G. JC General 97

March 20, 1997

Mat Johansen, DOE/AIP/POC
U. S. Department of Energy
Los Alamos Area Office, MS: A316
Los Alamos, NM 87544

Subject: **Review of Development of a Site-Wide Geologic Model for Los Alamos National Laboratory (Draft).**

Dear Mr. Johansen:

The DOE Oversight Bureau (DOE OB) has reviewed the subject document. The attached comments are provided for the purpose of communicating the results of the review. They are not provided or intended for the purpose of representing the regulatory position of the New Mexico Environment Department.

The subject document was reviewed from a number of standpoints which include how useful it is on its own and in comparison to existing site-wide geologic/geophysical data (from which it was largely drawn), if all existing site-wide geologic features are included in the model, and which features present appear to be undefined. Review of the model is presented in the form of bullets defining where in the document critique occurred, and what it concerned.

If there are any questions, please contact me at 505-672-0448 or Scott P. Anderson of the DOE Oversight Bureau at 505-827-1536.

Sincerely,

Steve Yanicak, LANL POC
Department of Energy Oversight Bureau

SY:SPA:spa

Attachment

12988

cc: John Parker, NMED, Chief, DOE Oversight Bureau
Ted Taylor, DOE LAAO, Program Manager, MS A316
Steve Rae, LANL, Group Leader, ESH-18, MS K497
D. Vaniman, LANL, EES-1, MS D462
G. Cole, LANL, EES-1, MS D462
J. Gardner, LANL, EES-1, MS D462
J. Conaway, LANL, NIS-6, MS J562
D. Broxton, LANL, EES-1, MS D462
S. Reneau, LANL, EES-1, MS D462
M. Rice, LANL, EES-13, MS J521
G. WoldeGabriel, LANL, EES-1, MS D462
J. Blossom, LANL, EES-1, MS D462
F. Goff, LANL, EES-1, MS D462

Review of
Development of a Site-Wide Geologic Model of Los Alamos National Laboratory
(Draft)

General comments

The orthophoto maps are an improvement on conventional cross-section/fence diagrams and block diagrams. The maps created from this model appear to incorporate conventional diagrams well, and the final orthophoto map product provides a useful visual representation of the geology of the Pajarito Plateau.

Some of the wells located on the orthophoto maps have various color intervals marked on them that do not appear to match the surrounding stratigraphy. A description of these colored intervals on the map or in the text would be helpful.

Los Alamos National Laboratory may want to include locations/positions of perched ground water within the Bandelier Tuff which discharge as springs (e.g., TA-18 Spring or Burning Ground Spring).

Specific comments

- **Page 7, Table 1**. The Cerro Toledo Rhyolite includes a unit informally called the Cerro Toledo interval, which is composed of sediments. In the model, both the rhyolite and sediments are combined as Qct. Are the different geohydrologic properties of the rhyolite and sediments properly accounted for in the model?

- **Page 16, paragraph 3**. Discrete point selection is noted as the key to the model's accuracy. What potential error is involved in selecting and plotting these points?

- **Page 17, paragraph 1**. What is the error between the apparent point position (interpolated) and the mapped topographical contact position? Is this represented on the final orthophoto map?

- **Page 17, paragraph 2**. What geologic structures could be missed with the minimum 100' spacing of points selected along a contact? Could any critical hydrogeologic properties exist in the missed intervals, and if so are they accounted for in the model?

- **Page 17, paragraph 3**. How are the differences in map overlap data resolved? If the differences are large, does the model and map indicate by how much?

- **Page 18, paragraph 2**. How are the main aquifer water table/perched aquifer zone locations displayed on the orthophoto maps?

- **Page 18, paragraph 3**. Why was conversion and calibration of elevation left out of the model generation? Will this exclusion result in any in any scale exaggeration on the orthophoto map?

- **Page 18, paragraph 4**. Perched alluvial aquifers/saturated zones in some of the canyons are contaminated with various constituents. Because of this, and because of the significance of these zones as potential migration pathways, the canyon alluvium should perhaps be considered in more detail in the initial digital model. In addition, during the drilling of SHB-4 ground water was encountered just beneath the Tsankawi Pumice Bed (depth of 125' below land surface), and this wet zone may be within the Cerro Toledo interval; therefore, it is recommended that this unit should be included individually in the model.

- **Page 21, Table 3**. Unit Qbt_1 (Unit 1, Tshirege Mbr.) is defined individually on this table, but is not defined on Table 1 (page 7).

- **Page 24/25, paragraph 1**. How significant are the errors noted in this paragraph? How much might these errors influence the utility of the model?

- **Page 30, paragraph 1**. How reliable is the "poor-overall" data from the logs? Can it justifiably be used with other highly reliable field data, or will it potentially degrade it?

- **Page 31, paragraphs 1 & 2**. This auto-calibration technique seems elegant, is noted to be "suitable" and definitely can be used, but will the data derived from it and its incorporation into the model detract from other better defined data?

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Development of a Site-Wide Geologic Model for Los Alamos National Laboratory

D. Vaniman, G. Cole, J. Gardner, J. Conaway, D. Broxton, S. Reneau, M. Rice,
G. WoldeGabriel, J. Blossom, and F. Goff

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   Section 10.12: Set of Visualizations (2 each of TA-21 and TA-49)

DRAFT

*acronyms and abbreviations used**

API	American Petroleum Institute
DEM	Digital Elevation Model
EPA	Environmental Protection Agency
ER	Environmental Restoration
ESTC	Earth Sciences Technical Council
FIMAD	Facility for Information Management, Analysis, and Display
GIS	Geographic Information System
GWPP	Ground Water Protection Plan
HSWA	Hazardous and Solid Waste Amendments
IEL	Induction Electric Log
ka	thousand years before present
LANL	Los Alamos National Laboratory
LASL	Los Alamos Scientific Laboratory
Ma	million years before present
NMED	New Mexico Environment Department
NMSP	New Mexico State Plane
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SFL	Spherically Focused Log
SP	Spontaneous Potential
TIN	Triangular Integrated Network
USGS	United States Geological Survey

*abbreviated symbols for stratigraphic units are listed in Table 1

abstract

A preliminary digital geologic model has been developed for Los Alamos National Laboratory. This model was developed using available geologic maps and drill-hole data that provided information on the locations of one or more of 17 different bedrock stratigraphic horizons. Incomplete or inconsistent information from drill holes was not used; nevertheless, data for the model were obtained from 114 drill holes. Data from surface geologic mapping by seven sources were also used. Where maps overlapped, all data from multiple sources were used. The process of model development included checking of drill-hole reports and logs, evaluation of geophysical logging methods on which many of the stratigraphic determinations in drill holes have been made, and preliminary cross-comparison of surface mapping products from different sources. Immediately recognizable errors (*e.g.*, errors in drill hole locations) were corrected as the model was developed; other errors are evident in automatically generated surfaces using the present version of the model. These errors will be addressed in ongoing development of the model, by re-evaluation of original source data and by incorporation of new or revised information. Geologic interpretation will be an important part of the next version of the model. The present version of the model is presented in this report as a "benchmark" representation of currently available sources, presented without interpretation except for a set of cross-sections that provide an adjusted and interpreted view of the LANL site geology.

1. Introduction

The Hazardous and Solid Waste Amendments (HSWA) Operating Permit requirements for Los Alamos National Laboratory (LANL) specify, under the call for Facility Investigations, that sufficient information on the environmental setting be collected to characterize soil and rock units above the water table (EPA, 1990). It is stipulated that a program be conducted to evaluate hydrogeologic conditions at LANL, including the use of both field studies and cores to determine the "depth, thickness, and lateral extent of hydrogeologic units [that] may be part of the migration pathways." The Permit provides guidelines for the RCRA Facility Investigation (RFI) needed to determine the nature and extent of hazardous waste releases. These guidelines include requirements for characterization of the environmental setting at LANL, as well as characterization of any contamination. Necessary information for characterization of the environmental setting and contamination includes investigations of site-wide processes and pathways by which contamination could reach human or ecological receptors. The Permit states that the scope of work should be modified as necessary to supply [only] that information necessary to complete the RFI for each task or potential source of hazardous waste release. This report provides an initial version of a unified, site-wide geologic model of the LANL area to which individual RFI plans can refer.

Although many cores have been obtained at LANL and several geologic maps are available, there has previously been no single, integrated effort to compile both surface and subsurface geologic data into a unified geologic model of the site. This report describes the development of such a model. The guidance for this project is largely provided in the Site-Wide Study Plan (Cole and ESTC, 1996), where the content of a LANL site-wide geologic model is outlined:

> "This study will provide a tool for the 3-dimensional visualization of the geology, hydrology, surface topography and features, wells and drill holes, hydrologic modeling results, spatial characterization of contamination, and draped presentation of surface data. This visualization will help in the development of conceptual exposure pathways, placement of test and monitoring wells, and evaluation of remediation strategies (Cole and ESTC, 1996, p. 84)."

The site-wide LANL geologic model described below was designed to provide the data base from which such a tool can function. At present, there are not sufficient data on the hydrologic properties, hydrologic modeling, and spatial distribution of contaminants to include these in the model. However, site-specific modeling efforts and individual contaminant occurrences can be compared against the stratigraphic constructs that constitute the model in its present form. This model and the visualization tools used with it will be of use to two efforts that are important to the future of the LANL site: the Environmental Restoration (ER) Project and the development and implementation of a LANL Ground Water Protection Plan (GWPP). Both efforts require an understanding of the stratigraphic distribution of geohydrologic units at the site.

The ER Project seeks both to remediate those parts of the LANL site where hazards can be isolated and removed and to understand the risks that are associated with hazards at the site. Risks are associated with pathways that lead to human access and subsurface pathways are dependent on the stratigraphy of the site. Therefore an accurate model of site stratigraphy (or knowledge of credible alternate interpretations of this stratigraphy) is needed. Specific hydrogeologic properties of the stratigraphic units are needed before the models of site stratigraphy can be used in risk calculations. Some data are available for tuff units within the unsaturated zone (ref. Rogers and Gallaher, 1995) and water production data are available from the saturated zone, principally for sediments of the Santa Fe Group (Purtymun, 1995), but more data are needed. However, the purpose of this report is to provide a preliminary integrated stratigraphic model for which ranges of hydrologic properties can be developed. The determination of hydrogeologic parameters for stratigraphic units should be addressed in future studies.

The GWPP will define the role of groundwater in transporting hazards from source areas to areas of human access. The GWPP has intrinsic links to the ER Project, with many goals in common - particularly the understanding of site geohydrologic stratigraphy. However, the GWPP includes a broader consideration of surrounding drainages and groundwater systems that communicate with the LANL site. This includes the need for deep drill-hole data on groundwater-producing units as well as the effort needed to understand communication between these units and the Rio Grande hydrogeologic system.

The site-wide geologic model described in this report is a basic component for both ER and GWPP efforts. The initial goals of this work were to provide (1) the best credible model of site geohydrologic stratigraphy based on existing data, (2) error estimates on the locations and thicknesses of important horizons, and (3) recommendations on studies needed to fill gaps in the data. However, it became evident during the project that, for the sub-Bandelier strata in particular, the incomplete data from drill holes leads to such a large number of possible visualizations of the site stratigraphy that the second goal could not be attained for many of the deeper geohydrologic units. This is particularly the case for the principal aquifer within the Santa Fe Group and its relationships with interfingering basaltic and intermediate lavas. Also, because of time limitations, no attempt was made in this phase of the study to eliminate outcrop data generated from old reports (e.g., Griggs, 1994) where it has been superseded by more recent field checking (e.g., Broxton and Reneau, 1996). Internal quality checks have yet to be completed and used to revise the model. Cases where intersected surfaces from the model violate stratigraphic sequence can be seen, for example, in the projected strata intersections of Ground Water Protection Plan monitoring wells in Appendix Section 10.8. The plates that accompany this report illustrate these problems by showing where uninterpreted stratigraphic surfaces, generated by fits to surface map and drill-hole data, interpenetrate rather than maintain rational stratigraphic relations. A set of interpretive cross-sections supplied with this report illustrate rationalized interpretations of the model data, but each cross-section must be recognized as one visualization of several that are possible. A full treatment, based on such interpretations in a three-dimensional mode,

must wait for further work. Nevertheless, we have provided a digital, integrated model of major geohydrologic units at the LANL site, with illustrations of the utility of the model in three-dimensional projections of specific locations. Work to be performed in FY97 will reduce much of the uncertainty in the model, especially in the upper units, and better quantify uncertainties in the lower units.

2. Stratigraphy for the Model

In its present form, the model consists of stratigraphic units that provide complete vertical coverage, without gaps, from the surface to the deepest units sampled in drilling. Some of these units have greater importance in geohydrology than do others, but all are necessary to provide complete visualizations of the LANL site. Particularly important strata in transport modeling include:

1) the pumice beds of the Bandelier Tuff (the Tsankawi and Guaje pumice Beds), because of their low unsaturated permeability and low fracture abundance that make these beds barriers to transport beneath most of the LANL site.
2) the Cerro Toledo unit between the two Members of the Bandelier Tuff, because it provides both depositional and erosional boundaries, locally clay-bearing or carbonate-plugged, with interbedded nonwelded pumice units. This complex unit may provide a number of barriers to transport under much of the LANL site.
3) the basalts that underlie the Bandelier Tuff across most of the eastern part of the LANL site. These basalts are highly fractured but also contain discontinuous interflow horizons; their impact on transport is presently difficult to model but may be significant.

This is not a complete listing of the geohydrologically important stratigraphic units. The determination of such importance is not within the scope of this report and will depend on the results of modeling efforts that are ongoing. Finer divisions of units used in this report may be called for in the future, for example in situations where surge beds within Tshirege units can provide significant horizons for water movement to mesa margins (Rogers and Gallaher, 1995). Surficial units, soils and alluvium in particular, will be important to define in more detail for understanding recharge and near-surface transport (Purtymun, 1995; Newman, 1996). These are modifications that can be added in revisions of the model.

Stratigraphic usage is derived from a number of sources. In this section we explain the units of present and potential use in the site-wide model. Symbology follows that developed in previous mapping projects, with fundamental subdivision of Quaternary (Q, <1.8 Ma) and Tertiary (T, 1.8 - 66.4 Ma) units. One of the most detailed and broadly-based previous mapping projects is that of Rogers (1995); Table 1 compares the unit symbology used in our site-wide system with that of Rogers (1995).

Table 1: Stratigraphic Units for the Site-wide Model, Compared with Rogers (1995)

Symbology in this report	unit	Symbology of Rogers (1995)
Qmt	Mesa-top Soils	
Qc	colluvium	Qco
Qls	landslide	Ql
Qf	fan deposits	Qf
Qal	alluvium	Qal
Qt	terrace deposits	Qt_1, Qt_2
Qec	El Cajete Mbr., Valles Rhy.	Qvec
Qbt5	Tshirege Member, 5, Bandelier Tuff (BT)	Qbt_F
Qbt4	Tshirege Member, 4, BT	Qbt_E
Qbt3	Tshirege Member, 3, BT	Qbt_D
*Qbt3nw	Tshirege Member, 3, nonwelded base, BT	
Qbt2	Tshirege Member, 2, BT	Qbt_C
Qbt1v	Tshirege Member, 1, vapor phase (no glass), BT	Qbt_B
Qbt1g	Tshirege Member, 1, glassy, BT	Qbt_A
Qbtt	Tshirege Member, Tsankawi Pumice, BT	
Qct	Cerro Toledo rhyolites and sediments	
Qbof	Otowi Member, ash flow, BT	Qbo
Qbog	Otowi Member, Guaje Pumice, BT	Qbog
Tpf	Puye Formation, fanglomerate	Qtp
Tpt	Puye Formation, Totavi equivalents	Qtp
Tpl	Puye Formation, lakebeds	Qtp
Tb	Cerros del Rio basaltic rocks	Qtb
Tt	Tschicoma Formation	
Tsfuv	Santa Fe Group undifferentiated, volcaniclastic	Tsf
Tsfu	Santa Fe Group undifferentiated	Tsf

*Qbt3nw distinguished within base of Qbt3 only in the central-western part of LANL.

In some sources, Quaternary units, either of surficial, Bandelier Tuff, or Cerro Toledo, were not mapped or were combined in a problematic stratigraphy that could not be incorporated into the model. In these cases, the missing or problematic units were designated as "Qu" in the model. Descriptions of the Quaternary and Tertiary units listed in Table 1 are given in the text that follows.

2.1. Surficial Units (<1.22 Ma)

Surface deposits post-dating eruption of the Bandelier Tuff span Holocene (0-10 ka) and much of Pleistocene (10 ka to 1.8 Ma) time. We include in the classification of surficial deposits not only the soils and products of erosion, but also the El Cajete rhyolite pumice that was deposited as a fallout unit across the Pajarito Plateau in the late Pleistocene (~50-60 thousand years ago; Toyoda et al., 1995 and Reneau et al., 1996).

There are several maps and reports that address these surficial units, but there are as yet insufficient data on depths or thicknesses to incorporate the surficial units into a three-dimensional model. Nevertheless, we include the following descriptions as a prelude to future incorporation of these important units into a site-wide stratigraphy.

2.1.1. Disturbed surfaces and fill (Qfill)

Many technical areas at LANL have been excavated, filled, or graded for roadways and structures. Disposal pits, generally excavated through natural cover and into bedrock, are common. Most of these features are incorporated into the catalog of anthropogenic features that is part of the FIMAD database. Disturbed surfaces and fill are not presently incorporated into the site-wide geologic model.

2.1.2. Mesa-top soils (Qmt)

The mesa surfaces at LANL have a complex variety of soil types. An informal site-wide categorization exists (Nyhan et al., 1978) but a linkage to formal soil stratigraphy has not been made. Recent studies of soil development include aspects of chronostratigraphy that will be an important part of the site-wide geologic model; the importance of these studies lies in their use for defining the longevity and stability of various surfaces across the LANL site. Other soils occur on slopes and in valleys; the stratigraphic symbology may be modified to accommodate different geomorphic soil settings if future studies can define significant control of local setting over soil development. Conversely, some mesa tops have limited alluvial deposits that are remnants of ancient streams (Reneau et al., 1995a and Rogers, 1995). At present, with the location of most drill holes and excavations either on mesa tops (largely soil covered) or in canyon bottoms (alluvium filled), the site-wide geologic model only distinguishes mesa-top soils (Qmt) from canyon alluvium (Qal).

2.1.3. Colluvium (Qc)

Colluvium includes a wide variety of materials, ranging from boulder deposits on canyon walls to finer-textured slopewash at the margins of canton floors. These are the products of transport outside of significant stream channels, either by gravitational processes such as rockfalls or by shallow and dispersed surface runoff. Colluvium is generally thicker and more abundant on north-facing than on south-facing canyon walls across the Pajarito Plateau. Colluvium is generally distinguished from landslide debris through origin via gradual and dispersed movement, as opposed to movement in massive units, although the distinction between colluvium and landslides can sometimes be arbitrary.

2.1.4. Landslides (Qls)

Landslides are masses of rock and/or soil that generally move as a single or segmented unit under the force of gravity. These units are often large enough to be

individually mapped. Of minimal importance across most of the Pajarito Plateau, landslides are the predominant unit in White Rock Canyon. Because the landslide units are still poorly known in three dimensions, they are not presently included in the LANL site-wide geologic model. However, the mapping completed by Reneau et al. (1995b) provides the information needed for inclusion of landslide rupture surfaces in interpretive cross-sections (see text section 6 below).

2.1.5. Fan deposits (Qf)

Small alluvial fans occur at the mouths of minor drainages across the Pajarito Plateau, but the most significant accumulations of fan deposits are along the western margin of the LANL site where large and extensive fans spread westward from the uplifted footwalls of the Pajarito fault zone. Fan deposits underlie extensive portions of Technical Areas 8, 9, 16, 58, and 69. Local recharge and spring discharge in these Technical Areas may be partly influenced by the distribution of fan materials. Unfortunately, there has been little mapping in these areas and not enough is known about the depths and forms of these deposits to include them in the LANL site three-dimensional model.

2.1.6. Alluvium (Qal)

Stream deposits (alluvium) represent the uppermost unit penetrated by most wells drilled in the canyons of the Pajarito Plateau. Typically the alluvium rests directly on bedrock; the contact between bedrock and alluvium is a common horizon for perching of water (Purtymun, 1995). Alluvium in canyon bottoms may bury soils and terraces of older canyon-bottom surfaces, but the detail available from present studies only allows designation of a single Qal unit mappable on a site-wide basis. The designation "Qal" is restricted to canyon-bottom alluvium in this report, excluding mesa-top alluvial deposits that are in part designated "Qf" or that are included in "Qmt." Canyon-bottom alluvium is also locally designated as "Qt" where specific terraces can be mapped (see Section 2.1.7 below).

2.1.7. Terrace deposits (Qt)

Previous depositional surfaces in canyons may be preserved as terraces above the presently active canyon bottoms. The broadest terraces within the LANL site are those mapped by Rogers (1995) in Los Alamos Canyon, along the southern canyon wall. Other terraces have not been systematically studied and have not been incorporated into the LANL site-wide geologic model.

2.1.8. El Cajete Member of the Valles Rhyolite (Qec; 50-60 ka)

The El Cajete Member of the Valles Rhyolite is represented across the Pajarito Plateau as distinctive but discontinuous deposits of primary and reworked fallout pumice. The El Cajete pumice, a porphyritic rhyolite with distinctive biotite phenocrysts, is

preserved on mesa tops and in some canyons. The age of the El Cajete has been difficult to constrain. Recent work by Toyoda et al. (1995) and by Reneau et al. (1996) that considers electron-spin resonance, thermoluminescence, and ^{14}C constraints puts the age between 50 and 60 ka. Although representative of a specific volcanic event and thus useful as a time horizon, the El Cajete pumice is also reworked and transported with younger surficial materials in parts of the Pajarito Plateau.

2.2. Tshirege Member of the Bandelier Tuff (Qbt; 1.22 ± 0.01 Ma)

Several studies have subdivided the Bandelier Tuff into a variety of stratigraphic subunits. With the exception of the formally recognized basal airfall, the Tsankawi Pumice Bed, none of the other subdivisions are formally recognized. Many of these subdivisions, however, can be mapped across large portions of the Pajarito Plateau; these subdivisions have been incorporated into the site-wide digital model. Several differing subdivisions of the Tshirege have been proposed (Weir and Purtymun, 1962; Baltz et al., 1963; Smith and Bailey, 1966; Crowe et al., 1978; Vaniman and Wohletz, 1991; Purtymun, 1995; Reneau et al., 1995; Rogers, 1995). The subdivisions used for the digital site-wide model are based on the synthesis by Broxton and Reneau (1995), which considered the earlier subdivisions and sought to develop uniform criteria for subdividing the Tshirege across the central and eastern Pajarito Plateau. The only modification to the Broxton and Reneau subdivisions that we have made is in adding unit 5, corresponding to Rogers' (1995) unit F (see Table 1), to cover the higher stratigraphic section exposed to the west beyond the region dealt with by Broxton and Reneau (1995).

2.2.1. Unit 5 of the Tshirege Member, Bandelier Tuff (Qbt5)

This unit is described by Rogers (1995) as pervasively vapor-phase altered unit with ~6% phenocrysts. A sandy surge bed separates Unit 5 from Unit 4. Exposures along roadcuts and shallow canyons in the western part of the LANL site show multiple surge beds within this unit. Work in progress (Broxton, oral comm.) indicates complex variation, including fine- and coarse-pumice subunits, on both sides of the Pajarito fault. Detailed knowledge of Unit 5 may be important in paleoseismology studies along the Pajarito fault system. Faulting and thick fan deposits complicate the stratigraphy and cover exposures in this unit at the western margin of the LANL site; contacts between fan deposits and bedrock may be zones of hydrologic significance, providing zones of perching with discharge to local springs and seeps.

2.2.2. Unit 4 of the Tshirege Member, Bandelier Tuff (Qbt4)

Unit 4 is distinguished by a prominent, mappable surge bed at its base, marking the contact with Unit 3. Where this contact is not exposed, the characteristic lack of relict pumice and consequent fine texture of the matrix is useful in distinguishing this unit. Where chemical data are available, Unit 4 is distinguished by lower Si and higher Ti, Fe, Sr, and Ba content compared with the underlying Tshirege units (Broxton et al., 1995).

2.2.3. Unit 3 of the Tshirege Member, Bandelier Tuff (Qbt3, locally subdivided into Qbt3w and Qbt3nw)

Although small, rounded cliffs can form in Unit 4, Unit 3 is the principal cliff-forming unit that defines the mesa tops across most of the central LANL site. It is distinguished from Unit 4 by large (>3 cm) relict pumices. In much of the central LANL site, Unit 3 can be subdivided into an upper welded zone (Qbt3w) and a lower nonwelded zone (Qbt3nw). The welded zone provides the prominent cliff exposures, whereas the nonwelded base is very poorly exposed, slope-forming, and covered by dispersed colluvium of Qbt3w. The lateral and vertical extent of Qbt3nw is nevertheless readily determined in the field and it is therefore mapped as a Tshirege unit rather than as colluvium.

2.2.4. Unit 2 of the Tshirege Member, Bandelier Tuff (Qbt2)

The upper boundary of Unit 2, against the poorly-welded base of Unit 3, is a distinctive densely-welded and hematite-altered (red) lithology in the central part of the LANL site. This transition from Unit 3 to Unit 2 is abrupt, occurring over less than 1 m (Broxton and Reneau, 1995). Unit 2 provides the most prominent cliffs in the central and eastern parts of the LANL site. The lower part of this unit is gradational into the underlying Unit 1; this is generally the most difficult contact to assign in both outcrop and drill-hole studies (Broxton and Reneau, 1995). However, Unit 2 has locally traceable surge beds in its lowest 1 to 3 m in the eastern part of the LANL site, providing a reliable stratigraphic break between Units 2 and 1 at the base of this surge sequence. This guide to stratigraphy at the base of Unit 2 is more readily recognized in the field than in core samples; the Unit 2/Unit 1v contact is generally obtainable only from field studies or from the most recent core logs.

2.2.5. Unit 1 of the Tshirege Member, Bandelier Tuff (Qbt1, subdivided into Qbt1v and Qbt1g)

Although often difficult to precisely separate from the overlying Unit 2, Unit 1 has a distinctive internal contact between an upper vapor-phase altered portion (Qbt1v which, like most overlying parts of the Tshirege, retains none of its original glass) and a lower portion that has not been vapor-phase altered and retains most of its glass (Qbt1g). The contact between these two portions is sharply gradational, within 1 to 2 m, and often marked at the top by an erosionally weak layer that forms a "vapor-phase notch" that is readily mapped in outcrop. The fibrous texture and vitreous luster of the glassy pumices in Qbt1g are readily distinguished from the granular, crystalline texture of the vapor-phase altered pumices in Qbt1v. The base of Unit 1 is often marked by a surge deposit, similar to the base of Unit 2, but the most reliable marker of the base of Unit 1 is the sharp (cm-scale) transition to the Tsankawi Pumice Bed.

2.2.6. Tsankawi Pumice Bed of the Tshirege Member, Bandelier Tuff (Qbtt)

The Tsankawi Pumice is a distinctive and almost ubiquitous 20 to 100 cm layer of matrix-poor, clast-supported pumice lapilli that occurs at the base of the Tshirege across the LANL site. There are rare instances where this pumice bed has been eroded by the overlying Qbt1 ash flow and is therefore absent. The distinctive Qbtt pumice assemblage is a prominent horizon, readily recognizable in outcrop and in drill cores. In some earlier drill-hole logs, the Tsankawi Pumice is not distinguished from the underlying Cerro Toledo unit; the Qbtt/Qct contact is thus not recorded for many of the older LANL drill holes. Nevertheless, model isopach maps of the Qbtt unit (Self et al., 1995) provide evidence of continuous and smooth thinning of the Qbtt unit from WNW to ESE across the LANL site except where locally eroded by the Qbt1 ash flow.

2.3. Cerro Toledo Rhyolite and Sediments (Qct; 1.22 to 1.61 Ma)

Following the eruption of the Otowi Member of the Bandelier Tuff and preceding the eruption of the Tshirege Member, for a period of ~400 thousand years, the Otowi surface was alternately eroded by rainfall or streamflow and covered by sediments and minor pyroclastic deposits. The resulting irregular deposits of tephras and volcaniclastic sediments are referred to as the Cerro Toledo interval. Thicknesses of this interval vary markedly (0 to at least 42 m; Broxton and Reneau, 1995). Paleosols with calcic horizons have been recognized within the Cerro Toledo interval in the northern part of the LANL site. Such horizons may be relatively impermeable, in contrast to the porous pumice beds that also occur in the Cerro Toledo and in the bounding basal Tshirege and upper Otowi members of the Bandelier Tuff.

2.4. Otowi Member of the Bandelier Tuff (Qbo; 1.61 ± 0.01 Ma)

The Otowi Member of the Bandelier Tuff is not as well exposed as the Tshirege Member across the LANL site. Thicknesses of the Otowi Member are more difficult to predict in drill core because of the poorer record of outcrop data, because of deposition across surfaces of the underlying units (Puye Formation and intermediate to basaltic lavas) that were almost certainly eroded into a complex terrain, and because of the ~400,000 years of erosion and covering by Cerro Toledo deposits prior to eruption of the Tshirege Member. Generally poorly welded to nonwelded, the Otowi Member is more massive than the Tshirege and is simply divided into ash-flow and pumice-bed components.

2.4.1. Ash-flow Component of the Otowi Member, Bandelier Tuff (Qbof)

The Otowi ash flow is readily eroded and tends to form smooth slopes where it is exposed across the LANL site. It is glassy throughout, with no evidence of vapor-phase alteration. Where stratigraphic relations are obscured, the Otowi can be distinguished from Tshirege units by its characteristic content of up to 5% chocolate-brown, black, and

red lithic fragments derived from intermediate-composition lava flows. Most of the information on the Otowi has been derived from examination of exposures in outcrops at the eastern and northern parts of the Pajarito Plateau; however, a thick section was sampled in drill hole SHB-3 in the southwestern part of the Plateau. The character of the Otowi here is generally similar to that seen elsewhere on the Plateau.

2.4.2. Guaje Pumice Bed of the Otowi Member, Bandelier Tuff (Qbog)

The Guaje Pumice Bed, like the Tsankawi Pumice Bed of the Tshirege Member, is a distinctive layer of matrix-poor, clast-supported pumice lapilli at the base of overlying ash-flow units. The Guaje is also a distinctive pumice assemblage that provides a prominent horizon, readily recognizable in outcrop and in drill cores. However, the Guaje is thicker than the Tsankawi (up to 15 m in the northwestern part of the LANL site, versus ~0.1 m for the Tsankawi) yet more variable and less predictable in thickness. For example, the Guaje is virtually absent in drill hole SHB-3, for reasons that are yet poorly understood. It is possible that the exceptionally thick pumice falls that comprise the Guaje were subject to slumping on steep slopes before the following Qbof ash flow was emplaced, or the ash flow may have locally scoured the Guaje pumice. Alternatively, compound dispersal directions of multiple blasts that comprise the Guaje (Self et al., 1995) may have resulted in complex variations in the composite initial depositional thickness.

2.5. Puye Formation (Tp; ~4.0 to 1.61 Ma)

The Puye Formation is a complex depositional series that reflects variation in both source lithology and in depositional environments. Substantial information is available on the Puye Formation to the north, including the northernmost parts of the LANL site (Waresback and Turbeville, 1990). Here the Puye consists predominantly of fan deposits (Tpf) that include sheetflood, debris flow, and stream-channel deposits with minor (~5%) airfall and ash-flow tuffs, of uncertain source, that predate the Bandelier Tuff deposits. However, the Puye is seldom exposed and less well known to the south, beneath the LANL site. The Puye includes a widely-distributed but problematic basal coarse-cobble unit (the Totavi, Tpt) and, near the Rio Grande, sporadic deposits of lakebed sediments (Tpl).

2.5.1. Puye Formation fan deposits (Tpf)

The fan deposits of the Puye described by Waresback and Turbeville (1990) to the north contain clasts derived principally from portions of the Tschicoma intermediate volcanic flows that form highlands to the NW of Los Alamos. Waresback and Turbeville (1990) describe the fan deposits as thinning from >140 m near the Tschicoma source, to ~65 m near the Rio Grande, to <30 m where the deposits wedge out against the Cerros del Rio basalts to the SE. In comparison, several drill-hole records in the center of the Pajarito Plateau have been interpreted to have up to ~220 m of Puye fan deposits (Griggs, 1994). These extended thicknesses may reflect the addition of sources of basalt from the

east (Cerros del Rio basalts) in addition to dacites from the west (Tschicoma), as well as the additional intercalation of dacite flows and basalt flows (principally from the west and east, respectively). Such thick accumulations, however, require an existing or growing basin for deposition between the Tschicoma and Cerros del Rio source areas during Puye time.

2.5.2. The Totavi "lentil" of the Puye Formation (Tpt)

The Totavi is widely recognized in drill holes at the LANL site. The principal discriminant in separating the Totavi from the rest of the Puye Formation is the occurrence of abundant river gravels derived from more distant metamorphic and plutonic sources, in addition to the local volcanic sources. In particular, the Totavi is defined by the common presence of clasts derived from the Precambrian Ortega Quartzite. The modifier "lentil" may be attached in descriptions of the Totavi, where the lenticular form of the deposits is associated with paleo-stream channels that represent the ancestral Rio Grande system. The lithologies from distant sources require riverine transport. However, the model of lenticular form does not explain the widespread occurrence of the Totavi beneath the Puye fan deposits across the LANL site. An alternative depositional model would derive the Totavi deposits as a series of riverine benches (terraces) during early Puye time, cut and capped by gravels in succession from west to east as the Rio Grande migrated eastward toward its present position (Reneau and Dethier, 1996).

2.5.3. Lakebed deposits of the Puye Formation (Tpl)

Lakebed sediments of the Puye Formation can be found in outcrop up to 4 km west of the present channel of the Rio Grande. These deposits represent paleo-lakes created when basaltic flows of the Cerros del Rio dammed the Rio Grande (Kelley, 1952; Griggs, 1964; Waresback and Turbeville, 1990; Reneau et al., 1995b). These units are restricted in occurrence and are not presently part of the LANL digital geologic model.

2.6. Santa Fe Group (Tsfu, Tsfuv; ~28 to ~4 Ma)

The Santa Fe Group has been variously subdivided beneath the Pajarito Plateau, based on information from the few drill holes that have penetrated the unit. Recent reports have separated the Tesuque and Chamita Formations and proposed a new formation name, the Chaquehui, for the upper unit that is the principal aquifer for the LANL site (Purtymun, 1995). With few data and several indications that the Santa Fe stratigraphy beneath LANL may not be readily correlated with other formations nearby, we have focused on what we consider to be the best established intra-Group break recognized in drill holes, the functional break between an upper aquifer unit and a lower zone that is a poor aquifer. This break correlates with the demarcation between Purtymun's Chaquehui (upper Santa Fe) and the lower Santa Fe. This distinction was also made by Griggs (1964) and we rely on his description of the upper unit as being undifferentiated except for bearing distinctive gravel to boulder-size volcanic clasts (v in Tsfuv), in contrast to the underlying Santa Fe units which are simply undifferentiated

(Tsfu). As characteristics of Tsfuv, Griggs (1964) identifies abundant Tschicoma intermediate lavas, derived from the west, and arkosic sands derived from the east. The arkosic sands extend downward into Tsfu, whereas the Tschicoma detritus does not. Because Purtymun (1995) reports Santa Fe Group sediments with aquifer characteristics of Tsfuv in drill hole Otowi 4, intercalated with basalt flows of 9 Ma (Woldegabriel, in prep.), we consider it likely that lavas older than the Tschicoma (i.e., >7 Ma) and probably derived from the Keres Group (~13 to 7 Ma) to the W and SW contributed comparable coarse volcanic detritus to the Santa Fe Group sediments. This would make the transition from Tsfu to Tsfuv conceivably as old as ~13 Ma in the central and southern part of the LANL area, while the transition could be younger (~7 Ma) to the north.

2.7. Basalts (Tb; ~13-12, ~9, and ~4.4-2.3 Ma)

Contemporaneous with Puye sedimentation, basaltic volcanism played an important role in determining the course of the ancestral Rio Grande and in the damming and infilling of a deep (~250 m) paleocanyon in the vicinity of what is now White Rock Canyon (Reneau and Dethier, 1996). Although the most evident sources of volcanic activity in this period are east of the present Rio Grande channel, vents of this period also occur at TA-33 and west of White Rock, providing evidence of local eruptive sources well toward the center of the Pajarito Plateau. The actual extent of these Pliocene basaltic centers remains unknown.

Earlier, Miocene basaltic volcanism (~13-22 and ~9 Ma) with unknown sources interfingers with sediments of the Santa Fe Group. Exposures of ~ 9 Ma Miocene basalt flows are found along White Rock Canyon below TA-33 but the oldest Miocene flows (~13 to 12 Ma) occur only in one drill hole (Otowi 1) near the mouth of Pueblo Canyon. Basalts of ~13-12 Ma age interfinger with Tsfu sediments in Otowi 1, whereas basalts of ~9 Ma age interfinger with Tsfuv sediments in Otowi 4.

2.8. Tschicoma Formation (Tt; ~7 to 3 Ma); possible Keres Group volcanic detritus.

The Tschicoma Formation is the only unit of the Polvadera Group (which also includes the El Rechuelos Rhyolite and the Lobato Basalt) that provides significant volcanic detritus from the west during Puye and late Santa Fe time. The volcanic materials contributed from these sources are principally intermediate-composition lavas. Detailed descriptions of Tschicoma lithologies are available in Goff et al. (1989). As noted above in Section 2.6, the volcaniclastic aquifer sediments (Tsfuv) of the Santa Fe Group gain their coarse character partly from Tschicoma Formation volcanic detritus. The occurrence of large Keres Group volcanic structures to the W and SW at earlier times (~13 to 7 Ma) raises the possibility that coarse, aquifer sediments of Tsfuv type extend back in time to ~13 Ma beneath the central and southern LANL site. Future deep drill cores will help considerably in clarifying these relationships, for the distinction of source regions may be obtained based on petrologic recognition of distinctive Keres Group and Tschicoma Formation sources.

3. The Data

The goal of this initial site-wide effort was to evaluate the existing geologic knowledge base of the LANL site and incorporate potentially useful information into a database that would support three-dimensional (3-D) modeling efforts of geohydrologic processes. Data selection was based upon relevance to possible geohydrologic models. Both drill-hole and mapped surface data were utilized in the development of the preliminary model. However, other data, such as hand-contoured geologic surfaces, were entered in the data base for possible later use in more elaborate models based on Expert Systems or Artificial Intelligence methods.

3.1 Data collection strategy

Geologic structure and stratigraphy are considered to be primary controls in the migration of groundwater. Any information that could provide the spatial framework of structures and statigraphic boundaries, especially where such boundaries could reflect corresponding changes in physical properties such as hydrologic or chemical parameters, was entered in the data base. Data that could identify boundaries indirectly, i.e. geophysical data, were evaluated for their potential use but only previous interpretations based on geophysical data, principally from borehole logs, were used. Section 5 of this report evaluates the reliability of the borehole geophysical data. All of the data support for the current model is based on either field mapping or on logs from drill cores, supplementing earlier workers' interpretations of the borehole geophysical logs. The structural data which we have collected provide few quantitative constraints and are not yet incorporated in the model.

The data set used to create the model consists of a large number of discrete points, each identifying a 3-dimensional position at some stratigraphic boundary. Each point reflects a contact between an upper and lower stratigraphic unit. The set of points for the same upper/lower unit pair is used to define the surface of contact between the two units. The distribution, density, and accuracy of the set of points determines how close the modeled surface represents reality.

The data base also includes some points collected in the interior of stratigraphic units; for example, the bottom or end point in the drill holes. These points have a different data type code and are useful in providing constraints on the extent of a stratigraphic unit.

3.2 Acquisition of 3-D data from 1-D and 2-D data sets

Stratigraphic contact 'picks' from drill logs have associated depths. Estimated contacts provided by geologic maps are generally obtained with geographic coordinates in two dimensions. It is necessary to combine these with other data to get true 3-dimensional positions.

Converting drill hole depths to 3-D positions requires knowledge of the 3-dimensional position of the drill hole collar, as well as the dip and azimuth of the drill hole. Obtaining elevation values for geographical coordinates requires topographic data. The horizontal placement of geologic field data is often dependent on the topographic base map that is used, since geologic contacts are often responsible for and therefore spatially associated with topographic features. New topographic surveys often have better horizontal (and/or) vertical control and may result in horizontal and/or vertical migration of topographic features on the revised maps. If the original (x,y) location of a contact point is used to interpolate an elevation from a revised topographic base map, and the point was originally located along a cliff face, the apparent position of the point on the new base could migrate to either the top or base of the cliff, resulting in a very large error in the elevation assignment. It is therefore important to use the original topographic base map when assigning elevation values to mapped contacts.

Geologic data drawn upon USGS quadrangle base maps were not available in digital format; therefore contact points had to be manually recovered from paper maps. Data points were selected where contacts crossed contour lines. The {x,y} value was obtained by a digitizer, and the z (elevation) value was keyed into the computer as an attribute of the point. Most of the geologic contact data mapped upon the 1976 LANL topo base also had to be digitized. However, as the 1976 contours were available in digital form, software was written to identify the intersections of digitized contour and contact lines, in order to automatically obtain control points along the contact with {x,y,z} coordinates. Most of the geologic data mapped upon the 1991 LANL topo base were already available as digital lines at FIMAD (the Facility for Information Management Analysis and Display). One-foot digital elevation model (DEM) data were also available for the LANL site. Although elevation values could have been automatically interpolated from the DEM for every point along the digitized contact lines, points were selected at an approximate (not less than) spacing of 100' along the course of the contacts.

3.3 Data sets utilized

Numerous references and data sets were evaluated during construction of the database (see references). Much work had already been done by the ER Project in obtaining available geologic data for selected areas of the Laboratory and townsite; many of these data are in digital format at FIMAD. We attempted to incorporate all relevant, well-defined data into our database, performing quality checks where appropriate. For data obtained from surface mapping, all well-defined sources were used. In many cases the maps from several sources overlap in areal coverage; in these cases the data from both sources were entered into the database despite the overlap. It was not deemed appropriate at this stage to weight and discard information from potentially conflicting sources where the overlapping sources both represent well-defined geologic information. These judgments will be provided in later versions of the site-wide geologic model.

