in preparing other tables.

B.1.5 Files for Table 6-4 and Figure 6-10

Information presented in Table 6-4 were compiled in *Final calcs. for report-Rev 01.xls* using several worksheets. Borehole location data (DTN: MO0512SPASURFD.000 [DIRS 175870]) were taken from worksheet 'BH compile' and from *SOILMAP6.INP* (USGS 2000 [DIRS 175858], folder Soilmap6), then ARCINFO was used to determine the calculated soil thickness and soil depth code for the grid cell in which each borehole is located. The results are shown on worksheet 'Code assign' in columns E and F. Relevant data were then copied to worksheet 'Soilmap BH diff' as columns A through D and sorted by the *SOILMAP6.INP* soil depth code. The difference between the measured borehole soil depth and the *SOILMAP6.INP* calculated depth was then calculated in column F of 'Soilmap BH diff'. The column F values are shown as an absolute difference in column E. Averages for the absolute differences are calculated for the depth codes in column H. Differences were not calculated for Soil Depth Code 4, where the borehole depth exceeded 6 m, because the result would not be meaningful; soil depth code uses a constant value of 6 m and, as long as the borehole value exceeded the constant, the difference between the two measures provides no information on the accuracy of the *SOILMAP6.INP* prediction. Relevant columns were copied to columns M through O of 'Soilmap BH diff' to create Figure 6-10.

B.1.6 Files for Tables 6-7, 6-8, and 6-9, and Figures 6-15, 6-17, and 6-19

Information presented in Tables 6-7 to 6-9, and in Figures 6-15, 6-17, and 6-19, were compiled in *Final calcs. for report-Rev 01.xls* using several worksheets. Borehole location data were taken from worksheet 'BH compile' and from output DTN: MO0608SPASDFIM.006 for soil depth classes (Figure 6-12), then ARCINFO was used to determine the soil depth class for the grid cell in which each borehole is located. The results are shown on worksheet 'Code assign' in column I and on worksheet 'Borehole depth class' in column J. The data in 'Borehole depth class' were then transferred to worksheet 'Sorted Boreholes' and sorted by soil depth class. The appropriate segment of data for each depth class was then copied and transferred to worksheets 'Class 3', 'Class 2', and 'Class 1' in columns A through F. In 'Class 3' the modified depths, natural logarithm values, mean, and standard deviation appear in columns S and Z through AA, respectively. The sample median, which is also the estimated population median (Gilbert 1987 [DIRS 163705], p. 171), is calculated in cell AC2 using the standard Excel® function. For the mean and the standard deviation calculations, five additional values were added from the field measurements, which are shown in cells S12 through S16 of 'Class 3' in *Final calcs. for report-Rev 01.xls*; these values are from worksheets 'Original Data' and 'Class 3' of *Taylor soil depth-Rev 01.xls.* The calculation for the histograms on Figure 6-15 is shown in 'Class 3' of *Final calcs. for report-Rev 01.xls,* in columns I through P for the linear version of the histogram and in columns AE through AI for the log transformed version of the histogram.

Worksheet 'Class 2' of *Final calcs. for report-Rev 01.xls* does not use a lognormal distribution and, therefore, does not display columns related to this calculation. Two different calculations of the sample statistics are presented, one set with the lower bound truncation value at 0.00 m and another with the truncation value at 0.5 m. The sample mean, sample standard deviation, and sample median, are calculated in cells S2, T2, and U2 for a lower bound of 0.5 m and in cells R14, S14, and T14 for a lower bound of 0.0 m. The standard error is calculated in cell U6. The sample median, which is also the estimated population median (Gilbert 1987 [DIRS 163705], p. 171), is calculated in cell U2 using the standard Excel® function. The calculation for the histogram appears in columns J through P.

Worksheet 'Class 1' of *Final calcs. for report-Rev 01.xls* shows the only calculation for the histogram, being that a uniform distribution was used and no other calculations were necessary.

B.1.7 Files for Figure 6-11

Information presented in Figure 6-11 were compiled in *Final calcs. for report-Rev 01.xls*. Borehole location data were taken from worksheet 'BH compile' and from output DTN: MO0608SPASDFIM.006 for soil depth classes (Figure 6-12), then ARCINFO was used to determine the soil depth class for the grid cell in which each borehole is located. The results are shown on worksheet 'Code assign' in column I and on worksheet 'Borehole depth class' in column J. The data in 'Borehole depth class' were transferred to worksheet 'Sorted Boreholes' and were subsequently sorted by soil depth class. The borehole data from Midway Valley were then copied to worksheet 'Midway Valley depth'. The distance east of the UE-25 NRG#1 borehole was calculated by subtracting the State Plane easting coordinate for UE-25 NRG#1 from the easting coordinates for the boreholes on the list in column G. This result was converted from feet to meters in column H.