Source overlap was not a problem in the incorporation of drill-hole data, although some judgments were made where different information was available from different sources evaluating the same drill hole (specifically for the Sigma Mesa or EGH-LA-1 drill hole). A summary of the drill holes used in the model is provided in Appendix Section 10.4. A summary of the processing for the source data sets is provided as Table 2. The numeric and areal distribution of contact control points used in our model is provided in Table 3 and Fig. 1.

To support the data presentation, several sets of non-geological data were used to provide cultural features and the hydrography. Features such as roads, political boundaries, and streams were obtained from the ER Project Geographic Information System (GIS) maintained by FIMAD. The water table surface we use is based on a contour plot by Purtymun and others (1984). The locations of several perched water zones were obtained from drill hole logs.

3.3.1 Topographic/geographic data

The geographical locations and elevations utilized in our model as {x,y,z} coordinates are based on New Mexico State Planar (NAD83) coordinates and the 1991 ER Aerial Survey. Source geographic data were presented in a variety of other formats, (i.e., Geodetic, NM State Planar NAD27, the LASL grid) and were converted to model coordinates. Source elevation data were based on USGS sources, the 1976 LANL aerial survey, or the 1991 ER areal survey. No conversion or calibration of elevations was done during model generation.

3.3.2 Drill hole data

Drill hole data were obtained through a review of relevant LANL records and reports, the data available at FIMAD, and an assessment of recent and current drilling activities at the Laboratory. Records of 424 drill holes were checked for stratigraphic contacts potentially useable in generating the digital stratigraphic model. Because most records recognize no finer distinctions than "soil" or "alluvium" in units above bedrock, and the primary goal in generating the initial digital model was to define bedrock stratigraphy, those holes that did not penetrate into bedrock or provided no useable information on bedrock units were not considered further. In addition, drill holes so far removed from the LANL site that they had no bearing on site stratigraphy were not considered further. Finally, consideration was limited to those drill holes that provided information on sub-Bandelier stratigraphy or that had reliable information on the Bandelier basal contact or on subunit contacts within the Bandelier Tuff and the Cerro Toledo deposits. The criteria used for defining "useable" Bandelier subunits are based on those laid out by Broxton and Reneau (1995). Earlier stratigraphic systems that could be correlated with the Broxton and Reneau criteria were used after converting to the systemic stratigraphic system outlined in section 2 of this report. However, particularly problematic stratigraphies were not used, such as those that include the Cerro Toledo

deposits with the Tsankawi pumice. The result of this screening was a set of 104 drill holes considered useable in generating the 1996 LANL digital geologic model.

Table 2: Summary of processing activities which transformed source data sets into 3-dimensional stratigraphic control points (see text for details).

DATA SET CODE (REFERENCE)	PROCESSING NOTES
Bro,Ren,1996 (Broxton and Reneau, 1996)	Control points based on drill holes removed to avoid duplication with drill hole data set
Drill Hole Data	Stratigraphic and drill information obtained from FIMAD (this work). DEM elevations used to identify expected elevation at drill holes. Statigraphic assignments evaluated. Suspected erroneous locations (based on elevation differences) field checked. Drill hole stratigraphic data processed into {x,y,z} contact "picks" with simultaneous creation of listings and visualization data structures.
Gof,1995 (Goff, 1995)	Polygon coverage obtained from FIMAD converted to line coverage with upper and lower unit attributes. QA performed though check plot. Elevations obtained from 1991 DEM. Computer code developed to adjust Qbt2/Qbt1v contact - adjustment not made at this time. Contact points extracted at 100-foot intervals from line coverage.
Gri,1964 (Griggs, 1964)	Intersections of specific unit contacts with contour lines digitized as points and assigned an elevation attribute. Data converted from geodetic to NMSP NAD83 coordinates. Individual unit coverages converted to contact "picks". QA performed on locations and assignment of contact picks.
Rog,1995 (Rogers, 1995)	Geologic contacts from 25 sheets digitized as line coverages with upper and lower unit attributes. QA performed though check plots. Digital contour lines from the 1976 survey obtained from FIMAD. Contacts and contour lines converted from geodetic to NMSP NAD83 coordinates. Contact picks obtained by intersecting 10' contours with contact lines.
Van,Woh,1990 (Vaniman and Wohletz, 1990)	Polygon coverage obtained from FIMAD converted to line coverage with upper and lower unit attributes. QA performed though check plot. Line coverage split into northern and southern areas to reflect appropriate topographic bases for data collection. Elevations obtained from 1991 DEM for northern two-thirds of study area. Contact points extracted at 100-foot intervals from northern area line coverage. Contact points for southern portion obtained by intersection of digital contacts with digital contours of the 1976 survey.
Wal,1996 (Walters, 1966)	Polygon coverage obtained from Walters and converted to a line coverage with upper and lower unit attributes. QA performed though check plot. Contact points extracted at 100-foot intervals from line coverage.

Table 3: Number of data points for stratigraphic contact control.

	Bro,Ren, 1996	drill holes (this rept.)	Gof, 1995	Gri, 1964	Rog, 1995	Van,Woh, 1990 ('76 topo)	Van,Woh, 1990 ('91 topo)	Wal, 1996	Total
Qfill	0	5	274 qf	0	0	0	0	134 qf	413
Qc	0	0	310 qtc	0	3063 qco	0	0	125 qtc	3498
Qmt	0	38	160 qmt	0	0	0	0	57 qmt	255
Qls	0	0	0	0	654 ql	0	0	0	654
Qf	0	0	0	0	482 qf	0	0	0	482
Qal	0	36	303 qal qoal	0	4536 qal	32 white	0	93 qal	5000
Qt	0	0	0	0	123 qt1 qt2	0	0	0	123
Qec	0	0	0	0	2331 quec	0	0	0	2331
Qbt5	0	0	0	0	928 qbtf	0	0	0	928
Qbt4	0	1	0	0	1929 qbte	246 unit 4	123	0	2299
Qbt3	0	0	29 qbt-3	0	2931 qbtd	0	0	57 qbt-3	3017
Qbt3w	0	4	225 qbt-3	0	0	761 unit 3	413	0	1403
Qbt3nw	0	17	120 qbt-nw	0	0	413 unit 2 nonwelded	369	20 qbt-nw	939
Qbt2	0	61	84 qbt-2	0	4670 qbtc	110 unit 2	167	55 qbt-2	5147
Qbt1	0	0	14 qbt-1	0	0	0 unit 1	0	0	14
Qbt1v	0	46	0	0	2827 qbtb	0	0	45 qbt-1v	2918
Qbt1g	0	38	0	0	1045 qbta	0	0	10 qbt-1g	1093
Qbtt	346	29	0	910 qbt	0	0	0	0	1285
Qct	0	28	5 qct	0	0	0	0	2 qct	35
Qbof	0	23	0	294 qbo	487 qbo	0	0	0 qbo	804
Qbog	40	26	0	348 qbg	544 qbog	0	0	0	958
Tp	0	0	0	0	71 qtp	0	0	0	71
Tpf	0	56	0	63 qtpf	0	0	0	0	119
Tpt	0	23	0	118 qtpt	0	0	0	0	141
Tsfuv	0	45	0	0 tsu	0 tsf	0	0	0	45
Tsfu	0	19	0	104 tsu	0 tsf	0	0	0	123
Tb	0	71	0	107 qb4	53	0	0	0	231
Tt	0	7	0	0	0	0	0	0	7
Total	386	612	1524	1944	26674	1562	1072	598	34333

The number of control points contributed by each data set are listed for individual contacts. The numbers listed beside each unit identify the number of "picks" for the base of this unit. The original stratigraphic designation of the unit on the source map(s) is provided to the right of the number when different from the stratigraphic model presented here.

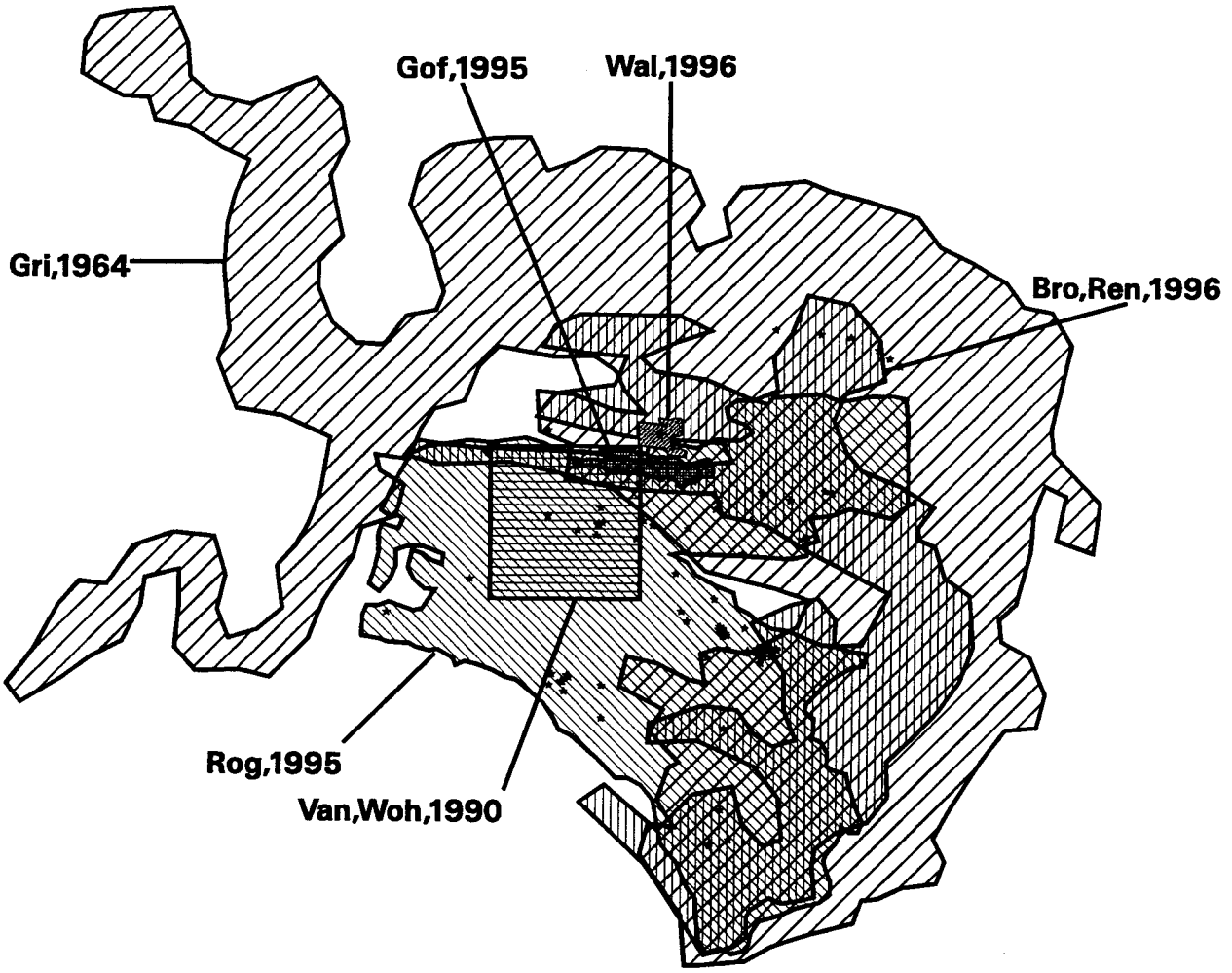

Fig. 1: Areal coverage of source data sets. The approximate extent of source geologic mapping is identified by the set of overlapping polygons. The Laboratory area is shown with light gray shading. The locations of drill holes which were considered to provide valid stratigraphic control are identified by stars.

3.3.3 Geologic map data

Seven geologic maps based on surface studies contributed to the integrated site-wide LANL geologic model. Some maps extend down into lavas and sediments of the sub-Bandelier stratigraphy (e.g., Broxton and Reneau, 1996), but the principal use of surface mapping is in subdividing units within the Tshirege Member of the Bandelier Tuff.

The only available site-wide geologic map that subdivides units within the Tshirege Member is that of Rogers (1995). Cross-correlation between source data maps, including the site-wide map by Rogers (1995), and the stratigraphy used for the LANL site-wide digital geologic model is provided in Table 3. All units were not always differentiated in the various studies. For example, Rogers (1995) did not "break out" the subdivisions: Qbt3nw, Qbtt (Tsankawi Pumice) or Qct (Cerro Toledo Rhyolite) within the Bandelier Tuff. None of the other studies provided detail of the Qbt5/Qbt4 contact, so all data for this contact are from Rogers (1995). All other contacts were found to be correlatable within +/- 10 feet with the exception of the Qbt2/Qbt1v contact, which is generally ~45 feet lower on Rogers' maps than on the other studies. This difference is a reflection of both differences in field criteria for locating this contact and difficulty in establishing useful site-wide criteria for finding this contact in the field (Broxton and Reneau, 1995). It would be possible to provide a mechanical (computed) adjustment to mitigate the differences in this particular contact. Software code was developed to do this, but this adjustment is awaiting a detailed review by geologists utilizing the graphical presentation of the integrated raw source data presented in Appendix Section 10.11.

3.4 Data quality

3.4.1 Topographic/geographic data quality

Source geologic information was mapped upon a variety of topographic base maps including that used by Griggs (1964; 1:31,680 scale, 20' contour interval), a 1976 aerial survey of the Laboratory (1:4,800 scale, 10' contour interval), and a 1991 aerial survey of the Laboratory and Los Alamos County funded by the ER Project (1:1,200 and 1:4,800 scale, 2 and 10' contours). Nominal standard map errors (i.e. 90% confidence interval) for these three map scales and contour intervals are {53.0', 8.0', 2.0'} horizontal, and {10.0', 5.0' and 1.0'} vertical. Actual topographic data quality is known only for the 1991 topographic data set which has standard map errors of {1.6', 7.8'} horizontal and {1.3',6.8'} vertical for the Laboratory and county respectively (Cole, 1993). Note that the errors in vertical position apply to relatively flat terrain and may be considerably larger on cliffs. Comparison and calibration of the early base map topography with the 1991 survey topography will be necessary before accuracy and precision of early base map elevations can be assessed.

3.4.2 Drill hole data quality

The drill hole data can have errors in location of the hole and in stratigraphic unit identification/depth position within the hole. The stratigraphic unit assignments were checked for reasonableness and consistency by comparison with the Bandelier and Cerro Toledo stratigraphic system of Broxton and Reneau (1995) and with the criteria in Section 2 of this report. As many of the older drill hole data were obtained from archival records and maps, usually old engineering drawings with LASL coordinates, the locations were of unknown quality. Several gross mislocations of drill holes were discovered during the early stages of data assessment. A procedure was therefore set up to screen the locations for those drill holes relevant to the 3-D model. The location of a drill hole was first checked by comparing the published collar elevation at the drill site with the 1991 survey elevation (assumed accurate to 1.3') for that site. When the deviation between the two exceeded 5', the {x,y} coordinates were assumed to be in error. In every case, field checks utilizing the orthophotos associated with the 1991 survey verified that the reported coordinates were in error, sometimes by amounts exceeding 100 feet. For those holes the {x,y} coordinates were corrected before the drill holes were integrated into the site-wide geologic model. The results of these corrections can be seen in Appendix Section 10.4.2: small deviations (<5') between original (o) and corrected (c) surface elevations were not corrected in the field and therefore the original (o) and corrected (c) {x,y} coordinates are the same; larger deviations in original (o) and corrected (c) surface elevations were corrected in the field, resulting in differences between the original (o) and corrected (c) {x,y} coordinates.

There is a slight possibility that an erroneously located hole could fortuitously have been mislocated at the proper elevation. However, unless the location error is significant (>100'), errors in the position (with correct elevation) of stratigraphic picks would have a minor effect on the model because of the flat-lying nature of most stratigraphic units. Ultimately, all drill holes which contribute stratigraphic information to the site-wide model should have their locations field checked.

3.4.3 Geologic map data quality

Although some of the relevant data were already in digital format, much of the source data were presented as paper maps or text. Conversion of the data to electronic/digital format was accomplished with minimum degradation in data quality. Line and point digitizing were done at such a scale that digitizing errors (normally less than .04 inches) were insignificant in comparison to typical field positional errors. For all data sets, check plots of digitized locations and unit names were compared with original data, generally by someone not involved in the digitizing process. Qualitative and/or quantitative error estimates assigned by the original field worker were stored in the data record to assist in future data quality assessments.

The generation of individual geologic maps involves both ground mapping and extrapolation utilizing aerial photographs and topographic maps. Principal sources of

error in placing geologic boundaries on a base map include: the correct and consistent definition and identification of unit boundaries at select sites in the map area, correct extrapolation/interpolation between and beyond these sites, and correct positioning of the geologic observations on the base map. Factors which influence the source error include the ease with which geologic feature can be identified in outcrop, the amount of outcrop available, and the ease with which fields positions can be properly located on a base map.

Our database is a compilation of geologic map data from many sources with varying quality and scales. A primary source of error in this compilation is lack of consistency in published stratigraphic unit definitions, which could result in merging of contact information which does not truly reflect the same stratigraphic boundary. Additional errors in the database compilation are due to the mix of topographic data used for the base maps. While the proper source topographic data were used in the acquisition of digital location data from the geologic maps, an in-depth comparison and calibration of the three topo bases could not be accomplished within the scope of this study. This calibration is an important next step in quantifying the quality of the available data. The database table for the contact points contains a qualitative (non-numeric) quality field, based upon information from the source data, and a quantitative quality field which reflects the quality issues discussed here. The quantitative data quality measure has not yet been assigned for our observations. Such an assignment requires detailed field checks in order to calibrate the data-set specific, descriptive quality measure with a database-standard, numeric quantity. Future assessments of these data for generation of stratigraphic models should incorporate the quality of the individual control points as well as the data density of the points from each data set, in order to provide a proper and unbiased weighting of the data.

3.5 Additional data sources not utilized for the current model

There are other data available in our data set which are not utilized in our current model. Most of these data are of a derivative nature. For example, there are contoured representations (interpretations) of the base of the Tshirege and Otowi Formations (Broxton and Reneau, 1996). We also have digitized isopachs of the Tsankawi and Gauje Pumice beds (from Self et. al., 1995) which will derive their 3-D representation from our placement of their basal contacts. Various sources of geophysical data may provide models for indirect identification of structural features and/or stratigraphic contacts. Cross-sections, including those provided by this report, can be digitized and integrated into the data set in order to provide a model refined by expert opinion.

Additional surface observational data will eventually be available to provide important stratigraphic controls on both the north (Guaje and Rendija Canyons) and south (Frijoles Canyon) sides of the Laboratory. Additional drilling, coring, and logging will also occur in the near future, and will provide a test of the predictive capabilities of the current 3-D geologic model.

4. The Model

The model which is presented as the 1996 3-D geologic model is based upon a minimum of geological and mathematical interpretations and/or assumptions. This model consists of a collection of surfaces which model the contacts between the stratigraphic units. The surfaces that model the contacts are piece-wise linear. Structures that could result in step-wise offsets of units and contacts are not a part of this model. The intent of this first model is to present a three-dimensional view of the quantified geologic knowledge base (raw data). Positioning of contacts is probably correct (within drilling, logging, or fieldwork uncertainty) at control points only. Interpolation or extrapolation by linear prediction provides a first order visualization of reality which can be greatly improved by our qualitative knowledge of the regional and local geology. This model does have predictive capabilities and therefore can be validated (with quantifiable uncertainties) by future geologic work. Future models can incorporate added observations, adjustments based on expert opinions (e.g., topography of basal Tshirege and basal Bandelier surfaces in Broxton and Reneau, 1996), selective weighting of observations based upon data quality and density of observations, numerical smoothing of interpolated surfaces, etc.; and replace the current model as a predictive tool.

4.1 Tools

A combination of commercial and locally-written software was used in the generation of the model. Local software was used for data formatting, acquisition of elevation values, creation of 3-D data structures, and extraction of data from the database. ARC/INFO software was used to digitize line information and create the 3-D surfaces representing unit boundaries. IBM Data Explorer software was used to perform visualizations of the 3-D database.

4.1.1 Model Creation

The contact surfaces were defined by creation of TINs (Triangular Integrated Networks) and subsequent gridding of the resultant surface. Tools for this task were available from the ARC/INFO software. The TIN surface for a particular contact is a continuous faceted surface of triangles whose vertices are the observed contact (control) points from our 3-D database. The ARC/INFO procedure uses Delaunay triangulation: i.e. a circle drawn through the three vertices of a triangle will contain no other points. This insures that:

- triangles are as equiangular as possible,

- any point on the surface is as close as possible to a node, and

- the triangulation is independent of the processing order for points.

Any point on the edge of a triangle is a linear interpolation between two vertices; any point on the face of the triangle is a linear interpolation at the surface defined by the three surrounding control points. For this model, there was no explicit definition of the zone of interpolation of the data. Therefore the region is defined by the maximum-sized polygon that can be generated by the outer points (called the convex hull).

The TIN surface was then gridded at resolutions of both 50 and 100-feet and clipped by a rectangle that included all areas of the Laboratory and townsite which were of interest and had data. The gridded region extends from:

1,606,000 - 1,666,000 feet East (NMSP NAD83)
1,732,000 - 1,796,000 feet North

The choice of grid sizes is somewhat arbitrary. The control points are generally spaced at greater than 100 feet, so the 100-foot grid provides a suitable graphical presentation of the surface. As there are only one-fourth as many cells (641 x 601) for the 100-foot grid as for the 50-foot grid (1281 x 1201), visualizations can be accomplished at a faster rate with the lower grid resolution. However, interpolation/smoothing errors are more noticeable in the coarser grid, especially near the control points and edges of the TIN, where abrupt slope changes occur. The finer grid allows smoother rendition of the region where grid cells penetrate the land surface.

4.1.2 Information extraction

Tools locally developed to extract information from the 3-D database include the utilities: get_elev and get_strat. The program: get_elev provides elevation values for sets of geographic coordinates. The program: get_strat provides elevations and depths of intersection to the set of stratigraphic boundaries for a set of geographic coordinates. The program: get_cross_xy generates a set of equally-spaced points (x,y coordinates) along a set of scattered control points (fence posts). Output from this program can be used as input to get_strat, in order to create cross-sections or fence diagrams. These programs are described in Appendix Section 10.6.

4.2 Model Rationale

The 3-D database contains the locations of contacts between stratigraphic units. Most but not all of the points identify units that are adjacent in the stratigraphic column. For a variety of reasons, contacts are also present for units that are not adjacent on the stratigraphic column. For example, there could be a geologic disconformity representing a time interval during which portions of some units were removed by erosion prior to subsequent deposition; or there could have been highlands within the depositional environment.

The stratigraphic boundaries presented in the model represent the bottom of a particular unit. The selected set of points used to generate a surface met the requirement

that the upper unit was the unit of interest; the lower unit for the selected point could be from any stratigraphically lower unit. Illustration of the lower boundary of the units was in part predicated by the assumption that this surface would be more like to provide pathways for ground water migration. For example, the lower portions of the Bandelier flow units are permeable pumice beds; many clastic units typically "fine upwards", i.e. the coarser-grained and more permeable sections are near the base, and buried erosional surfaces, i.e. the basin for new deposition, provide an impervious layer to flow and encourage flow in the base of the overlying units.

All of the surficial deposits: Qfill, Qc, Qmt, Qls, Qf, Qal, Qt, and Qec, are grouped together due to their discontinuous nature, although the present model does permit the separation of Qmt and Qal (see Section 2.1). Mesa-top pumice deposits, the El Cajete Member (Qec) of Rogers (1995), are probably considered as surficial by other researchers and thus are included in this group. The base of this collective group provides the "bedrock" surface.

When unit deposition occurs in an area with topographic highs, the unit may pinch out. Although no control points for the base of this unit would be found in the area of former highlands, there could be control points surrounding this region. The modeling process therefore interpolates a surface boundary through the area of the former topographic high, even though deposition never occurred here. For those stratigraphic intervals where this was considered a problem, additional control utilizing other units was provided to define this "pre-depositional" surface. For example, the Bandelier Tuff was deposited on an existing erosional surface, so that the basal Guaje Pumice (Qbog) has pinch-outs against pre-existing older basalts. In order to identify this surface, the set of control points included contacts whose upper unit was of age Qbog or younger, and whose lower unit was of an age older than Qbog. This approach assumes that the highland was ultimately buried by a younger unit. The elevation of the contact over the highland region would be modified (reduced) somewhat by post-Qbog erosion occurring prior to its burial. We created pre-depositional surfaces for the following units: Tsfuv, Tpt, Tpf, Qbog, and Qbtt (see Section 2).

4.3 Results

The results of our modeling efforts are a series of stratigraphic surfaces that can be viewed in 2 or 3 dimensions. Due to the large differences in the horizontal and vertical range of the data, and the topographic complexities, it is very difficult to view all the stratigraphic surfaces for the entire study area at a single time. The individual stratigraphic surfaces are presented as a series of contour plots, showing the data support as well as the TIN surface. These plots will assist in review of the data quality of individual data points and data sets. Several site-wide plots illustrating the present, pre-Tshirege, and pre-Otowi topography have been produced using the processed/contour data of Broxton and Reneau (1996) for the older units. The database and modeling tools are more effective at a larger scales. Appendix 10.12 provides more complete, larger-scale illustrations of the stratigraphy at TA-21 and TA-49.

The current model provides interpolation and extrapolation of our control (contact) data set and allows "linear" prediction of expected stratigraphy for areas of interest. The predictive capabilities of the model are tested by providing a list of predicted stratigraphic intersections for the proposed set of monitoring wells (Appendix Section 10.8). These predictions can be updated as the model is improved. As these holes are completed, actual and predicted intersections can be compared to provide a quality measure for the existing model, form the foundation for new models, and assist in identifying where additional information is needed.

5. Assessment of Geophysical Logs and Petrologic Constraints on Interpretations

Stratigraphic interpretations from drill holes that are not cored can be determined from drill-hole geophysical logging. In cored holes, geophysical logs can provide finer detail for intervals that are not well preserved in the core. In this section, we examine the quality of existing geophysical logs and assess the possibility of getting useful information from them. The aim was to look at several logs, assess the quality of the geophysical data, flag problems, and answer three questions:

1. Can the logs be made quantitative?
2. Can we distinguish lava flows from sedimentary units?
3. Can we estimate grain size of sediments to distinguish, say, a sand from a gravel or cobble bed?

Geophysical logs and supporting data from three boreholes were compared in detail; other geophysical logs were briefly reviewed. Appendix 10.2 summarizes the available logs for all drill holes at the LANL site. The three primary boreholes examined were Pajarito Mesa 1 (PM-1), Otowi 4, and Sigma Mesa (EGH-LA-1). From this examination, the three questions above can be answered.

5.1. Can the logs be made quantitative?

Many of the logs, although not all, can be made quantitative. There is no simple set of rules to determine *a priori* which ones can be made quantitative. Generally, logs run in cased boreholes cannot be made quantitative, at least not reliably, because reliable corrections cannot be applied for the unknown conditions behind the casing such as borehole diameter. Logs run in uncased boreholes by experienced contractors (e.g., Schlumberger) can generally be made quantitative, even in the case of very old data. For example, PM-1, which was logged by Schlumberger in 1964, is a good candidate for a quantitative interpretation. Similarly, the data from Otowi-4, logged in 1990 by Schlumberger, is already fairly quantitative. On the other hand, the data from Sigma Mesa EGH-LA-1, logged by Schlumberger in 1979, can not provide quantitative results because only crude field prints are available and some important data are missing. Also, Sigma Mesa was a very large diameter borehole that exceeded the normal operating range of some of the logging tools.

It is worth considering the problems with the borehole geophysical logs in the Sigma Mesa hole, because they illustrate problems that should be avoided in future logging. The logs from this hole, run by Schlumberger, include dual induction/spherically focused log/SP, bulk density/neutron/gross gamma, and caliper. The quality of the logs is poor overall. Only field prints are available; there are no final prints and no digital copies. There is evidence of serious drift and/or malfunction, with possible knobbing (adjusting during logging). The borehole was drilled with a 26" bit and is generally rugose and frequently enlarged. The large diameter is a good reason why the logs might be bad. Pad-type tools may not have maintained good wall contact and data from such tools are therefore likely to be compromised. Locally, the caliper indicates a fairly uniform borehole at about 28" from 830-1330' and from 360-520 and 620-660. This probably indicates fairly competent material that drills well. There are problems with ambiguity in scales - backup curves are supposed to be hatched to distinguish them from the standard scales, but they are not. The gamma log goes offscale above the water level (1170') for no apparent reason and is useless above that depth. The dual induction log shows very high resistivities with the deep induction but modest resistivities with the medium induction above 1270', a phenomenon that suggests equipment problems. Bulk density indicates a lot of high density (2.5 g/cm^3) material from 1315' to the bottom. Specific zones of high density occur at 1318, 1330, 1352-1362, 1368-1384, 1389-1418, 1425-1435, 1470-1482, 1520, 1548-1560, 1564, 1584, 1590-1595, 1605-1667, 1687-1732, 1790, 1817, 1824, 1851-1855, 1877-1882, 1910-TD. These high-density layers don't necessarily correlate well with the resistivity log, which is odd and another possible indication of tool problems. In summary, the lack of calibration and documentation makes it extremely difficult to obtain quantitative data from these logs.

In comparison, the example of PM-1 will be used here to give an indication of typical procedures for making the data quantitative. PM-1 was logged by Schlumberger on October 28, 1964. The drilling fluid in PM-1 was fresh mud; at the time of logging the borehole was fluid-filled to the surface and cased from the surface to a depth of 742 ft. Log results and the potential for quantification in PM-1 are described below.

5.1.1. Gamma Ray Neutron Log

As the name implies, the Gamma Ray Neutron tool produces two curves, gamma ray and neutron. The tool contains a neutron source, a neutron detector, and a gamma-ray detector.

Neutron log

The neutron log is made using a neutron source and one or more detectors spaced along the tool. In the case of the Schlumberger neutron log run in borehole PM-1, the detector was a GM tube and the source was a 5 curie plutonium-beryllium source that produces neutrons based on the (α,n) reaction. The source-detector spacing was 19.5 in. The neutron log is primarily affected by hydrogen in the formation and borehole fluids, and is therefore used mostly for estimating water content of the formation.

The neutron log from borehole PM-1 is plotted in API (American Petroleum Institute) neutron log units. These units are proportional to count rate and essentially inversely proportional to the logarithm of water content. The blueline (blueprint copy of log curves, in z-fold form) does not provide a calibration, but a rough calibration can be made from the log itself if we are willing to make some assumptions. The procedure is to estimate porosity (water content of a saturated formation in percent by volume) in a low porosity zone(Φ_L) and a high porosity zone (Φ_H). These values, and the deflection of the log in those two zones in API units (D_L and D_H), allow us to estimate porosity in an unknown zone, Φ, from the log deflection in that zone, D, using the following equation:

$$\frac{\log\Phi - \log 45}{D - D_H} = \frac{\log\Phi_L - \log\Phi_H}{D_L - D_H} \qquad (1)$$

To estimate a value for Φ_L we must pick one or more zones that appear to be the least porous (have the highest API values) and assign them a reasonable porosity (generally 1 - 3 per cent). To estimate a value for Φ_H we make use of the fact that this particular neutron tool characteristically saturated (reached a minimum API reading) at around 45 per cent saturated porosity and produced essentially that same reading at 100 percent water. Therefore, we use the tool reading in a large washout to give $D_H = D_{45\%}$ and $\Phi_H = 45\%$. For borehole PM-1, I used $D_H = 400$ API at $\Phi_H = 45\%$ and $D_L = 1300$ API at $\Phi_L = 1\%$ to provide an approximate calibration.

Other neutron logging tools have other response characteristics, but generally a suitable calibration can be made using procedures similar to those given above if the tool characteristics are documented in the literature, as in this case.

Gamma-ray log

The gamma-ray log is also called gross-count gamma ray or natural gamma ray, among other names. This log is made using a gamma-ray detector, in this case a scintillation detector, that records gamma radiation from the formation and the borehole fluid. The gamma-ray log from borehole PM-1 is plotted in API (American Petroleum Institute) gamma-ray log units. These units are proportional to the gamma-ray count rate seen by the detector. Since this type of tool is not capable of identifying the emitting radionuclides, the gamma-ray log provides only a qualitative indication of formation radioactivity.

The gamma-ray log is used in petroleum logging primarily to estimate shale content of potential oil reservoir rocks. It could potentially supply useful lithologic information for the Los Alamos environmental program as well, but we would need more information on the concentration of natural gamma emitters in the various formations in this region to utilize this log fully.

5.1.2. Microlog

The Microlog was an early pad-type micro-resistivity device introduced by Schlumberger in the late 1940's. It was later replaced by more sophisticated micro-resistivity devices such as the Micro-SFL (Spherically Focused Log). The Microlog tool

used a small insulating pad containing three exposed button electrodes aligned vertically one inch apart. Early versions of the Microlog used a solid rubber pad and a bow spring to hold the pad against the borehole wall. By the time the logs were run in LANL borehole PM-1, the tool had been redesigned with an oil-filled hollow rubber pad to conform better to the borehole wall. In the redesigned tool, the pad was held against the borehole wall by a deployable arm assisted by a backup arm deployed against the opposite wall.

Three curves are shown on the Microlog blueline: (1) Microcaliper, (2) Micro-normal 2", and (3) Micro-inverse 1" x 1". The caliper curve (called Microcaliper because it was part of the Microlog service, not because it had exceptional resolution) was obtained from the pad deployment arm and the backup arm described above. The Micro-normal curve used the lower electrode as the current electrode and the upper electrode as a potential measuring electrode; current return and the potential reference are both to a remote electrode, which could be farther up the tool string or on the surface. The Micro-inverse also used the lower electrode as the current electrode and measured potential between the upper two electrodes; current return is once again remote.

The Microlog has great vertical resolution, revealing variations in resistivity between beds just a few inches thick. As such, the curves are very active with rapid excursions that can be real or can result from intermittent pad contact, especially in rugose sections of the borehole. When the Microlog pad is unable to follow the borehole wall in washouts, especially large washouts, it should read essentially the mud resistivity R_m. The mud resistivity reported for PM-1 in the log headers was 7 ohm-m^2/m (usually simplified to ohm-m) at 72 °F. There are a number of washouts indicated on the caliper log where the Microlog seems to be reading essentially the borehole mud resistivity, including between roughly 740-840 ft, 995-1055 ft, 1130-1140 ft, and 1695-1716 ft in PM-1.

Mudcake and formation permeability

The Microlog is primarily suited to identifying mudcake and as a qualitative permeability indicator. Micro-resistivity readings will tend to decrease as formation permeability increases. In a borehole drilled with mud, mudcake is likely to form along the borehole walls in permeable formations. In such situations, the Microlog pad is likely to ride on or in the mudcake layer; this is especially true in fresh-water muds, less so in salt or gypsum-bearing muds. Generally, the Micro-inverse curve is influenced more by the mudcake than the Micro-normal curve because the Micro-normal has a greater depth of investigation, on the order of 4 in. compared with 1.5 in. for the Micro-inverse. Since formation resistivity is generally greater than mudcake resistivity, permeable formations will typically exhibit a "positive separation" with the Micro-normal indicating greater resistivity than the Micro-inverse. Low porosity formations will generally be indicated by high Microlog resistivities which may or may not exhibit separation between the two Micro-resistivity curves. Separation in the case of impermeable zones is likely to be caused by poor pad contact.

Mud resistivity

The logging engineer lists the mud resistivity on the log header as being 7 ohm-m at 72 °F. Presumably, that value was measured on the surface from a mud sample. The Microlog tool was run over a portion of borehole PM-1 with the pad and backup arm collapsed so it reads mostly mud resistivity. For PM-1, it is possible to estimate R_m = 5 ohm-m at 2230 ft and R_m = 6 ohm-m at 1520 ft. Checking the temperature log, temperatures at those depths are around 78 °F and 71.5 °F, respectively. Correcting these estimates of R_m for the variation in resistivity with temperature indicates a range of mud resistivities from 5 to 6.2 ohm-m at 78 °F (Table 4). This information is needed for a qualitative understanding the behavior of the various resistivity curves and can also be used for applying borehole corrections if a more detailed quantitative analysis of the logs is to be made.

Table 4. Estimated values of borehole mud resistivity Rm with temperature corrections.

Depth (ft.)	Measured R_m (ohm-m)	Temperature of R_m measurement (°F)	R_m corrected to 78 °F (ohm-m)	Comments
0	7.0	72.0	6.2	Surface reading from mud pit
1520	6.0	71.5	5.5	Microlog (collapsed)
2230	5.0	78.0	5.0	Microlog (collapsed)

Caliper

Caliper logs are typically obtained using one or more spring-loaded fingers that follow the borehole wall. The Microcaliper curve from the Microlog is obtained from the arm holding the pad containing the electrode array and the backup arm deployed against the opposite wall. The caliper curve provides several types of important information.

- *Borehole correction* - The caliper log reveals enlarged zones where the log may give erroneous data because of increased influence of the borehole on the log. For example, in a washed-out borehole, a low-resistivity borehole fluid could cause formation resistivity estimates to be too low because the tool averages in more of the low-resistivity medium than would happen under the standard conditions for which the tool was designed. Sometimes these borehole effects can be corrected using tool-specific borehole correction charts or algorithms.
- *Borehole rugosity* - The caliper log reveals rugged sections of borehole where pad-type tools such as the Microlog may be affected by local variable gaps between the pad and the borehole wall.
- *Lithology* - The character of the caliper log supplies corroborating information to aid in lithologic identification and correlation between boreholes. Enlarged zones may be loose, soluble, or friable. Zones with smooth walls at bit diameter may be

relatively impermeable with good mechanical properties for drilling. Zones below bit diameter may be permeable (see below).

- *Permeability* - The caliper log can help identify permeable zones in certain lithologies where the caliper log may read below bit size. This occurs in mud-drilled holes because the liquid in the mud is forced into the formation by excess pressure in the borehole, leaving behind mudcake on the wall of the borehole. This process can continue for some time after the bit has been removed from the borehole.

5.1.3. Induction Electric Log

Four curves are plotted on the Induction Electric Log (IEL) blueline, induction conductivity, induction resistivity, short-normal resistivity, and spontaneous potential (SP).

Induction resistivity

Induction conductivity is measured by a method similar to the electromagnetic survey techniques used in surface geophysics, inducing currents in the formation and measuring the secondary field induced in one or more of the instrument coils by the currents in the formation. The induction tool used in borehole PM-1 was the Schlumberger 6FF40, a six-coil design with four focusing coils and a 40-in primary transmitter-receiver coil spacing.

The induction technique is sensitive to conductive beds, including relatively thin (~2 ft or greater) conductive beds in thick resistive sequences. It is relatively insensitive at high resistivities and resistive beds in thick conductive sequences must be 6 ft thick or more to give a reasonable response. Induction resistivity is basically the inverse of induction conductivity, or

$$C = 1000/R$$

where C is conductivity in millimhos/m and R is resistivity in ohm-m.

Induction logs run by the major logging companies can be corrected for non-standard borehole conditions using published charts. This can be a tedious process if the entire log is corrected, but it is fairly easy to correct the data for a few zones of particular interest. Mostly, this log can be used qualitatively for identification of particular lithologies such as basalt.

Short-normal resistivity

The short-normal resistivity measurement is one of a number of direct-current or low-frequency measurements used in boreholes, analogous to electrical resistivity measurement techniques used in surface geophysics and roughly similar to measuring the resistance of an electrical circuit with a volt/ohm meter. The short-normal measurement uses two electrodes on the non-conductive tool exterior, a current electrode and a potential electrode, spaced 16 in. apart. A long-normal measurement is sometimes made with an electrode spacing of 64 in., although a long-normal measurement was not made in

this borehole. A current return electrode and a voltage reference electrode are located elsewhere on the logging cable, a relatively large distance from the electrodes on the tool body.

The short normal device does a reasonable job of estimating resistivity in beds 4 feet thick or greater. Relatively thin conductive beds also show up well, although generally resistivity and bed thickness are both overestimated in this case. Instrument response in thin resistive beds is poor and such beds may be missed in the analysis of the short-normal log. Again, correction can be applied using published charts if quantitative results are needed.

Spontaneous potential

The spontaneous potential or SP curve shows the relative dc voltage (with no recorded zero) measured between an electrode on the tool housing and a remote electrode. It is very similar to the SP measurements made in surface geophysics, although the target of the survey is generally different. In a sense, the SP curve basically reveals combinations of geologic materials acting as natural batteries. In the case of surface geophysics for mineral exploration, the target is generally sulfide deposits. In borehole logging (other than minerals logging) the SP log is usually used (1) to identify permeable zones (without indicating relative permeability), (2) determine values of formation water resistivity (R_w), and (3) to give a qualitative indication of formation shaliness. For the SP log to be useful for these three functions requires water of two distinctly different salinities in the presence of a shaley formation. SP is inherently qualitative.

5.1.4 Temperature Log

The temperature log is a record of borehole fluid temperature obtained with a temperature sensor such as a thermistor. The vertical temperature profile in undisturbed ground is primarily a function of regional heat flow rates, thermal resistivity of the rock, surface climate, and local heat sources such as radionuclides in the rock. In addition to these fundamental factors, borehole temperatures are affected by thermal effects of drilling and borehole completion and disturbances of the borehole fluid such as caused by groundwater flows. Borehole temperature profiles recorded shortly after completion of drilling are typically highly disturbed by the drilling process, requiring weeks or months to approach thermal equilibrium. Since PM-1 was logged on the day total depth was reached in the drilling, the temperature log is useful mostly for correcting other log curves for temperature effects. It is possible that the temperature log could supply some information related to groundwater flows in PM-1, but that topic is beyond the scope of this report.

5.2. Can lava flows be distinguished from sedimentary units?

There are no absolute rules for identifying rock types based on geophysical logs. In general, log analysts learn the characteristics of the various logs to lithologic units in a given region. We are just beginning that process at Los Alamos. From the logs examined to date it appears that basalts can be identified unambiguously in many cases.

Basalt is typically more dense and less porous than other rocks found in the Los Alamos area. Basalt layers in PM-1 appear to share the following characteristics on the geophysical logs:

- Electrical resistivity: high. This is consistent with low water content, implying low porosity and/or permeability.
- Neutron water content: low. Again, this is consistent with low water content, implying low porosity and/or permeability.
- Gamma radiation: low. This is probably due to low potassium content. This diagnostic characteristic could be negated by elevated U or Th family gamma emitters and is probably the least reliable of these indicators. A spectral gamma-ray log would be capable of identifying the emitting nuclides and therefore would be a more definitive indicator of lithology.
- Bulk density: density logs were not run in PM-1. As expected, density logs in other local boreholes seem to exhibit high excursions in basalt zones.

5.3 Can grain size be determined in sedimentary units?

The initial assessment of this issue is that grain size in sediments cannot in general be identified, even qualitatively, based on the logs alone. As we gain experience in looking at geophysical logs from the Los Alamos area we may learn to identify particular lithologic units based on the log response, and we may know that those units tend to be of a particular grain size. Borehole logs can give information regarding porosity and, in a qualitative sense, permeability when conditions are favorable; also shaliness can be estimated, although that will require more experience in this particular area, but there is no way to calculate grain size.

5.4 Do the existing geophysical logs provide important information for the site geologic model?

The existing geophysical logs contain much information, but the use of these logs is severely limited by the general lack of calibration and of digital data. The latter problem can be dealt with to some extent by falling back on subjective interpretations or by manually digitizing the curves from paper copies of the logs. However, we feel that this effort would be difficult to justify because of the calibration problems. To insure that future geophysical logs provide cost-effective information, it is vital that they be calibrated and provided in digital form.

5.5 "Bootstrapping" of geophysical and petrologic data from future cored holes

Stratigraphic interpretations based on cuttings from drill holes can be problematic. This is particularly the case where units without adequate outcrop exposure are being sampled. To a large extent, this applies to virtually all of the sub-Bandelier stratigraphic units of the LANL site. The large thicknesses of Puye sediments reported for the central LANL area contrast with the field studies that show the Puye thinning from the north toward the LANL site (Waresback and Turbeville, 1990). This suggests a new basin structure with new sources in most of the drill holes of the LANL site. The Totavi unit at

the base of the Puye may only be superficially continuous, if it is indeed comprised of a set of buried Pliocene terraces (Reneau and Dethier, 1996). The basin form and source regions for the main aquifer (Tsfuv) remain poorly known. Finally, the sources and varieties of lava units intercalated with these sediments still defy simple correlation between available drill holes. Collection of core samples from these key units, rather than cuttings, will provide the basis for much more defensible models of LANL site stratigraphy. Core samples will preserve the clast populations and clast size distributions, as well as the textural properties, critical to interpreting sedimentary units. Core samples will also allow the reconstruction of flow versus interflow units, including intercalated sediments, in the lavas beneath the site. The collection of core materials must be supplemented with competent collection of digital borehole geophysical data.

The principal use of borehole geophysical data from cored holes will be in developing a library of quantified geophysical properties that are well-correlated with lithologic units. This will include measures of both saturated water content and permeability, based on the tools and logging methods described above. By correlating these data with the petrographic analysis of core samples, specific signatures of important geohydrologic units can be categorized. By these means the geophysical recognition of key units can be "bootstrapped" from the library of core comparisons. The library of geohydrologic unit characteristics can then be used to evaluate the geophysical data from the majority of future drill holes that are likely to be drilled without core collection.

6. Interpretive Cross-Sections

Appendix Section 10.9 shows cross-sections that were prepared, based on the site-wide digital stratigraphic model, to illustrate the interpretations and predictive uses of the digital model. Six section lines were prepared. All six sections are represented at 10x vertical exaggeration. Five sections (excluding A-A') that include the Bandelier Tuff are also represented by sections at 25x vertical exaggeration to display unit stratigraphy within the Bandelier. All sections are drawn at the same horizontal scale (1 cm = 2500 ft). The sections are controlled by borehole intersections; all boreholes are shown at scale depth. Included are intersections with the principal "library' boreholes proposed for the Ground Water Protection Plan; these are the future cored holes R-1, R-6, R-9, R-14, R-16, R-25, R-28, and R-32. Strata intersections are interpolated across or projected to these drill cores.

At present, it is not possible to generate "final" cross sections automatically using the digital database. Lack of sufficient drill-hole control and lack of complete contact information in all existing drill holes allows intersecting stratigraphic surfaces. In addition, interfingering transitions, particularly between lava flows and sediments, are not coded into the digital model. These additions will take considerably more effort and will require subjective evaluations and interpretations based on extant knowledge of source lithologies, age controls, structural framework, basin morphology, volcanic sources and flow directions, and erosional history (disconformities). Thus the controls taken directly from the digital model and used in these cross-sections are as follows:

- surface terrain
- all contact intersections with the surface terrain
- the pre-Qbtt surface (modified only for Rendija Canyon and Guaje Mountain fault offsets)
- the pre-Qbog surface (modified for the same fault offsets as the pre-Qbtt surface and modified east of DT-9 in Section C-C')
- all solid-line intersections with existing drill holes (dashed or dotted lines are inferred; connections between drill holes are straight-line projections with the exception of the pre-Qbtt and pre-Qbog surfaces)
- all Tt or Tb lavas in existing drill holes (lava patterns between drill holes are interpolated)
- the water table

With these controls in mind, there are several points to consider in each of the sections in Appendix Section 10.9:

6.1 Section A-A'

Segment between R-1 and G-6 is highly speculative; there are no subsurface data in this area. Basinal form of Tsfuv/Tsfu contact, rising to the west, is based on projection from Section B-B" and assumes east-facing slope from Tt volcanic constructs to west. Fault shown between G-3 and G-2 is suggested in Griggs (1964).

6.2 Section B-B'

Occurrence of Tpt in H-19 is questionable; deepening of the target depth for R-6 by at least 50 ft would help to resolve this question. Basinal form of Tsfuv/Tsfu contact, rising to the west, is based on projection from Section B-B" and assumes east-facing slope from Tt volcanic constructs to west. Offsets along the Rendija Canyon and Guaje Mountain faults are speculative; both are interpreted as growth faults. Unnamed fault immediately west of O-4 is inferred based on fracture-density studies (Vaniman and Wohletz, 1990). Buried faults between O-4 and O-1 are suggested only; the abrupt rise of the Tsfu upper surface between these two drill holes (1500 feet in a distance of less than 12,000 feet) suggests the possibility of such structural control. Alternatively, the rise may reflect an erosional highland, a facies transition that is time-transgressive, or a misassignment of stratigraphy.

6.3 Section B-B"

The Rendija Canyon fault is projected farther south than the Guaje Mountain fault; paleoseismology studies in progress may affect this interpretation. Stratigraphy in the Sigma Mesa hole deviates from that reported for the digital model (see Appendix Section 10.4.2), based on work in progress by J. Gardner that places the Totavi (Tpt) lower than reported in the existing logs; this lower placement is in line with projections

between PM-5 and H-19 and avoids a problematic sharp upward rise in the Tpt unit at the Sigma Mesa locale. Faults east of PM-2 are highly speculative, extended from those suggested in Section B-B'. Basaltic feeder east of TH-5 is based on occurrence of basaltic vent in Pajarito Canyon (Dethier, in press). Arcuate fault and Toreva block at Rio Grande are based on work by Reneau et al. (1995b). The same sources provide evidence for rise in Tpt above the present Rio Grande, representing axial river gravels from former elevated base levels (ref. also Fig. 2 in Waresback and Turbeville, 1990).

6.4 Section C-C'

Amounts and forms of Tschicoma volcanic rocks beneath SHB-3 are unknown; Keres Group volcanic rocks may be present beneath or in place of Tschicoma lavas. The Qbt stratigraphy in SHB-3 is problematic; units Qbt1 and Qbt2 may be absent, either as shown (pinching out from the east) or by faulting. Future drill hole R-25 should be fully cored through the Bandelier to help resolve this question. Presence, form, and depth of Tsfuv/Tsfu contact is unknown. Basaltic feeder west of 33-1231 is based on occurrence of basaltic vent at TA-33.

6.5 Section D-D'

As in section C-C', form of Tsfuv/Tsfu contact to south is speculative.

6.6 Section A"-A'

As in section C-C', form of Tsfuv/Tsfu contact to south is speculative; core samples combined with geophysical logging data from R-28 should help in defining the base of the Tsfuv aquifer. The depth reported for the Tpt unit in PM-2 is problematic because the resulting "sawtooth" pattern in Tpt is unlikely. The absence of Tsfuv and sharp rise in Tsfu at O-1 leads to an odd dome-like structure in this section, caused by the oblique slice of Section A"-A' through the hypothetical faults shown between O-4 and O-1 in section B-B'. This odd structure points out the structural problems in the sharp upward rise of Tsfu and absence of Tsfuv in O-1, compared with O-4 and PM-3. Complete core sampling in R-9 will help to resolve this problem, although R-9 should extend an additional 500 ft beyond its present target depth to test whether the Tsfuv aquifer is indeed absent at this spot.

7. Data Limitations and Data Needs

7.1 Core control

Examination of geophysical logs, combined with re-examination of thin sections prepared from cuttings from the Sigma Mesa drill hole, shows that stratigraphic assignments based on logs plus cuttings (without thin-section analysis) are problematic. As a result of the reanalysis of Sigma Mesa, the Totavi (Tpt) may be reassigned to a depth 200 ft deeper than reported in Appendix Section 10.4.2. Cuttings are particularly

difficult to work with where contributing formations vary greatly in consolidation and sedimentary units may include beds of coarse cobbles. Collection of core samples from drill holes in representative localities will be necessary to correct this limitation.

7.2 Quantitative borehole geophysical data

Digital geophysical logs are available for only some instruments and only from the most recently drilled, shallow holes that did not penetrate significantly beneath the Bandelier Tuff. Most of the stratigraphic uncertainties at the LANL site are beneath the Bandelier Tuff. Although it was found that some of the borehole geophysical logs might be made quantitative, many have significant problems and the labor required to correct these problems would be intensive. Instrument calibration records and supply of data in digital form should be required for future borehole logging.

7.3 Integration of geohydrologic parameters with geologic model

Geohydrologic parameters, particularly the values for bulk density and saturated hydraulic conductivity, might be linked to several of the Bandelier subunits and the Cerro Toledo as defined in the current sitewide geologic model (ref. Rogers and Gallaher, 1995). Largely unknown but of importance are the geohydrologic properties for the Puye units, the Santa Fe Group sediments, and the intermediate and basaltic lavas. Many of the subsurface pathways at the LANL site, both saturated and unsaturated, are separated from the Rio Grande by basaltic lavas, by basaltic lava interflow units, and potentially by basaltic phreatomagmatic deposits. These important units should be characterized.

7.4 Structural data (fault systems)

Borehole strata interpretations, hydrologic data (Purtymun, 1995), and areal gravity data (Ferguson et al., 1995) all suggest a major depositional basin beneath the LANL site. It is quite possible that this basin is structurally controlled, bounded by portions of the Pajarito Fault system to the west and perhaps by yet unknown fault systems closer to the present axis of the Rio Grande. Because faults can have a significant effect on flow and transport, data are needed on the presence or absence of such structures. In addition, the importance of the Tsfuv unit as the principal aquifer beneath the LANL site points to a need for understanding the structural controls on its origin and the possible structural connections between this unit and the Rio Grande.

8. Recommended Future Work

8.1 Checks of drill-hole locations

Several errors in recorded drill-hole locations were discovered in the course of this study (see Section 3.4.2). Obvious errors have were corrected during the course of the study, but time was not available for systematic field checking of the accurate

location of all drill holes used for the geologic model. Such a check, based on field locations compared with digital orthophotos, should be completed.

8.2 Checks of contact locations

The digital geologic model can be intersected with the digital elevation model to provide images that can be checked against field data. Because the surfaces in the digital geologic model are based on a combination of several map sources as well as internal contacts reported from drill holes, there will inevitably be some cases where the intersections with the land surface are in error. Images of the intersections need to be checked and corrected in the field. In addition, judgments must be made where data for overlapping maps by different workers are entered into the database. Field-checking should be a part of the evaluation required for deciding between multiple credible sources.

8.3 Correction of unrealistic drill-hole or outcrop intersections of stratigraphic contacts

Following the field evaluation of the stratigraphic contacts, each stratum needs to be evaluated for unrealistic properties (e.g., impossible strata interpenetrations or topologies). Interpretation, based on reasonable geologic assumptions, then needs to be applied to correct these problems. It will be very important to clearly flag those portions of the model that are interpretive and those that are based on intersection data controlled by outcrops or drill holes.

8.4 Additional field data (canyons and fans)

Several field projects, either in progress or planned, have the potential to add significantly to the existing geologic model. Critical maps are about to be compiled or released for Frijoles Canyon (providing much new information in previously unknown areas to the south) and for White Rock Canyon (providing control to the east). In addition, field studies may provide thickness and structure information for the important fan deposits at the western margin of the site. These data should be incorporated into the geologic model.

8.5 Incorporation of non-borehole geophysical data

Non-borehole geophysical data have the potential to contribute greatly to the site geologic model. Gravity data have provided strong support for the inference of a structural depression beneath the central and western part of the LANL site (Ferguson et al., 1995). Seismic methods have been attempted with little success, but the use of advanced instrumentation and methods along canyon bottoms may yet provide useful information on subsurface structure. Electrical methods may hold promise in understanding perched systems. An evaluation of cost versus benefit for a suite of surface-based geophysical studies should be made.

8.6 Linkage of future cored-hole petrography with geophysical data

Borehole geophysical data of variable but generally limited utility have been collected in the past. In future drilling, it will be important to emphasize *calibration*, *digitization*, and most importantly *quality* in the collection of borehole geophysical data. Determinations of stratigraphy should be based on multi-log comparisons, in order to obtain the most information from the data purchased and to flag those sections where particular tools must be considered unreliable (e.g., washouts). If the logging methods are to be used successfully in uncored holes, then an initial comparison between core samples and geophysical data must be obtained from holes that penetrate the principal strata of interest. This should be linked with petrographic core analysis that will help to resolve many of the stratigraphic questions that remain unresolved at beneath the LANL site (sediment and lava sources, identification of marker units, offsets of marker units, presence or absence of lava vents, extent of phreatomagmatic sequences, presence or absence of lakebed units west of the present Rio Grande, etc.).

8.7 Centralization of all future data (ER, seismic hazards, etc.) for integration into the sitewide model, with adequate QA control on data inputs.

At present, the incorporation of geologic data into the FIMAD database is not accomplished under central authority. The database is generated piecemeal with input from a number of independent programs and sources. Stratigraphic usage is variable, with many workers generating field stratigraphies to fit individual mapping needs. It is important to maintain the flexibility of individual mapping or logging decisions while providing a common basis for input of principal stratigraphic data into the database. A team, composed of representatives from the disciplines of geology, geohydrology, and geophysics, system should be tasked with the assessment and quality checking of data input into the geologic model and ultimately into the FIMAD database.

9. Acknowledgments and References

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Note: Designations in bold, within square brackets, identify abbreviated citations as used in the electronic database.

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10. Appendices

Appendix Section 10.1: The Digital Database

Appendix Section 10.2: Available Geophysical Logs

Appendix Section 10.3: Available Cuttings from Deep Drill Holes

Appendix Section 10.4: Compilation of Drill Holes and Stratigraphic Contacts

Appendix Section 10.5: Margaret Anne Rogers Data Use Agreement

Appendix Section 10.6: Computer Programs

Appendix Section 10.7: Digitized line work transfer to Margaret Anne Rogers

Appendix Section 10.8: Projected Intersections of Ground Water Protection Plan Monitoring Wells with the Current Model Contacts

Appendix Section 10.9: Set of Cross-Sections (6 at 10x and 5 at 25x vertical exaggerations)

Appendix Section 10.10: Color Key for Geologic Units

Appendix Section 10.11: Set of stratigraphic contact maps (23 each)

Appendix Section 10.12: Set of visualizations (2 each of TA-21 and TA-49)

Appendix Section 10.1: The Digital Database

10.1.1 Oracle tables and values

Oracle data tables were created and populated to facilitate the provision to FIMAD of a copy of the 3-dimensional database. The Oracle database will also facilitate future statistical and graphical analysis, and may be ultimately linked to the visualization software.

10.1.1.1 Foreign key tables and data entries

Foreign key tables provide lists of acceptable values for input into the data tables, and/or allow entry and storage of abbreviated codes rather than long data strings. The tables provide an automatic quality check during the process of entering data into tables. The checks are accomplished through table constraints. These constraints are applied when data is entered into the main tables. The "foreign key" constraint requires that data being entered in some column of the main table match an entry in some column of a foreign table. The scripts which create the foreign key tables are provided in the following subsections. The names of foreign key tables have been given a suffix of "_list". The entries following the "create table" statement identify the table columns or variables {name, type, length}, followed by table constraint clauses if applicable.

10.1.1.1.1 Table bound_type_list

This table identifies codes for boundary types in the 3-D contact table.

A. Table creation script:

```
create table bound_type_list   /* list of bound_type codes and bound_types */
    (
    bound_type_code      varchar2    ( 3),      /* i.e. c            */
    bound_type_name      varchar2    (15)       /* i.e. contact      */
    bound_type_desc      varchar2    (200)      /* i.e. conformable (...*/
    )
    tablespace    geol3d_fk1;
```

B. Data entries:

b[bedrock[interface between bedrock and unconsolidated material
c[contact[conformable (depositional or emplacement) contact
e[erosion[interface where erosion has occurred over a significant time interval
f[fault[interface along which significant offset has occurred
i[interior[point interior to a stratigraphic unit (not a boundary)

10.1.1.1.2 Table meas_type_list

This table identifies codes for measurement types in the 3-D contact table.

A. Table creation script:

```
create table meas_type_list    /* list of meas_type codes and meas_types */
    (
    meas_type_code      varchar2    ( 3),     /* i.e. s            */
    meas_type_name      varchar2    (15)      /* i.e. surface      */
    meas_type_desc      varchar2    (200)     /* i.e. measure from ...*/
    )
    tablespace    geol3d_fk1;
```

B. Data entries:

d[drill hole[measure from drill hole or well, usually by inspection of core
s[surface[measure from surface mapping
g[geophysics[measure from geophysical tool
p[processed[measure from processing of data; i.e. interpolated contours

10.1.1.1.3 Table ref_list

This table identifies codes for the data references.

A. Table creation script:

```
create table ref_list        /* list of acceptable ref codes and refs */
    (
    ref_code        varchar2    (15),     /* i.e. Bec,1994      */
    ref_name        varchar2    (400)     /* Becker, N.M., 1994...*/
    )
    tablespace    geol3d_fk1;
```

B. Data entries:

All data entries accessible by foreign keys are listed in square brackets and in bold text at the end of each associated reference in the reference section (Section 9) of this report.

10.1.1.1.4 Table strat_list

This table provides the stratigraphic model used in the 3-D database. This table has some special constraints due to "parent-child" relationships between some of the columns. These constraints require that the table be loaded (entered into the database)

with the proper stratigraphic sequence, youngest to oldest. In other words, a strat code must be present in the database before it can be a valid strat_group_code or upper_strat_code, to a successive strat_list record.

A. Table creation script:

```
create table strat_list        /* stratigraphic nomenclature and structure */
    (
    strat_code              varchar2    ( 7),       /* i.e. Qbog          */
    strat_group_code        varchar2    ( 7),       /* i.e. Qbo           */
    upper_strat_code        varchar2    ( 7),       /* i.e. Qbof          */
    strat_col_pos           number      ( 3),       /* i.e. 29          */
    strat_name              varchar2    (30),       /* i.e. Guaje         */
    strat_name_syn          varchar2    (30),       /* i.e. Otowi Pumice   */

    CONSTRAINT     fk_strat_group_code
      FOREIGN KEY  ( strat_group_code )
      REFERENCES   strat_list ( strat_code ),
    CONSTRAINT     fk_upper_strat_code
      FOREIGN KEY  ( upper_strat_code )
      REFERENCES   strat_list ( strat_code )
    )
    tablespace     geol3d_fk1;
```

B. Data entries ("["-delimited):

```
R[[[1[Regolith Group[
Qu[R[R[2[undifferentiated[
Qfill[Qu[Qu[3[fill[backfill
Qc[Qu[Qfill[4[colluvium[
Qmt[Qu[Qc[5[mesa top soil[
Qls[Qu[Qmt[6[landslide[
Qf[Qu[Qls[7[fan deposits[
Qal[Qu[Qf[8[alluvium[colluvium[
Qt[Qu[Qal[9[terrace deposits[
T[[Qt[10[Tewa Group[
Qv[T[T[11[Valles Rhyolite Formation[
Qec[Qv[Qv[12[El Cajete Member[
Qcr[T[Qec[13[Cerro Rubio Quartz Latite[
Qb[T[Qcr[14[Bandelier Formation[
Qbt[Qb[Qb[15[Tshirege Member[
Qbt5[Qbt[Qbt[16[ash flow[
Qbt4[Qbt[Qbt5[17[ash flow[
Qbt3[Qbt[Qbt4[18[ash flow[
Qbt3w[Qbt3[Qbt3[19[ash flow[Qbt3u
```

Qbt3nw[Qbt3[Qbt3nw[20[ash flow[Qbt3l
Qbt2[Qbt[Qbt3nw[21[ash flow[
Qbt1[Qbt[Qbt2[22[ash flow[
Qbt1v[Qbt1[Qbt1[23[ash flow[
Qbt1g[Qbt1[Qbt1v[24[ash flow[
Qbtt[Qbt[Qbt1g[25[Tsankawi[
Qct[Qb[Qbtt[26[Cerro Toledo Member[
Qbo[Qb[Qct[27[Otowi Member[
Qbof[Qbo[Qbo[28[ash flow[
Qbog[Qbo[Qbof[29[Guaje[Otowi Pumice
Tp[T[Qbog[30[Puye Formation[
Tpf[Tp[Tp[31[fanglomerate[unit "n"
Tpt[Tp[Tpf[32[conglomerate[
Tpl[Tp[Tpt[33[lakebed[
Tsf[[Tpl[34[Santa Fe Group[
Tsfuv[Tsf[Tsf[35[aquifer[Chaquehui, Chamita (?)
Tsfu[Tsf[Tsfuv[36[lower units[Chamita, Tesuque
Tb[[Tsfu[37[basalts[
P[[Tb[38[Polvadera Group[
Tt[P[P[39[Tschicoma Formation[int. lavas

10.1.1.1.5 Table task_list

This table identifies codes for the various tasks required to create the 3-D data base.

A. Table creation script:

```
create table task_list        /* list of acceptable task codes and tasks */
    (
    task_code        varchar2        ( 3),        /* i.e. dp          */
    task             varchar2        (15)         /* i.e. data processing */
    )
    tablespace    geol3d_fk1;
```

B. Data entries:

dig[digitize
dp[data processing (interpolation, contouring, reformatting, etc.)
qa[quality assurance

10.1.1.1.6 Table worker_list

This table identifies codes for the data references.

A. Table creation script:

```
create table worker_list          /* permissible worker codes defined */
    (
    worker_code    varchar2    ( 4),    /* i.e. DTV          */
    worker_name    varchar2    (30),    /* i.e. David T. Vaniman*/
    worker_org     varchar2    (40),    /* i.e. Los Alamos Na...*/
    worker_city    varchar2    (15),    /* i.e. Los Alamos     */
    worker_state   varchar2    ( 2)     /* i.e. NM           */
    worker_phone   varchar2    (12)     /* i.e. 505-665-2807   */
    )
    tablespace nts_fk1;
```

B. Data entries:

GLC[Gregory L. Cole[Los Alamos National Laboratory[Los Alamos[NM[505-667-1858
DTV[David T. Vaniman[Los Alamos National Laboratory[Los Alamos[NM[505-667-1863
JB[Jeff Blossom[Los Alamos National Laboratory[Los Alamos[NM[505-665-3610
GWG[Giday Wolde-Gabriel[Los Alamos National Laboratory[Los Alamos[NM[505-667-8749
DW[Doug Walters[Los Alamos National Laboratory[Los Alamos[NM[505-665-2807

10.1.1.2 Primary or main tables

These are the main tables of the database and are used to support visualization, geographical and statistical analysis if the 3-D data. In many cases, these data must be reformatted after extraction or export in order to be used by other local or commercial software. SAS statistical software, and ARC/INFO GIS software provide linkage to Oracle databases. Scripts or filters can be written to facilitate data transfer between various software products.

10.1.1.2.1 Table contact

This table provides the contact points used to create stratigraphic surfaces used in the 3-D model. These data are available as both Oracle and Info (from ARC/INFO) tables. (Note: The column/field "id" is an internally-assigned, unique number to allow geographical identification and table linkage of individual contact points in the database.)

A. Table creation script:

```
create table contact   /* geologic strat boundary locations */
    (
    id                      number      ( 9)
                CONSTRAINT pk_id PRIMARY KEY,  /* i.e. 013382        */
    east                    number      (9,-2),        /* i.e. 1647420.0     */
    north                   number      (9,-2),        /* i.e. 1767878.0     */
    elev                    number      (7,-2),        /* i.e. 6471.0        */
    upper_strat_code        varchar2    ( 7),          /* i.e. Qal           */
    lower_strat_code        varchar2    ( 7),          /* i.e. Qbof          */
    bound_type_code         varchar2    ( 2),          /* i.e. b             */
    meas_type_code varchar2     ( 2),          /* i.e. d             */
    qual_desc               varchar2    (15),          /* i.e.               */
    qual_score              number      ( 2),          /* i.e. (Not Assigned  */
    data_ref_code           varchar2    (15),          /* i.e. Bro,1996      */
    data_desc               varchar2    (15),          /* i.e. SCOI-3        */
    CONSTRAINT              fk_us_code
      FOREIGN KEY           ( upper_strat_code )
      REFERENCES            strat_list ( strat_code ),
    CONSTRAINT              fk_ls_code
      FOREIGN KEY           ( lower_strat_code )
      REFERENCES            strat_list ( strat_code ),
    CONSTRAINT              fk_bt_code
      FOREIGN KEY           ( bound_type_code )
      REFERENCES            bound_type_list ( bound_type_code ),
    CONSTRAINT              fk_mt_code
      FOREIGN KEY           ( meas_type_code )
      REFERENCES            meas_type_list ( meas_type_code ),
    CONSTRAINT              ck_qual_desc
      CHECK                 ( qual_score BETWEEN 0 and 10 ),
    CONSTRAINT              fk_dr_code
      FOREIGN KEY           ( data_ref_code )
      REFERENCES            ref_list ( ref_code )
    )
    tablespace    geol3d1;
```

B. Data entries (46,869 entries):

```
    ...
013254[1629427.4[1773924.5[6818.2[Qal[Qbof[b[d[[0[Van,1996[LAOI(A)-1.1
013382[1647420.0[1767878.0[6471.0[Qal[Qbof[b[d[[0[Bro,1996[SCOI-3
014789[1637520.55[1773304.50[6636.79[Qal[Qbof[b[s[apparent[0[Gof,1995[TA-21
014790[1637450.23[1773394.75[6647.50[Qal[Qbof[b[s[apparent[0[Gof,1995[TA-21
    ...
```

10.1.1.2.2 Table contact_aux

This table provides auxiliary data for the contact points including quality measures and cross-referencing information. No data have been entered into this table at this time.

A. Table creation script:

```
create table contact_aux      /* auxiliary boundary info */
    (
    id              number      ( 9)      CONSTRAINT pk_id PRIMARY KEY,
    horiz_uncer     number      (5,-2),
    elev_uncer      number      (5,-2),
    strat_id_qual   number      ( 2),
    source_loc_id   varchar2    (10),
    fimad_loc_id    varchar2    (10),
    fimad_hole_id   varchar2    (10),

    CONSTRAINT    ck_ui_uncer
     CHECK      ( strat_id_qual BETWEEN 0 and 10 )
    )
    tablespace    geol3d1;
```

10.1.1.2.3 Table data_source

This table provides information necessary to reconstruct the processing history for transformation of source data into entries in the contact table.

A. Table creation script:

```
create table data_source      /* contributors to final data entry */
    (
    data_ref_code   varchar2    (15),       /* i.e. Rog,1995      */
    task_code       varchar2    ( 3),       /* i.e. dig         */
    worker_code     varchar2    ( 5),       /* i.e. GWG         */
    task_date       date            ,       /* i.e. NOV-95      */
    comments        varchar2    (2000),     /* i.e. digitized app...*/

    CONSTRAINT          fk_dr3_code
      FOREIGN KEY       ( data_ref_code )
      REFERENCES        ref_list ( ref_code ),
    CONSTRAINT          fk_task_code
      FOREIGN KEY       ( task_code )
      REFERENCES        task_list ( task_code ),
    CONSTRAINT          fk_w_code
```

```
    FOREIGN KEY      ( worker_code )
    REFERENCES       worker_list (worker_code )
  )
  tablespace    geol3d1;
```

B. Data entries (one example of 36 entries):

...

Rog,1995[dig[GWG[NOV-95[digitized approximately 5 sheets for contacts and structure, using ARC/Info software

Rog,1995[dig[JB[APR-96[digitized approximately 13 sheets for contacts using ARC/Info software

Rog,1995[dig[GLC[MAY-96[digitized remaining sheets for contacts and cleaned coverages for all 25 sheets, using ARC/Info software

Rog,1995[qa[GLC[MAY-96[performed final QA in ARC/Info for dangles and intersections, produced check plots, made final corrections to ARC/Info coverages

Rog,1995[qa[DTV[MAY-96[performed visual comparison of check plots with original data

Rog,1995[dp[GLC[MAY-96[imported 1976 contour coverage into ARC/Info and tagged contours for Sheet 1 (NOTE: no clean-up or QA performed on original data)

Rog,1995[dp[GLC[JUN-96[generated contact xyz-values through intersection of digitized contacts and 1976 topo contours, using ARC/Info software and the program: get_contact_picks

Rog,1995[dp[GLC[JUN-96[put contact data in database format, using the program: prep_for_db1

...

10.1.2 ARC/INFO coverages, TINs and grids

An ARC/INFO coverage was made for graphical representation of the information in the Oracle table: contact. Similar coverages were made of subsets of these data, with selection based on the values of the upper_unit and lower_unit columns in the Info table. These coverages were used to develop the stratigraphic surfaces (grids) presented with this report. TINs and grids were created for each of the stratigraphic surfaces and provide a first attempt to model the stratigraphy as Los Alamos. This model will be modified many times in the future, based upon acquisition of addition data into the table: contact.

These coverages, TINs, and grids can be exported to FIMAD if wider distribution of the preliminary model is deemed feasible. The digitized linework of Rogers (1995) will not be given further distribution as stipulated in the legal agreement between Rogers and the laboratory.

Appendix Section 10.2: Available Geophysical Logs

Inventory of Geophysical Logs

well	title	date	units	notes	location	company	individual
					folders in office 116, building 116/117, TA59 contact Craig Burger, 5-5636		
1-B	Gamma Ray - Neutron	12/19/59	micrograms,standard CPS	none	#58	D.W. Falls, Inc	Wood
1-B	Micro Logging	12/18/59	microcaliper,ohm	none	#58	D.W. Falls, Inc	Wood
1-B	Electrical Log	12/18/59	mv,ohm,ohm	test	#58	D.W. Falls, Inc	Wood
Well 2	Neutron Log	5/29/69	n/d	none	#59	USGS	Basler, Cruz, Kunkler
Well 2	Gamma Log	5/29/69	n/d	none	#59	USGS	Basler, Cruz, Kunkler
Well 2	Caliper Log	5/29/69	n/d	none	#59	USGS	Basler, Cruz, Kunkler
LA-4	Caliper Log	1/27/69	n/d	none	#60	USGS	Hudson and Basler
LA-4	Gamma Log	1/27/69	n/d	none	#60	USGS	Hudson and Basler
LA-6	Gamma Ray - Neutron	4/17/76	api,api	none	#61	Zia Company	McGee
LA-6	Temperature Log	4/17/76	degf	strat	#61	Zia Company	McGee
LA-6	Gamma Ray - Neutron	4/17/76	api,api	none	#61	Zia Company	McGee
LA-6	Temperature Log	4/16/76	degf	none	#61	Zia Company	McGee
LA-6	n/d	11/1/48	mv,ohm	strat	#61	Layne-Western	Decker
LA-6	Temperature Log	4/17/76	degf	none	#61	Zia Company	McGee
LA-6	Temperature Log	4/18/76	degf	none	#61	Zia Company	McGee
LA-6	Temperature Log	4/16/76	degf	test	#61	Zia Company	McGee
LA-6	Gamma Ray - Neutron	4/17/76	api,api	strat	#61	Zia Company	McGee
LA-6	Temperature Log	4/17/76	degf	none	#61	Zia Company	McGee
LA-6	Temperature Log	4/16/76	degf	none	#61	Zia Company	McGee
LA-6	Salinometer	4/17/76	ohm	test	#61	Zia Company	McGee
LA-6	Temperature Log	4/17/76	degf	none	#61	Zia Company	McGee
LA-6	Temperature Log	4/17/76	degf	none	#61	Zia Company	McGee
LA-6	Temperature Log	4/18/76	degf	none	#61	Zia Company	McGee
LA-6	Salinometer	4/17/76	ohm	none	#61	Zia Company	McGee
n/d	n/d	n/d	n/d	strat	#61	n/d	n/d
G-1	Resistivity	4/16/50	ohm,m2/m	strat	#62	Layne-Western	Brush
G-1	Resistivity	4/16/50	ohm,m2/m	strat	#62	Layne-Western	Brush
LA-6	Temperature Log	4/18/76	degf	none	#62.5	Zia Company	McGee
LA-6	Temperature Log	4/17/76	degf	none	#62.5	Zia Company	McGee
LA-6	Gamma Ray Neutron	4/17/76	api	none	#62.5	Zia Company	McGee
LA-6	Temperature Log	4/16/76	degf	none	#62.5	Zia Company	McGee
LA-6	Salinometer	4/17/76	ohm	none	#62.5	Zia Company	McGee
LA-6	Temperature Log	4/18/76	degf	none	#62.5	Zia Company	McGee
LA-6	Temperature Log	4/17/76	degf	none	#62.5	Zia Company	McGee
LA-6	Temperature Log	4/18/76	degf	none	#62.5	Zia Company	McGee
LA-6	Temperature Log	4/17/76	degf	none	#62.5	Zia Company	McGee
LA-6	Temperature Log	4/18/76	degf	none	#62.5	Zia Company	McGee
LA-6	Salinometer	4/17/76	ohm	none	#62.5	Zia Company	McGee
G-2	n/d	n/d	n/d	test	#63	n/d	n/d
G-4	Resistivity	10/30/54	1"x1" microinv	test	#64	B&W drilling co	Tefft
G-4	Gamma Log	5/18/66	n/d	none	#64	USGS	Hudson and Basler
G-4	Neutron Log	5/18/66	n/d	none	#64	USGS	Hudson and Basler
G-4	Electric Log	5/18/66	n/d	strat	#64	n/d	n/d
G-4	Caliper Log	5/18/66	inches	none	#64	USGS	Hudson and Basler
G-5	Caliper Log	n/d	n/d	strat	#65	n/d	n/d
G-5	Caliper Log	Oct-66	inches	none	#65	USGS	Hudson and Purtymun
G-5	Electrical Log	n/d	n/d	strat and test	#65	n/d	n/d
G-5	n/d	n/d	n/d	strat	#65	n/d	n/d
G-6	Microlog	1/28/64	n/d	none	#66	Atomic Energy Commission	Dilli
G-6	Gamma Ray Neutron	1/28/64	api	test	#66	Atomic Energy Commission	Dilli
G-6	Temperature Log	1/28/64	degf	none	#66	Atomic Energy Commission	Dilli
G-6	Temperature Log	1/28/64	degf	strat	#66	Atomic Energy Commission	Dilli
G-6	Induction Electrical Log	1/28/64	n/d	none	#66	Atomic Energy Commission	Dilli
PM-1	Drillers Log Stratigraphy	1/25/65	n/d	strat	#67	Layne Texas	n/d
PM-1	Drillers Log Stratigraphy	1/25/65	n/d	strat	#67	Layne Texas	n/d
PM-1	Micro Log	10/28/64	hole diameter inches,ohm,m2/m	none	#67	Atomic Energy Commission	Dilli
PM-1	Induction Electrical Log	10/28/64	mv, millimhos/m	none	#67	Atomic Energy Commission	Dilli
PM-1	Gamma Ray Neutron	10/28/64	api,api	none	#67	Atomic Energy Commission	Dilli
PM-1	Temperature Log	10/28/64	degf	strat	#67	Atomic Energy Commission	Dilli
PM-2	Induction Electrical Log	3/25/65	mv, millimhos	none	#68	Atomic Energy Commission	Ledy
PM-2	Micro Log	3/25/65	hole dia inches, ohms, m2/m	strat	#68	Atomic Energy Commission	Ledy
PM-2	Gamma Ray Neutron	3/25/65	api,api	none	#68	Atomic Energy Commission	Ledy
PM-2	Temperature Log	3/25/65	degf	none	#68	Atomic Energy Commission	Ledy
PM-3	Microcaliper	6/30/66	hole diameter,inches	none	#69	Atomic Energy Commission	Kimball and Brooks
PM-3	Induction Electrical Log	6/30/66	mv, millimhos/m	strat	#69	Atomic Energy Commission	Kimball and Brooks
PM-3	Gamma Ray Neutron	6/30/66	api,api	strat	#69	Atomic Energy Commission	Kimball and Brooks
PM-3	Temperature Log	6/30/66	degf	none	#69	Atomic Energy Commission	Kimball and Brooks
PM-4	Drillers Stratigraphy Log	4/20/81	n/d	strat	#70	n/d	n/d
PM-4	Driller Rate Log	4/20/81	n/d	test	#70	n/d	n/d

Inventory of Geophysical Logs

PM-4	Micro Laterolog	4/20/81	in,ohm,ohm	strat	#70	DOE	Johnson
PM-4	Micro Laterolog	4/20/81	in,ohm,ohm	strat	#70	DOE	Johnson
PM-4	Dual Induction-SFL	4/20/81	mv,ohm,ohm,mm/m	test	#70	DOE	Johnson
PM-4	Temperature Log	4/20/81	degf	none	#70	DOE	Johnson
PM-4	Compensated Neutron Formation Density	4/20/81	inches,gapi,g/cc,g/cc	test and strat	#70	DOE	Johnson
PM-5	Dual Induction-SFL	3/11/82	mv,ohm,ohm,millimhos	none	#71	DOE	Stam
PM-5	Dual Induction-SFL	3/11/82	mv,ohm,ohm,mmho	strat	#71	DOE	Stam
PM-5	Compensated Neutron Formation Density	3/11/82	in,gapi,g/cc,g/cc	strat	#71	DOE	Stam
PM-5	Compensated Neutron Formation Density	3/11/82	in,gapi,g/cc,g/cc	strat	#71	DOE	Stam
PM-5	Micro Log	3/11/82	in,ohm,ohm,	none	#71	DOE	Stam
PM-5	Micro Log	3/11/82	in,ohm,ohm,	strat and test	#71	DOE	Stam
PM-5	Temperature Log	3/11/82	degf	none	#71	DOE	Stam
PM-5	Temperature Log	3/11/82	degf	none	#71	DOE	Stam
Otowi 1	Dual Induction-SFL	5/23/90	mv,gapi,ohm,ohm	strat and test	After well data folders	LANL	Garber
Otowi 1	Temperature Log	5/23/90	ohm,gapi,degf,degf	test	After well data folders	LANL	Garber
Otowi 1	Compensated Neutron Formation Density	5/23/90	in,gapi,lbf,g/cc,g/cc	test	After well data folders	LANL	Garber
Otowi 1	Micro-Log	5/23/90	in,gapi,ohm,ohm	test	After well data folders	LANL	Garber
Otowi 1	Micro-Log	5/23/90	in,gapi,ohm,ohm	strat and test	After well data folders	LANL	Garber
Otowi 1	Temperature Log	5/23/90	ohm,gapi,degf,degf	test	After well data folders	LANL	Garber
Otowi 1	Compensated Neutron Formation Density	5/23/90	in,gapi,lbf,g/cc,g/cc	test	After well data folders	LANL	Garber
Otowi 1	Dual Induction-SFL	5/23/90	mv,gapi,ohm,ohm	test	After well data folders	LANL	Garber
CP2-1	Caliper	12/19/79	n/d	none	CP2-1 copy 2	USGS	Hudson and Cruz
CP2-1	Neutron	12/19/79	n/d	none	CP2-1 copy 2	USGS	Hudson and Cruz
CP2-1	Density	12/19/79	n/d	test	CP2-1 copy 2	USGS	Hudson and Cruz
CP2-1	Gamma	12/19/79	n/d	none	CP2-1 copy 2	USGS	Hudson and Cruz
CP2-1	Caliper	12/19/79	n/d	test	CP2-1 copy 3	USGS	Hudson and Cruz
CP2-1	Neutron	12/19/79	n/d	none	CP2-1 copy 3	USGS	Hudson and Cruz
CP2-1	Gamma	12/19/79	n/d	none	CP2-1 copy 3	USGS	Hudson and Cruz
CP2-1	Density	12/19/79	n/d	none	CP2-1 copy 3	USGS	Hudson and Cruz
CP5-1	Caliper	12/18/79	inches	test	CP5-1 copy 2	USGS	Hudson and Cruz
CP5-1	Density	12/18/79	cps	none	CP5-1 copy 2	USGS	Hudson and Cruz
CP5-1	Density	12/18/79	cps	none	CP5-1 copy 2	USGS	Hudson and Cruz
CP5-1	Gamma	12/18/79	cps	none	CP5-1 copy 2	USGS	Hudson and Cruz
CP5-1	Neutron	12/18/79	cps	none	CP5-1 copy 2	USGS	Hudson and Cruz
CP5-1	Caliper	12/18/79	inches	none	CP5-1 copy 3	USGS	Hudson and Cruz
CP5-1	Gamma	12/18/79	cps	none	CP5-1 copy 3	USGS	Hudson and Cruz
CP5-1	Neutron	12/18/79	cps	none	CP5-1 copy 3	USGS	Hudson and Cruz
CP6-1	Caliper	12/18/79	inches	none	CP6-1 copy 1	USGS	Hudson and Cruz
CP6-1	Density	12/18/79	cps	test	CP6-1 copy 1	USGS	Hudson and Cruz
CP6-1	Gamma	12/18/79	cps	none	CP6-1 copy 1	USGS	Hudson and Cruz
CP6-1	Neutron	12/18/79	cps	none	CP6-1 copy 1	USGS	Hudson and Cruz
CP6-1	Caliper	12/18/79	inches	none	CP6-1 copy 2	USGS	Hudson and Cruz
CP6-1	Density	12/18/79	cps	none	CP6-1 copy 2	USGS	Hudson and Cruz
CP6-1	Gamma	12/18/79	cps	none	CP6-1 copy 2	USGS	Hudson and Cruz
CP6-1	Neutron	12/18/79	cps	none	CP6-1 copy 2	USGS	Hudson and Cruz
CS99-1	Neutron	12/19/79	n/d	none	CS99-1 copy 1	USGS	Hudson and Cruz
CS99-1	Gamma	12/19/79	cps	none	CS99-1 copy 1	USGS	Hudson and Cruz
CS99-1	Caliper	12/19/79	inches	none	CS99-1 copy 1	USGS	Hudson and Cruz
CS99-1	density	12/19/79	n/d	test	CS99-1 copy 1	USGS	Hudson and Cruz
CS99-1	Neutron	12/19/79	n/d	none	CS99-1 copy 2	USGS	Hudson and Cruz
CS99-1	Gamma	12/19/79	cps	none	CS99-1 copy 2	USGS	Hudson and Cruz
CS99-1	Caliper	12/19/79	inches	none	CS99-1 copy 2	USGS	Hudson and Cruz
CS99-1	density	12/19/79	n/d	test	CS99-1 copy 2	USGS	Hudson and Cruz
CS99-1	Neutron	12/19/79	n/d	none	CS99-1 copy 3	USGS	Hudson and Cruz
CS99-1	Gamma	12/19/79	cps	none	CS99-1 copy 3	USGS	Hudson and Cruz
CS99-1	Caliper	12/19/79	inches	none	CS99-1 copy 3	USGS	Hudson and Cruz
CS99-1	density	12/19/79	n/d	none	CS99-1 copy 3	USGS	Hudson and Cruz
FP1-1	Caliper	12/19/79	n/d	none	FP1-1 copy 3	USGS	Hudson and Cruz
FP1-1	Density	12/19/79	Kcpa/d	none	FP1-1 copy 3	USGS	Hudson and Cruz
FP1-1	Gamma	12/19/79	cps	none	FP1-1 copy 3	USGS	Hudson and Cruz
FP1-1	Neutron	12/19/79	cps	none	FP1-1 copy 3	USGS	Hudson and Cruz
FPI-1	Caliper	12/18/79	inches	none	FPI-1 copy 1	USGS	Hudson and Cruz
FPI-1	Density	12/18/79	cps	none	FPI-1 copy 1	USGS	Hudson and Cruz
FPI-1	Gamma	12/18/79	cps	none	FPI-1 copy 1	USGS	Hudson and Cruz
FPI-1	Neutron	12/18/79	cps	none	FPI-1 copy 1	USGS	Hudson and Cruz
FPI-1	Caliper	12/18/79	inches	none	FPI-1 copy 2	USGS	Hudson and Cruz
FPI-1	Density	12/18/79	cps	none	FPI-1 copy 2	USGS	Hudson and Cruz
FPI-1	Gamma	12/18/79	cps	none	FPI-1 copy 2	USGS	Hudson and Cruz
FPI-1	Neutron	12/18/79	cps	none	FPI-1 copy 2	USGS	Hudson and Cruz
G-1A	Micro Logging	9/22/54	mv,ohm,m2/m	strat and test	G-1A	B&W drilling co	Tefft
G-1A	Electrical Log	9/22/54	mv,ohm,m2/m	test and strat	G-1A	B&W drilling co	Tefft
GP26-1	Caliper	12/18/79	inches	none	GP26-1 copy 1	USGS	Hudson and Cruz