B.1.8 Files for Section 6.2.1 – W Test for DTN: GS011208312212.004, Calculation for Mean and Standard Deviation for Class 4, Table 6-6, and Figures 6-13 and 6-14

Section 6.2.1 discusses a W test for a field measurement data set that provides soil depth (DTN: GS011208312212.004 [DIRS 176317], Table S02086_001). Data used to conduct the test are from *Taylor soil depth-Rev 01.xls*. The original data, copied from DTN: GS011208312212.004 [DIRS 176317], Table S02086_001, are shown on worksheet

'Original Data'. This worksheet includes location information from the scientific notebook associated with the DTN. The depths interpreted as belonging to Soil Class 4 were copied to column A of worksheet 'Wtest' and then sorted. The natural logarithm value for the depths was calculated in column B. The actual W test for the lognormal hypothesis is carried out in columns W through Z. The equation for calculating the "W" value was implemented as a series of steps using basic Excel® functions in cells Y38 through Y45. A parallel W test for the normal hypothesis is shown in columns AC through AE. The lognormal mean and standard deviation for this data set are also calculated for the distribution for Soil Depth Class 4 (Section 6.2.1). These values are calculated in cells G21 and G22. The sample median, which is also the estimated population median (Gilbert 1987 [DIRS 163705], p. 171), is calculated in cell J21 using the standard Excel® function. The arithmetic mean, standard deviation, and standard error are calculated in cells E21 to E23.

The data shown on Table 6-6 are from the listing in columns A and B of worksheet 'Wtest'. This listing was extracted from the original data copied from DTN: GS011208312212.004 [DIRS 176317], Table S02086_001 in worksheet 'Original Data'. Measurements with a "Deposit Unit" designation of "Tpc" or "stone st" were interpreted as belonging to Soil Depth Class 4 (Section 6.2.1). Figure 6-13 was generated on 'Wtest' from the data in columns A and B and from the histogram data in cells F3 to F18, G3 to G18, I3 to I15, and J3 to J15, which were generated using the HISTOGRAM function from the Excel® Data Analysis menu. Figure 6-14 was generated from the calculations shown in columns AI through AN on 'Wtest'.

B.1.9 Files for Section 6.2.1 – W Test for Boreholes in Class 4 and Figure 6-15

The W test for the Soil Depth Class 4 borehole data is documented in *Final calcs. for report-Rev 01.xls*. The modified depth values related to Soil Depth Class 4 were extracted from worksheet 'Class 4' (Section B.1.6), pasted into column A of worksheet 'W-test C4', and then sorted. The natural logarithm value for the depth was calculated in column B and the square of the natural logarithm value was calculated in column C. The equation for calculating the W value is implemented as a series of steps using basic Excel® functions in cells B25 through B35. A parallel W test for the normal hypothesis is shown in columns D through F. A second parallel W test for the normal hypothesis using unmodified data is shown in columns H through J. The values for the probability plot shown in Figure 6-15 are calculated in columns N through S.

B.1.10 Files for Section 6.2.1 – W Test for Class 3 and Figure 6-16

The W test for the Soil Depth Class 3 data is documented in *Final calcs. for report-Rev 01.xls*. The modified depth values for the boreholes related to Soil Depth Class 3 and the field measurements were extracted from worksheet 'Class 3' (Section B.1.6), pasted into column S of worksheet 'W-test C3', and then sorted. The natural logarithm value for the depth was calculated in column T and the square of the natural logarithm value was calculated in column U. The equation for calculating the W value is implemented as a series of steps using basic Excel® functions in cells T20 to T33. A parallel W test for the normal hypothesis is shown in columns W to X. The probability plot illustrated in Figure 6-16 is calculated in columns AB through AG.

B.1.11 Files for Section 6.2.1 – D'Agostino's Test for Class 2 and Figure 6-18

D'Agostino's Test for the Soil Depth Class 2 data is documented in *Final calcs. for report-Rev 01.xls*. The modified depth values related to Soil Depth Class 2 were extracted from worksheet 'Class 2' (Section B.1.6), pasted into column A of worksheet 'DAg test', and then sorted. Parameters related to the test are calculated in columns B through F. The equation for calculating the Y value of the test is implemented as a series of steps using basic Excel® functions in cells D68 to D70, F71 to F73, and B74 to B75. The values for significance levels used to compare with the Y value are given in cells B76 to B77 and C76 to C77. The calculation of the values shown on the probability plot shown in Figure 6-18 is given in columns K, L, M, P, and Q. Columns N, O, R, and S relate to a probability plot (not shown) to test the effect of the truncation at zero on the test results. Column T relates to a probability plot (not shown) for the normal logarithm hypothesis.