Inventory of Geophysical Logs

GP26-1	Density	12/18/79	cps	test	GP26-1 copy 1	USGS	Hudson and Cruz
GP26-1	Gamma	12/18/79	cps	none	GP26-1 copy 1	USGS	Hudson and Cruz
GP26-1	Neutron	12/18/79	cps	none	GP26-1 copy 1	USGS	Hudson and Cruz
GP26-1	Neutron	12/17/79	cps	none	GP26-1 copy 3	USGS	Hudson and Cruz
GP26-1	Gamma	12/17/79	cps	none	GP26-1 copy 3	USGS	Hudson and Cruz
GP26-1	Density	12/17/79	Kcps	none	GP26-1 copy 3	USGS	Hudson and Cruz
GP26-1	Caliper	12/17/79	n/d	none	GP26-1 copy 3	USGS	Hudson and Cruz
GP7-2	Caliper	12/18/79	n/c	none	GP7-2 copy 1	USGS	Hudson and Cruz
GP7-2	Density	12/18/79	Kcps	none	GP7-2 copy 1	USGS	Hudson and Cruz
GP7-2	Neutron	12/18/79	cps	none	GP7-2 copy 1	USGS	Hudson and Cruz
GP7-2	Gamma	12/18/79	cps	none	GP7-2 copy 1	USGS	Hudson and Cruz
GP7-2	Caliper	12/18/79	n/c	none	GP7-2 copy 2	USGS	Hudson and Cruz
GP7-2	Density	12/18/79	Kcps	none	GP7-2 copy 2	USGS	Hudson and Cruz
GP7-2	Neutron	12/18/79	cps	none	GP7-2 copy 2	USGS	Hudson and Cruz
GP7-2	Gamma	12/18/79	cps	none	GP7-2 copy 2	USGS	Hudson and Cruz
GP7-2	Gamma	12/18/79	cps	none	GP7-2 copy 3	USGS	Hudson and Cruz
GP7-2	Caliper	12/18/79	inches	none	GP7-2 copy 3	USGS	Hudson and Cruz
GP7-2	Density	12/18/79	Kcps	none	GP7-2 copy 3	USGS	Hudson and Cruz
GP7-2	Neutron	12/18/79	cps	none	GP7-2 copy 3	USGS	Hudson and Cruz
GP7-3	Gamma	12/18/79	n/d	none	GP7-3 copy 1	USGS	Hudson and Cruz
GP7-3	Neutron	12/18/79	cps	none	GP7-3 copy 1	USGS	Hudson and Cruz
GP7-3	Density	12/18/79	Kcps	none	GP7-3 copy 1	USGS	Hudson and Cruz
GP7-3	Caliper	12/18/79	n/d	none	GP7-3 copy 1	USGS	Hudson and Cruz
GP7-3	Caliper	12/18/79	inches	none	GP7-3 copy 2	USGS	Hudson and Cruz
GP7-3	Density	12/18/79	cps	none	GP7-3 copy 2	USGS	Hudson and Cruz
GP7-3	Gamma	12/18/79	cps	none	GP7-3 copy 2	USGS	Hudson and Cruz
GP7-3	Neutron	12/18/79	cps	none	GP7-3 copy 2	USGS	Hudson and Cruz
GP7-3	Neutron	12/18/79	cps	none	GP7-3 copy 3	USGS	Hudson and Cruz
GP7-3	Gamma	12/18/79	n/d	none	GP7-3 copy 3	USGS	Hudson and Cruz
GP7-3	Density	12/18/79	Kcps	none	GP7-3 copy 3	USGS	Hudson and Cruz
GP7-3	Caliper	12/18/79	n/d	none	GP7-3 copy 3	USGS	Hudson and Cruz
EGH LA-1	Temperature Log	8/12/79	degf	test	green folder	LANL	MCGlothin
EGH LA-1	Compensation Neutron Formation Density	8/12/79	api	test	green folder	LANL	MCGlothin
EGH LA-1	Dual Induction-SFL	8/12/79	mv,ohm,milliohs/m	test	green folder	LANL	MCGlothin
EGH LA-1	Geothermal Data Log	7/2/79	degf,psig,ppm	strat and test	green folder	LANL	Criss, Hinson, Gary Netzley
EGH LA-1	Geothermal Data Log	7/2/79	degf,psig,ppm	strat and test	green folder	LANL	Criss, Hinson, Gary Netzley, Robert Wiley
n/d	BGT Heading	n/d	n/d	strat	green folder	n/d	McGlothin
n/d	nn-1	n/d	g/cc	test	green folder	n/d	n/d
n/d	nn-2	n/d	g/cc	test	green folder	n/d	n/d
USA 1	Geothermal Data Log	7/2/79	degf,psig,ppm	strat and test	green folder	LANL	Jack Hinson, Gary Netzley
GS50-1	Neutron	12/18/79	n/d	none	GS50-1 copy 1	USGS	Hudson and Cruz
GS50-1	Caliper	12/18/79	n/d	none	GS50-1 copy 1	USGS	Hudson and Cruz
GS50-1	Density	12/17/79	n/d	none	GS50-1 copy 1	USGS	Hudson and Cruz
GS50-1	Gamma	12/18/79	n/d	none	GS50-1 copy 1	USGS	Hudson and Cruz
GS50-1	Neutron	12/18/79	n/d	none	GS50-1 copy 2	USGS	Hudson and Cruz
GS50-1	Caliper	12/18/79	n/d	none	GS50-1 copy 2	USGS	Hudson and Cruz
GS50-1	Density	12/17/79	n/d	none	GS50-1 copy 2	USGS	Hudson and Cruz
GS50-1	Gamma	12/18/79	n/d	none	GS50-1 copy 2	USGS	Hudson and Cruz
GS50-1	Neutron	12/18/79	n/d	none	GS50-1 copy 3	USGS	Hudson and Cruz
GS50-1	Caliper	12/18/79	n/d	none	GS50-1 copy 3	USGS	Hudson and Cruz
GS50-1	Density	12/17/79	n/d	none	GS50-1 copy 3	USGS	Hudson and Cruz
GS50-1	Gamma	12/18/79	cps	none	GS50-1 copy 3	USGS	Hudson and Cruz
GS50-3	Gamma	12/18/79	n/d	none	GS50-3 copy 1	USGS	Hudson and Cruz
GS50-3	Density	12/17/79	Kcps	none	GS50-3 copy 1	USGS	Hudson and Cruz
GS50-3	Caliper	12/18/79	n/d	none	GS50-3 copy 1	USGS	Hudson and Cruz
GS50-3	Neutron	12/17/79	cps	none	GS50-3 copy 1	USGS	Hudson and Cruz
GS50-3	Gamma	12/18/79	cps	none	GS50-3 copy 2	USGS	Hudson and Cruz
GS50-3	Density	12/17/79	Kcps	none	GS50-3 copy 2	USGS	Hudson and Cruz
GS50-3	Caliper	12/18/79	n/d	none	GS50-3 copy 2	USGS	Hudson and Cruz
GS50-3	Neutron	12/17/79	cps	none	GS50-3 copy 2	USGS	Hudson and Cruz
GS50-3	Gamma	12/17/79	cps	none	GS50-3 copy 3	USGS	Hudson and Cruz
GS50-3	Density	12/17/79	Kcps	none	GS50-3 copy 3	USGS	Hudson and Cruz
GS50-3	Caliper	12/18/79	n/d	none	GS50-3 copy 3	USGS	Hudson and Cruz
GS50-3	Neutron	12/17/79	cps	none	GS50-3 copy 3	USGS	Hudson and Cruz
GS50-5	Natural Gamma	12/18/79	n/d	none	GS50-5 copy 1	USGS	Hudson and Cruz
GS50-5	Density	12/17/79	g/g	none	GS50-5 copy 1	USGS	Hudson and Cruz
GS50-5	Caliper	12/18/79	n/d	none	GS50-5 copy 1	USGS	Hudson and Cruz
GS50-5	Neutron	12/18/79	cps	none	GS50-5 copy 1	USGS	Hudson and Cruz
GS50-5	Natural Gamma	12/18/79	n/d	none	GS50-5 copy 2	USGS	Hudson and Cruz
GS50-5	Density	12/17/79	g/g	none	GS50-5 copy 2	USGS	Hudson and Cruz
GS50-5	Caliper	12/18/79	n/d	none	GS50-5 copy 2	USGS	Hudson and Cruz
GS50-5	Neutron	12/18/79	cps	none	GS50-5 copy 2	USGS	Hudson and Cruz

Inventory of Geophysical Logs

GS50-5	Caliper	12/18/79	inches	none	GS50-5 copy 3	USGS	Hudson and Cruz
GS50-5	Density	12/18/79	cps	test	GS50-5 copy 3	USGS	Hudson and Cruz
GS50-5	Gamma	12/18/79	cps	none	GS50-5 copy 3	USGS	Hudson and Cruz
GS50-5	Neutron	12/18/79	cps	none	GS50-5 copy 3	USGS	Hudson and Cruz
TA52-1	Caliper	12/19/79	n/d	none	TA 52-1	USGS	Hudson and Cruz
TA52-1	Density	12/18/79	Kcps	test	TA 52-1	USGS	Hudson and Cruz
TA52-1	Gamma	12/18/79	cps	none	TA 52-1	USGS	Hudson and Cruz
TA52-1	Neutron	12/19/79	Water Content by Volume	none	TA 52-1	USGS	Hudson and Cruz
TA51-1	Density	12/18/79	cps	test	TA51-1 copy 1	USGS	Hudson and Cruz
TA51-1	Gamma	12/18/79	cps	none	TA51-1 copy 1	USGS	Hudson and Cruz
TA51-1	Neutron	12/18/79	cps	none	TA51-1 copy 1	USGS	Hudson and Cruz
TA51-1	n/d	12/18/79	n/d	none	TA51-1 copy 2	USGS	Hudson and Cruz
TA51-1	Gamma	12/18/79	cps	none	TA51-1 copy 2	USGS	Hudson and Cruz
TA51-1	Density	12/18/79	Kcps	none	TA51-1 copy 2	USGS	Hudson and Cruz
TA51-1	Neutron	12/18/79	cps	none	TA51-1 copy 2	USGS	Hudson and Cruz
TA51-1	n/d	12/18/79	n/d	none	TA51-1 copy 3	USGS	Hudson and Cruz
TA51-1	Gamma	12/18/79	cps	none	TA51-1 copy 3	USGS	Hudson and Cruz
TA51-1	Density	12/18/79	Kcps	none	TA51-1 copy 3	USGS	Hudson and Cruz
TA51-1	Neutron	12/18/79	cps	none	TA51-1 copy 3	USGS	Hudson and Cruz
TA52-1	Gamma	12/18/79	cps	none	TA52-1 copy 2	USGS	Hudson and Cruz
TA52-1	Density	12/18/79	Kcps	none	TA52-1 copy 2	USGS	Hudson and Cruz
TA52-1	Caliper	12/19/79	n/d	none	TA52-1 copy 2	USGS	Hudson and Cruz
TA52-1	Neutron	12/19/79	n/d	none	TA52-1 copy 2	USGS	Hudson and Cruz
TA52-1	Neutron	12/19/79	cps	none	TA52-1 copy 3	USGS	Hudson and Cruz
TA52-1	Density	12/18/79	Kcps	none	TA52-1 copy 3	USGS	Hudson and Cruz
TA52-1	Gamma	12/18/79	cps	none	TA52-1 copy 3	USGS	Hudson and Cruz
TA52-1	Caliper	12/19/79	n/d	none	TA52-1 copy 3	USGS	Hudson and Cruz
CH-1	n/d	n/d	n/d	strat and test	Test Well GP Logs (2 of 2)	n/d	n/d
CH-3	n/d	n/d	n/d	strat and test	Test Well GP Logs (2 of 2)	n/d	n/d
CH-4	n/d	n/d	n/d	strat and test	Test Well GP Logs (2 of 2)	n/d	n/d
CH2	Electrical Log	12/17/59	mv,ohm,m2/m	none	Test Well GP Logs (2 of 2)	Los Alamos Constructors Inc	Francis
DT-10	Induction-Electrical Log	3/12/60	mv,ohms,m2/m	test	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-10	Sonic Log	3/12/60	microseconds/foot,	test	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-10	Gamma Ray - Neutron	3/12/60	micrograms,standard CPS	test	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-10	Temperature Log	3/12/60	degf	none	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-9	Temperature Log	2/10/60	degf	strat	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-9	Laterolog	2/10/60	micrograms,ohm,ohm	none	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-9	Gamma Ray - Neutron	2/10/60	micrograms,standard CPS	test	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-9	Sonic log	2/10/60	micrograms,microseconds/foot	none	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-9	Induction-Electrical Log	2/10/60	mv,ohms,m2/m	no	Test Well GP Logs (2 of 2)	Zia Company	Handley
DT-9	Gamma Radiation	4/13/60	n/d	test	Test Well GP Logs (2 of 2)	USGS	n/d
H-19	Gamma Radiation	5/7/60	n/d	none	Test Well GP Logs (2 of 2)	USGS	W.N. Palmquist and Bert Weir
Near TW-2	Caliper Log	3/20/67	n/d	none	Test Well GP Logs (2 of 2)	USGS	Hudson, Purtymun and Kunkler
TA 49 Area 2	Gamma Ray - Neutron	12/17/59	micrograms,standard CPS	test	Test Well GP Logs (2 of 2)	Los Alamos Constructors Inc	Francis
Test Well 8	Gamma Radiation	11/29/61	n/d	none	Test Well GP Logs (2 of 2)	USGS	Koopman
TW-4	Gamma Radiation	5/7/60	n/d	strat and test	Test Well GP Logs (2 of 2)	USGS	W.N. Palmquist and Bert Weir
DT-5	Induction Log	2/10/60	millimhos/m	none	Test Well GP Logs 1 of 2	Zia Company	Handley
DT-5	Gamma Ray Neutron	12/18/59	micrograms,standard cps	test notes	Test Well GP Logs 1 of 2	Los Alamos Constructors Inc.	Francis
DT-5	Temperature Log	12/18/59	degf	strat notes	Test Well GP Logs 1 of 2	Los Alamos Constructors Inc.	Francis
DT-5A	Laterolog	1/25/60	mg,ohm,m2/m	none	Test Well GP Logs 1 of 2	Zia Company	Handley
DT-5A	Sonic Log	1/24/60	mg,microseconds/foot	none	Test Well GP Logs 1 of 2	Zia Company	Handley
DT-5A	Gamma Ray Neutron	1/24/60	mg,standard cps	none	Test Well GP Logs 1 of 2	Zia Company	Handley
DT-5A	Micro Logging	1/24/60	Hole diameter in inches,ohms,m2/m	none	Test Well GP Logs 1 of 2	Zia Company	Handley
DT-5A	Electric Log	1/24/60	mv,ohm,m2/m	few	Test Well GP Logs 1 of 2	Zia Company	Handley
TA 49 1-200	Gamma Ray Neutron	2/10/60	micrograms,cps	none	Test Well GP Logs 1 of 2	Zia Company	Handley
TA 49 1-200	Induction Log	2/10/60	micrograms,ohm,m2/m	none	Test Well GP Logs 1 of 2	Zia Company	Handley
Otowi 4	Dual Induction-SFL	1/4/90	gapi,mv,ohm,ohm	none	Well O-4 Geophysical log	n/d	n/d
Otowi 4	Micro Log	1/4/90	in,gapi,ohm,ohm	none	Well O-4 Geophysical log	n/d	n/d
Otowi 4	Compensated Neutron Formation Density	1/4/90	gapi,lbf,g/cc	none	Well O-4 Geophysical log	n/d	n/d
Otowi 4	Temperature Log	1/4/90	gapi,deg/f,degf,lbf	none	Well O-4 Geophysical log	n/d	n/d
					the following folders at ERM, custody of Bob Gilkeson, 662-3700		
LGC-85-09	Magnetic Susceptibility	8/14/85	micro cgs	strat	ERM	Bendix	Knutson
LGC-85-09	Gamma/Caliper/Apparent	8/28/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	Sloan
LGC-85-09	Spectral Gamma	8/14/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LGC-85-09	Caliper	8/14/85	inches	none	ERM	Bendix	Knutson
LGC-85-09	Natural Gamma	8/15/85	cps	none	ERM	Bendix	Knutson
LGC-85-09	Epithermal Neutron-Neutron	8/15/85	cps	none	ERM	Bendix	Knutson
LGC-85-09	Vertical Deviation	8/15/85	n/d	none	ERM	Bendix	Knutson
LGC-85-09	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LGC-85-10	Magnetic Susceptibility	8/22/85	micro cgs	none	ERM	Bendix	Knutson
LGC-85-10	Spectral Gamma	8/28/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LGC-85-10	Caliper	8/28/85	inches	none	ERM	Bendix	Traub

Inventory of Geophysical Logs

LGC-85-10	Natural Gamma	8/22/85	cps	none	ERM	Bendix	Knutson
LGC-85-10	Epithermal Neutron-Neutron	8/22/85	cps	none	ERM	Bendix	Knutson
LGC-85-10	Vertical Deviation	8/22/85	n/d	none	ERM	Bendix	Knutson
LGC-85-10	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LGC-85-10	Gamma/Caliper/Apparent	8/28/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LGM-85-06	Magnetic Susceptibility	8/13/85	micro cgs	none	ERM	Bendix	Knutson
LGM-85-06	Spectral Gamma	8/8/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LGM-85-06	Caliper	8/8/85	inches	none	ERM	Bendix	Knutson
LGM-85-06	Natural Gamma	8/7/85	cps	none	ERM	Bendix	Knutson
LGM-85-06	Epithermal Neutron-Neutron	8/7/85	cps	none	ERM	Bendix	Knutson
LGM-85-06	Vertical Deviation	8/7/85	n/d	none	ERM	Bendix	Knutson
LGM-85-06	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LGM-85-06	Gamma/Caliper/Apparent	8/28/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LGM-85-11	Magnetic Susceptibility	8/22/85	micro cgs	strat	ERM	Bendix	Knutson
LGM-85-11	Gamma/Caliper/Apparent	8/28/85	API/inches/(G/cc)	well elevation on log	ERM	Bendix/Century Geophysical	Sloan
LGM-85-11	Spectral Gamma	8/22/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LGM-85-11	Caliper	8/22/85	inches	none	ERM	Bendix	Traub
LGM-85-11	Natural Gamma	8/22/85	cps	none	ERM	Bendix	Knutson
LGM-85-11	Epithermal Neutron-Neutron	8/22/85	cps	none	ERM	Bendix	Knutson
LGM-85-11	Vertical Deviation	8/22/85	n/d	none	ERM	Bendix	Knutson
LGM-85-11	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LGN-85-08	Magnetic Susceptibility	8/13/85	micro cgs	none	ERM	Bendix	Knutson
LGN-85-08	Spectral Gamma	8/14/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LGN-85-08	Caliper	8/14/85	inches	none	ERM	Bendix	Traub
LGN-85-08	Natural Gamma	8/14/85	cps	none	ERM	Bendix	Knutson
LGN-85-08	Epithermal Neutron-Neutron	8/14/85	cps	none	ERM	Bendix	Knutson
LGN-85-08	Vertical Deviation	8/14/85	n/d	none	ERM	Bendix	Knutson
LGN-85-08	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LGP-85-07	Magnetic Susceptibility	8/13/85	micro cgs	none	ERM	Bendix	Knutson
LGP-85-07	Spectral Gamma	8/14/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LGP-85-07	Caliper	8/14/85	inches	none	ERM	Bendix	Knutson
LGP-85-07	Natural Gamma	8/14/85	cps	none	ERM	Bendix	n/d
LGP-85-07	Epithermal Neutron-Neutron	8/14/85	cps	none	ERM	Bendix	n/d
LGP-85-07	Vertical Deviation	8/14/85	n/d	none	ERM	Bendix	n/d
LGP-85-07	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LGP-85-07	Gamma/Caliper/Apparent	8/28/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-85-12	Magnetic Susceptibility	8/27/85	micro cgs	none	ERM	Bendix	Traub
LLC-85-12	Spectral Gamma	8/27/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LLC-85-12	Caliper	8/27/85	inches	none	ERM	Bendix	Traub
LLC-85-12	Natural Gamma	8/27/85	cps	none	ERM	Bendix	Traub
LLC-85-12	Epithermal Neutron-Neutron	8/27/85	cps	none	ERM	Bendix	Traub
LLC-85-12	Vertical Deviation	8/27/85	n/d	none	ERM	Bendix	Traub
LLC-85-12	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLC-85-12	Gamma/Caliper/Apparent	8/26/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-85-13	Magnetic Susceptibility	8/30/85	micro cgs	none	ERM	Bendix	Traub
LLC-85-13	Spectral Gamma	8/30/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LLC-85-13	Caliper	8/30/85	inches	none	ERM	Bendix	Traub
LLC-85-13	Natural Gamma	8/30/85	cps	none	ERM	Bendix	Traub
LLC-85-13	Epithermal Neutron-Neutron	8/30/85	cps	none	ERM	Bendix	Traub
LLC-85-13	Vertical Deviation	8/30/85	n/d	none	ERM	Bendix	Traub
LLC-85-13	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLC-85-13	Gamma/Caliper/Apparent	8/27/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-85-14	Natural Gamma	8/29/85	cps	none	ERM	Bendix	Traub
LLC-85-14	Epithermal Neutron-Neutron	8/29/85	cps	none	ERM	Bendix	Traub
LLC-85-14	Vertical Deviation	8/29/85	n/d	none	ERM	Bendix	Traub
LLC-85-14	Magnetic Susceptibility	8/29/85	micro cgs	none	ERM	Bendix	Traub
LLC-85-14	Spectral Gamma	8/29/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LLC-85-14	Caliper	8/29/85	inches	none	ERM	Bendix	Traub
LLC-85-14	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLC-85-14	Gamma/Caliper/Apparent	8/26/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	Sloan
LLC-85-15	Magnetic Susceptibility	8/29/85	micro cgs	none	ERM	Bendix	Traub
LLC-85-15	Spectral Gamma	8/29/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LLC-85-15	Caliper	8/29/85	inches	none	ERM	Bendix	Knutson
LLC-85-15	Natural Gamma	8/29/85	cps	none	ERM	Bendix	Traub
LLC-85-15	Epithermal Neutron-Neutron	8/29/85	cps	none	ERM	Bendix	Traub
LLC-85-15	Vertical Deviation	8/29/85	n/d	none	ERM	Bendix	Traub
LLC-85-15	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLC-85-15	Gamma/Caliper/Apparent	8/26/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-85-16	Natural Gamma	8/29/85	cps	none	ERM	Bendix	Traub
LLC-85-16	Epithermal Neutron-Neutron	8/29/85	cps	none	ERM	Bendix	Traub

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LLC-85-16	Vertical Deviation	8/29/85	n/d	none	ERM	Bendix	Traub
LLC-85-16	Spectral Gamma	8/29/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LLC-85-16	Caliper	8/29/85	inches	none	ERM	Bendix	Traub
LLC-85-16	Magnetic Susceptibility	8/29/95	micro cgs	none	ERM	Bendix	Traub
LLC-85-16	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLC-85-16	Gamma/Caliper/Apparent	8/26/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	Sloan
LLC-85-17	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLC-85-17	Natural Gamma	8/28/85	cps	none	ERM	Bendix	Traub
LLC-85-17	Epithermal Neutron-Neutron	8/28/85	cps	none	ERM	Bendix	Traub
LLC-85-17	Vertical Deviation	8/28/85	n/d	none	ERM	Bendix	Traub
LLC-85-17	Spectral Gamma	8/28/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LLC-85-17	Caliper	8/28/85	inches	none	ERM	Bendix	Traub
LLC-85-17	Magnetic Susceptibility	8/28/82	micro cgs	strat, well elevation	ERM	Bendix	Traub
LLC-85-17	Gamma/Caliper/Apparent	8/27/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	Sloan
LLC-85-18	Natural Gamma	8/28/85	cps	none	ERM	Bendix	Traub
LLC-85-18	Epithermal Neutron-Neutron	8/28/85	cps	none	ERM	Bendix	Traub
LLC-85-18	Vertical Deviation	8/28/85	n/d	none	ERM	Bendix	Traub
LLC-85-18	Spectral Gamma	8/27/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Traub
LLC-85-18	Caliper	8/27/85	inches	none	ERM	Bendix	Traub
LLC-85-18	Magnetic Susceptibility	8/28/95	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-85-18	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLC-85-18	Gamma/Caliper/Apparent	8/27/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	Sloan
LLC-86-19	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-19	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher
LLC-86-19	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher
LLC-86-19	Magnetic Susceptibility	8/18/85	micro cgs	strat	ERM	Bendix	Krabacher
LLC-86-19	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	well elevation on log	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-19	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher
LLC-86-19	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher
LLC-86-19	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-20	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Traub
LLC-86-20	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Traub
LLC-86-20	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-20	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-20	Magnetic Susceptibility	8/19/86	micro cgs	strat, well elevation	ERM	Bendix	Krabacher/Traub
LLC-86-20	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-21	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-21	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-21	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-21	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-21	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-21	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-22	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-22	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-22	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-22	Magnetic Susceptibility	8/18/85	micro cgs	strat	ERM	Bendix	Krabacher
LLC-86-22	Gamma/Caliper/Apparent	9/2/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-22	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-22	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-22	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-23	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-23	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-23	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-23	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-23	Magnetic Susceptibility	8/18/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-23	Vertical Deviation	8/18/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-24	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-24	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-24	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-24	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-24	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-24	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-25	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-25	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-25	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-25	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-25	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub
LLC-86-25	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLC-86-25	Magnetic Susceptibility	8/19/86	micro cgs	none	ERM	Bendix	Krabacher/Traub
LLC-86-25	Vertical Deviation	8/19/86	n/d	none	ERM	Bendix	Krabacher/Traub

Inventory of Geophysical Logs

LLC-86-25	Gamma/Caliper/Apparent	9/2/86	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLM-85-01	Magnetic Susceptibility	8/1/85	micro cgs	none	ERM	Bendix	Knutson
LLM-85-01	Spectral Gamma	8/25/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LLM-85-01	Caliper	8/25/85	inches	none	ERM	Bendix	Knutson
LLM-85-01	Natural Gamma	8/1/85	cps	none	ERM	Bendix	Knutson
LLM-85-01	Epithermal Neutron-Neutron	8/1/85	cps	none	ERM	Bendix	Knutson
LLM-85-01	Vertical Deviation	8/1/85	n/d	none	ERM	Bendix	Knutson
LLM-85-01	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLM-85-01	Gamma/Caliper/Apparent	8/27/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLM-85-02	Magnetic Susceptibility	8/3/85	micro cgs	none	ERM	Bendix	Knutson
LLM-85-02	Spectral Gamma	8/3/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LLM-85-02	Caliper	8/3/85	inches	none	ERM	Bendix	Knutson
LLM-85-02	Natural Gamma	8/3/85	cps	none	ERM	Bendix	Knutson
LLM-85-02	Epithermal Neutron-Neutron	8/3/85	cps	none	ERM	Bendix	Knutson
LLM-85-02	Vertical Deviation	8/3/85	n/d	none	ERM	Bendix	Knutson
LLM-85-02	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLM-85-02	Gamma/Caliper/Apparent	8/26/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields
LLM-85-05	Magnetic Susceptibility	8/6/85	micro cgs	strat	ERM	Bendix	Knutson
LLM-85-05	Gamma/Caliper/Apparent	8/26/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	Sloan
LLM-85-05	Spectral Gamma	8/6/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LLM-85-05	Caliper	8/6/85	inches	none	ERM	Bendix	Knutson
LLM-85-05	Natural Gamma	8/6/85	cps	none	ERM	Bendix	Knutson
LLM-85-05	Epithermal Neutron-Neutron	8/6/85	cps	none	ERM	Bendix	Knutson
LLM-85-05	Vertical Deviation	8/6/85	n/d	none	ERM	Bendix	Knutson
LLM-85-05	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLN-85-04	Magnetic Susceptibility	8/4/85	micro cgs	none	ERM	Bendix	Knutson
LLN-85-04	Spectral Gamma	8/4/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LLN-85-04	Caliper	8/4/85	inches	none	ERM	Bendix	Knutson
LLN-85-04	Natural Gamma	8/4/85	cps	none	ERM	Bendix	Knutson
LLN-85-04	Epithermal Neutron-Neutron	8/4/85	cps	none	ERM	Bendix	Knutson
LLN-85-04	Vertical Deviation	8/4/85	n/d	none	ERM	Bendix	Knutson
LLN-85-04	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLP-85-03	Magnetic Susceptibility	8/5/85	micro cgs	none	ERM	Bendix	Knutson
LLP-85-03	Spectral Gamma	8/5/85	K(ppm), U(ppm), T(ppm), TG(cps)	none	ERM	Bendix	Knutson
LLP-85-03	Caliper	8/5/85	inches	none	ERM	Bendix	Knutson
LLP-85-03	Natural Gamma	8/5/85	cps	none	ERM	Bendix	Knutson
LLP-85-03	Epithermal Neutron-Neutron	8/5/85	cps	none	ERM	Bendix	Knutson
LLP-85-03	Vertical Deviation	8/5/85	n/d	none	ERM	Bendix	Knutson
LLP-85-03	Moisture	9/5/85	% by volume	bargraph in foot increments	ERM	n/d	n/d
LLP-85-03	Gamma/Caliper/Apparent	8/26/85	API/inches/(G/cc)	none	ERM	Bendix/Century Geophysical	M. Shields

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Tool ID	Depth range of log (ft)	Repeats
GNT-F	50-2250	yes, 50-2250
PMS-A	150-2254	no
n/d	100-2257	yes, 100-2257
n/d	6-868	no
n/d	6-872	no
n/d	6-872	no
n/d	21731	no
n/d	21731	no
n/d	0-1783	yes, 0-1783, 1650-1783
LDAH-6010	20-1783	no
n/d	0-1783	yes, 0-1783, 1650-1783
LDAH-6010	20-1783	no
n/d	271-2043	no
LDAH-6010	150-1783	no
LDAH-6010	150-1783	no
LDAH-6010	20-1783	no
n/d	0-1776	yes, 0-1160
LDAH-6010	150-1783	no
LDAH-6010	20-1783	no
n/d	200-1783	no
LDAH-6010	150-1782	no
LDAH-6010	151-1778	no
LDAH-6010	150-1783	no
n/d	200-1780	no
n/d	1150-1783	yes, 1650-1783
n/d	236-2023	no
n/d	236-2023	no
LDAH-6010	151-1778	no
LDAH-6010	150-1783	no
n/d	0-1782	yes, 0-1783, 1650-1783
LDAH-6010	20-1783	no
n/d	200-1783	no
LDAH-6010	150-1782	no
LDAH-6010	20-1783	no
LDAH-6010	151-1778	no
LDAH-6010	150-1782	no
LDAH-6010	150-1783	no
n/d	20-1780	no
n/d	50-2000	no
n/d	434-1380	no
n/d	0-752	no
n/d	6-752	no
n/d	200-2006	no
n/d	6-752	no
n/d	220-2000	no
n/d	0-672	no
n/d	220-2000	no
n/d	500-2000	no
n/d	207-2006	no
GNTF	150-2004	yes, 150-2004
n/d	200-2005	no
n/d	200-2005	yes, 200-2005
IRSK-84	207-2005	yes, 207-2005
n/d	7-2600	no
n/d	7-2600	no
n/d	742-2504	yes, 1400-2400
n/d	742-2504	yes, 742-2504
GNT-F	350-2504	yes, 350-2505
n/d	300-2504	yes, 200-2504
96-M	31-2594	yes, 31-2594
121-A	31-2592	yes, 1000-2592
GNT-G	50-2592	yes, 50-2592
n/d	300-2505	no
n/d	200-2553	yes, 1200-2400
n/d	100-2553	yes, 100-2553
n/d	50-2552	yes, 50-2552
n/d	70-2553	no
n/d	0-290	no
n/d	13-292	no

Inventory of Geophysical Logs

n/d		896-2918	yes, 896-2918, 2700-2918
n/d		896-2918	yes, 896-2918, 2700-2918
n/d		821-2913	yes, 821-2913
n/d		0-2920	no
	244	50-2918	yes, 2660-2918, 2700-2918, 50-2918, 2660-2918, 2700-2918, 2540-218, 2700-2918
	268	1190-2406	yes, 1190-2406, 2160-2406
	268	1190-2406	yes, 1190-2406, 2160-2406
	406	368-2409	yes, 2160-2409, 360-2409, 2160-2409
	406	368-2409	yes, 2160-2409, 360-2409, 2160-2409
	514	1190-2409	yes, 1190-2409, 2050-2409
	514	1190-2409	yes, 1190-2409, 2050-2409
n/d		328-2407	yes, 328-2407
n/d		328-2407	yes, 328-2407
DIC-300, DIS-356, SGTL-2719, TCCB-371, AMS, IEM-1037, TCM-1169		662-2603	yes 662-2603, 2450-2603
AMS-771, SGTL-2719, TCCB-371, TCM-1169		662-2603	yes 662-2603, 2450-2603
DRS-2902, NSC-2896, PGD-2781, CNC-2343, PCD-FARM, SGTL-2719, TCCB-371, TCM-		662-2603	yes 2450-2603, 662-2603
DRS-2902, NSC-2896, PGD-2781, CNC-2343, PCD-FARM, SGTL-2719, TCCB-371, TCM-		662-2603	yes 2450-2603, 662-2603
DRS-2902, NSC-2896, PGD-2781, CNC-2343, PCD-FARM, SGTL-2719, TCCB-371, TCM-		662-2603	yes 2450-2603, 662-2603
AMS-771, SGTL-2719, TCCB-371, TCM-1169		662-2603	yes 2450-2603, 662-2603
DRS-2902, NSC-2906, PGD-2781, CNC-2343, PCD-FARM, SGTL-2719, TCCB-371, TCM-		662-2603	yes 2450-2603,2450-2603, 662-2603
DIC-300, DIS-356, SGTL-2719, TCCB-371, AMS, IEM-1037, TCM-1169		662-2603	yes 2450-2603, 662-2603
n/d		5-105	no
n/d		5-105	no
n/d		5-105	no
n/d		5-105	no
n/d		5-105	no
n/d		5-105	no
n/d		5-105	no
n/d		5-105	no
n/d		31532	no
n/d		31532	no
n/d		31532	no
n/d		31532	no
n/d		31532	no
n/d		31532	no
n/d		31532	no
n/d		31532	no
n/d		26053	no
n/d		26084	no
n/d		26053	no
n/d		26053	no
n/d		26053	no
n/d		26084	no
n/d		26053	no
n/d		26053	no
n/d		33755	no
n/d		34089	no
n/d		33358	no
n/d		34089	no
n/d		33755	no
n/d		34089	no
n/d		33358	no
n/d		34089	no
n/d		33755	no
n/d		34089	no
n/d		33358	no
n/d		34089	no
n/d		23862	no
n/d		23862	no
n/d		23862	no
n/d		23131	no
n/d		23862	no
n/d		23862	no
n/d		23862	no
n/d		23131	no
n/d		23862	no
n/d		23862	no
n/d		23862	no
n/d		23131	no
n/d		245-2076	no
n/d		245-2076	yes, 245-2076
n/d		5-168	no

Inventory of Geophysical Logs

n/d	4-171	no
n/d	3-171	no
n/d	4-171	no
n/d	4-171	no
n/d	3-171	no
n/d	4-171	no
n/d	5-168	no
n/d	26053	no
n/d	26023	no
n/d	25627	no
n/d	26023	no
n/d	26053	no
n/d	26023	no
n/d	25627	no
n/d	26023	no
n/d	26023	no
n/d	26053	no
n/d	26023	no
n/d	25627	no
n/d	22401	no
n/d	22401	no
n/d	22371	no
n/d	16-65	no
n/d	15-75	no
n/d	22371	no
n/d	22401	no
n/d	22401	no
n/d	22401	no
n/d	22401	no
n/d	22371	no
n/d	15-65	no
n/d	70-2071	yes 70-2071
Bowsring	60936	yes 11-2070
FINS and CME-Z on DIC	60936	yes 11-2070
Silicon chip	85-850	no
silicon chip	85-2292	no
n/d	75-2060	yes 75-2060
n/d	0-2043	yes 1680-1810
n/d	0-2043	yes 1680-1810
n/d	85-2300	no
n/d	13970	no
n/d	14000	no
n/d	13970	no
n/d	14153	no
n/d	13970	no
n/d	14000	no
n/d	13970	no
n/d	14153	no
n/d	13970	no
n/d	14000	no
n/d	13970	no
n/d	14153	no
n/d	11809	no
n/d	12174	no
n/d	11809	no
n/d	11779	no
n/d	11809	no
n/d	12174	no
n/d	11809	no
n/d	11779	no
n/d	11809	no
n/d	12174	no
n/d	11809	no
n/d	11779	no
n/d	15066	no
n/d	15066	no
n/d	15096	no
n/d	15066	no
n/d	15066	no
n/d	15066	no
n/d	15096	no
n/d	15066	no

Inventory of Geophysical Logs

n/d	15096	no
n/d	15066	no
n/d	15066	no
n/d	15066	no
n/d	8-191	no
n/d	2-191	no
n/d	6-191	no
n/d	7-191	no
n/d	6-182	no
n/d	0-182	no
n/d	7-182	no
n/d	7-182	no
n/d	0-182	no
n/d	6-182	no
n/d	6-182	no
n/d	7-182	no
n/d	0-182	no
n/d	6-182	no
n/d	6-182	no
n/d	6-191	no
n/d	2-191	no
n/d	8-191	no
n/d	7-191	no
n/d	7-191	no
n/d	2-191	no
n/d	6-191	no
n/d	8-191	no
n/d	8-491	no
n/d	8-300	no
n/d	8-304	no
n/d	70-368	yes 70-368
n/d	1128-1425	yes 1100-1400
n/d	1127-1404	yes 1127-1404
GNAM 4	100-1425	yes 100-1425
n/d	20-1425	no
n/d	100-1301	no
n/d	1050-1300	yes 1050-1300
GNT-F	50-1303	yes 50-1303
n/d	1005-1301	no
n/d	10-1302	yes 10-1325
n/d	1092-1508	no
GR Probe 1036	15-253	no
n/d	8-223	no
GNT-F	20-201	yes 20-201
n/d	78-1068	no
GR Probe 1036	10-1200	no
n/d	184-970	yes 184-970
GNTF	20-963	yes 850-963
n/d	20-963	yes 20-963
n/d	520-1824	no
n/d	450-1800	no
GNAM 4	100-1824	no
n/d	500-1824	yes 800-1700
n/d	520-1829	no
GNAM 4	20-189	yes 20-189
n/d	10-181	yes 10-181
n/d	n/d	n/d
n/d	n/d	n/d
n/d	n/d	n/d
n/d	n/d	n/d
truck #1912	0-105	no
NaI	0-107	no
NaI	1-105	no
n/d	1-105	no
NaI	0-100	no
He+3 @ 10 atm	1-105	no
n/d	0-107	no
Epithermal Neutron	0-105	no
truck #1912	0-108	no
NaI	2-100.5	no
n/d	2-100.5	no

Inventory of Geophysical Logs

NaI	0-103	no
He+3 @ 10 atm	1-108	no
n/d	0-109	no
Epithermal Neutron	0-107	no
NaI	0-108	no
truck #1912	5-123	no
NaI	2-118	no
n/d	2-118	no
NaI	0-120	no
He+3 @ 10 atm	1-125	no
n/d	0-127	no
Epithermal Neutron	0-125	no
NaI	0-121	no
truck #1912	0-125	no
NaI	0-126	no
NaI	1-120	no
n/d	1-120	no
NaI	0-123	no
He+3 @ 10 atm	1-128	no
n/d	0-130	no
Epithermal Neutron	0-128	no
truck #1912	8-50	no
NaI	1.5-49	no
n/d	1.5-49	no
NaI	0-48	no
He+3 @ 10 atm	1-53	no
n/d	0-54	no
Epithermal Neutron	5-53	no
truck #1912	8-52	no
NaI	2-46	no
n/d	2-46	no
NaI	0-47	no
He+3 @ 10 atm	1-52	no
n/d	0-53	no
Epithermal Neutron	0-52	no
NaI	0-53	no
truck #1912	5-105	no
NaI	1.5-99.5	no
n/d	1.5-99.5	no
NaI	0-100	no
He+3 @ 10 atm	5-105	no
n/d	0-106	no
Epithermal Neutron	5-68	no
NaI	0-108	no
truck #1912	5-110	no
NaI	1-107.5	no
n/d	1-107.5	no
NaI	0-107	no
He+3 @ 10 atm	1-112	no
n/d	0-113	no
Epithermal Neutron	.5-112.5	no
NaI	0-116	no
NaI	0-105	no
He+3 @ 10 atm	3-110	no
n/d	0-112	no
truck #1912	5-109	no
NaI	1.5-104	no
n/d	1.5-104	no
Epithermal Neutron	2-110	no
NaI	0-112	no
truck #1912	5-109	no
NaI	1-109.5	no
n/d	1-109.5	no
NaI	0-109	no
He+3 @ 10 atm	2-114	no
n/d	0-115	no
Epithermal Neutron	1-114	no
NaI	0-119	no
NaI	0-111	no
He+3 @ 10 atm	2-116	no

Inventory of Geophysical Logs

n/d	0-118	no
NaI	1-110	no
n/d	1-110	no
truck #1912	5-109	no
Epithermal Neutron	1.5-115.5	no
NaI	0-119	no
Epithermal Neutron	2-140	no
NaI	0-135	no
He+3 @ 10 atm	0-140	no
n/d	0-142	no
NaI	1.5-133.5	no
n/d	1.5-133.5	no
truck #1912	0-140	no
NaI	0-149	no
NaI	0-98	no
He+3 @ 10 atm	3-103	no
n/d	0-105	no
NaI	1-99.5	no
n/d	1-99.5	no
truck #1912	5-102	no
Epithermal Neutron	2-103	no
NaI	0-107	no
NaI	0-157	no
truck #1912	0-157	yes 5-156,5-157
#9055A-78	0-157	yes 0-157
truck #1912	0-156	no
NaI	0-157	no
truck #1912	5-156	yes 5-157
#9055A-78	0-157	no
NaI	0-157	no
truck #1912	0-224	no
#9055A-78	0-224	no
truck #1912	5-224	yes 5-223
#9055A-78	0-224	no
truck #1912	5-224	yes 5-224, 5-223
#9055A-78	0-224	yes 0-224
truck #1912	5-217	yes 5-200
#9055A-78	0-220	no
truck #1912	5-217	yes 5-200
#9055A-78	0-220	no
truck #1912	5-217	yes 5-200
#9055A-78	0-220	no
NaI	0-212	no
truck #1912	5-213	yes 5-215, 5-213, 5-215
#9055A-78	0-216	no
truck #1912	0-215	no
NaI	0-212	no
NaI	0-212	no
truck #1912	5-213	yes 5-215
#9055A-78	0-216	no
truck #1912	5-215	yes 5-200
#9055A-78	0-216	no
truck #1912	5-215	yes 5-200
#9055A-78	0-216	no
truck #1912	5-215	yes 5-200
#9055A-78	0-216	no
truck #1912	5-211	yes 0-205
#9055A-78	0-211	no
truck #1912	5-212	yes 5-211
#9055A-78	0-211	no
truck #1912	5-212	yes 5-211
#9055A-78	0-211	no
NaI	0-215	no
truck #1912	5-219	yes 5-200
#9055A-78	0-219	no
truck #1912	5-219	yes 5-200
#9055A-78	0-219	no
NaI	0-215	no
truck #1912	5-219	yes 5-200
#9055A-78	0-219	no

Inventory of Geophysical Logs

NaI	0-215	no
truck #1912	8-119	no
NaI	5-110.5	no
n/d	5-110.5	no
NaI	0-114	no
He+3 @ 10 atm	4-119	no
n/d	0-121	no
Epithermal Neutron	3-119	no
NaI	0-116	no
truck #1912	10-124.5	no
NaI	2-118	no
n/d	2-118	no
NaI	0-119	no
He+3 @ 10 atm	1-125	no
n/d	0-126	no
Epithermal Neutron	0-124	no
NaI	0-125	no
truck #1912	0-120	no
NaI	0-122	no
NaI	1-116	no
n/d	1-116	no
NaI	0-118	no
He+3 @ 10 atm	1-123	no
n/d	0-124	no
Epithermal Neutron	.5-121.5	no
truck #1912	8-109	no
NaI	0-102	no
n/d	0-102	no
NaI	0-110	no
He+3 @ 10 atm	0-115	no
n/d	0-117	no
Epithermal Neutron	0-115.5	no
truck #1912	5-96	no
NaI	2-91	no
n/d	2-91	no
NaI	0-91	no
He+3 @ 10 atm	2-96	no
n/d	0-97	no
Epithermal Neutron	1.5-95.5	no
NaI	0-97	no

Appendix Section 10.3: Available Cuttings from Deep Drill Holes

Inventory of ESH-18 Borehole Samples			Completed by Craig A. Burger		11/20/95
Borehole Name	Sample Type	Total Footage	Individual sample footage	Location	Notes
O-1	cuttings	0-2609		TA 64 Bldg 8	In small manila envelopes taped shut, samples in 10' intervals
O-1	cuttings		2226-2230	TA 64 Bldg 8	samples in 1' intervals
O-1	cuttings		-695	TA 64 Bldg 8	sample from bit
O-1	cuttings		1100-1110	TA 64 Bldg 8	two envelopes
O-1	cuttings		660-670	TA 64 Bldg 8	no sample
O-1	cuttings		770-780	TA 64 Bldg 8	no sample
O-1	cuttings		1090-1100	TA 64 Bldg 8	no sample
O-1	cuttings		1210-1220	TA 64 Bldg 8	no sample
O-1	cuttings		2180-2190	TA 64 Bldg 8	no sample
O-1	cuttings		2220-2225	TA 64 Bldg 8	no sample
O-1	cuttings		2400-2410	TA 64 Bldg 8	no sample
O-4	cuttings	0-2826		TA 64 Bldg 8	In small manila envelopes taped shut, samples in 10' intervals
O-4	cuttings		160-210	TA 64 Bldg 8	no sample
O-4	cuttings		790-810	TA 64 Bldg 8	no sample
O-4	cuttings		1110-1120	TA 64 Bldg 8	no sample
PM-4	cuttings	45-2920		TA 64 Bldg 8	In glass or plastic vials, increments of 5',10' or 20'
PM-4	cuttings		95-140	TA 64 Bldg 8	no sample
PM-4	cuttings		215-220	TA 64 Bldg 8	no sample
PM-4	cuttings		610-620	TA 64 Bldg 8	no sample
PM-4	cuttings		780-870	TA 64 Bldg 8	no sample
PM-4	cuttings		890-910	TA 64 Bldg 8	no sample
PM-4	cuttings		930-995	TA 64 Bldg 8	no sample
PM-4	cuttings		1970-1980	TA 64 Bldg 8	no sample
PM-4	cuttings		2090-2100	TA 64 Bldg 8	no sample
PM-4	cuttings		2200-2210	TA 64 Bldg 8	no sample
PM-4	cuttings		2410-2420	TA 64 Bldg 8	no sample
PM-5	cuttings	40-3120		TA 64 Bldg 8	In envelopes clipped shut, 10' increments
PM-5	cuttings		-3120	TA 64 Bldg 8	from top of mud pit, 3 envelopes
PM-5	cuttings		1550-1560	TA 64 Bldg 8	two envelopes
PM-5	cuttings		1200-2000	TA 64 Bldg 8	Most of these are very small samples.
PM-5	cuttings		260-270	TA 64 Bldg 8	no sample
PM-5	cuttings		360-370	TA 64 Bldg 8	no sample
PM-5	cuttings		570-580	TA 64 Bldg 8	no sample
PM-5	cuttings		660-680	TA 64 Bldg 8	no sample
PM-5	cuttings		810-820	TA 64 Bldg 8	no sample
PM-5	cuttings		900-910	TA 64 Bldg 8	no sample
PM-5	cuttings		920-990	TA 64 Bldg 8	no sample
PM-5	cuttings		1000-1010	TA 64 Bldg 8	no sample
PM-5	cuttings		1100-1110	TA 64 Bldg 8	no sample
PM-5	cuttings		1180-1190	TA 64 Bldg 8	no sample
PM-5	cuttings		1510-1520	TA 64 Bldg 8	no sample
PM-5	cuttings		1530-1550	TA 64 Bldg 8	no sample
PM-5	cuttings		1560-1570	TA 64 Bldg 8	no sample
PM-5	cuttings		1780-1790	TA 64 Bldg 8	no sample
PM-5	cuttings		1890-1900	TA 64 Bldg 8	no sample
PM-5	cuttings		1910-2050	TA 64 Bldg 8	no sample
PM-5	cuttings		2180-2190	TA 64 Bldg 8	no sample
PM-5	cuttings		2230-2240	TA 64 Bldg 8	no sample
PM-5	cuttings		2260-2270	TA 64 Bldg 8	no sample
PM-5	cuttings		2280-2420	TA 64 Bldg 8	no sample
PM-5	cuttings		2430-2440	TA 64 Bldg 8	no sample
PM-5	cuttings		2540-2550	TA 64 Bldg 8	no sample
PM-5	cuttings		2630-2640	TA 64 Bldg 8	no sample
PM-5	cuttings		2730-2740	TA 64 Bldg 8	no sample
PM-5	cuttings		3050-3060	TA 64 Bldg 8	no sample
CDBM-1	cores	0-180		TA 64 Bldg 8	In metal cylinders, ends closed with plastic caps and electrical tape. Most in ziploc bags as well. Cylinders labeled as CDBM-2.
CDBM-1	cores		7-7.5	TA 64 Bldg 8	

CDBM-1	cores		8-8.5	TA 64 Bldg 8	chloride (written on container)
CDBM-1	cores		12.0-12.5	TA 64 Bldg 8	
CDBM-1	cores		28.5-29.0	TA 64 Bldg 8	hydro
CDBM-1	cores		32.5-33.0	TA 64 Bldg 8	metals
CDBM-1	cores		37.5-38.0	TA 64 Bldg 8	metals
CDBM-1	cores		38.5-39.0	TA 64 Bldg 8	hydro
CDBM-1	cores		42.5-43	TA 64 Bldg 8	metals
CDBM-1	cores		48.5-49	TA 64 Bldg 8	hydro
CDBM-1	cores		51.5-52.0	TA 64 Bldg 8	chloride
CDBM-1	cores		52.5-53	TA 64 Bldg 8	metals
CDBM-1	cores		62-62.5	TA 64 Bldg 8	chloride
CDBM-1	cores		62.5-63	TA 64 Bldg 8	metals
CDBM-1	cores		68-68.5	TA 64 Bldg 8	
CDBM-1	cores		73-73.5	TA 64 Bldg 8	
CDBM-1	cores		78-78.5	TA 64 Bldg 8	
CDBM-1	cores		78.5-79	TA 64 Bldg 8	
CDBM-1	cores		98-98.5	TA 64 Bldg 8	
CDBM-1	cores		103-103.5	TA 64 Bldg 8	
CDBM-1	cores		108-108.5	TA 64 Bldg 8	
CDBM-1	cores		113-113.5	TA 64 Bldg 8	
CDBM-1	cores		118-118.5	TA 64 Bldg 8	
CDBM-1	cores		123-123.5	TA 64 Bldg 8	
CDBM-1	cores		128-128.5	TA 64 Bldg 8	
CDBM-1	cores		133-133.5	TA 64 Bldg 8	
CDBM-1	cores		138.5-139	TA 64 Bldg 8	
CDBM-1	cores		143-143.5	TA 64 Bldg 8	
CDBM-1	cores		148-148.5	TA 64 Bldg 8	
CDBM-1	cores		153-153.5	TA 64 Bldg 8	
CDBM-1	cores		158-158.5	TA 64 Bldg 8	
CDBM-1	cores		163-163.5	TA 64 Bldg 8	
CDBM-1	cores		168-168.5	TA 64 Bldg 8	
CDBM-1	cores		173-173.5	TA 64 Bldg 8	
CDBM-1	cores		178-178.5	TA 64 Bldg 8	
CDBM-1	cores		178.5-179	TA 64 Bldg 8	
CDBM-1	cores		183-183.5	TA 64 Bldg 8	
CDBM-2	cores	0-80		TA 64 Bldg 8	In metal cylinders, ends closed with plastic caps and electrical tape. Most in ziploc bags as well. Cylinders labeled as CDBM-3.
CDBM-2	cores		2-2.5	TA 64 Bldg 8	
CDBM-2	cores		17-17.5	TA 64 Bldg 8	
CDBM-2	cores		32.5-33	TA 64 Bldg 8	
CDBM-2	cores		42.5-43	TA 64 Bldg 8	
CDBM-2	cores		46.5-47	TA 64 Bldg 8	
CDBM-2	cores		52.5-53	TA 64 Bldg 8	
CDBM-2	cores		57.5-58	TA 64 Bldg 8	
CDBM-2	cores		62.5-63	TA 64 Bldg 8	
CDBM-2	cores		72.5-73	TA 64 Bldg 8	
CDBM-2	cores		77.5-78	TA 64 Bldg 8	
			Tin Label:		
Unknown	cores		A:75.08	TA 64 Bldg 8	In 3" dia. tins. Box says: TA-60 1001-5->1002-5,10,15
Unknown	cores		AA:75.00	TA 64 Bldg 8	Other side of box says: TA-49
Unknown	cores		AB:76.10	TA 64 Bldg 8	Gallaher may know what the labels mean.
Unknown	cores		AC:75.10	TA 64 Bldg 8	
Unknown	cores		AD:75.50	TA 64 Bldg 8	
Unknown	cores		AE:74.80	TA 64 Bldg 8	
Unknown	cores		AF:75.30	TA 64 Bldg 8	
Unknown	cores		AG:75.50	TA 64 Bldg 8	
Unknown	cores		AH:75.20	TA 64 Bldg 8	
Unknown	cores		AI:75.70	TA 64 Bldg 8	
Unknown	cores		AJ:74.90	TA 64 Bldg 8	
Unknown	cores		AK:74.80	TA 64 Bldg 8	
Unknown	cores		AL:74.12	TA 64 Bldg 8	
Unknown	cores		AM:75.04	TA 64 Bldg 8	
Unknown	cores		AN:74.75	TA 64 Bldg 8	

Unknown	cores		AO:74.56	TA 64 Bldg 8	
Unknown	cores		AP:75.93	TA 64 Bldg 8	
Unknown	cores		AQ:75.11	TA 64 Bldg 8	
Unknown	cores		AR:74.84	TA 64 Bldg 8	
Unknown	cores		AS:74.20	TA 64 Bldg 8	
Unknown	cores		AT:74.87	TA 64 Bldg 8	
Unknown	cores		AU:74.46	TA 64 Bldg 8	
Unknown	cores		AV:74.82	TA 64 Bldg 8	
Unknown	cores		AW:74.41	TA 64 Bldg 8	
Unknown	cores		AX:74.70	TA 64 Bldg 8	
Unknown	cores		AY:75.29	TA 64 Bldg 8	
Unknown	cores		B:74.83	TA 64 Bldg 8	
Unknown	cores		C:75.77	TA 64 Bldg 8	
Unknown	cores		D:75.29	TA 64 Bldg 8	
Unknown	cores		E:74.60	TA 64 Bldg 8	
Unknown	cores		F:74.99	TA 64 Bldg 8	
Unknown	cores		G:74.29	TA 64 Bldg 8	
Unknown	cores		H:75.76	TA 64 Bldg 8	
Unknown	cores		I:74.52	TA 64 Bldg 8	
Unknown	cores		J:74.86	TA 64 Bldg 8	
Unknown	cores		K:75.02	TA 64 Bldg 8	
Unknown	cores		L:74.89	TA 64 Bldg 8	
Unknown	cores		M:74.96	TA 64 Bldg 8	
Unknown	cores		N:75.39	TA 64 Bldg 8	
Unknown	cores		O:74.69	TA 64 Bldg 8	
Unknown	cores		P:74.78	TA 64 Bldg 8	
Unknown	cores		Q:75.30	TA 64 Bldg 8	
Unknown	cores		R:75.10	TA 64 Bldg 8	
Unknown	cores		S:74.90	TA 64 Bldg 8	
Unknown	cores		T:74.93	TA 64 Bldg 8	
Unknown	cores		U:73.93	TA 64 Bldg 8	
Unknown	cores		V:75.30	TA 64 Bldg 8	
Unknown	cores		W:75.40	TA 64 Bldg 8	
Unknown	cores		X:75.30	TA 64 Bldg 8	
Unknown	cores		Y:74.70	TA 64 Bldg 8	
Unknown	cores		Z:75.70	TA 64 Bldg 8	

Appendix Section 10.4: Compilation of Drill Holes and Stratigraphic Contacts

10.4.1: Listing of drill holes for which data were examined, with listings of the lowest contact encountered and the number of contacts used for the digital model (holes that did not provide data for the digital model have blank entries in the last two columns).

10.4.2: Detailed listing of all contact positions in those drill holes used to create the digital geologic model. The original (o) and corrected (c) east and north coordinates differ only for those drill holes whose locations were checked in the field against FIMAD digital orthophotos. Corrected elevations differ from original for most holes because the elevations for all holes were adjusted to the digital elevation model.

Appendix Section 10.4.1: Listing of Drill Holes Evaluated

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
T-5	BH-1479	263		
T-6	BH-1480	300		
T-7	BH-1481	55		
TA-46	BH-1351	747		
TBM-1	BH-1352	139		
TBM-2	BH-1353	64		
TEST HOLE 1	BH-1354	23		
TEST HOLE 1-53	BH-1355	49		
TEST HOLE 2	BH-1356	103		
TEST HOLE 2-53	BH-1357	49		
TEST HOLE 3-53	BH-1358	49		
TEST HOLE 4-53	BH-1359	49		
TEST HOLE 5-53	BH-1360	100		
TEST HOLE 6-53	BH-1361	150	Qbt1v	2
TEST HOLE 7-53	BH-1362	80	Qbof	2
TH-3	BH-1371	123		
TH-4	BH-1373	79		
TH-5	BH-1377	262.9	Tb	3
TH-6	BH-1378	299.9	Tpf	3
TH-7	BH-1379	55	Tb	2
TH-8	BH-1380	299		
TSCM-1	BH-1385	22		
TSCO-1	BH-1386	37		
TW-1	BH-1387	642	Tpt	7
TW-1A	BH-1388	225	Tb	3
TW-2	BH-1389	834	Tpt	2
TW-2A	BH-1390	133		
TW-2B	BH-1391	133		
TW-3	BH-1392	815	Tpt	3
TW-4	BH-1393	1205	Tt	2
TW-8	BH-1394	1065	Tpf	4
UM-3	BH-1520	56		
USGS TH	BH-1395	210	Qbt2	1
WCM-1	BH-1398	10		
WCO-1	BH-1400	37		
WCO-2	BH-1401	38		
WCO-3	BH-1402	13.9	Tb	1

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
PO-1C	BH-1304	22		
PO-1D	BH-1305	23		
PO-2	BH-1306	30		
PO-2A	BH-1307	11		
PO-2B	BH-1308	11		
PO-3	BH-1309	27		
PO-3A	BH-1310	33		
PO-3B	BH-1311	73		
PO-4	BH-1312	43		
PO-4A	BH-1313	43		
PO-4B	BH-1314	57		
PO-5	BH-1315	22		
PO-6	BH-1316	18		
POTM-1	BH-1317	50		
POTM-2	BH-1318	56		
POTM-3	BH-1319	52		
POTO-4A	BH-1320	174	Qbof	2
POTO-4B	BH-1321	99		
POTO-4C	BH-1322	48		
POTO-5A	BH-1323	77.5		
POTO-5B	BH-1324	27		
RGT-1	BH-1325	53		
RGT-2	BH-1326	497		
RGT-3	BH-1327	495		
RGT-4	BH-1328	495		
SC-10	BH-1519	15		
SC-5	BH-1514	40		
SC-6	BH-1515	40		
SC-7	BH-1516	40		
SC-8	BH-1517	37		
SC-9	BH-1518	15		
SCO-1	BH-1333	79		
SCO-2	BH-1335	29		
SCOI-3	na	132	Tb	3
SHB-1	BH-1341	700	Tb	11
SHB-2	BH-1342	200		
SHB-3	BH-1343	860	Tpf	6
SHB-4	BH-1344	200	Qbof	3
SIGMA MESA (EGH-LA-1)	BH-1345	2292	Tt	8
SIMO	BH-1346	104	Qbof	3
SIMO-1	BH-1347	163		
SKI BASIN	BH-1348	400		
SOUTH	33-1232	246	Tpf	6

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
MIDDLE	33-1231	217	Tb	8
NORTH	33-1230	230	Tpf	6
O-1	BH-1261	2609	Tsfu	9
O-4	BH-1262	2806	Tsfu	9
P-0	BH-1263	110		
P-1	BH-1264	35		
P-10	BH-1265	150		
P-11	BH-1266	70		
P-12	BH-1267	200	Qbt2	2
P-13	BH-1268	103		
P-14	BH-1269	85		
P-15	BH-1270	70		
P-16	BH-1271	105		
P-17	BH-1272	30		
P-18	BH-1273	30		
P-19	BH-1274	30		
P-2	BH-1275	10		
P-20	BH-1276	30		
P-3	BH-1277	9		
P-4	BH-1278	10		
P-5	BH-1279	35		
P-6	BH-1280	10		
P-7	BH-1281	35		
P-8	BH-1282	10		
P-9	BH-1283	35		
PC-1	BH-1284	2178		
PC-2	BH-1287	1825		
PCM-1	BH-1288	60		
PCM-2	BH-1289	120		
PCM-3	BH-1290	60		
PCM-4	BH-1291	60		
PCO-1	36-2020	22		
PCO-2	36-2021	22		
PCO-3	36-2022	20		
PCTH-1	BH-1295	74		
PM-1	BH-1296	2501	Tsfu	15
PM-2	BH-1297	2600	Tsfu	12
PM-3	BH-1298	2552	Tsfu	11
PM-4	BH-1299	2920	Tsfuv	12
PM-5	BH-1300	3120	Tsfu	17
PO-1	BH-1301	16		
PO-1A	BH-1302	36		
PO-1B	BH-1303	18		

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
MCM-5.1	BH-1205	111.5	Qct	2
MCM-5.9A	BH-1206	194	Qbof	3
MCM-5A	BH-1207	25		
MCM-5B	BH-1208	30		
MCM-5C	BH-1209	37		
MCM-6.5	BH-1210	95		
MCM-6.5A	BH-1211	23		
MCM-6A	BH-1212	18		
MCM-6B	BH-1213	52		
MCM-6C	BH-1214	57		
MCM-6D	BH-1215	35		
MCM-6E	BH-1216	21		
MCM-7.5	BH-1217	94		
MCM-8A	BH-1218	17		
MCM-8B	BH-1219	30		
MCM-8C	BH-1220	66		
MCM-8D	BH-1221	86		
MCM-8E	BH-1222	53		
MCM-8F	BH-1223	23		
MCO-1	BH-1224	8		
MCO-11	BH-1225	23		
MCO-12	BH-1227	112		
MCO-13	BH-1228	112		
MCO-2	BH-1229	10		
MCO-3	BH-1230	18		
MCO-4	BH-1231	24		
MCO-4A	BH-1232	24		
MCO-4B	BH-1233	34		
MCO-5	BH-1234	47		
MCO-6	BH-1235	82		
MCO-6.5A	BH-1237	47		
MCO-6.5B	BH-1238	42		
MCO-6A	BH-1239	36		
MCO-6B	BH-1240	48		
MCO-7	BH-1241	77		
MCO-7.5A	BH-1242	63		
MCO-7.5B	BH-1243	63		
MCO-7A	BH-1244	47		
MCO-8	BH-1245	92		
MCO-8.2	BH-1246	72		
MCO-8A	BH-1247	52		
MCO-9	BH-1248	57		
MCO-9.5	BH-1249	57		

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
LLC-86-20	54-2020	198		
LLC-86-21	54-2021	198		
LLC-86-22	54-2022	197		
LLC-86-23	54-2023	199		
LLC-86-24	54-2024	198		
LLC-86-25	54-2025	198		
LLC-88-26	54-2026	198		
LLC-88-27	54-2027	263		
LLC-88-28	54-2028	267		
LLC-88-29	54-2029	298		
LLC-88-30	54-2030	273		
LLC-89-31	54-2031	291		
LLC-89-32	54-2032	171		
LLC-89-33	54-2033	293		
LLC-90-34	54-2034	317		
LLC-90-35	54-2035	351		
LLM-85-01	54-2001	124		
LLM-85-02	54-2002	124		
LLM-85-05	54-2005	124		
LLP-85-03	54-2003	99		
M-1	BH-1182	40		
M-2	BH-1183	20		
M-3	BH-1184	8		
MCC-8.2	BH-1185	184	Qbof	3
MCM-10	BH-1187	67		
MCM-10-1	BH-1188	119		
MCM-10-2	BH-1189	43		
MCM-10-3A	BH-1190	33		
MCM-10-3B	BH-1191	43		
MCM-12A	BH-1192	98		
MCM-12B	BH-1186	79		
MCM-1A	BH-1193	12		
MCM-1B	BH-1194	11		
MCM-2.2	BH-1195	64		
MCM-2.8	BH-1196	52		
MCM-2A	BH-1197	11		
MCM-2B	BH-1198	1		
MCM-3A	BH-1199	13		
MCM-3B	BH-1200	10		
MCM-4.5	BH-1201	48		
MCM-4.8	BH-1202	33		
MCM-4A	BH-1203	9		
MCM-4B	BH-1204	24		

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
L-19	BH-1122	30		
L-20	BH-1123	30		
LA-1	BH-1124	1001		
LA-1B	BH-1125	2256		
LA-2	BH-1126	882		
LA-3	BH-1127	910		
LA-4	BH-1128	2019	Tsfu	3
LA-5	BH-1129	2024		
LA-6	BH-1130	2030		
LADP-3	21-1682	349	Tpf	3
LADP-4	21-1683	800	Tpf	9
LAO-1	BH-1133	32		
LAO-1.2	BH-1134	38		
LAO-1.8	BH-1135	48		
LAO-2	BH-1136	32		
LAO-3	BH-1137	32		
LAO-3A	BH-1138	18		
LAO-4	BH-1139	31		
LAO-4.5	BH-1140	62	Tb	2
LAO-4.5A	BH-1141	20		
LAO-4.5B	BH-1142	35		
LAO-4.5C	BH-1143	25		
LAO-5	BH-1144	26.9	Tb	1
LAO-6	BH-1145	26	Tb	1
LAO-6A	BH-1146	15	Tb	1
LAO-C	BH-1147	14		
LAOI(A)-1.1	02-1075	323	Tpf	3
LAUZ-1	21-1811	260		
LAUZ-2	21-1812	15		
LAYNE WESTERN	BH-1148	157		
LGC-85-09	54-2009	99		
LGC-85-10	54-2010	99		
LGM-85-06	54-2006	124		
LGM-85-11	54-2011	124		
LGP-85-07	54-2007	49		
LLC-85-12	54-2012	99		
LLC-85-13	54-2013	99		
LLC-85-14	54-2014	99		
LLC-85-15	54-2015	99		
LLC-85-16	54-2016	99		
LLC-85-17	54-2017	149		
LLC-85-18	54-2018	99		
LLC-86-19	54-2019	201		

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
CH-3	BH-1056	300	Qbt1v	1
CH-4	BH-1057	303	Qbt1v	1
DM-2	39-1121	40		
DM-4	39-1133	25		
DM-5	BH-1521	55		
DM-6	BH-1522	60		
DMB-1	39-1132	124	Tb	4
DPS-1	BH-1059	50		
DPS-10	BH-1060	35		
DPS-11	BH-1061	50		
DPS-12	BH-1062	36		
DPS-13	BH-1063	35		
DPS-2	BH-1064	25		
DPS-3	BH-1067	50		
DPS-4	BH-1068	25		
DPS-5	BH-1070	50		
DPS-6	BH-1071	50		
DPS-7	BH-1072	25		
DPS-8	BH-1073	50		
DPS-9	BH-1074	25		
DT-10	BH-1075	1409	Tsfuv	5
DT-5	BH-1076	961.9	Tpf	1
DT-5A	BH-1077	1821	Tsfuv	7
DT-5P	BH-1078	692	Qu	1
DT-9	BH-1079	1501	Tsfuv	5
FCO-1	BH-1081	29		
G-1	BH-1085	2020	Tsfu	6
G-1A	BH-1086	2071	Tsfu	8
G-2	BH-1087	2006	Tsfu	4
G-3	BH-1088	1996	Tsfu	7
G-4	BH-1089	2002	Tsfu	11
G-5	BH-1090	1997	Tsfu	9
G-6	BH-1091	2005	Tsfu	11
GAMMA	BH-1092	54		
GT-2	BH-1095	50		
GT-3	BH-1096	475		
GT-4	BH-1097	315		
GT-5	BH-1098	475		
H-16	BH-1106	1269		
H-17	BH-1107	493		
H-19	BH-1108	2000	Tt	6
L-17	BH-1120	30		
L-18	BH-1121	30		

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
54-G-5	na	113	Qbt1g	2
5M-1	BH-1025	39		
5M-2	BH-1026	19		
6M-1	BH-1027	19		
9M-1	BH-1028	19		
9M-2	BH-1029	19		
9M-3	BH-1030	19		
9M-4	BH-1031	19		
ALPHA	BH-1032	189		
APCO-1	BH-1033	20		
ASC-0	BH-1500	80		
ASC-1	BH-1501	80		
ASC-11	BH-1505	80		
ASC-12	BH-1506	80		
ASC-13	BH-1507	80		
ASC-14	BH-1508	80		
ASC-15	BH-1509	80		
ASC-16	BH-1510	80		
ASC-17	BH-1511	80		
ASC-18	BH-1512	80		
ASC-19	BH-1513	79		
ASC-2	BH-1502	80		
ASC-3	BH-1503	80		
ASC-4	BH-1504	80		
B-1	BH-1034	5		
B-2	BH-1035	2		
B-3	BH-1036	14		
B-4	BH-1037	19		
B-5	BH-1038	12		
BETA	BH-1039	180		
CDBM-1	BH-1043	189	Qbof	3
CDBM-2	BH-1044	99	Qbof	4
CDBO-1	BH-1045	15		
CDBO-2	BH-1046	18		
CDBO-3	BH-1047	12		
CDBO-4	BH-1048	12		
CDBO-5	BH-1049	17.5		
CDBO-6	BH-1050	49		
CDBO-7	BH-1051	44		
CDBO-8	BH-1052	23		
CDBO-9	BH-1053	34		
CH-1	BH-1054	501	Qbt1v	1
CH-2	BH-1055	507	Qbt1g	3

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
48-2068	na	8.5		
48-2069	na	8.5		
49-2-10-1	49-2902	10		
49-2-10-2	49-2903	9.8		
49-2-10-3	49-2904	10.1		
49-2-10-4	49-2905	10		
49-2-150-1	49-2906	150		
49-2-150-2	49-2907	150		
49-2-700-1	49-2901	700	Qbof	9
4M-1	BH-1012	49		
4M-2	BH-1013	20		
4M-3	BH-1014	19		
4M-4	BH-1015	19		
54-1001	na	314	Qct	5
54-1002	na	310	Qct	5
54-1003	na	299	Qct	5
54-1004	na	340	Qbof	6
54-1005	na	290.5	Qct	5
54-1006	na	320	Qct	5
54-1007	na	150		
54-1008	na	150	Qbt1g	3
54-1009	na	150	Qbt1g	3
54-1015	na	530	Tb	8
54-1016	na	605	Tb	7
54-1102	na	121.5	Qbt1v	2
54-1106	na	73.5	Qbt1v	2
54-1107	na	130	Qbt1g	3
54-1108	na	63.6	Qbt1g	2
54-1110	na	103	Qbt1g	2
54-1111	na	153	Qct	4
54-1112	na	60.5	Qbt1v	2
54-1114	na	59	Qbt1v	2
54-1115	na	134.9	Qbt1v	2
54-1116	na	89.5	Qbt1g	3
54-1117	na	92.5	Qbt1g	3
54-1120	na	70	Qbt1v	2
54-1121	na	148	Qbof	6
54-1123	na	100	Qct	4
54-1124	na	77	Qbt1v	2
54-1125	na	63.5	Qbt1v	2
54-1126	na	102	Qbt1v	2
54-1128	na	82.4	Qbt1v	2
54-G-2	na	102	Qbt1g	2

Well Name	FIMAD or other number	depth (ft)	lowest contact encountered	number of contacts used
10M-1	BH-1000	29		
10M-2	BH-1001	20		
1M-1	BH-1002	49		
1M-2	BH-1003	19		
1M-3	BH-1004	19		
1M-3A	BH-1005	49		
21-1811	na	260	Qct	5
21-2523	na	320	Qct	7
2M-1	BH-1006	49		
2M-2	BH-1007	10		
2M-3	BH-1008	19		
35-2004	na	100	Qbt2	2
35-2005	na	100	Qbt2	2
35-2006	na	100	Qbt2	3
35-2007	na	93	Qbt2	2
35-2008	na	100	Qbt2	2
35-2009	na	100	Qbt2	2
35-2011	na	100	Qbt2	2
35-2013	na	100	Qbt2	2
35-2028	na	299	Qbof	7
3M-1	BH-1009	50		
3M-2	BH-1010	19		
3M-3	BH-1011	20		
42-1028	na	28		
42-1029	na	28.5		
42-1030	na	28		
42-1031	na	27		
48-2007	na	1		
48-2008	na	3		
48-2009	na	3		
48-2010	na	15		
48-2011	na	15		
48-2013	na	15		
48-2014	na	15		
48-2015	na	15		
48-2021	na	15		
48-2022	na	15		
48-2023	na	15		
48-2024	na	15		
48-2025	na	14		
48-2037	na	3		
48-2056	na	2		
48-2067	na	10		

Appendix Section 10.4.2: Compilation of Stratigraphic Contacts in Drill Holes used for the LANL Site-Wide Geologic Model

DRILL HOLE ID: 21-1811

East Coordinate:	1633435.1 (c)	1633435.1 (o)
North Coordinate:	1774809.8 (c)	1774809.8 (o)
Elevation:	7032.5 (c)	7032.4 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	260.0	
Reference:	Sto,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1633435.1	1774809.8	7032.5	7032.4	0.0	surface
	Qmt				
1633435.1	1774809.8	7026.0	7025.9	6.5	b
	Qbt2				
1633435.1	1774809.8	6939.0	6938.9	93.5	c
	Qbt1v				
1633435.1	1774809.8	6892.5	6892.4	140.0	c
	Qbt1g				
1633435.1	1774809.8	6779.0	6778.9	253.5	c
	Qbtt				
1633435.1	1774809.8	6778.6	6778.5	253.9	c
	Qct				
1633435.1	1774809.8	6772.5	6772.4	260.0	i
	Qct				

DRILL HOLE ID: 21-2523

East Coordinate:	1631442.9 (c)	1631442.9 (o)
North Coordinate:	1774550.0 (c)	1774550.0 (o)
Elevation:	7159.0 (c)	7159.9 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	320.0	
Reference:	Woh,Sto,1996	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1631442.9	1774550.0	7159.0	7159.9	0.0	surface
	Qmt				
1631442.9	1774550.0	7157.0	7157.9	2.0	b
	Qbt3w				
1631442.9	1774550.0	7094.0	7094.9	65.0	c
	Qbt3nw				
1631442.9	1774550.0	7070.0	7070.9	89.0	c
	Qbt2				
1631442.9	1774550.0	6999.0	6999.9	160.0	c
	Qbt1v				
1631442.9	1774550.0	6937.0	6937.9	222.0	c
	Qbt1g				
1631442.9	1774550.0	6861.3	6862.2	297.7	c
	Qbtt				
1631442.9	1774550.0	6859.0	6859.9	300.0	c
	Qct				
1631442.9	1774550.0	6839.0	6839.9	320.0	i
	Qct				

DRILL HOLE ID: 33-1230

East Coordinate:	1638984.0 (c)	1638984.0 (o)
North Coordinate:	1740078.9 (c)	1740078.9 (o)
Elevation:	6514.0 (c)	6517.5 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	.0	
Reference:	Sti,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1638984.0	1740078.9	6514.0	6517.5	0.0	surface
	Qmt				
1638984.0	1740078.9	6512.7	6516.2	1.3	b
	Qbt2				
1638984.0	1740078.9	6442.0	6445.5	72.0	c
	Qbt1v				
1638984.0	1740078.9	6344.0	6347.5	170.0	c
	Qbt1g				
1638984.0	1740078.9	6292.0	6295.5	222.0	c
	Qbtt				
1638984.0	1740078.9	6291.0	6294.5	223.0	c
	Tb				
1638984.0	1740078.9	6287.0	6290.5	227.0	c
	Tpf				
1638984.0	1740078.9	6284.0	6287.5	230.0	i
	Tpf				

DRILL HOLE ID: 33-1231

East Coordinate:	1638986.3 (c)	1638986.3 (o)
North Coordinate:	1740039.9 (c)	1740039.9 (o)
Elevation:	6516.0 (c)	6516.9 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	268.0	
Reference:	Sti,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1638986.3	1740039.9	6516.0	6516.9	0.0	surface
	Qmt				
1638986.3	1740039.9	6515.8	6516.7	.2	b
	Qbt3nw				
1638986.3	1740039.9	6506.0	6506.9	10.0	c
	Qbt2				
1638986.3	1740039.9	6443.0	6443.9	73.0	c
	Qbt1v				
1638986.3	1740039.9	6346.0	6346.9	170.0	c
	Qbt1g				
1638986.3	1740039.9	6300.0	6300.9	216.0	c
	Qbtt				
1638986.3	1740039.9	6299.0	6299.9	217.0	c
	Qct				
1638986.3	1740039.9	6294.0	6294.9	222.0	c
	Tpf				
1638986.3	1740039.9	6248.0	6248.9	268.0	c
	Tb				
1638986.3	1740039.9	6201.0	6201.9	315.0	i
	Tb				

DRILL HOLE ID: 33-1232

East Coordinate:	1638991.8 (c)	1638991.8 (o)
North Coordinate:	1739975.5 (c)	1739975.5 (o)
Elevation:	6517.0 (c)	6518.5 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	246.0	
Reference:	Sti,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1638991.8	1739975.5	6517.0	6518.5	0.0	surface
	Qmt				
1638991.8	1739975.5	6515.5	6517.0	1.5	b
	Qbt3nw				
1638991.8	1739975.5	6507.0	6508.5	10.0	c
	Qbt2				
1638991.8	1739975.5	6441.0	6442.5	76.0	c
	Qbt1v				
1638991.8	1739975.5	6343.0	6344.5	174.0	c
	Qbt1g				
1638991.8	1739975.5	6303.0	6304.5	214.0	c
	Qbtt				
1638991.8	1739975.5	6302.0	6303.5	215.0	c
	Tpf				
1638991.8	1739975.5	6271.0	6272.5	246.0	i
	Tpf				

DRILL HOLE ID: 35-2004

East Coordinate:	1628476.2 (c)	1628476.2 (o)
North Coordinate:	1768119.3 (c)	1768119.3 (o)
Elevation:	7180.2 (c)	7174.3 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Ste,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628476.2	1768119.3	7180.2	7174.3	0.0	surface
	Qmt				
1628476.2	1768119.3	7163.7	7157.8	16.5	b
	Qu				
1628476.2	1768119.3	7125.2	7119.3	55.0	i
	Qbt3nw				
1628476.2	1768119.3	7094.2	7088.3	86.0	c
	Qbt2				
1628476.2	1768119.3	7080.2	7074.3	100.0	i
	Qbt2				

DRILL HOLE ID: 35-2005

East Coordinate:	1628605.1 (c)	1628605.1 (o)
North Coordinate:	1769123.8 (c)	1769123.8 (o)
Elevation:	7170.7 (c)	7170.3 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Ste,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628605.1	1769123.8	7170.7	7170.3	0.0	surface
	Qmt				
1628605.1	1769123.8	7155.7	7155.3	15.0	b
	Qu				
1628605.1	1769123.8	7119.7	7119.3	51.0	i
	Qbt3nw				
1628605.1	1769123.8	7082.7	7082.3	88.0	c
	Qbt2				
1628605.1	1769123.8	7070.7	7070.3	100.0	i
	Qbt2				

DRILL HOLE ID: 35-2006

East Coordinate:	1628560.0 (c)	1628560.0 (o)
North Coordinate:	1769068.2 (c)	1769068.2 (o)
Elevation:	7179.9 (c)	7178.9 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Koc,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628560.0	1769068.2	7179.9	7178.9	0.0	surface
	Qfill				
1628560.0	1769068.2	7177.4	7176.4	2.5	b
	Qbt3w				
1628560.0	1769068.2	7104.9	7103.9	75.0	c
	Qbt3nw				
1628560.0	1769068.2	7084.9	7083.9	95.0	c
	Qbt2				
1628560.0	1769068.2	7079.9	7078.9	100.0	i
	Qbt2				

DRILL HOLE ID: 35-2007

East Coordinate:	1628613.9 (c)	1628613.9 (o)
North Coordinate:	1769054.8 (c)	1769054.8 (o)
Elevation:	7175.5 (c)	7174.6 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	93.0	
Reference:	Ste,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628613.9	1769054.8	7175.5	7174.6	0.0	surface
	Qmt				
1628613.9	1769054.8	7175.0	7174.1	.5	b
	Qu				
1628613.9	1769054.8	7115.5	7114.6	60.0	i
	Qbt3nw				
1628613.9	1769054.8	7083.5	7082.6	92.0	c
	Qbt2				
1628613.9	1769054.8	7082.5	7081.6	93.0	i
	Qbt2				