B.1.12 Files for Section 6.2.2 and Table 6-10 – Confidence Intervals

The confidence intervals for the Soil Depth Class 4 mean are calculated on worksheet 'Wtest' in *Taylor soil depth-Rev 01.xls*. The sample mean and the sample standard deviation are given in cells G21 and G22. The estimated population mean, calculated as the sample mean plus one-half the sample variance, is calculated in cells G25 and G26. Two methods were considered for calculating the estimated population mean (Gilbert 1987 [DIRS 163705]). This analysis uses the "Less Efficient But Simpler Estimator" (Gilbert 1987 [DIRS 163705], Equation 13.7) rather than an alternative method (Gilbert 1987 [DIRS 163705], Equation 13.13), because the approach does not require interpolating a ψ value from a table and the equations for the confidence limits have the estimated population mean from Equation 13.7 embedded in them.

A comparison of the results between the two approaches is shown in cells F56, E56, and G26 on worksheet 'Wtest' in *Taylor soil depth-Rev 01.xls*. The comparison indicates that the difference between the two approaches is less than 1%. A second comparison between the two equations for the Soil Depth Class 3 estimated population mean is shown on worksheet 'Class 3' of *Final calcs. for report-Rev 01.xls* in cells W29 to W31 and W5. This comparison shows a somewhat larger difference of 5.6%. The upper and lower confidence limits for Soil Class 4 are calculated using equations and tables (Gilbert 1987 [DIRS 163705], Equations 13.13 and 13.14; Tables A10 to A13) in cells G33 through G49 on 'Wtest'. The "H" values used in the calculation were taken from the tables using the n and s_y values closest to the sample value, meaning that no interpolation was performed. Interpolation was not performed because the differences between adjacent values on the source tables are small and do not significantly affect the calculation.

The confidence intervals for the Soil Depth Class 3 mean are calculated in similar fashion on worksheet 'Class 3' in *Final calcs. for report-Rev 01.xls*. The sample mean and the sample standard deviation are given in cells Z2 and AA2. The estimated population mean is calculated in cells W4 and W5. The upper and lower confidence limits are calculated in cells W10 through W24. The confidence intervals for the Soil Depth Class 2 mean are calculated using the Student's *t*-distribution on worksheet 'Class 2' in *Final calcs. for report-Rev 01.xls*. The sample mean and the sample standard deviation are given in cells S2 and T2. The upper and lower confidence limits are calculated in cells R5 to R12, S10 to S12, and T10 to T12. The estimated population mean for Soil Depth Class 1 is calculated as 0.5(40 + 150). Confidence limits are not provided for this class because they are not meaningful for this case. The confidence intervals for the Soil Depth Class 4 median are calculated on worksheet 'Wtest' in *Taylor soil depth-Rev 01.xls* using equation 13.20 by Gilbert (1987 [DIRS 163705]). The equation is implemented as a series of Excel® calculations in cells G53 to G66, H53 to H66, and I53 to I64. The confidence intervals for the Soil Depth Class 3 median are calculated in similar fashion on worksheet 'Class 3' in *Final calcs. for report-Rev 01.xls*. The equation is implemented as a series of Excel® calculations in cells AA3 to AA15, AB3 to AB15, and AC3 to AC13.

B.1.13 Files for Figure 7-1

Figure 7-1 was generated on worksheet 'Figure 7-1' in *Section 7 comparison.xls*. Values appearing in *Depth eq. test.xls* (Section B.1.2) for Soil Depth Code 1 were copied and pasted into *Section 7 comparison.xls*. These data were then plotted using the HISTOGRAM function from the Excel® Data Analysis menu in cells D52 through D67 and E52 through E67. The mean for these data are calculated in cell E22. Values for the sample mean and the sample standard deviation for Soil Depth Class 4 (Table 6-10) were then used to create a hypothetical distribution for the same number of values. This distribution is calculated in cells D32 though I44.

B.2 COMPACT DISC FOR ELECTRONIC SPREADSHEETS AND WORKBOOK–WORKSHEETS FOR CALCULATIONS PRESENTED IN THE ANALYSIS

The compact disc that accompanies this analysis contains the following files as part of Appendix B:

- *Depth eq. test.xls*
- *Final calcs. for report-Rev 01.xls*
- *Guertal Test.xls*
- *Section 7 comparison.xls*
- *Taylor soil depth-Rev 01.xls*

The directory path, sizes, and dates of the files are as follows:

Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.

H:\>D:

D:\>dir

Volume in drive D is 060908_1154
Volume Serial Number is CDFB-EB9A

```
Directory of D:\

05/19/2006  11:08a        12,540,928 Depth eq. test.xls
09/05/2006  06:18p           338,944 Final calcs. for report-Rev 01.xls
03/08/2006  09:55a            18,432 Guertal Test.xls
06/29/2006  02:47p         1,597,952 Section 7 comparison.xls
09/05/2006  06:03p           101,888 Taylor soil depth-Rev 01.xls.
               5 File(s)     14,598,144 bytes
               0 Dir(s)               0 bytes free

D:\>
```

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