DRILL HOLE ID: 35-2008

East Coordinate:	1628640.0 (c)	1628640.0 (o)
North Coordinate:	1769177.4 (c)	1769177.4 (o)
Elevation:	7172.0 (c)	7171.4 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Ste,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628640.0	1769177.4	7172.0	7171.4	0.0	surface
	Qmt				
1628640.0	1769177.4	7158.0	7157.4	14.0	b
	Qu				
1628640.0	1769177.4	7122.0	7121.4	50.0	i
	Qbt3nw				
1628640.0	1769177.4	7082.5	7081.9	89.5	c
	Qbt2				
1628640.0	1769177.4	7072.0	7071.4	100.0	i
	Qbt2				

DRILL HOLE ID: 35-2009

East Coordinate:	1628655.3 (c)	1628655.3 (o)
North Coordinate:	1769153.2 (c)	1769153.2 (o)
Elevation:	7165.3 (c)	7165.4 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Ste,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628655.3	1769153.2	7165.3	7165.4	0.0	surface
	Qmt				
1628655.3	1769153.2	7155.3	7155.4	10.0	b
	Qbt3nw				
1628655.3	1769153.2	7084.3	7084.4	81.0	c
	Qbt2				
1628655.3	1769153.2	7065.3	7065.4	100.0	i
	Qbt2				

DRILL HOLE ID: 35-2011

East Coordinate:	1628649.0 (c)	1628649.0 (o)
North Coordinate:	1769116.3 (c)	1769116.3 (o)
Elevation:	7166.8 (c)	7167.4 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Ste,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628649.0	1769116.3	7166.8	7167.4	0.0	surface
	Qmt				
1628649.0	1769116.3	7156.8	7157.4	10.0	b
	Qu				
1628649.0	1769116.3	7112.8	7113.4	54.0	i
	Qbt3nw				
1628649.0	1769116.3	7082.3	7082.9	84.5	c
	Qbt2				
1628649.0	1769116.3	7066.8	7067.4	100.0	i
	Qbt2				

DRILL HOLE ID: 35-2013

East Coordinate:	1628611.7 (c)	1628611.7 (o)
North Coordinate:	1769147.5 (c)	1769147.5 (o)
Elevation:	7171.1 (c)	7170.3 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Ste,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628611.7	1769147.5	7171.1	7170.3	0.0	surface
	Qmt				
1628611.7	1769147.5	7155.1	7154.3	16.0	b
	Qu				
1628611.7	1769147.5	7112.1	7111.3	59.0	i
	Qbt3nw				
1628611.7	1769147.5	7085.1	7084.3	86.0	c
	Qbt2				
1628611.7	1769147.5	7071.1	7070.3	100.0	i
	Qbt2				

DRILL HOLE ID: 35-2028

East Coordinate:	1629013.2 (c)	1629013.2 (o)
North Coordinate:	1769223.5 (c)	1769223.5 (o)
Elevation:	7103.4 (c)	7102.9 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	300.0	
Reference:	Koc,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1629013.2	1769223.5	7103.4	7102.9	0.0	surface
	Qal				
1629013.2	1769223.5	7098.9	7098.4	4.5	b
	Qbt3nw				
1629013.2	1769223.5	7078.4	7077.9	25.0	c
	Qbt2				
1629013.2	1769223.5	7013.4	7012.9	90.0	c
	Qbt1v				
1629013.2	1769223.5	6955.4	6954.9	148.0	c
	Qbt1g				
1629013.2	1769223.5	6885.9	6885.4	217.5	c
	Qbtt				
1629013.2	1769223.5	6883.9	6883.4	219.5	c
	Qct				
1629013.2	1769223.5	6806.4	6805.9	297.0	c
	Qbof				
1629013.2	1769223.5	6803.4	6802.9	300.0	i
	Qbof				

DRILL HOLE ID: 49-2901

East Coordinate:	1625984.5 (c)	1625984.5 (o)
North Coordinate:	1755209.0 (c)	1755209.0 (o)
Elevation:	7133.9 (c)	7134.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	700.0	
Reference:	Sti,etal,1996	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1625984.5	1755209.0	7133.9	7134.0	0.0	surface
	Qmt				
1625984.5	1755209.0	7125.9	7126.0	8.0	b
	Qbt4				
1625984.5	1755209.0	7060.9	7061.0	73.0	c
	Qbt3w				
1625984.5	1755209.0	7007.9	7008.0	126.0	c
	Qbt3nw				
1625984.5	1755209.0	6951.9	6952.0	182.0	c
	Qbt2				
1625984.5	1755209.0	6819.9	6820.0	314.0	c
	Qbt1v				
1625984.5	1755209.0	6754.9	6755.0	379.0	c
	Qbt1g				
1625984.5	1755209.0	6576.9	6577.0	557.0	c
	Qbtt				
1625984.5	1755209.0	6572.9	6573.0	561.0	c
	Qct				
1625984.5	1755209.0	6536.4	6536.5	597.5	c
	Qbof				

DRILL HOLE ID: 54-1001

East Coordinate:	1640464.6 (c)	1640464.6 (o)
North Coordinate:	1759065.1 (c)	1759065.1 (o)
Elevation:	6782.2 (c)	6782.5 (o)
Dip:	68.0	
Azimuth:	180.0	
Depth:	314.0	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640464.6	1759065.1	6782.2	6782.5	0.0	surface
	Qal				
1640464.6	1759064.6	6781.2	6781.5	1.1	b
	Qbt2				
1640464.6	1759052.3	6750.7	6751.0	34.0	c
	Qbt1v				
1640464.6	1759012.5	6652.1	6652.4	140.3	c
	Qbt1g				
1640464.6	1758958.9	6519.3	6519.6	283.5	c
	Qbtt				
1640464.6	1758958.5	6518.4	6518.7	284.5	c
	Qct				
1640464.6	1758947.4	6491.0	6491.4	314.0	i
	Qct				

DRILL HOLE ID: 54-1002

East Coordinate:	1640084.4 (c)	1640084.4 (o)
North Coordinate:	1759005.1 (c)	1759005.1 (o)
Elevation:	6788.7 (c)	6789.3 (o)
Dip:	68.0	
Azimuth:	180.0	
Depth:	310.0	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640084.4	1759005.1	6788.7	6789.3	0.0	surface
	Qmt				
1640084.4	1759004.3	6786.8	6787.5	2.0	b
	Qbt2				
1640084.4	1758988.2	6747.0	6747.6	45.0	c
	Qbt1v				
1640084.4	1758951.7	6656.6	6657.2	142.5	c
	Qbt1g				
1640084.4	1758901.1	6531.4	6532.0	277.5	c
	Qbtt				
1640084.4	1758900.2	6529.1	6529.7	280.0	c
	Qct				
1640084.4	1758888.9	6501.2	6501.9	310.0	i
	Qct				

DRILL HOLE ID: 54-1003

East Coordinate:	1640249.7 (c)	1640249.7 (o)
North Coordinate:	1759123.9 (c)	1759123.9 (o)
Elevation:	6791.2 (c)	6794.5 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	299.0	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640249.7	1759123.9	6791.2	6794.5	0.0	surface
	Qmt				
1640249.7	1759123.9	6789.1	6792.4	2.1	b
	Qbt2				
1640249.7	1759123.9	6751.2	6754.5	40.0	c
	Qbt1v				
1640249.7	1759123.9	6657.2	6660.5	134.0	c
	Qbt1g				
1640249.7	1759123.9	6529.2	6532.5	262.0	c
	Qbtt				
1640249.7	1759123.9	6526.2	6529.5	265.0	c
	Qct				
1640249.7	1759123.9	6492.2	6495.5	299.0	i
	Qct				

DRILL HOLE ID: 54-1004

East Coordinate:	1640235.3 (c)	1640235.3 (o)
North Coordinate:	1759247.6 (c)	1759247.6 (o)
Elevation:	6787.1 (c)	6788.4 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	340.0	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640235.3	1759247.6	6787.1	6788.4	0.0	surface
	Qmt				
1640235.3	1759247.6	6785.6	6786.9	1.5	b
	Qbt2				
1640235.3	1759247.6	6749.6	6750.9	37.5	c
	Qbt1v				
1640235.3	1759247.6	6659.6	6660.9	127.5	c
	Qbt1g				
1640235.3	1759247.6	6532.6	6533.9	254.5	c
	Qbtt				
1640235.3	1759247.6	6531.1	6532.4	256.0	c
	Qct				
1640235.3	1759247.6	6492.1	6493.4	295.0	c
	Qbof				
1640235.3	1759247.6	6447.1	6448.4	340.0	i
	Qbof				

DRILL HOLE ID: 54-1005

East Coordinate:	1640389.9 (c)	1640389.9 (o)
North Coordinate:	1759253.2 (c)	1759253.2 (o)
Elevation:	6778.1 (c)	6779.5 (o)
Dip:	68.0	
Azimuth:	0.0	
Depth:	290.5	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640389.9	1759253.2	6778.1	6779.5	0.0	surface
	Qmt				
1640389.9	1759253.9	6776.2	6777.7	2.0	b
	Qbt2				
1640389.9	1759266.3	6745.6	6747.1	35.0	c
	Qbt1v				
1640389.9	1759303.0	6654.8	6656.2	133.0	c
	Qbt1g				
1640389.9	1759349.8	6538.9	6540.3	258.0	c
	Qbtt				
1640389.9	1759352.4	6532.4	6533.8	265.0	c
	Qct				
1640389.9	1759362.0	6508.7	6510.2	290.5	i
	Qct				

DRILL HOLE ID: 54-1006

East Coordinate:	1640155.9 (c)	1640155.9 (o)
North Coordinate:	1759289.2 (c)	1759289.2 (o)
Elevation:	6789.2 (c)	6790.6 (o)
Dip:	66.0	
Azimuth:	180.0	
Depth:	320.0	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640155.9	1759289.2	6789.2	6790.6	0.0	surface
	Qmt				
1640155.9	1759288.7	6788.1	6789.5	1.2	b
	Qbt2				
1640155.9	1759272.9	6752.7	6754.1	40.0	c
	Qbt1v				
1640155.9	1759231.2	6659.0	6660.4	142.5	c
	Qbt1g				
1640155.9	1759173.4	6529.1	6530.5	284.7	c
	Qbtt				
1640155.9	1759172.5	6527.3	6528.7	286.7	c
	Qct				
1640155.9	1759159.0	6496.9	6498.3	320.0	i
	Qct				

DRILL HOLE ID: 54-1008

East Coordinate:	1639720.9 (c)	1639720.9 (o)
North Coordinate:	1759585.6 (c)	1759585.6 (o)
Elevation:	6796.3 (c)	6796.6 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	150.0	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1639720.9	1759585.6	6796.3	6796.6	0.0	surface
	Qmt				
1639720.9	1759585.6	6795.3	6795.6	1.0	b
	Qbt2				
1639720.9	1759585.6	6758.3	6758.6	38.0	c
	Qbt1v				
1639720.9	1759585.6	6665.3	6665.6	131.0	c
	Qbt1g				
1639720.9	1759585.6	6646.3	6646.6	150.0	i
	Qbt1g				

DRILL HOLE ID: 54-1009

East Coordinate:	1639955.4 (c)	1639955.4 (o)
North Coordinate:	1759464.6 (c)	1759464.6 (o)
Elevation:	6792.2 (c)	6792.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	150.0	
Reference:	Cap,1994a	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1639955.4	1759464.6	6792.2	6792.0	0.0	surface
	Qal				
1639955.4	1759464.6	6791.2	6791.0	1.0	b
	Qbt2				
1639955.4	1759464.6	6757.2	6757.0	35.0	c
	Qbt1v				
1639955.4	1759464.6	6660.7	6660.5	131.5	c
	Qbt1g				
1639955.4	1759464.6	6642.2	6642.0	150.0	i
	Qbt1g				

DRILL HOLE ID: 54-1015

East Coordinate:	1639785.9 (c)	1639785.9 (o)
North Coordinate:	1759842.7 (c)	1759842.7 (o)
Elevation:	6706.3 (c)	6708.2 (o)
Dip:	61.5	
Azimuth:	196.4	
Depth:	.0	
Reference:	Mar,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1639785.9	1759842.7	6706.3	6708.2	0.0	surface
	Qmt				
1639785.7	1759842.2	6705.4	6707.3	1.0	b
	Qbt1v				
1639780.7	1759825.3	6672.9	6674.8	38.0	c
	Qbt1g				
1639760.8	1759757.5	6542.9	6544.7	186.0	c
	Qbtt				
1639760.4	1759756.1	6540.2	6542.1	189.0	c
	Qct				
1639755.1	1759738.3	6506.0	6507.8	228.0	c
	Qbof				
1639740.2	1759687.5	6408.4	6410.3	339.0	c
	Qbog				
1639738.5	1759681.7	6397.3	6399.2	351.6	c
	Tpf				
1639737.4	1759677.9	6390.0	6391.8	360.0	c
	Tb				
1639714.5	1759600.1	6240.6	6242.4	530.0	i
	Tb				

DRILL HOLE ID: 54-1016

East Coordinate:	1640128.9 (c)	1640128.9 (o)
North Coordinate:	1759686.0 (c)	1759686.0 (o)
Elevation:	6700.2 (c)	6700.4 (o)
Dip:	59.5	
Azimuth:	191.5	
Depth:	605.0	
Reference:	Mar,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640128.9	1759686.0	6700.2	6700.4	0.0	surface
	Qmt				
1640128.8	1759685.5	6699.3	6699.5	1.0	b
	Qbt1v				
1640125.2	1759668.1	6669.1	6669.4	36.0	c
	Qbt1g				
1640110.2	1759594.4	6541.6	6541.9	184.1	c
	Qbtt				
1640110.1	1759593.9	6540.8	6541.0	185.1	c
	Qct				
1640104.3	1759565.1	6490.8	6491.0	243.0	c
	Qbof				
1640097.5	1759531.6	6432.8	6433.0	310.3	c
	Qbog				
1640096.5	1759527.0	6424.7	6424.9	319.7	c
	Tb				
1640067.6	1759385.1	6178.9	6179.1	605.0	i
	Tb				

DRILL HOLE ID: 54-1102

East Coordinate:	1642365.4 (c)	1642365.4 (o)
North Coordinate:	1757703.8 (c)	1757703.8 (o)
Elevation:	6720.6 (c)	6720.6 (o)
Dip:	32.0	
Azimuth:	304.0	
Depth:	121.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1642365.4	1757703.8	6720.6	6720.6	0.0	surface
	Qmt				
1642365.0	1757704.0	6720.3	6720.3	.5	b
	Qbt2				
1642308.4	1757742.2	6677.7	6677.7	81.0	c
	Qbt1v				
1642280.0	1757761.4	6656.2	6656.2	121.5	i
	Qbt1v				

DRILL HOLE ID: 54-1106

East Coordinate:	1643156.1 (c)	1643156.1 (o)
North Coordinate:	1757509.5 (c)	1757509.5 (o)
Elevation:	6699.6 (c)	6700.4 (o)
Dip:	45.0	
Azimuth:	259.0	
Depth:	73.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643156.1	1757509.5	6699.6	6700.4	0.0	surface
	Qmt				
1643154.7	1757509.2	6698.2	6699.0	2.0	b
	Qbt2				
1643114.4	1757501.4	6657.1	6658.0	60.0	c
	Qbt1v				
1643105.1	1757499.6	6647.6	6648.4	73.5	i
	Qbt1v				

DRILL HOLE ID: 54-1107

East Coordinate:	1643245.1 (c)	1643245.1 (o)
North Coordinate:	1757924.1 (c)	1757924.1 (o)
Elevation:	6717.8 (c)	6718.1 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	130.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643245.1	1757924.1	6717.8	6718.1	0.0	surface
	Qmt				
1643245.0	1757924.1	6715.9	6716.1	2.0	b
	Qbt2				
1643245.0	1757924.1	6660.9	6661.1	57.0	c
	Qbt1v				
1643245.0	1757924.1	6615.9	6616.1	102.0	c
	Qbt1g				
1643245.0	1757924.1	6587.9	6588.1	130.0	i
	Qbt1g				

DRILL HOLE ID: 54-1108

East Coordinate:	1643589.8 (c)	1643589.8 (o)
North Coordinate:	1757984.1 (c)	1757984.1 (o)
Elevation:	6701.8 (c)	6701.0 (o)
Dip:	45.0	
Azimuth:	210.0	
Depth:	63.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643589.8	1757984.1	6701.8	6701.0	0.0	surface
	Qmt				
1643588.8	1757982.3	6699.8	6699.1	2.8	b
	Qbt2				
1643569.6	1757949.1	6661.5	6660.7	57.0	c
	Qbt1v				
1643567.3	1757945.1	6656.9	6656.2	63.6	i
	Qbt1v				

DRILL HOLE ID: 54-1110,G-3

East Coordinate:	1643397.0 (c)	1643397.0 (o)
North Coordinate:	1757365.9 (c)	1757365.9 (o)
Elevation:	6690.4 (c)	6691.2 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	103.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643397.0	1757365.9	6690.4	6691.2	0.0	surface
	Qbt2				
1643396.9	1757365.9	6690.4	6691.2	.1	i
	Qbt2				
1643396.9	1757365.9	6642.4	6643.2	48.0	c
	Qbt1v				
1643396.9	1757365.9	6605.4	6606.2	85.0	c
	Qbt1g				
1643396.9	1757365.9	6587.4	6588.2	103.0	i
	Qbt1g				

DRILL HOLE ID: 54-1111,G-4

East Coordinate:	1643562.7 (c)	1643562.7 (o)
North Coordinate:	1757063.9 (c)	1757063.9 (o)
Elevation:	6675.4 (c)	6674.6 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	153.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643562.7	1757063.9	6675.4	6674.6	0.0	surface
	Qbt2				
1643562.6	1757063.9	6675.4	6674.6	.1	i
	Qbt2				
1643562.6	1757063.9	6635.4	6634.6	40.0	c
	Qbt1v				
1643562.6	1757063.9	6595.4	6594.6	80.0	c
	Qbt1g				
1643562.6	1757063.9	6537.4	6536.6	138.0	c
	Qbtt				
1643562.6	1757063.9	6535.4	6534.6	140.0	c
	Qct				
1643562.6	1757063.9	6522.4	6521.6	153.0	i
	Qct				

DRILL HOLE ID: 54-1112

East Coordinate:	1643899.0 (c)	1643899.0 (o)
North Coordinate:	1758010.5 (c)	1758010.5 (o)
Elevation:	6694.1 (c)	6693.2 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	60.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643899.0	1758010.5	6694.1	6693.2	0.0	surface
	Qmt				
1643899.0	1758010.4	6691.2	6690.4	2.8	b
	Qbt2				
1643899.0	1758010.4	6655.2	6654.4	38.8	c
	Qbt1v				
1643899.0	1758010.4	6633.5	6632.7	60.5	i
	Qbt1v				

DRILL HOLE ID: 54-1114

East Coordinate:	1643918.6 (c)	1643918.6 (o)
North Coordinate:	1757453.7 (c)	1757453.7 (o)
Elevation:	6667.7 (c)	6667.2 (o)
Dip:	45.0	
Azimuth:	227.0	
Depth:	59.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643918.6	1757453.7	6667.7	6667.2	0.0	surface
	Qmt				
1643918.1	1757453.1	6666.9	6666.5	1.1	b
	Qbt2				
1643899.2	1757435.5	6641.1	6640.6	37.6	c
	Qbt1v				
1643888.1	1757425.2	6625.9	6625.4	59.0	i
	Qbt1v				

DRILL HOLE ID: 54-1115

East Coordinate:	1643928.5 (c)	1643928.5 (o)
North Coordinate:	1757147.9 (c)	1757147.9 (o)
Elevation:	6672.4 (c)	6672.0 (o)
Dip:	32.0	
Azimuth:	332.0	
Depth:	135.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643928.5	1757147.9	6672.4	6672.0	0.0	surface
	Qmt				
1643928.2	1757148.4	6672.0	6671.7	.7	b
	Qbt2				
1643897.8	1757205.5	6631.6	6631.2	77.0	c
	Qbt1v				
1643874.7	1757248.9	6600.9	6600.5	134.9	i
	Qbt1v				

DRILL HOLE ID: 54-1116

East Coordinate:	1644409.5 (c)	1644409.5 (o)
North Coordinate:	1757940.8 (c)	1757940.8 (o)
Elevation:	6683.8 (c)	6683.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	89.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644409.5	1757940.8	6683.8	6683.0	0.0	surface
	Qmt				
1644409.5	1757940.7	6683.3	6682.5	.5	b
	Qbt2				
1644409.5	1757940.7	6645.0	6644.2	38.8	c
	Qbt1v				
1644409.5	1757940.7	6599.3	6598.5	84.5	c
	Qbt1g				
1644409.5	1757940.7	6594.3	6593.5	89.5	i
	Qbt1g				

DRILL HOLE ID: 54-1117

East Coordinate:	1644458.5 (c)	1644458.5 (o)
North Coordinate:	1758013.9 (c)	1758013.9 (o)
Elevation:	6680.3 (c)	6679.6 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	92.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644458.5	1758013.9	6680.3	6679.6	0.0	surface
	Qmt				
1644458.4	1758013.8	6679.8	6679.2	.5	b
	Qbt2				
1644458.4	1758013.8	6648.3	6647.7	32.0	c
	Qbt1v				
1644458.4	1758013.8	6599.3	6598.7	81.0	c
	Qbt1g				
1644458.4	1758013.8	6587.8	6587.2	92.5	i
	Qbt1g				

DRILL HOLE ID: 54-1120

East Coordinate:	1644616.4 (c)	1644616.4 (o)
North Coordinate:	1757984.3 (c)	1757984.3 (o)
Elevation:	6688.0 (c)	6683.3 (o)
Dip:	45.0	
Azimuth:	237.0	
Depth:	70.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644616.4	1757984.3	6688.0	6683.3	0.0	surface
	Qmt				
1644615.8	1757983.9	6687.3	6682.6	1.0	b
	Qbt2				
1644584.9	1757963.8	6650.5	6645.8	53.1	c
	Qbt1v				
1644574.9	1757957.3	6638.5	6633.8	70.0	i
	Qbt1v				

DRILL HOLE ID: 54-1121

East Coordinate:	1644583.7 (c)	1644583.7 (o)
North Coordinate:	1757548.6 (c)	1757548.6 (o)
Elevation:	6673.5 (c)	6673.1 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	148.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644583.7	1757548.6	6673.5	6673.1	0.0	surface
	Qmt				
1644583.7	1757548.5	6672.5	6672.1	1.0	b
	Qbt2				
1644583.7	1757548.5	6647.0	6646.6	26.5	c
	Qbt1v				
1644583.7	1757548.5	6595.5	6595.1	78.0	c
	Qbt1g				
1644583.7	1757548.5	6554.2	6553.8	119.3	c
	Qbtt				
1644583.7	1757548.5	6550.5	6550.1	123.0	c
	Qct				
1644583.7	1757548.5	6530.5	6530.1	143.0	c
	Qbof				
1644583.7	1757548.5	6525.5	6525.1	148.0	i
	Qbof				

DRILL HOLE ID: 54-1123

East Coordinate:	1645062.7 (c)	1645062.7 (o)
North Coordinate:	1757887.6 (c)	1757887.6 (o)
Elevation:	6667.4 (c)	6665.3 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	100.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1645062.7	1757887.6	6667.4	6665.3	0.0	surface
	Qbt2				
1645062.6	1757887.5	6667.4	6665.3	.1	i
	Qbt2				
1645062.6	1757887.5	6639.4	6637.3	28.0	c
	Qbt1v				
1645062.6	1757887.5	6599.4	6597.3	68.0	c
	Qbt1g				
1645062.6	1757887.5	6579.9	6577.8	87.5	c
	Qbtt				
1645062.6	1757887.5	6577.9	6575.8	89.5	c
	Qct				
1645062.6	1757887.5	6567.4	6565.3	100.0	i
	Qct				

DRILL HOLE ID: 54-1124

East Coordinate:	1645070.3 (c)	1645070.3 (o)
North Coordinate:	1757751.9 (c)	1757751.9 (o)
Elevation:	6669.3 (c)	6669.8 (o)
Dip:	30.0	
Azimuth:	290.0	
Depth:	77.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1645070.3	1757751.9	6669.3	6669.8	0.0	surface
	Qmt				
1645068.6	1757752.4	6668.3	6668.8	2.0	b
	Qbt2				
1645012.5	1757772.9	6633.8	6634.3	71.0	c
	Qbt1v				
1645007.6	1757774.6	6630.8	6631.3	77.0	i
	Qbt1v				

DRILL HOLE ID: 54-1125

East Coordinate:	1644816.2 (c)	1644816.2 (o)
North Coordinate:	1757555.6 (c)	1757555.6 (o)
Elevation:	6663.8 (c)	6669.4 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	63.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644816.2	1757555.6	6663.8	6669.4	0.0	surface
	Qmt				
1644816.1	1757555.5	6662.8	6668.4	1.0	b
	Qbt2				
1644816.1	1757555.5	6625.8	6631.4	38.0	c
	Qbt1v				
1644816.1	1757555.5	6600.3	6605.9	63.5	i
	Qbt1v				

DRILL HOLE ID: 54-1126

East Coordinate:	1644854.7 (c)	1644854.7 (o)
North Coordinate:	1757199.3 (c)	1757199.3 (o)
Elevation:	6656.0 (c)	6655.8 (o)
Dip:	30.0	
Azimuth:	271.5	
Depth:	102.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644854.7	1757199.3	6656.0	6655.8	0.0	surface
	Qmt				
1644854.2	1757199.2	6655.8	6655.6	.6	b
	Qbt2				
1644805.5	1757200.5	6627.6	6627.4	56.8	c
	Qbt1v				
1644766.4	1757201.5	6605.0	6604.8	102.0	i
	Qbt1v				

DRILL HOLE ID: 54-1128

East Coordinate:	1644520.6 (c)	1644520.6 (o)
North Coordinate:	1757132.5 (c)	1757132.5 (o)
Elevation:	6652.9 (c)	6653.2 (o)
Dip:	30.0	
Azimuth:	93.0	
Depth:	82.5	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644520.6	1757132.5	6652.9	6653.2	0.0	surface
	Qmt				
1644521.0	1757132.5	6652.7	6653.0	.5	b
	Qbt2				
1644555.2	1757130.7	6633.0	6633.2	40.0	c
	Qbt1v				
1644591.9	1757128.8	6611.7	6612.0	82.4	i
	Qbt1v				

DRILL HOLE ID: 54-G-2

East Coordinate:	1643354.9 (c)	1643354.9 (o)
North Coordinate:	1757443.5 (c)	1757443.5 (o)
Elevation:	6694.1 (c)	6694.2 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	102.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643354.9	1757443.5	6694.1	6694.2	0.0	surface
	Qbt2				
1643354.8	1757443.4	6694.1	6694.2	.1	i
	Qbt2				
1643354.8	1757443.4	6642.1	6642.2	52.0	c
	Qbt1v				
1643354.8	1757443.4	6607.6	6607.7	86.5	c
	Qbt1g				
1643354.8	1757443.4	6592.1	6592.2	102.0	i
	Qbt1g				

DRILL HOLE ID: 54-G-5

East Coordinate:	1643484.1 (c)	1643484.1 (o)
North Coordinate:	1757636.0 (c)	1757636.0 (o)
Elevation:	6699.1 (c)	6699.1 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	113.0	
Reference:	Mar,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643484.1	1757636.0	6699.1	6699.1	0.0	surface
	Qbt2				
1643484.1	1757636.0	6699.1	6699.1	.0	i
	Qbt2				
1643484.1	1757636.0	6644.1	6644.1	55.0	c
	Qbt1v				
1643484.1	1757636.0	6604.1	6604.1	95.0	c
	Qbt1g				
1643484.1	1757636.0	6586.1	6586.1	113.0	i
	Qbt1g				

DRILL HOLE ID: CDBM-1

East Coordinate:	1639296.0 (c)	1639296.0 (o)
North Coordinate:	1762355.0 (c)	1762355.0 (o)
Elevation:	6721.6 (c)	6722.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Rog,Gal,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1639296.0	1762355.0	6721.6	6722.0	0.0	surface
	Qal				
1639296.0	1762355.0	6714.6	6715.0	7.0	b
	Qbt1g				
1639296.0	1762355.0	6639.6	6640.0	82.0	c
	Qbtt				
1639296.0	1762355.0	6636.6	6637.0	85.0	i
	Qu				
1639296.0	1762355.0	6629.6	6630.0	92.0	i
	Qct				
1639296.0	1762355.0	6626.6	6627.0	95.0	c
	Qbof				
1639296.0	1762355.0	6532.6	6533.0	189.0	i
	Qbof				

DRILL HOLE ID: CDBM-2

East Coordinate:	1642126.0 (c)	1642126.0 (o)
North Coordinate:	1759697.0 (c)	1759697.0 (o)
Elevation:	6634.1 (c)	6633.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Rog,Gal,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1642126.0	1759697.0	6634.1	6633.0	0.0	surface
	Qal				
1642126.0	1759697.0	6620.1	6619.0	14.0	b
	Qbt1g				
1642126.0	1759697.0	6583.6	6582.5	50.5	c
	Qbtt				
1642126.0	1759697.0	6581.6	6580.5	52.5	c
	Qct				
1642126.0	1759697.0	6579.6	6578.5	54.5	c
	Qbof				
1642126.0	1759697.0	6535.1	6534.0	99.0	i
	Qbof				

DRILL HOLE ID: CH-1

East Coordinate:	1624469.0 (c)	1624469.0 (o)
North Coordinate:	1755478.0 (c)	1755478.0 (o)
Elevation:	7170.6 (c)	7170.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Wei,Pur,1962	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1624469.0	1755478.0	7170.6	7170.0	0.0	surface
	Qbt2				
1624469.0	1755478.0	7170.6	7170.0	.0	i
	Qbt2				
1624469.0	1755478.0	6886.6	6886.0	284.0	c
	Qbt1v				
1624469.0	1755478.0	6669.6	6669.0	501.0	i
	Qbt1v				

DRILL HOLE ID: CH-2

East Coordinate:	1625826.0 (c)	1625826.0 (o)
North Coordinate:	1755344.0 (c)	1755344.0 (o)
Elevation:	7141.3 (c)	7137.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Wei,Pur,1962	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1625826.0	1755344.0	7141.3	7137.0	0.0	surface
	Qfill				
1625826.0	1755344.0	7135.3	7131.0	6.0	b
	Qu				
1625826.0	1755344.0	6944.3	6940.0	197.0	i
	Qbt2				
1625826.0	1755344.0	6843.3	6839.0	298.0	c
	Qbt1v				
1625826.0	1755344.0	6648.3	6644.0	493.0	c
	Qbt1g				
1625826.0	1755344.0	6634.3	6630.0	507.0	i
	Qbt1g				

DRILL HOLE ID: CH-3

East Coordinate:	1624196.0 (c)	1624196.0 (o)
North Coordinate:	1754493.0 (c)	1754493.0 (o)
Elevation:	7169.9 (c)	7170.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	300.0	
Reference:	Wei,Pur,1962	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1624196.0	1754493.0	7169.9	7170.0	0.0	surface
	Qbt2				
1624196.0	1754493.0	7169.9	7170.0	.0	i
	Qbt2				
1624196.0	1754493.0	6874.9	6875.0	295.0	c
	Qbt1v				
1624196.0	1754493.0	6869.9	6870.0	300.0	i
	Qbt1v				

DRILL HOLE ID: CH-4

East Coordinate:	1625537.0 (c)	1625537.0 (o)
North Coordinate:	1753898.0 (c)	1753898.0 (o)
Elevation:	7118.2 (c)	7116.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	303.0	
Reference:	Wei,Pur,1962	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1625537.0	1753898.0	7118.2	7116.0	0.0	surface
	Qbt2				
1625537.0	1753898.0	7118.2	7116.0	.0	i
	Qbt2				
1625537.0	1753898.0	6830.2	6828.0	288.0	c
	Qbt1v				
1625537.0	1753898.0	6815.2	6813.0	303.0	i
	Qbt1v				

DRILL HOLE ID: DMB-1

East Coordinate:	1639992.3 (c)	1639992.3 (o)
North Coordinate:	1743175.9 (c)	1743175.9 (o)
Elevation:	6276.1 (c)	6278.3 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	117.5	
Reference:	Shi,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1639992.3	1743175.9	6276.1	6278.3	0.0	surface
	Qal				
1639992.3	1743175.9	6249.6	6251.8	26.5	b
	Qbof				
1639992.3	1743175.9	6176.1	6178.3	100.0	c
	Qbog				
1639992.3	1743175.9	6171.1	6173.3	105.0	c
	Tpf				
1639992.3	1743175.9	6158.6	6160.8	117.5	c
	Tb				
1639992.3	1743175.9	6152.1	6154.3	124.0	i
	Tb				

DRILL HOLE ID: DT-10

East Coordinate:	1628994.0 (c)	1628994.0 (o)
North Coordinate:	1754448.0 (c)	1754448.0 (o)
Elevation:	7019.0 (c)	7020.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	1409.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628994.0	1754448.0	7019.0	7020.0	0.0	surface
	Qu				
1628994.0	1754448.0	6190.0	6191.0	829.0	i
	Qbog				
1628994.0	1754448.0	6155.0	6156.0	864.0	c
	Tpf				
1628994.0	1754448.0	6047.0	6048.0	972.0	c
	Tb				
1628994.0	1754448.0	5728.0	5729.0	1291.0	c
	Tpf				
1628994.0	1754448.0	5663.0	5664.0	1356.0	c
	Tpt				
1628994.0	1754448.0	5617.0	5618.0	1402.0	c
	Tsfuv				
1628994.0	1754448.0	5610.0	5611.0	1409.0	i
	Tsfuv				

DRILL HOLE ID: DT-5A

East Coordinate:	1625310.0 (c)	1625310.0 (o)
North Coordinate:	1754789.0 (c)	1754789.0 (o)
Elevation:	7144.2 (c)	7144.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	1821.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1625310.0	1754789.0	7144.2	7144.0	0.0	surface
	Qu				
1625310.0	1754789.0	6229.2	6229.0	915.0	i
	Qbog				
1625310.0	1754789.0	6214.2	6214.0	930.0	c
	Tpf				
1625310.0	1754789.0	5977.2	5977.0	1167.0	c
	Tb				
1625310.0	1754789.0	5851.2	5851.0	1293.0	c
	Tpf				
1625310.0	1754789.0	5713.2	5713.0	1431.0	c
	Tb				
1625310.0	1754789.0	5687.2	5687.0	1457.0	c
	Tpf				
1625310.0	1754789.0	5669.2	5669.0	1475.0	c
	Tpt				
1625310.0	1754789.0	5617.2	5617.0	1527.0	c
	Tsfuv				
1625310.0	1754789.0	5323.2	5323.0	1821.0	i
	Tsfuv				

DRILL HOLE ID: DT-5P

East Coordinate:	1625442.0 (c)	1625442.0 (o)
North Coordinate:	1754804.0 (c)	1754804.0 (o)
Elevation:	7136.8 (c)	7144.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Wei,Pur,1962	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1625442.0	1754804.0	7136.8	7144.0	0.0	surface
	Qu				
1625442.0	1754804.0	6954.8	6962.0	182.0	i
	Qbt2				
1625442.0	1754804.0	6854.8	6862.0	282.0	c
	Qbt1v				
1625442.0	1754804.0	6651.8	6659.0	485.0	i
	Qu				
1625442.0	1754804.0	6444.8	6452.0	692.0	i
	Qu				

DRILL HOLE ID: DT-9

East Coordinate:	1628993.0 (c)	1628993.0 (o)
North Coordinate:	1751498.0 (c)	1751498.0 (o)
Elevation:	6936.0 (c)	6935.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	1501.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628993.0	1751498.0	6936.0	6935.0	0.0	surface
	Qu				
1628993.0	1751498.0	6134.0	6133.0	802.0	i
	Qbog				
1628993.0	1751498.0	6086.0	6085.0	850.0	c
	Tpf				
1628993.0	1751498.0	6012.0	6011.0	924.0	c
	Tb				
1628993.0	1751498.0	5774.0	5773.0	1162.0	c
	Tpf				
1628993.0	1751498.0	5617.0	5616.0	1319.0	c
	Tpt				
1628993.0	1751498.0	5579.0	5578.0	1357.0	c
	Tsfuv				
1628993.0	1751498.0	5435.0	5434.0	1501.0	i
	Tsfuv				

DRILL HOLE ID: G-1

East Coordinate:	1656190.6 (c)	1656190.6 (o)
North Coordinate:	1783609.3 (c)	1783609.3 (o)
Elevation:	5978.9 (c)	5973.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2020.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1656190.6	1783609.3	5978.9	5973.0	0.0	surface
	Qal				
1656190.6	1783609.3	5966.9	5961.0	12.0	b
	Tpf				
1656190.6	1783609.3	5953.9	5948.0	25.0	c
	Tpt				
1656190.6	1783609.3	5903.9	5898.0	75.0	c
	Tsfuv				
1656190.6	1783609.3	5298.9	5293.0	680.0	c
	Tsfu				
1656190.6	1783609.3	4438.9	4433.0	1540.0	c
	Tb				
1656190.6	1783609.3	4140.9	4135.0	1838.0	c
	Tsfu				
1656190.6	1783609.3	3958.9	3953.0	2020.0	i
	Tsfu				

DRILL HOLE ID: G-1A

East Coordinate:	1655240.9 (c)	1655240.9 (o)
North Coordinate:	1784353.3 (c)	1784353.3 (o)
Elevation:	6015.9 (c)	6014.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2071.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1655240.9	1784353.3	6015.9	6014.0	0.0	surface
	Qal				
1655240.9	1784353.3	6003.9	6002.0	12.0	b
	Tpf				
1655240.9	1784353.3	5956.9	5955.0	59.0	c
	Tpt				
1655240.9	1784353.3	5893.9	5892.0	122.0	c
	Tsfuv				
1655240.9	1784353.3	5155.9	5154.0	860.0	c
	Tsfu				
1655240.9	1784353.3	4510.9	4509.0	1505.0	c
	Tb				
1655240.9	1784353.3	4340.9	4339.0	1675.0	c
	Tsfu				
1655240.9	1784353.3	4260.9	4259.0	1755.0	c
	Tb				
1655240.9	1784353.3	4225.9	4224.0	1790.0	c
	Tsfu				
1655240.9	1784353.3	3944.9	3943.0	2071.0	i
	Tsfu				

DRILL HOLE ID: G-2

East Coordinate:	1654210.5 (c)	1654210.5 (o)
North Coordinate:	1785123.3 (c)	1785123.3 (o)
Elevation:	6057.8 (c)	6056.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2006.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1654210.5	1785123.3	6057.8	6056.0	0.0	surface
	Qal				
1654210.5	1785123.3	6044.8	6043.0	13.0	b
	Tpf				
1654210.5	1785123.3	6027.8	6026.0	30.0	c
	Tpt				
1654210.5	1785123.3	5982.8	5981.0	75.0	c
	Tsfuv				
1654210.5	1785123.3	5137.8	5136.0	920.0	c
	Tsfu				
1654210.5	1785123.3	4051.8	4050.0	2006.0	i
	Tsfu				

DRILL HOLE ID: G-3

East Coordinate:	1651676.4 (c)	1651676.4 (o)
North Coordinate:	1786218.3 (c)	1786218.3 (o)
Elevation:	6138.8 (c)	6139.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1651676.4	1786218.3	6138.8	6139.0	0.0	surface
	Qal				
1651676.4	1786218.3	6121.8	6122.0	17.0	b
	Tpf				
1651676.4	1786218.3	6080.8	6081.0	58.0	c
	Tpt				
1651676.4	1786218.3	6028.8	6029.0	110.0	c
	Tsfuv				
1651676.4	1786218.3	5217.8	5218.0	921.0	c
	Tb				
1651676.4	1786218.3	5202.8	5203.0	936.0	c
	Tsfu				
1651676.4	1786218.3	5126.8	5127.0	1012.0	c
	Tb				
1651676.4	1786218.3	5048.8	5049.0	1090.0	c
	Tsfu				
1651676.4	1786218.3	4142.8	4143.0	1996.0	i
	Tsfu				

DRILL HOLE ID: G-4

East Coordinate:	1648949.1 (c)	1648949.1 (o)
North Coordinate:	1786452.3 (c)	1786452.3 (o)
Elevation:	6235.0 (c)	6229.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2002.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1648949.1	1786452.3	6235.0	6229.0	0.0	surface
	Qal				
1648949.1	1786452.3	6220.0	6214.0	15.0	b
	Tpf				
1648949.1	1786452.3	6175.0	6169.0	60.0	c
	Tpt				
1648949.1	1786452.3	6115.0	6109.0	120.0	c
	Tsfuv				
1648949.1	1786452.3	5736.0	5730.0	499.0	c
	Tb				
1648949.1	1786452.3	5709.0	5703.0	526.0	c
	Tsfuv				
1648949.1	1786452.3	5380.0	5374.0	855.0	c
	Tb				
1648949.1	1786452.3	5310.0	5304.0	925.0	c
	Tsfuv				
1648949.1	1786452.3	5279.0	5273.0	956.0	c
	Tb				
1648949.1	1786452.3	5262.0	5256.0	973.0	c
	Tsfuv				

1648949.1	1786452.3	5132.0	5126.0	1103.0	c
	Tb				
1648949.1	1786452.3	5085.0	5079.0	1150.0	c
	Tsfu				
1648949.1	1786452.3	4233.0	4227.0	2002.0	i
	Tsfu				

DRILL HOLE ID: G-5

East Coordinate:	1646949.6 (c)	1646949.6 (o)
North Coordinate:	1787907.3 (c)	1787907.3 (o)
Elevation:	6309.6 (c)	6309.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	1997.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1646949.6	1787907.3	6309.6	6309.0	0.0	surface
	Qal				
1646949.6	1787907.3	6301.6	6301.0	8.0	b
	Tpf				
1646949.6	1787907.3	6182.6	6182.0	127.0	c
	Tpt				
1646949.6	1787907.3	6109.6	6109.0	200.0	c
	Tsfuv				
1646949.6	1787907.3	5723.6	5723.0	586.0	c
	Tb				
1646949.6	1787907.3	5696.6	5696.0	613.0	c
	Tsfuv				
1646949.6	1787907.3	5403.6	5403.0	906.0	c
	Tb				
1646949.6	1787907.3	5174.6	5174.0	1135.0	c
	Tsfuv				
1646949.6	1787907.3	5098.6	5098.0	1211.0	c
	Tb				
1646949.6	1787907.3	4979.6	4979.0	1330.0	c
	Tsfu				

1646949.6	1787907.3	4312.6	4312.0	1997.0	i
	Tsfu				

DRILL HOLE ID: G-6

East Coordinate:	1644824.5 (c)	1644824.5 (o)
North Coordinate:	1786851.3 (c)	1786851.3 (o)
Elevation:	6424.4 (c)	6422.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2005.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1644824.5	1786851.3	6424.4	6422.0	0.0	surface
	Qal				
1644824.5	1786851.3	6384.4	6382.0	40.0	b
	Tpf				
1644824.5	1786851.3	6294.4	6292.0	130.0	c
	Tpt				
1644824.5	1786851.3	6224.4	6222.0	200.0	c
	Tsfuv				
1644824.5	1786851.3	5354.4	5352.0	1070.0	c
	Tb				
1644824.5	1786851.3	5254.4	5252.0	1170.0	c
	Tsfuv				
1644824.5	1786851.3	5244.4	5242.0	1180.0	c
	Tb				
1644824.5	1786851.3	5204.4	5202.0	1220.0	c
	Tsfuv				
1644824.5	1786851.3	5154.4	5152.0	1270.0	c
	Tb				
1644824.5	1786851.3	4999.4	4997.0	1425.0	c
	Tsfuv				

1644824.5	1786851.3	4979.4	4977.0	1445.0	c
	Tb				
1644824.5	1786851.3	4954.4	4952.0	1470.0	c
	Tsfu				
1644824.5	1786851.3	4419.4	4417.0	2005.0	i
	Tsfu				

DRILL HOLE ID: H-19

East Coordinate:	1618459.0 (c)	1618444.0 (o)
North Coordinate:	1775590.0 (c)	1775462.1 (o)
Elevation:	7172.0 (c)	7178.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	1490.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1618459.0	1775590.0	7172.0	7178.0	0.0	surface
	Qal				
1618459.0	1775590.0	7145.0	7151.0	27.0	b
	Qu				
1618459.0	1775590.0	6757.0	6763.0	415.0	i
	Qbog				
1618459.0	1775590.0	6700.0	6706.0	472.0	c
	Tt				
1618459.0	1775590.0	6353.0	6359.0	819.0	c
	Tpf				
1618459.0	1775590.0	5962.0	5968.0	1210.0	c
	Tt				
1618459.0	1775590.0	5692.0	5698.0	1480.0	c
	Tpt				
1618459.0	1775590.0	5682.0	5688.0	1490.0	c
	Tt				
1618459.0	1775590.0	5172.0	5178.0	2000.0	i
	Tt				

DRILL HOLE ID: LA-4

East Coordinate:	1657447.1 (c)	1657447.1 (o)
North Coordinate:	1771233.1 (c)	1771233.1 (o)
Elevation:	5970.9 (c)	5975.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2019.0	
Reference:	Cus,1965	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1657447.1	1771233.1	5970.9	5975.0	0.0	surface
	Qal				
1657447.1	1771233.1	5943.9	5948.0	27.0	b
	Tpf				
1657447.1	1771233.1	5857.9	5862.0	113.0	c
	Tpt				
1657447.1	1771233.1	5807.9	5812.0	163.0	c
	Tsfu				
1657447.1	1771233.1	3951.9	3956.0	2019.0	i
	Tsfu				

DRILL HOLE ID: LADP-3

East Coordinate:	1632989.0 (c)	1632989.0 (o)
North Coordinate:	1773469.1 (c)	1773469.1 (o)
Elevation:	6755.6 (c)	6756.7 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	349.0	
Reference:	Sti,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1632989.0	1773469.1	6755.6	6756.7	0.0	surface
	Qct				
1632989.0	1773469.1	6691.6	6692.7	64.0	c
	Qbof				
1632989.0	1773469.1	6445.6	6446.7	310.0	c
	Qbog				
1632989.0	1773469.1	6426.1	6427.2	329.5	c
	Tpf				
1632989.0	1773469.1	6406.6	6407.7	349.0	i
	Tpf				

DRILL HOLE ID: LADP-4

East Coordinate:	1633175.6 (c)	1633175.6 (o)
North Coordinate:	1774718.1 (c)	1774718.1 (o)
Elevation:	7049.7 (c)	7050.5 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	800.0	
Reference:	Cap,1994b	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1633175.6	1774718.1	7049.7	7050.5	0.0	surface
	Qmt				
1633175.6	1774718.1	7043.7	7044.5	6.0	b
	Qbt3nw				
1633175.6	1774718.1	7035.7	7036.5	14.0	c
	Qbt2				
1633175.6	1774718.1	6967.7	6968.5	82.0	c
	Qbt1v				
1633175.6	1774718.1	6891.7	6892.5	158.0	c
	Qbt1g				
1633175.6	1774718.1	6803.2	6804.0	246.5	c
	Qbtt				
1633175.6	1774718.1	6798.7	6799.5	251.0	c
	Qct				
1633175.6	1774718.1	6755.2	6756.0	294.5	c
	Qbof				
1633175.6	1774718.1	6503.2	6504.0	546.5	c
	Qbog				
1633175.6	1774718.1	6482.7	6483.5	567.0	c
	Tpf				

1633175.6	1774718.1	6249.7	6250.5	800.0	i
	Tpf				

DRILL HOLE ID: LAOI(A)-1.1

East Coordinate:	1629427.4 (c)	1629427.4 (o)
North Coordinate:	1773924.5 (c)	1773924.5 (o)
Elevation:	6833.2 (c)	6835.2 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	323.0	
Reference:	Van,1996	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1629427.4	1773924.5	6833.2	6835.2	0.0	surface
	Qal				
1629427.4	1773924.5	6818.2	6820.2	15.0	b
	Qbof				
1629427.4	1773924.5	6539.0	6541.0	294.2	c
	Qbog				
1629427.4	1773924.5	6517.2	6519.2	316.0	c
	Tpf				
1629427.4	1773924.5	6510.2	6512.2	323.0	i
	Tpf				

DRILL HOLE ID: MCC-8.2

East Coordinate:	1636844.0 (c)	1636844.0 (o)
North Coordinate:	1768762.1 (c)	1768762.1 (o)
Elevation:	6775.2 (c)	6780.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Sto,etal,1991	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1636844.0	1768762.1	6775.2	6780.0	0.0	surface
	Qal				
1636844.0	1768762.1	6699.2	6704.0	76.0	b
	Qbt1g				
1636844.0	1768762.1	6691.2	6696.0	84.0	c
	Qbtt				
1636844.0	1768762.1	6688.2	6693.0	87.0	i
	Qu				
1636844.0	1768762.1	6674.2	6679.0	101.0	i
	Qct				
1636844.0	1768762.1	6671.2	6676.0	104.0	c
	Qbof				
1636844.0	1768762.1	6591.2	6596.0	184.0	i
	Qbof				

DRILL HOLE ID: MCM-5.1

East Coordinate:	1632744.0 (c)	1632744.0 (o)
North Coordinate:	1769462.1 (c)	1769462.1 (o)
Elevation:	6870.8 (c)	6870.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Sto,etal,1991	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1632744.0	1769462.1	6870.8	6870.0	0.0	surface
	Qal				
1632744.0	1769462.1	6839.8	6839.0	31.0	b
	Qbt1g				
1632744.0	1769462.1	6777.8	6777.0	93.0	c
	Qbtt				
1632744.0	1769462.1	6774.8	6774.0	96.0	i
	Qu				
1632744.0	1769462.1	6762.3	6761.5	108.5	i
	Qct				
1632744.0	1769462.1	6759.3	6758.5	111.5	i
	Qct				

DRILL HOLE ID: MCM-5.9A

East Coordinate:	1633603.0 (c)	1633603.0 (o)
North Coordinate:	1769030.8 (c)	1769030.8 (o)
Elevation:	6850.2 (c)	6852.3 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Sto,etal,1991	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1633603.0	1769030.8	6850.2	6852.3	0.0	surface
	Qal				
1633603.0	1769030.8	6812.2	6814.3	38.0	b
	Qbt1g				
1633603.0	1769030.8	6752.2	6754.3	98.0	c
	Qbtt				
1633603.0	1769030.8	6749.2	6751.3	101.0	i
	Qu				
1633603.0	1769030.8	6735.2	6737.3	115.0	i
	Qct				
1633603.0	1769030.8	6732.2	6734.3	118.0	c
	Qbof				
1633603.0	1769030.8	6656.2	6658.3	194.0	i
	Qbof				

DRILL HOLE ID: O-1

East Coordinate:	1649396.3 (c)	1649396.3 (o)
North Coordinate:	1772231.1 (c)	1772231.1 (o)
Elevation:	6400.9 (c)	6396.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2609.0	
Reference:	Pur,etal,1993	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1649396.3	1772231.1	6400.9	6396.0	0.0	surface
	Qal				
1649396.3	1772231.1	6350.9	6346.0	50.0	b
	Tpf				
1649396.3	1772231.1	6320.9	6316.0	80.0	c
	Tb				
1649396.3	1772231.1	6120.9	6116.0	280.0	c
	Tpf				
1649396.3	1772231.1	5960.9	5956.0	440.0	c
	Tb				
1649396.3	1772231.1	5930.9	5926.0	470.0	c
	Tpf				
1649396.3	1772231.1	5710.9	5706.0	690.0	c
	Tpt				
1649396.3	1772231.1	5650.9	5646.0	750.0	c
	Tsfu				
1649396.3	1772231.1	4181.9	4177.0	2219.0	c
	Tb				
1649396.3	1772231.1	4169.9	4165.0	2231.0	c
	Tsfu				

1649396.3	1772231.1	3791.9	3787.0	2609.0	i
	Tsfu				

DRILL HOLE ID: O-4

East Coordinate:	1637329.0 (c)	1637337.3 (o)
North Coordinate:	1773013.0 (c)	1772995.1 (o)
Elevation:	6639.0 (c)	6627.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2806.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1637329.0	1773013.0	6639.0	6627.0	0.0	surface
	Qal				
1637329.0	1773013.0	6611.0	6599.0	28.0	b
	Qu				
1637329.0	1773013.0	6469.0	6457.0	170.0	i
	Qbog				
1637329.0	1773013.0	6456.0	6444.0	183.0	c
	Tpf				
1637329.0	1773013.0	5927.0	5915.0	712.0	c
	Tpt				
1637329.0	1773013.0	5829.0	5817.0	810.0	c
	Tsfuv				
1637329.0	1773013.0	5485.0	5473.0	1154.0	c
	Tb				
1637329.0	1773013.0	5292.0	5280.0	1347.0	c
	Tsfuv				
1637329.0	1773013.0	5218.0	5206.0	1421.0	c
	Tb				
1637329.0	1773013.0	5174.0	5162.0	1465.0	c
	Tsfuv				

1637329.0	1773013.0	4299.0	4287.0	2340.0	c
	Tsfu				
1637329.0	1773013.0	3833.0	3821.0	2806.0	i
	Tsfu				

DRILL HOLE ID: P-12

East Coordinate:	1616908.0 (c)	1616908.0 (o)
North Coordinate:	1764098.0 (c)	1764098.0 (o)
Elevation:	7451.6 (c)	7448.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	200.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1616908.0	1764098.0	7451.6	7448.0	0.0	surface
	Qmt				
1616908.0	1764098.0	7448.6	7445.0	3.0	b
	Qu				
1616908.0	1764098.0	7278.6	7275.0	173.0	i
	Qbt3nw				
1616908.0	1764098.0	7256.6	7253.0	195.0	c
	Qbt2				
1616908.0	1764098.0	7251.6	7248.0	200.0	i
	Qbt2				

DRILL HOLE ID: PM-1

East Coordinate:	1647734.3 (c)	1647734.3 (o)
North Coordinate:	1768112.1 (c)	1768112.1 (o)
Elevation:	6513.2 (c)	6520.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2501.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1647734.3	1768112.1	6513.2	6520.0	0.0	surface
	Qu				
1647734.3	1768112.1	6393.2	6400.0	120.0	i
	Qbog				
1647734.3	1768112.1	6348.2	6355.0	165.0	c
	Tb				
1647734.3	1768112.1	6006.2	6013.0	507.0	c
	Tpf				
1647734.3	1768112.1	5738.2	5745.0	775.0	c
	Tpt				
1647734.3	1768112.1	5718.2	5725.0	795.0	c
	Tsfuv				
1647734.3	1768112.1	5677.2	5684.0	836.0	c
	Tb				
1647734.3	1768112.1	5547.2	5554.0	966.0	c
	Tsfuv				
1647734.3	1768112.1	5459.2	5466.0	1054.0	c
	Tb				
1647734.3	1768112.1	5419.2	5426.0	1094.0	c
	Tsfuv				

1647734.3	1768112.1	5347.2	5354.0	1166.0	c
	Tb				
1647734.3	1768112.1	5333.2	5340.0	1180.0	c
	Tsfuv				
1647734.3	1768112.1	5007.2	5014.0	1506.0	c
	Tb				
1647734.3	1768112.1	5003.2	5010.0	1510.0	c
	Tsfuv				
1647734.3	1768112.1	4967.2	4974.0	1546.0	c
	Tb				
1647734.3	1768112.1	4965.2	4972.0	1548.0	c
	Tsfuv				
1647734.3	1768112.1	4715.2	4722.0	1798.0	c
	Tsfu				
1647734.3	1768112.1	4012.2	4019.0	2501.0	i
	Tsfu				

DRILL HOLE ID: PM-2

East Coordinate:	1636786.3 (c)	1636786.3 (o)
North Coordinate:	1760326.0 (c)	1760326.0 (o)
Elevation:	6712.0 (c)	6715.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2600.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1636786.3	1760326.0	6712.0	6715.0	0.0	surface
	Qal				
1636786.3	1760326.0	6682.0	6685.0	30.0	b
	Qu				
1636786.3	1760326.0	6307.0	6310.0	405.0	i
	Qbog				
1636786.3	1760326.0	6280.0	6283.0	432.0	c
	Tb				
1636786.3	1760326.0	6012.0	6015.0	700.0	c
	Tpf				
1636786.3	1760326.0	5978.0	5981.0	734.0	c
	Tb				
1636786.3	1760326.0	5942.0	5945.0	770.0	c
	Tpf				
1636786.3	1760326.0	5372.0	5375.0	1340.0	c
	Tpt				
1636786.3	1760326.0	5302.0	5305.0	1410.0	c
	Tsfuv				
1636786.3	1760326.0	4872.0	4875.0	1840.0	c
	Tb				

1636786.3	1760326.0	4820.0	4823.0	1892.0	c
	Tsfuv				
1636786.3	1760326.0	4494.0	4497.0	2218.0	c
	Tb				
1636786.3	1760326.0	4400.0	4403.0	2312.0	c
	Tsfuv				
1636786.3	1760326.0	4342.0	4345.0	2370.0	c
	Tsfu				
1636786.3	1760326.0	4112.0	4115.0	2600.0	i
	Tsfu				

DRILL HOLE ID: PM-3

East Coordinate:	1642593.0 (c)	1642593.0 (o)
North Coordinate:	1769527.0 (c)	1769527.0 (o)
Elevation:	6610.9 (c)	6610.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2552.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1642593.0	1769527.0	6610.9	6610.0	0.0	surface
	Qal				
1642593.0	1769527.0	6580.9	6580.0	30.0	b
	Qu				
1642593.0	1769527.0	6440.9	6440.0	170.0	i
	Qbog				
1642593.0	1769527.0	6420.9	6420.0	190.0	c
	Tpf				
1642593.0	1769527.0	6395.9	6395.0	215.0	c
	Tb				
1642593.0	1769527.0	6070.9	6070.0	540.0	c
	Tpf				
1642593.0	1769527.0	5865.9	5865.0	745.0	c
	Tpt				
1642593.0	1769527.0	5805.9	5805.0	805.0	c
	Tsfuv				
1642593.0	1769527.0	5505.9	5505.0	1105.0	c
	Tb				
1642593.0	1769527.0	5295.9	5295.0	1315.0	c
	Tsfuv				

1642593.0	1769527.0	5115.9	5115.0	1495.0	c
	Tb				
1642593.0	1769527.0	5070.9	5070.0	1540.0	c
	Tsfuv				
1642593.0	1769527.0	4550.9	4550.0	2060.0	c
	Tsfu				
1642593.0	1769527.0	4058.9	4058.0	2552.0	i
	Tsfu				

DRILL HOLE ID: PM-4

East Coordinate:	1635716.6 (c)	1635716.6 (o)
North Coordinate:	1764674.1 (c)	1764674.1 (o)
Elevation:	6916.1 (c)	6920.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2920.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1635716.6	1764674.1	6916.1	6920.0	0.0	surface
	Qu				
1635716.6	1764674.1	6376.1	6380.0	540.0	i
	Qbog				
1635716.6	1764674.1	6316.1	6320.0	600.0	c
	Tb				
1635716.6	1764674.1	5816.1	5820.0	1100.0	c
	Tpf				
1635716.6	1764674.1	5616.1	5620.0	1300.0	c
	Tpt				
1635716.6	1764674.1	5496.1	5500.0	1420.0	c
	Tsfuv				
1635716.6	1764674.1	4966.1	4970.0	1950.0	c
	Tb				
1635716.6	1764674.1	4936.1	4940.0	1980.0	c
	Tsfuv				
1635716.6	1764674.1	4826.1	4830.0	2090.0	c
	Tb				
1635716.6	1764674.1	4766.1	4770.0	2150.0	c
	Tsfuv				

1635716.6	1764674.1	4726.1	4730.0	2190.0	c
	Tb				
1635716.6	1764674.1	4636.1	4640.0	2280.0	c
	Tsfuv				
1635716.6	1764674.1	4596.1	4600.0	2320.0	c
	Tb				
1635716.6	1764674.1	4486.1	4490.0	2430.0	c
	Tsfuv				
1635716.6	1764674.1	3996.1	4000.0	2920.0	i
	Tsfuv				

DRILL HOLE ID: PM-5

East Coordinate:	1632111.0 (c)	1633083.3 (o)
North Coordinate:	1767791.0 (c)	1767809.1 (o)
Elevation:	7094.0 (c)	7095.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	3120.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1632111.0	1767791.0	7094.0	7095.0	0.0	surface
	Qu				
1632111.0	1767791.0	6384.0	6385.0	710.0	i
	Qbog				
1632111.0	1767791.0	6354.0	6355.0	740.0	c
	Tb				
1632111.0	1767791.0	6334.0	6335.0	760.0	c
	Tpf				
1632111.0	1767791.0	6289.0	6290.0	805.0	c
	Tb				
1632111.0	1767791.0	6164.0	6165.0	930.0	c
	Tpf				
1632111.0	1767791.0	6129.0	6130.0	965.0	c
	Tb				
1632111.0	1767791.0	5949.0	5950.0	1145.0	c
	Tpf				
1632111.0	1767791.0	5624.0	5625.0	1470.0	c
	Tpt				
1632111.0	1767791.0	5544.0	5545.0	1550.0	c
	Tsfuv				

1632111.0	1767791.0	5329.0	5330.0	1765.0	c
	Tb				
1632111.0	1767791.0	5199.0	5200.0	1895.0	c
	Tsfuv				
1632111.0	1767791.0	5154.0	5155.0	1940.0	c
	Tb				
1632111.0	1767791.0	5019.0	5020.0	2075.0	c
	Tsfuv				
1632111.0	1767791.0	4934.0	4935.0	2160.0	c
	Tb				
1632111.0	1767791.0	4454.0	4455.0	2640.0	c
	Tsfuv				
1632111.0	1767791.0	4404.0	4405.0	2690.0	c
	Tb				
1632111.0	1767791.0	4354.0	4355.0	2740.0	c
	Tsfuv				
1632111.0	1767791.0	4314.0	4315.0	2780.0	c
	Tsfu				
1632111.0	1767791.0	3974.0	3975.0	3120.0	i
	Tsfu				

DRILL HOLE ID: POTO-4A

East Coordinate:	1638644.0 (c)	1638644.0 (o)
North Coordinate:	1757062.0 (c)	1757062.0 (o)
Elevation:	6622.0 (c)	6620.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Bec,1994	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1638644.0	1757062.0	6622.0	6620.0	0.0	surface
	Qbt1g				
1638644.0	1757062.0	6538.0	6536.0	84.0	c
	Qbtt				
1638644.0	1757062.0	6535.0	6533.0	87.0	i
	Qu				
1638644.0	1757062.0	6521.0	6519.0	101.0	i
	Qct				
1638644.0	1757062.0	6518.0	6516.0	104.0	c
	Qbof				
1638644.0	1757062.0	6448.0	6446.0	174.0	i
	Qbof				

DRILL HOLE ID: SCOI-3

East Coordinate:	1647420.0 (c)	1647420.0 (o)
North Coordinate:	1767878.0 (c)	1767878.0 (o)
Elevation:	6499.0 (c)	6500.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	132.0	
Reference:	Bro,1996	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1647420.0	1767878.0	6499.0	6500.0	0.0	surface
	Qal				
1647420.0	1767878.0	6471.0	6472.0	28.0	b
	Qbof				
1647420.0	1767878.0	6390.0	6391.0	109.0	c
	Qbog				
1647420.0	1767878.0	6369.0	6370.0	130.0	c
	Tb				
1647420.0	1767878.0	6367.0	6368.0	132.0	i
	Tb				

DRILL HOLE ID: SHB-1

East Coordinate:	1624015.0 (c)	1624015.0 (o)
North Coordinate:	1769855.0 (c)	1769855.0 (o)
Elevation:	7315.9 (c)	7314.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	700.0	
Reference:	Gar,etal,1993	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1624015.0	1769855.0	7315.9	7314.0	0.0	surface
	Qfill				
1624015.0	1769855.0	7314.9	7313.0	1.0	b
	Qbt3w				
1624015.0	1769855.0	7225.9	7224.0	90.0	c
	Qbt3nw				
1624015.0	1769855.0	7195.9	7194.0	120.0	c
	Qbt2				
1624015.0	1769855.0	7100.9	7099.0	215.0	c
	Qbt1v				
1624015.0	1769855.0	7045.9	7044.0	270.0	c
	Qbt1g				
1624015.0	1769855.0	7013.9	7012.0	302.0	c
	Qbtt				
1624015.0	1769855.0	7005.9	7004.0	310.0	c
	Qct				
1624015.0	1769855.0	6868.9	6867.0	447.0	c
	Qbof				
1624015.0	1769855.0	6725.9	6724.0	590.0	c
	Qbog				

1624015.0	1769855.0	6684.9	6683.0	631.0	c
	Tpf				
1624015.0	1769855.0	6671.9	6670.0	644.0	c
	Tb				
1624015.0	1769855.0	6615.9	6614.0	700.0	i
	Tb				

DRILL HOLE ID: SHB-3

East Coordinate:	1609310.0 (c)	1609310.0 (o)
North Coordinate:	1760990.0 (c)	1760990.0 (o)
Elevation:	7607.7 (c)	7607.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	860.0	
Reference:	Gar,etal,1993	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1609310.0	1760990.0	7607.7	7607.0	0.0	surface
	Qfill				
1609310.0	1760990.0	7606.7	7606.0	1.0	b
	Qu				
1609310.0	1760990.0	7457.7	7457.0	150.0	i
	Qbt1g				
1609310.0	1760990.0	7286.7	7286.0	321.0	c
	Qbtt				
1609310.0	1760990.0	7272.7	7272.0	335.0	c
	Qct				
1609310.0	1760990.0	7183.7	7183.0	424.0	c
	Qbof				
1609310.0	1760990.0	6769.7	6769.0	838.0	c
	Qbog				
1609310.0	1760990.0	6768.6	6767.9	839.1	c
	Tpf				
1609310.0	1760990.0	6747.7	6747.0	860.0	i
	Tpf				

DRILL HOLE ID: SHB-4

East Coordinate:	1636245.0 (c)	1636245.0 (o)
North Coordinate:	1761231.0 (c)	1761245.0 (o)
Elevation:	6747.7 (c)	6701.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	200.0	
Reference:	Gar,etal,1993	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1636245.0	1761231.0	6747.7	6701.0	0.0	surface
	Qbt1v				
1636245.0	1761231.0	6707.7	6661.0	40.0	c
	Qbt1g				
1636245.0	1761231.0	6630.7	6584.0	117.0	c
	Qbtt				
1636245.0	1761231.0	6627.7	6581.0	120.0	c
	Qbof				
1636245.0	1761231.0	6547.7	6501.0	200.0	i
	Qbof				

DRILL HOLE ID: SIMO

East Coordinate:	1641844.0 (c)	1641844.0 (o)
North Coordinate:	1766462.1 (c)	1766462.1 (o)
Elevation:	6655.4 (c)	6658.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Sto,etal,1991	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1641844.0	1766462.1	6655.4	6658.0	0.0	surface
	Qal				
1641844.0	1766462.1	6644.4	6647.0	11.0	b
	Qbt1g				
1641844.0	1766462.1	6608.4	6611.0	47.0	c
	Qbtt				
1641844.0	1766462.1	6605.4	6608.0	50.0	i
	Qu				
1641844.0	1766462.1	6594.4	6597.0	61.0	i
	Qct				
1641844.0	1766462.1	6591.4	6594.0	64.0	c
	Qbof				
1641844.0	1766462.1	6551.4	6554.0	104.0	i
	Qbof				

DRILL HOLE ID: Sigma Mesa

East Coordinate:	1628827.8 (c)	1624344.0 (o)
North Coordinate:	1770620.3 (c)	1771862.1 (o)
Elevation:	7209.5 (c)	7215.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	2295.0	
Reference:	Pot,1980	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1628827.8	1770620.3	7209.5	7215.0	0.0	surface
	Qu				
1628827.8	1770620.3	6514.5	6520.0	695.0	i
	Qbog				
1628827.8	1770620.3	6484.5	6490.0	725.0	c
	Tpf				
1628827.8	1770620.3	6364.5	6370.0	845.0	c
	Tt				
1628827.8	1770620.3	6239.5	6245.0	970.0	c
	Tpf				
1628827.8	1770620.3	5874.5	5880.0	1335.0	c
	Tpt				
1628827.8	1770620.3	5809.5	5815.0	1400.0	c
	Tsfuv				
1628827.8	1770620.3	5309.5	5315.0	1900.0	c
	Tt				
1628827.8	1770620.3	5274.5	5280.0	1935.0	c
	Tsfuv				
1628827.8	1770620.3	5214.5	5220.0	1995.0	c
	Tt				

1628827.8	1770620.3	4917.5	4923.0	2292.0	i
	Tt				

DRILL HOLE ID: TW-1

East Coordinate:	1650041.5 (c)	1650041.5 (o)
North Coordinate:	1772076.9 (c)	1772076.9 (o)
Elevation:	6369.9 (c)	6369.2 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	642.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1650041.5	1772076.9	6369.9	6369.2	0.0	surface
	Tpf				
1650041.5	1772076.9	6319.9	6319.2	50.0	c
	Tb				
1650041.5	1772076.9	6204.9	6204.2	165.0	c
	Tpf				
1650041.5	1772076.9	6193.9	6193.2	176.0	c
	Tb				
1650041.5	1772076.9	6114.9	6114.2	255.0	c
	Tpf				
1650041.5	1772076.9	5959.9	5959.2	410.0	c
	Tb				
1650041.5	1772076.9	5859.9	5859.2	510.0	c
	Tpf				
1650041.5	1772076.9	5764.9	5764.2	605.0	c
	Tpt				
1650041.5	1772076.9	5727.9	5727.2	642.0	i
	Tpt				

DRILL HOLE ID: TW-1A

East Coordinate:	1650056.9 (c)	1650056.9 (o)
North Coordinate:	1772065.9 (c)	1772065.9 (o)
Elevation:	6369.8 (c)	6369.3 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	225.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1650056.9	1772065.9	6369.8	6369.3	0.0	surface
	Tpf				
1650056.9	1772065.9	6319.8	6319.3	50.0	c
	Tb				
1650056.9	1772065.9	6204.8	6204.3	165.0	c
	Tpf				
1650056.9	1772065.9	6193.8	6193.3	176.0	c
	Tb				
1650056.9	1772065.9	6144.8	6144.3	225.0	i
	Tb				

DRILL HOLE ID: TW-2

East Coordinate:	1634231.3 (c)	1634231.3 (o)
North Coordinate:	1777267.9 (c)	1777267.9 (o)
Elevation:	6646.4 (c)	6648.6 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	834.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1634231.3	1777267.9	6646.4	6648.6	0.0	surface
	Qal				
1634231.3	1777267.9	6635.4	6637.6	11.0	b
	Qu				
1634231.3	1777267.9	6583.4	6585.6	63.0	i
	Tpf				
1634231.3	1777267.9	5946.4	5948.6	700.0	c
	Tpt				
1634231.3	1777267.9	5812.4	5814.6	834.0	i
	Tpt				

DRILL HOLE ID: TW-3

East Coordinate:	1637727.5 (c)	1637727.5 (o)
North Coordinate:	1773138.1 (c)	1773138.1 (o)
Elevation:	6626.9 (c)	6625.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	815.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1637727.5	1773138.1	6626.9	6625.0	0.0	surface
	Qu				
1637727.5	1773138.1	6451.9	6450.0	175.0	i
	Tpf				
1637727.5	1773138.1	6360.9	6359.0	266.0	c
	Tb				
1637727.5	1773138.1	6288.9	6287.0	338.0	c
	Tpf				
1637727.5	1773138.1	5873.9	5872.0	753.0	c
	Tpt				
1637727.5	1773138.1	5811.9	5810.0	815.0	i
	Tpt				

DRILL HOLE ID: TW-4

East Coordinate:	1624025.0 (c)	1624244.0 (o)
North Coordinate:	1777694.0 (c)	1777762.1 (o)
Elevation:	7242.7 (c)	7244.6 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	635.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1624025.0	1777694.0	7242.7	7244.6	0.0	surface
	Qu				
1624025.0	1777694.0	6874.7	6876.6	368.0	i
	Qbog				
1624025.0	1777694.0	6847.7	6849.6	395.0	c
	Tpf				
1624025.0	1777694.0	6607.7	6609.6	635.0	c
	Tt				
1624025.0	1777694.0	6037.7	6039.6	1205.0	i
	Tt				

DRILL HOLE ID: TW-8

East Coordinate:	1632573.9 (c)	1632573.9 (o)
North Coordinate:	1769506.8 (c)	1769506.8 (o)
Elevation:	6875.1 (c)	6877.6 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	1065.0	
Reference:	Bal,etal,1963	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1632573.9	1769506.8	6875.1	6877.6	0.0	surface
	Qal				
1632573.9	1769506.8	6835.1	6837.6	40.0	b
	Qu				
1632573.9	1769506.8	6430.1	6432.6	445.0	i
	Qbog				
1632573.9	1769506.8	6385.1	6387.6	490.0	c
	Tpf				
1632573.9	1769506.8	6295.1	6297.6	580.0	c
	Tb				
1632573.9	1769506.8	6150.1	6152.6	725.0	c
	Tpf				
1632573.9	1769506.8	5810.1	5812.6	1065.0	i
	Tpf				

DRILL HOLE ID: TestHole6-53

East Coordinate:	1639700.0 (c)	1639700.0 (o)
North Coordinate:	1771080.0 (c)	1771080.0 (o)
Elevation:	6921.2 (c)	6921.2 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Mcl,1991	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1639700.0	1771080.0	6921.2	6921.2	0.0	surface
	Qfill				
1639700.0	1771080.0	6918.2	6918.2	3.0	b
	Qu				
1639700.0	1771080.0	6853.2	6853.2	68.0	i
	Qbt2				
1639700.0	1771080.0	6808.2	6808.2	113.0	c
	Qbt1v				
1639700.0	1771080.0	6771.2	6771.2	150.0	i
	Qbt1v				

DRILL HOLE ID: TestHole7-53

East Coordinate:	1639350.0 (c)	1639350.0 (o)
North Coordinate:	1770510.0 (c)	1770510.0 (o)
Elevation:	6701.0 (c)	6701.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:		
Reference:	Mcl,1991	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1639350.0	1770510.0	6701.0	6701.0	0.0	surface
	Qal				
1639350.0	1770510.0	6700.0	6700.0	1.0	b
	Qu				
1639350.0	1770510.0	6677.0	6677.0	24.0	i
	Qct				
1639350.0	1770510.0	6658.0	6658.0	43.0	c
	Qbof				
1639350.0	1770510.0	6621.0	6621.0	80.0	i
	Qbof				

DRILL HOLE ID: USGS-TH

East Coordinate:	1626738.0 (c)	1626738.0 (o)
North Coordinate:	1768566.0 (c)	1768566.0 (o)
Elevation:	7227.4 (c)	7220.0 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	210.0	
Reference:	Tea,Pem,1984	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1626738.0	1768566.0	7227.4	7220.0	0.0	surface
	Qu				
1626738.0	1768566.0	7147.4	7140.0	80.0	i
	Qbt3nw				
1626738.0	1768566.0	7117.4	7110.0	110.0	c
	Qbt2				
1626738.0	1768566.0	7017.4	7010.0	210.0	i
	Qbt2				

DRILL HOLE ID: LAO-4.5

East Coordinate:	1643659.1 (c)	1643659.10 (o)
North Coordinate:	1772087.8 (c)	1772087.80 (o)
Elevation:	6479.8 (c)	6479.84 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	62.0	
Reference:	Pur,1969	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643659.1	1772087.8	6479.8	6479.8	0.0	surface
	Qal				
1643659.1	1772087.8	6467.9	6467.8	12.0	b
	Tpf				
1643659.1	1772087.8	6441.9	6441.8	38.0	c
	Tb				
1643659.1	1772087.8	6417.9	6417.8	62.0	i
	Tb				

DRILL HOLE ID: LAO-5

East Coordinate:	1646203.0 (c)	1646203.00 (o)
North Coordinate:	1771424.8 (c)	1771424.80 (o)
Elevation:	6427.1 (c)	6427.05 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	27.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1646203.0	1771424.8	6427.1	6427.0	0.0	surface
	Qal				
1646203.0	1771424.8	6415.1	6415.1	11.9	b
	Tb				
1646203.0	1771424.8	6400.1	6400.1	26.9	i
	Tb				

DRILL HOLE ID: LAO-6

East Coordinate:	1646222.1 (c)	1646222.10 (o)
North Coordinate:	1771329.5 (c)	1771329.50 (o)
Elevation:	6423.5 (c)	6423.54 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	26.0	
Reference:	Pur,1995	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1646222.1	1771329.5	6423.5	6423.5	0.0	surface
	Qal				
1646222.1	1771329.5	6412.6	6412.5	11.0	b
	Tb				
1646222.1	1771329.5	6397.6	6397.5	26.0	i
	Tb				

DRILL HOLE ID: DT-5

East Coordinate:	1625310.0 (c)	1625310.00 (o)
North Coordinate:	1754842.0 (c)	1754842.00 (o)
Elevation:	7144.5 (c)	7144.45 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	962.0	
Reference:	Wei,Pur,1962	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1625310.0	1754842.0	7144.5	7144.4	0.0	surface
	Qu				
1625310.0	1754842.0	6219.5	6219.5	924.9	i
	Qbog				
1625310.0	1754842.0	6204.5	6204.5	939.9	c
	Tpf				
1625310.0	1754842.0	6182.5	6182.5	961.9	i
	Tpf				

DRILL HOLE ID: TH-5

East Coordinate:	1643553.0 (c)	1625833.00 (o)
North Coordinate:	1756582.0 (c)	1755132.00 (o)
Elevation:	6590.7 (c)	7135.19 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	263.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1643553.0	1756582.0	6590.7	7135.1	0.0	surface
	Qal				
1643553.0	1756582.0	6567.8	7112.2	22.9	b
	Qu				
1643553.0	1756582.0	6550.8	7095.2	39.9	i
	Qbof				
1643553.0	1756582.0	6430.8	6975.2	159.9	c
	Qbog				
1643553.0	1756582.0	6419.8	6964.2	170.9	c
	Tb				
1643553.0	1756582.0	6327.8	6872.2	262.9	i
	Tb				

DRILL HOLE ID: LAO-6A

East Coordinate:	1646221.6 (c)	1646221.63 (o)
North Coordinate:	1771344.0 (c)	1771344.00 (o)
Elevation:	6423.8 (c)	6423.81 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	15.0	
Reference:	Pur,Sto,1990	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1646221.6	1771344.0	6423.8	6423.8	0.0	surface
	Qal				
1646221.6	1771344.0	6410.8	6410.8	13.0	b
	Tb				
1646221.6	1771344.0	6408.8	6408.8	15.0	i
	Tb				

DRILL HOLE ID: WCO-3

East Coordinate:	1640212.5 (c)	1639212.50 (o)
North Coordinate:	1750620.3 (c)	1750620.38 (o)
Elevation:	6433.9 (c)	6562.08 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	14.0	
Reference:	Pur,Sto,1990	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640212.5	1750620.3	6433.9	6562.0	0.0	surface
	Qal				
1640212.5	1750620.3	6423.0	6551.1	10.9	b
	Tb				
1640212.5	1750620.3	6420.0	6548.1	13.9	i
	Tb				

DRILL HOLE ID: TH-6

East Coordinate:	1640507.0 (c)	1640516.38 (o)
North Coordinate:	1757888.0 (c)	1757879.75 (o)
Elevation:	6642.4 (c)	6642.08 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	300.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640507.0	1757888.0	6642.4	6642.0	0.0	surface
	Qal				
1640507.0	1757888.0	6617.5	6617.1	24.9	b
	Qu				
1640507.0	1757888.0	6557.5	6557.1	84.9	i
	Qbof				
1640507.0	1757888.0	6377.5	6377.1	264.9	c
	Qbog				
1640507.0	1757888.0	6357.5	6357.1	284.9	c
	Tpf				
1640507.0	1757888.0	6342.5	6342.1	299.9	i
	Tpf				

DRILL HOLE ID: TH-7

East Coordinate:	1640744.1 (c)	1640744.13 (o)
North Coordinate:	1740461.9 (c)	1740461.88 (o)
Elevation:	6223.5 (c)	6223.50 (o)
Dip:	90.0	
Azimuth:	0.0	
Depth:	66.0	
Reference:	Gri,1955	

East (c)	North (c)	Elev (c)	Elev (o)	Dip_Depth	Boundary_Type
	Unit/Subunit				
1640744.1	1740461.9	6223.5	6223.5	0.0	surface
	Qal				
1640744.1	1740461.9	6213.5	6213.5	10.0	b
	Qu				
1640744.1	1740461.9	6193.5	6193.5	30.0	i
	Qbog				
1640744.1	1740461.9	6178.5	6178.5	45.0	c
	Tb				
1640744.1	1740461.9	6168.5	6168.5	55.0	i
	Tb				

Appendix Section 10.5: Margaret Anne Rogers Data Use Agreement

DATA USE AGREEMENT

The Regents of the University of California, a constitutional California corporation, at Los Alamos National laboratory (hereinafter referred to as "UNIVERSITY") and Margaret Anne Rogers, 1753 Camino Redondo, Los Alamos, NM 87544, (hereinafter referred to as "OWNER") agree as follows:

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THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

By: W A Barr

Name: William A. Barr

Title: Procurement Manager

Date: April 11,1996

MARGARET ANNE ROGERS

By: Margaret Anne Rogers

Date: 4-4-96

STRAT	X11 COLOR NAME	INTEGER				DECIMAL	
CODE		R	G	B	RED	GREEN	BLUE
Qu	white	255	255	255	1.000000	1.000000	1.000000
Qfill	gray54	128	125	124	.501961	.490196	.486275
Qmt	seashell3	200	191	182	.784314	.749020	.713726
Qc	DarkSeaGreen1	195	253	184	.764706	.992157	.721569
Qls	plum3	195	142	199	.764706	.556863	.780392
Qf	OliveDrab1	195	251	23	.764706	.984314	.090196
Qal	LightGoldenrodYellow	250	248	204	.980392	.972549	.800000
Qt	CadetBlue2	142	226	236	.556863	.886275	.925490
Qec	orchid	229	125	237	.898039	.490196	.929412
Qb	DarkOrchid1	176	65	255	.690196	.254902	1.000000
Qbt	maroon	129	5	65	.505882	.019608	.254902
Qbt5	LightGoldenrod2	236	214	114	.925490	.839216	.447059
Qbt4	peru	197	119	38	.772549	.466667	.149020
Qbt3	wheat1	254	228	177	.996078	.894118	.694118
Qbt3w	yellow	255	252	23	1.000000	.988235	.090196
Qbt3nw	pink2	231	161	176	.905882	.631373	.690196
Qbt2	HotPink3	194	82	131	.760784	.321569	.513726

1	2								
		Qbt1	thistle1	252	223	255	.988235	.874510	1.000000
		Qbt1v	goldenrod2	233	171	23	.913725	.670588	.090196
		Qbt1g	khaki	173	169	110	.678431	.662745	.431373
		Qbtt	gray81	202	202	201	.792157	.792157	.788235
		Qct	red2	228	27	23	.894118	.105882	.090196
		Qbo	purple1	137	59	255	.537255	.231373	1.000000
		Qbof	orange	248	122	23	.972549	.478431	.090196
		Qbog	LightSteelBlue3	154	173	199	.603922	.678431	.780392
		Tp	SeaGreen1	106	251	146	.415686	.984314	.572549
		Tpf	aquamarine2	125	234	190	.490196	.917647	.745098
		Tpt	DarkGoldenrod	175	120	23	.686275	.470588	.090196
		Tpl	MediumPurple2	145	114	236	.568627	.447059	.925490
		Tsf	pink	250	175	190	.980392	.686275	.745098
		Tsfuv	LightSteelBlue1	198	222	255	.776471	.870588	1.000000
		Tsfu	MistyRose	253	225	221	.992157	.882353	.866667
		Tb	magenta	244	62	255	.956863	.243137	1.000000
		Tt	chartreuse3	108	196	23	.423529	.768627	.079861

1 IRIS Realist 5030 InkJet Printer
2 Hewlett Packard Designjet 650C InkJet Printer

Appendix Section 10.11: Set of 20 stratigraphic contact maps

A set of 20 stratigraphic contact maps was created to facilitate evaluation of the quality of the source data and the resultant model. Fifteen of these maps represent the basal contacts of the units which comprise the 3-D stratigraphic model. Basal contact maps are available for the following units: bedrock (base of unconsolidated units), Qbt5, Qbt4, Qbt3w, Qbt3nw, Qbt2, Qbt1v, Qbt1g, Qbtt, Qct, Qbof, Qbog, Tpf, Tpt, and Tsfuv. Five of the maps represent erosional surfaces. The erosional surfaces portrayed are: pre-Qbtt, pre-Qbog, pre-Tpf, pre-Tpt and pre-Tsfuv. The erosional surface map of a given contact age identifies contacts between any unit older than the contact age, with any unit younger than the contact age. Determining the past erosional surface in this manner provides a minimal estimate of the topographic relief at the time that the contact was formed, especially if the overlying unit indicates a break in the depositional sequence.

The 3-D model is based on the gridding at 50 and 100-foot intervals of a triangular integration network (TIN) generated from contact observations (see main text for details). The extend of the grid is shown on the maps as a heavy black and white inner border. The TIN that was generated for each contact is displayed with shades of grey, incremented at 20-foot intervals, and repeated at 500-foot intervals. Areas with no data are shown in yellow. Control points indicating normal stratigraphic succession are shown in cyan; those that indicate missed intervals or contact with other (non-stratigraphic) units such as localized basalt flows, are shown in magenta. The symbol used for control points indicates the data source.

The sparsity and quality of the data, and simplicity of the model (linear interpolation) have resulted in poor definition of some contacts that leads to "impossible" intersections with underlying and/or overlying units. The locations of intersections of the basal contact being mapped, with the basal contact of the overlying and/or underlying units, are shown as colored lines to facilitate the identification and resolution of these model discrepancies. The intersection of the mapped contact with the topographic surface is also shown and should align with the location of mapped surface contact points.

Appendix Section 10.12: Set of visualizations (2 each of TA-21 and TA-49)

Several example visualizations of the 3-D stratigraphic model geology for TA-21 and TA-49 are provided to show the quality of both the model and the images that can be produced from the model. The basal contacts for the 14 stratigraphic units of the model are shown in these images. The visualizations also show stratigraphy encountered in boreholes. The diameter of the boreholes is enlarged to either 50 or 80-feet depending on the density on the data. Names and colors of the stratigraphic units represented in these images are provided in Appendix Section 10.10.

The bright yellow surface which appears in most of the images is the basal contact of the unit Qbt3w (within the Bandelier Tuff). The dark blue surface is the top of the water table. The opacity of the water table has been set to 1.0 (completely opaque), so that if the water table is the closest object to the viewer, underlying objects are obscured. The stratigraphic units have been assigned opacities of .7 so that stacking of units causes a change of colors. For example, in Plate 10.12-2, the subunits of the Puye Formation: Tpf (aquamarine) and Tpt (dark goldenrod[i.e. brown]), occur at the approximate elevation of the water table. Where Tpf is above the water table, and Tpt is below the water table, the apparent color is a mix of blue and aquamarine; where both Tpf and Tpt are above the water table, the apparent color is a mix of blue, aquamarine, and dark goldenrod.

The intersection of the basal contact of Tpf with the basal contact of Tpt identifies a model quality problem. These surfaces should not intersect. However, the piece-wise "linear" surfaces have control point elevations for differing sets of (x,y) locations, so that a control point specific to one surface provides relief in a region that is linearized by the other surface. The two subunits of the Otowi Formation: Qbof (orange) and Qbog (light steel blue) which occur above the Puye Formation, exhibit the same behavior. On the other hand, undulations in subunits of the Bandelier Tuff (the two surfaces below the bright yellow surface on the left side of 10.12-2), are probably due to mapping errors in which contacts of horizontal units were mapped as straight lines across dips in the topography.

The visualization software tools provide an infinite variety of views for a geographical data set having 3-D coordinates, and allow easy identification of deficiencies in the data and/or model.

Appendix Section 10.6: Computer Programs

PROGRAM: get_cross_xy

usage: get_cross_xy [-i infile] [-o outfile] [-d distance]

DESCRIPTION

get_cross_xy provides an infilling of x-y points with a spacing of "distance", for a set of control points consisting of {id,x,y}. The first point of the control set is assigned a distance of 0.0, and each added point, with the exception of the additional control points, is at a multiple of distance from the first control point, along the straight-line-segment path defined by the control points. The id of the added points which follow each control point is control point id followed by a left parenthesis, and the number of points added after the last control point; i.e. the seventh point after control point:

"drill hole alpha" would have the id:
"drill hole alpha(7"

The following options are required:

-i Path/name of input file containing records with the following information: point_id, x, y.

-o Path/name of output file to accept records with the following information: point id, x, y.

-d Distance at which to infill points along set of straight line segments defined by control

OR

-h Print this help message and stop.

Gregory L. Cole, August 1996, Version 1.0

PROGRAM: get_dem_value

usage: get_dem_value [-h (for detailed help)]

get_dem_value [-i infile] [-o outfile]

DESCRIPTION

get_dem_value provides topographic elevations for a set of x,y values. The values are interpolated from the 1 and 4 foot DEMs (Digital Elevation Models) created from contours of the 1991 ER Project aerial survey. Data I/O is accomplished through the use of MOSS format files which provides rapid import and export into the ARC/INFO software. The MOSS format is as follows:

record 1: id (optional), string (optional), n (# pts)
record 2: x (1), y (1)
.
.
.
record n+1: x (n), y (n)
record n+2: id (optional), string (optional), n (# pts)
record n+3: x (1), y (1)
.
.
.

MOSS (FORTRAN) format is: (i5,t16,a30,t51,i5,/,2f11.2).
The output format is: (i5,t16,a30,t51,i5,/,3f11.2),
with the z value following the original x,y, values.

The following options are required:

-i Path/name of input file containing records with the following information: point_id, x, y.

-o Path/name of output file to accept records with the following information: point id, x, y.

OR

-h Print this help message and stop.

Gregory L. Cole, August 1996, Version 1.0

PROGRAM: get_strat

usage: get_strat point_id x y [topographic z]

get_strat [-h (for detailed help)]

get_strat [-i infile] [-o outfile] [-c char]
[-p printed_output_option {a,b,c}]
[-d dem_cell_size {1}]
[-s strat_cell_size {100,50}]

DESCRIPTION

get_strat provides elevations and depths to a set of stratigraphic boundaries for x,y,z (optional) topographic surface locations. Default behavior is to calculate the stratigraphic elevations and depths for a single x,y point, with interpolation based on a 100-foot grid.

The following options alter the default behavior:

-i Path/name of input file containing records with the following information: point_id, x, y, surface z [optional]. {Default: stdio}

-o Path/name of output file to accept records with the following information: point id, stratigraphic boundary name, x, y, boundary z, boundary z, cumulative distance from flagged point. {Default: stdio}

-c Special character placed in "point id" to indicate the starting point for cumulative distances. The special character is not considered part of the point id. The character "-" should not be used as it causes unpredictable results. The characters "*" and "&" need to be enclosed in quotes. {Default: no cumulative distances provided}

This option allows the user to flag the starting point along a cross-section and obtain horizontal distance measurements for subsequent points. By default, distance measurements begin at first point.

-p Print option codes for three types of data:
a - stratigraphic intersections, positive depths
b - option (a) + negative depths
c - option (a) + NO_DATA (-9999.0) intersections
d - option (b) + option (c)
{Default: a}

-s Stratigraphic surface grid size. Acceptable values are: 100, and 50 feet. {Default: 100}

-d Topographic elevation (DEM) grid size. The only acceptable value is 1 foot. The 1-foot option requires significant additional time as the DEM grids must be loaded from optical discs into computer memory as 3000x2000-foot blocks (a two-minute process). If the input data range spans multiple blocks, repeated DEM loading is required. {Default: stratigraphic grid size}

-h Print this help message and stop.

Gregory L. Cole, August 1996, Version 1.0

-p Print option codes for three types of data:
a - stratigraphic intersections, positive depths
b - option (a) + negative depths
c - option (a) + NO_DATA (-9999.0) intersections
d - option (b) + option (c)
{Default: a}

-s Stratigraphic surface grid size. Acceptable values are: 100, and 50 feet. {Default: 100}

-d Topographic elevation (DEM) grid size. The only acceptable value is 1 foot. The 1-foot option requires significant additional time as the DEM grids must be loaded from optical discs into computer memory as 3000x2000-foot blocks (a two-minute process). If the input data range spans multiple blocks, repeated DEM loading is required. {Default: stratigraphic grid size}

-h Print this help message and stop.

Gregory L. Cole, August 1996, Version 1.0

PROGRAM: get_dem_value

usage: get_dem_value [-h (for detailed help)]

get_dem_value [-i infile] [-o outfile]

DESCRIPTION

get_dem_value provides topographic elevations for a set of x,y values. The values are interpolated from the 1 and 4 foot DEMs (Digital Elevation Models) created from contours of the 1991 ER Project aerial survey. Data I/O is accomplished through the use of MOSS format files which provides rapid import and export into the ARC/INFO software. The MOSS format is as follows:

record 1: id (optional), string (optional), n (# pts)
record 2: x (1), y (1)
.
.
.
record n+1: x (n), y (n)
record n+2: id (optional), string (optional), n (# pts)
record n+3: x (1), y (1)
.
.
.

MOSS (FORTRAN) format is: (i5,t16,a30,t51,i5,/,2f11.2).
The output format is: (i5,t16,a30,t51,i5,/,3f11.2),
with the z value following the original x,y, values.

The following options are required:

-i Path/name of input file containing records with the following information: point_id, x, y.

-o Path/name of output file to accept records with the following information: point id, x, y.

OR

-h Print this help message and stop.

Gregory L. Cole, August 1996, Version 1.0

Appendix Section 10.7: Digitized line work transfer to Margaret Anne Rogers

Digitized Contact and Structure Data from the Geologic Map of Los Alamos National Laboratory Reservation, 1995

The Geologic Map of Los Alamos National Laboratory Reservation, prepared by Margaret Anne Rogers (1995), is presented as a series of 25 sheets (21 actual printed sheets) at a scale of 1:4800. Contacts were digitized from all 25 of these sheets, and structures were digitized from 6 of these sheets. The line work was digitized at approximately 1/50th of an inch increments, which is equivalent to a ground distance of about 8 feet. Digitizing was done in the New Mexico State Planar (NAD27) coordinate system. Attribute data were also obtained during the digitizing process. Attribute data collected for the contacts include: upper_unit (as defined by Rogers), lower_unit (as defined by Rogers), bound_type {conformable, fault, erosional (as interpreted by the person doing the digitizing)}, and quality {apparent, approximate, possible}. Attribute data collected for the structures include: struct_type {fault, fold, syncline, anticline}, modifier {reverse, normal, symmetric, asymmetric}, direction {i.e. N 30 W}, and quality {apparent, approximate, possible}. These digitized data were plotted at map scale and overlain on the source map sheets to provide a quality check. A person not involved in the initial digitizing process identified any errors and final corrections were made to the original data set.

The original contact data set was processed further. This processing included a conversion from NAD27 to NAD83 State Planar Coordinates, and a recoding of some of the unit designations to fit with the LANL Environmental Restoration stratigraphic model. The digital contacts were processed together with digital topographic contour lines to obtain {x,y,z} positions of the stratigraphic contacts and these positions were added to the 3-dimensional database.

The original data set which represents the digitized source data in NAD27 State Planar Coordinates has been copied to a single set of 25 DOS-formatted, high-density, 3-1/2" floppy disks. This set of disks has been sent to Mrs. Margaret Anne Rogers, in accordance with the Data Use Agreement between the University of California and her. Each of the 25 disks contain stratigraphic contact data and attributes for one of the map sheets. Six of the disks: 1, 2, 3, 5, 6, 20, also contain structural data. The data are written in MOSS (ASCII) format. For each digitized line there is a header record, followed by a set of x and y coordinates for the line. The header record has the following format:

column 1- 5: ID,
column 16-45: string of attributes, each separated by a backslash,
column 51-55: number of points.

The records following the header have the following format:

column 1-11: x coordinate,
column 12-22: y coordinate.

The original, digitized, source data will not have any further distribution. The {x,y,z} contact positions are a part of a database which supports 3-D modeling activities and may ultimately result in an updated surface geology map of the laboratory and environs.

Appendix Section 10.8: Projected Intersections of Ground Water Protection Plan Monitoring Wells with the Current Model Contacts

Note The contacts listed have yet to be corrected and interpreted. Common errors in the present version of the digital geologic model are:

1) inversions of stratigraphic sequence that are not reasonable
2) excessive thickness of Qbtt, Qbog, and Tpt units

These problems will be addressed in revisions of the digital model.

Well ID: I-1

Surface	East	North	Elevation	Depth
topographic surface:	1649555.3	1772775.0	6357.7	0
base of tpf:	1649555.3	1772775.0	5724.4	633
base of tpt:	1649555.3	1772775.0	5664.9	693
base of tsfuv:	1649555.3	1772775.0	4832.9	1525
water table:	1649555.3	1772775.0	5755.3	602

Well ID: R-1

Surface	East	North	Elevation	Depth
topographic surface:	1632241.4	1787137.6	6884.0	0
water table:	1632241.4	1787137.6	5974.1	910

Well ID: R-2

Surface	East	North	Elevation	Depth
topographic surface:	1624564.6	1778877.2	6940.0	0
water table:	1624564.6	1778877.2	6078.4	862

Well ID: R-3

Surface	East	North	Elevation	Depth
topographic surface:	1629956.0	1778035.8	6747.6	0
base of qbof:	1629956.0	1778035.8	6708.4	39
water table:	1629956.0	1778035.8	5960.5	787

Well ID: R-4

Surface	East	North	Elevation	Depth
topographic surface:	1639871.2	1776621.1	6545.9	0
base of qbog:	1639871.2	1776621.1	6529.0	17
base of tpf:	1639871.2	1776621.1	5977.0	569
base of tpt:	1639871.2	1776621.1	5924.9	621
water table:	1639871.2	1776621.1	5838.8	707

Well ID: R-5

Surface	East	North	Elevation	Depth
topographic surface:	1650251.4	1772342.1	6343.8	0
base of tpf:	1650251.4	1772342.1	5771.0	573
base of tpt:	1650251.4	1772342.1	5676.8	667
water table:	1650251.4	1772342.1	5745.7	598

Well ID: R-6

Surface	East	North	Elevation	Depth
topographic surface:	1617854.2	1775841.2	7223.3	0
bedrock:	1617854.2	1775841.2	7203.7	20
base of qbof:	1617854.2	1775841.2	7206.9	16
base of qbog:	1617854.2	1775841.2	6778.9	444

Well ID: R-7

Surface	East	North	Elevation	Depth
topographic surface:	1630911.8	1773655.5	6791.1	0
base of qct:	1630911.8	1773655.5	6786.1	5
base of qbof:	1630911.8	1773655.5	6500.3	291
base of qbog:	1630911.8	1773655.5	6478.1	313
water table:	1630911.8	1773655.5	5937.9	853

Well ID: R-8

Surface	East	North	Elevation	Depth
topographic surface:	1637141.9	1773285.6	6737.4	0
bedrock:	1637141.9	1773285.6	6718.5	19
base of qct:	1637141.9	1773285.6	6708.9	28
base of qbof:	1637141.9	1773285.6	6503.0	234
base of qbog:	1637141.9	1773285.6	6460.0	277
base of tpf:	1637141.9	1773285.6	5927.3	810
base of tpt:	1637141.9	1773285.6	5838.8	899
water table:	1637141.9	1773285.6	5856.0	881

Well ID: R-9

Surface	East	North	Elevation	Depth
topographic surface:	1649841.4	1770997.3	6351.5	0
bedrock:	1649841.4	1770997.3	6350.5	1
base of qbog:	1649841.4	1770997.3	6338.6	13
base of tpf:	1649841.4	1770997.3	5762.8	589
base of tpt:	1649841.4	1770997.3	5687.0	665
water table:	1649841.4	1770997.3	5751.3	600

Well ID: R-10

Surface	East	North	Elevation	Depth
topographic surface:	1630320.5	1771826.4	6938.3	0
bedrock:	1630320.5	1771826.4	6924.3	14
base of qbt1g:	1630320.5	1771826.4	6915.8	22
base of qbtt:	1630320.5	1771826.4	6834.1	104
base of qct:	1630320.5	1771826.4	6752.1	186
base of qbof:	1630320.5	1771826.4	6534.8	403
base of qbog:	1630320.5	1771826.4	6466.0	472
base of tpf:	1630320.5	1771826.4	5889.6	1049
base of tpt:	1630320.5	1771826.4	5838.2	1100
water table:	1630320.5	1771826.4	5947.5	991

Well ID: R-11

Surface	East	North	Elevation	Depth
topographic surface:	1642055.5	1769575.9	6622.2	0
base of qbof:	1642055.5	1769575.9	6510.9	111
base of qbog:	1642055.5	1769575.9	6419.6	203
base of tpf:	1642055.5	1769575.9	5861.6	761
base of tpt:	1642055.5	1769575.9	5797.5	825
base of tsfuv:	1642055.5	1769575.9	4535.1	2087
water table:	1642055.5	1769575.9	5816.2	806

Well ID: R-12

Surface	East	North	Elevation	Depth
topographic surface:	1646899.8	1767982.6	6506.7	0
bedrock:	1646899.8	1767982.6	6492.3	14
base of qbof:	1646899.8	1767982.6	6401.2	105
base of qbog:	1646899.8	1767982.6	6374.7	132
base of tpf:	1646899.8	1767982.6	5737.5	769
base of tpt:	1646899.8	1767982.6	5712.0	795
base of tsfuv:	1646899.8	1767982.6	4686.9	1820
water table:	1646899.8	1767982.6	5785.5	721

Well ID: R-13

Surface	East	North	Elevation	Depth
topographic surface:	1629111.8	1769815.8	6994.2	0
base of qbt1v:	1629111.8	1769815.8	6960.5	34
base of qbt1g:	1629111.8	1769815.8	6897.2	97
base of qbtt:	1629111.8	1769815.8	6877.5	117
base of qct:	1629111.8	1769815.8	6796.6	198
base of qbof:	1629111.8	1769815.8	6588.3	406
base of qbog:	1629111.8	1769815.8	6473.7	521
base of tpf:	1629111.8	1769815.8	5838.3	1156
base of tpt:	1629111.8	1769815.8	5771.8	1222
water table:	1629111.8	1769815.8	5969.8	1024

Well ID: R-14

Surface	East	North	Elevation	Depth
topographic surface:	1632052.9	1769226.8	7050.0	0
bedrock:	1632052.9	1769226.8	6903.0	147
base of qbt3nw:	1632052.9	1769226.8	7036.7	13
base of qbt2:	1632052.9	1769226.8	6973.6	76
base of qbt1v:	1632052.9	1769226.8	6893.0	157
base of qbt1g:	1632052.9	1769226.8	6796.9	253
base of qbtt:	1632052.9	1769226.8	6844.8	205
base of qct:	1632052.9	1769226.8	6755.4	295
base of qbof:	1632052.9	1769226.8	6514.9	535
base of qbog:	1632052.9	1769226.8	6388.3	662
base of tpf:	1632052.9	1769226.8	5728.0	1322
base of tpt:	1632052.9	1769226.8	5649.0	1401
water table:	1632052.9	1769226.8	5923.4	1127

Well ID: R-15

Surface	East	North	Elevation	Depth
topographic surface:	1635323.4	1768468.8	6809.8	0
base of qbt1g:	1635323.4	1768468.8	6715.9	94
base of qbtt:	1635323.4	1768468.8	6806.1	4
base of qct:	1635323.4	1768468.8	6699.9	110
base of qbof:	1635323.4	1768468.8	6435.1	375
base of qbog:	1635323.4	1768468.8	6376.5	433
base of tpf:	1635323.4	1768468.8	5728.8	1081
base of tpt:	1635323.4	1768468.8	5627.4	1182
base of tsfuv:	1635323.4	1768468.8	4382.0	2428
water table:	1635323.4	1768468.8	5877.7	932

Well ID: R-16

Surface	East	North	Elevation	Depth
topographic surface:	1658163.9	1756289.0	6279.9	0
base of qbog:	1658163.9	1756289.0	6211.1	69
base of tpt:	1658163.9	1756289.0	5701.5	578
water table:	1658163.9	1756289.0	5598.2	682

Well ID: R-17

Surface	East	North	Elevation	Depth
topographic surface:	1620561.0	1770641.5	7240.3	0
bedrock:	1620561.0	1770641.5	7210.3	30
base of qbt3nw:	1620561.0	1770641.5	7239.8	0
base of qbt2:	1620561.0	1770641.5	7197.3	43
base of qbtt:	1620561.0	1770641.5	7201.9	38
base of qbof:	1620561.0	1770641.5	6872.2	368
base of qbog:	1620561.0	1770641.5	6699.3	541
water table:	1620561.0	1770641.5	6199.7	1041

Well ID: R-18

Surface	East	North	Elevation	Depth
topographic surface:	1621969.7	1766457.5	7097.9	0
base of qbt2:	1621969.7	1766457.5	7087.7	10
base of qbt1g:	1621969.7	1766457.5	6997.4	101
base of qbtt:	1621969.7	1766457.5	6989.0	109
base of qct:	1621969.7	1766457.5	6873.1	225
base of qbof:	1621969.7	1766457.5	6702.4	396
base of qbog:	1621969.7	1766457.5	6632.1	466
water table:	1621969.7	1766457.5	6148.5	949

Well ID: R-19

Surface	East	North	Elevation	Depth
topographic surface:	1631987.7	1763675.3	6822.1	0
base of qbt1v:	1631987.7	1763675.3	6810.7	11
base of qbt1g:	1631987.7	1763675.3	6726.9	95
base of qbtt:	1631987.7	1763675.3	6724.2	98
base of qct:	1631987.7	1763675.3	6654.8	167
base of qbof:	1631987.7	1763675.3	6551.0	271
base of qbog:	1631987.7	1763675.3	6294.3	528
base of tpf:	1631987.7	1763675.3	5632.8	1189
base of tpt:	1631987.7	1763675.3	5554.2	1268
water table:	1631987.7	1763675.3	5918.0	904

Well ID: R-20

Surface	East	North	Elevation	Depth
topographic surface:	1637674.2	1760368.8	6740.3	0
bedrock:	1637674.2	1760368.8	6722.4	18
base of qbt1v:	1637674.2	1760368.8	6688.5	52
base of qbt1g:	1637674.2	1760368.8	6592.3	148
base of qbtt:	1637674.2	1760368.8	6595.5	145
base of qct:	1637674.2	1760368.8	6592.2	148
base of qbof:	1637674.2	1760368.8	6441.2	299
base of qbog:	1637674.2	1760368.8	6320.0	420
base of tpf:	1637674.2	1760368.8	5405.4	1335
base of tpt:	1637674.2	1760368.8	5328.0	1412
water table:	1637674.2	1760368.8	5849.3	891

Well ID: R-21

Surface	East	North	Elevation	Depth
topographic surface:	1639338.2	1759989.7	6764.4	0
bedrock:	1639338.2	1759989.7	6699.3	65
base of qbt1v:	1639338.2	1759989.7	6676.4	88
base of qbt1g:	1639338.2	1759989.7	6555.0	209
base of qbtt:	1639338.2	1759989.7	6552.0	212
base of qct:	1639338.2	1759989.7	6550.2	214
base of qbof:	1639338.2	1759989.7	6416.5	348
base of qbog:	1639338.2	1759989.7	6384.8	380
base of tpf:	1639338.2	1759989.7	5498.7	1266
base of tpt:	1639338.2	1759989.7	5369.8	1395
water table:	1639338.2	1759989.7	5834.1	930

Well ID: R-22

Surface	East	North	Elevation	Depth
topographic surface:	1646223.3	1755413.5	6545.8	0
base of qbt1g:	1646223.3	1755413.5	6524.8	21
base of qbtt:	1646223.3	1755413.5	6539.1	7
base of qbof:	1646223.3	1755413.5	6388.1	158
base of qbog:	1646223.3	1755413.5	6480.2	66
base of tpt:	1646223.3	1755413.5	5506.0	1040
water table:	1646223.3	1755413.5	5760.2	786

Well ID: R-23

Surface	East	North	Elevation	Depth
topographic surface:	1644142.6	1753262.3	6493.6	0
base of qbof:	1644142.6	1753262.3	6382.6	111
base of qbog:	1644142.6	1753262.3	6458.2	36
base of tpt:	1644142.6	1753262.3	5454.1	1040
water table:	1644142.6	1753262.3	5778.3	715

Well ID: R-24

Surface	East	North	Elevation	Depth
topographic surface:	1609553.0	1767172.1	7711.8	0
base of qbt5:	1609553.0	1767172.1	7673.7	38
base of qbtt:	1609553.0	1767172.1	7613.0	99

Well ID: R-25

Surface	East	North	Elevation	Depth
topographic surface:	1616008.9	1764871.7	7335.4	0
bedrock:	1616008.9	1764871.7	7328.3	7
base of qbt3nw:	1616008.9	1764871.7	7295.6	40
base of qbt1g:	1616008.9	1764871.7	7158.0	177
base of qbtt:	1616008.9	1764871.7	7146.8	189
base of qct:	1616008.9	1764871.7	7037.0	298
base of qbof:	1616008.9	1764871.7	6747.5	588
base of qbog:	1616008.9	1764871.7	6725.5	610

Well ID: R-26

Surface	East	North	Elevation	Depth
topographic surface:	1607752.7	1760476.5	7530.3	0
base of qbtt:	1607752.7	1760476.5	7453.2	77

Well ID: R-27

Surface	East	North	Elevation	Depth
topographic surface:	1624680.3	1757636.7	6803.4	0
base of qbt1g:	1624680.3	1757636.7	6682.3	121
base of qbtt:	1624680.3	1757636.7	6677.1	126
base of qct:	1624680.3	1757636.7	6623.2	180
base of qbof:	1624680.3	1757636.7	6550.7	253
base of qbog:	1624680.3	1757636.7	6302.9	500
water table:	1624680.3	1757636.7	6005.4	798

Well ID: R-28

Surface	East	North	Elevation	Depth
topographic surface:	1632284.2	1755114.3	6623.3	0
base of qbt1g:	1632284.2	1755114.3	6545.2	78
base of qbtt:	1632284.2	1755114.3	6619.0	4
base of qct:	1632284.2	1755114.3	6514.1	109
base of qbof:	1632284.2	1755114.3	6430.6	193
base of qbog:	1632284.2	1755114.3	6216.4	407
base of tpf:	1632284.2	1755114.3	5519.6	1104
base of tpt:	1632284.2	1755114.3	5464.7	1159
water table:	1632284.2	1755114.3	5899.6	724

Well ID: R-29

Surface	East	North	Elevation	Depth
topographic surface:	1645630.9	1746074.9	6239.9	0
base of tpt:	1645630.9	1746074.9	5604.5	635
water table:	1645630.9	1746074.9	5696.0	544

Well ID: R-30

Surface	East	North	Elevation	Depth
topographic surface:	1625940.7	1755629.0	7103.3	0
bedrock:	1625940.7	1755629.0	6793.9	309
base of qbt4:	1625940.7	1755629.0	7059.9	43
base of qbt3w:	1625940.7	1755629.0	7014.2	89
base of qbt3nw:	1625940.7	1755629.0	6951.5	152
base of qbt2:	1625940.7	1755629.0	6844.5	259
base of qbt1v:	1625940.7	1755629.0	6654.7	449
base of qbt1g:	1625940.7	1755629.0	6589.6	514
base of qbtt:	1625940.7	1755629.0	6585.5	518
base of qct:	1625940.7	1755629.0	6546.2	557
base of qbof:	1625940.7	1755629.0	6508.5	595
base of qbog:	1625940.7	1755629.0	6211.2	892
base of tpf:	1625940.7	1755629.0	5666.0	1437
base of tpt:	1625940.7	1755629.0	5612.4	1491
water table:	1625940.7	1755629.0	5983.7	1120

Well ID: R-31

Surface	East	North	Elevation	Depth
topographic surface:	1637614.8	1745880.3	6355.6	0
base of qbof:	1637614.8	1745880.3	6240.6	115
base of qbog:	1637614.8	1745880.3	6185.4	170
base of tpt:	1637614.8	1745880.3	5614.4	741
water table:	1637614.8	1745880.3	5804.8	551

Well ID: R-32

Surface	East	North	Elevation	Depth
topographic surface:	1642187.3	1739268.4	6105.4	0
water table:	1642187.3	1739268.4	5670.3	435

Appendix Section 10.9: Set of Cross-Sections (6 at 10x and 5 at 25x vertical exaggerations)

Locations of Sections

Section A-A'

WELL	easting	northing
Future R-1	1632241	1787173
G-6	1644825	1786851
G-5	1646950	1787907
G-4	1648949	1786452
G-3	1651676	1786218
G-2	1654211	1785123
G-1A	1655241	1784353
G-1	1656191	1783609

Section B-B'

WELL	easting	northing
Future R-6	1617854	1775841
H-19	1618459	1775590
TW-4	1624025	1777694
21-2523	1631443	1774550
LADP-4	1633176	1774718
O-4	1637329	1773013
O-1	1649396	1772231
LA-4	1657447	1771233

Section B-B''

WELL	easting	northing
Future R-6	1617854	1775841
H-19	1618459	1775590
SHB-1	1624015	1769855
Sigma Mesa	1628828	1770620
PM-5	1632111	1767791
PM-4	1635717	1764674
PM-2	1636786	1760326
TH-6	1640507	1757888
TH-5	1643553	1756582
Future R-16	1659520	1756739
to Rio Grande	1664050	1756780

Section C-C'

WELL	easting	northing
SHB-3	1609310	1760990
Future R-25	1615927	1764939
DT-5A	1625310	1754789
DT-9	1628993	1751498
33-1231	1638986	1740039
Future R-32	1642187	1739268
to Rio Grande	1649740	1735695

Section D-D'

WELL	easting	northing
DT-5A	1625310	1754789
PM-5	1632111	1767791
Future R-14	1631962	1769252
TW-8	1632574	1769507
O-4	1637329	1773013
G-6	1644825	1786851

Section A"-A'

WELL	easting	northing
DT-9	1628993	1751498
Future R-28	1632284	1755114
PM-2	1636786	1760326
SIMO	1641844	1766462
PM-3	1642593	1769527
Future R-9	1649841	1770997
O-1	1649396	1772231
G-1	1656191	1783609

Cross-Sections of LANL Site Geology at 10x and 25x Vertical Eaxggeration

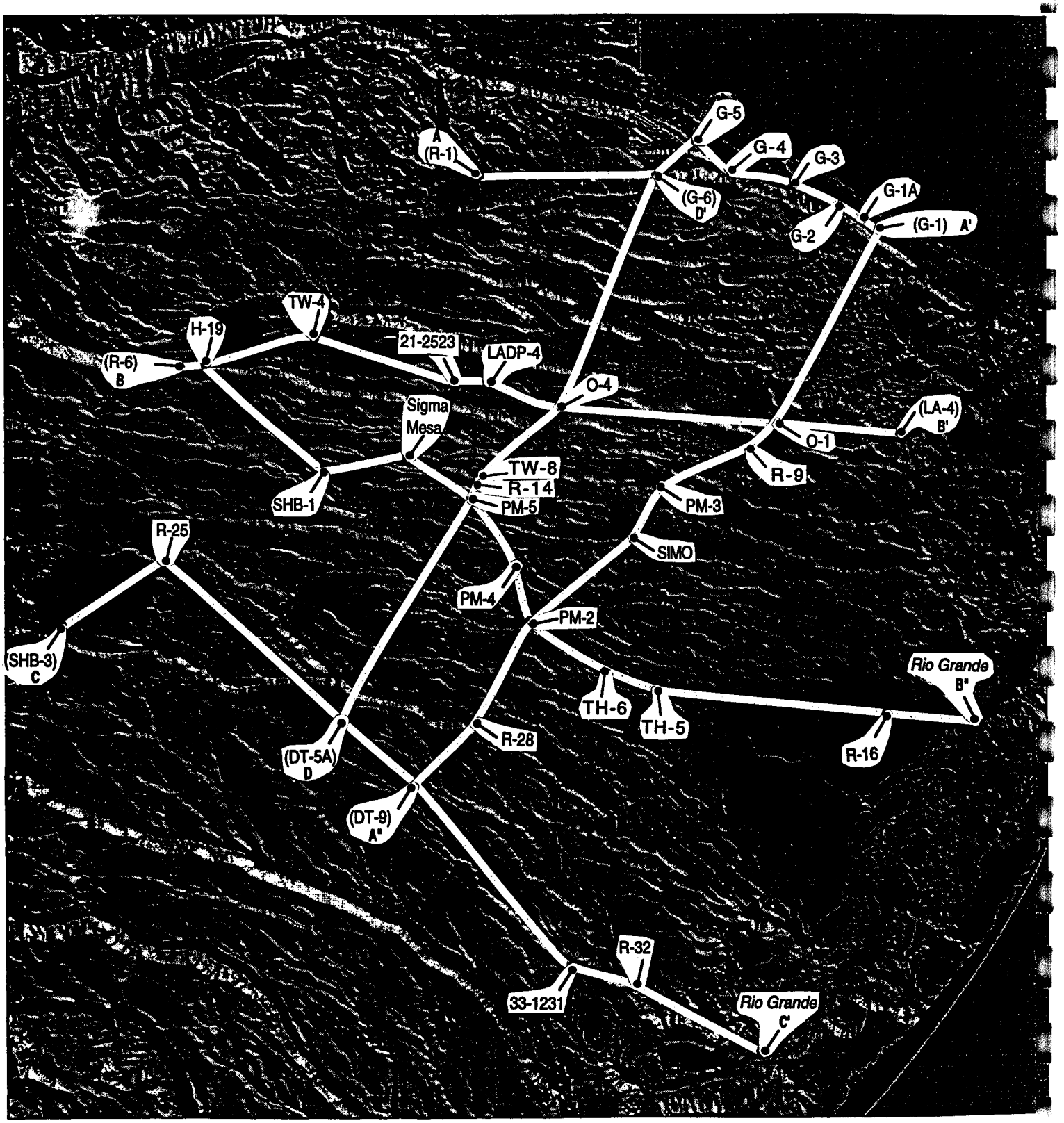
The following page shows the locations of six cross-sections (A-A', B-B', B-B", C-C', D-D', and A"-A') of LANL site geology at 10x vertical exaggeration, to depths below the water table. Additional cross-sections for all except A-A' are drawn at 25x vertical exaggeration to show interpretations of stratigraphy within the Bandelier Tuff. For the 25x exaggerated sections, subunits of the Tshirege Member of the Bandelier Tuff are designated by abbreviated symbols (5, 4, 3 or 3w/3nw, 2, 1v, and 1g for subunits of Qbt). The Tsankawi pumice bed (Qbtt) occurs everywhere at the base of Qbt1g, but is too thin (<5 ft) to be shown. Subunit 3 is subdivided into 3w and 3nw only in the central portion of the site.

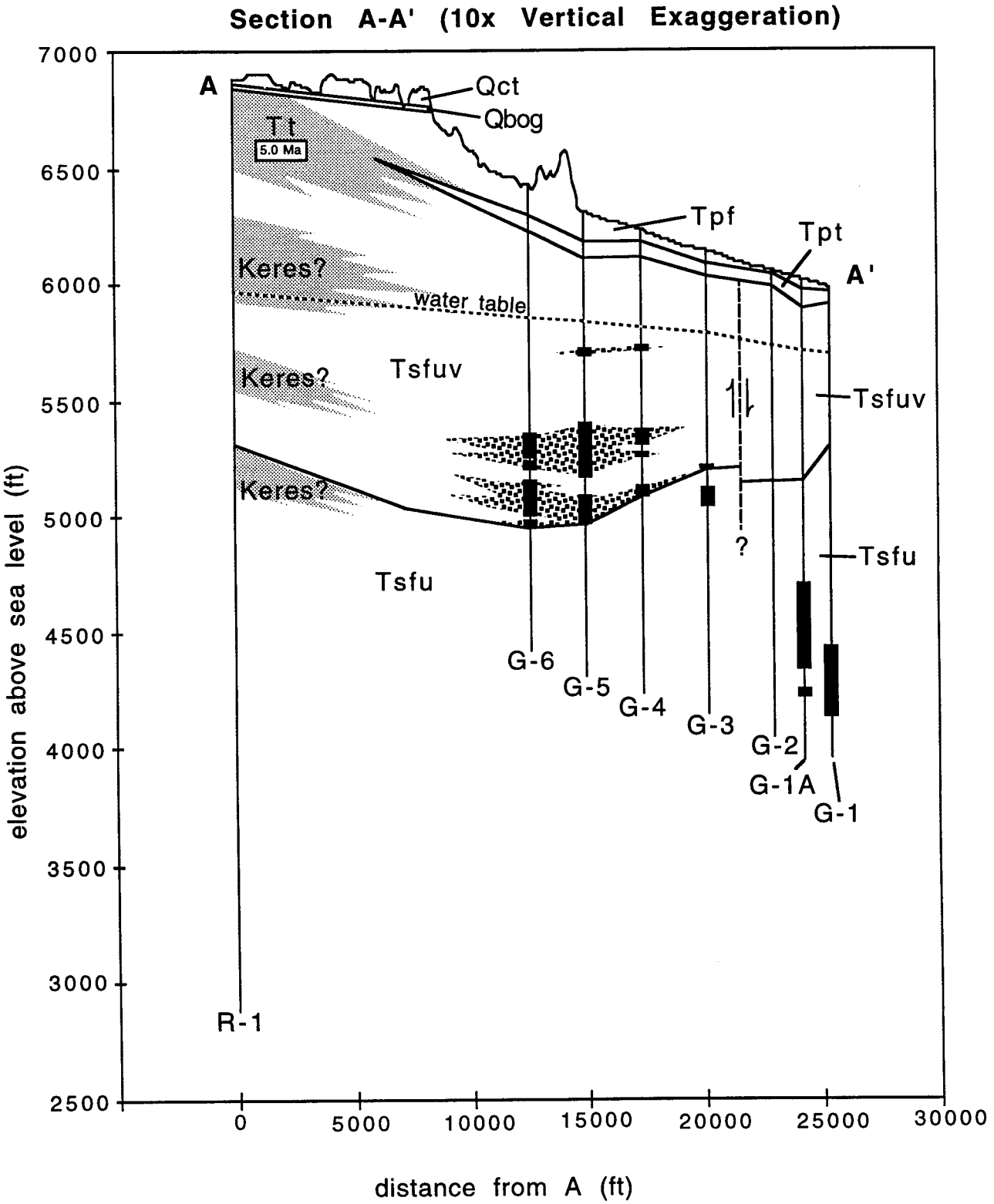
Descriptions of the surfaces and features portrayed in these cross-sections are given in Section 10.9 of the text.

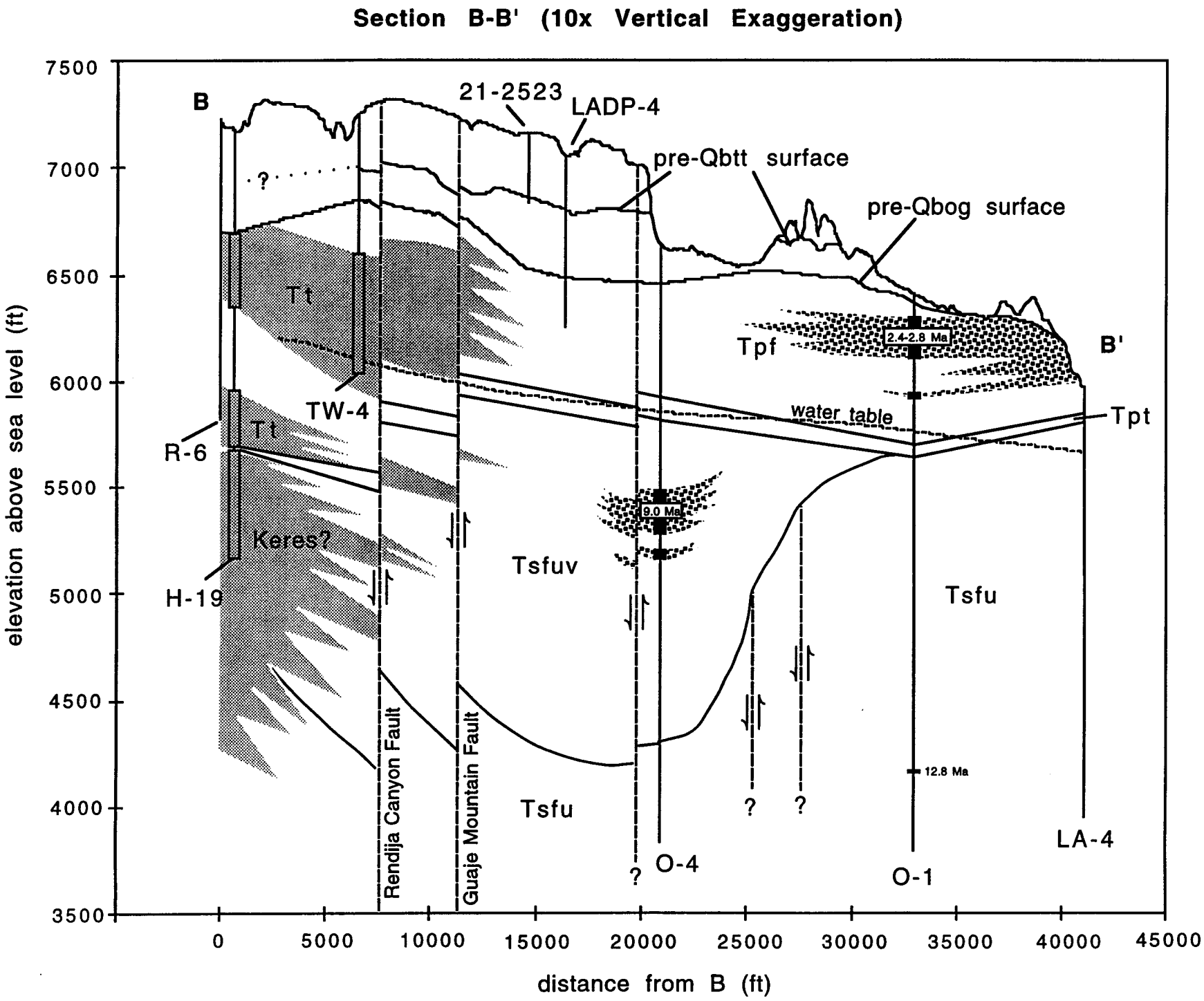
Basalts (Tb) and intermediate lavas of the Tschicoma Formation (Tt) are shown as vertical bars where actually reported in drill holes:

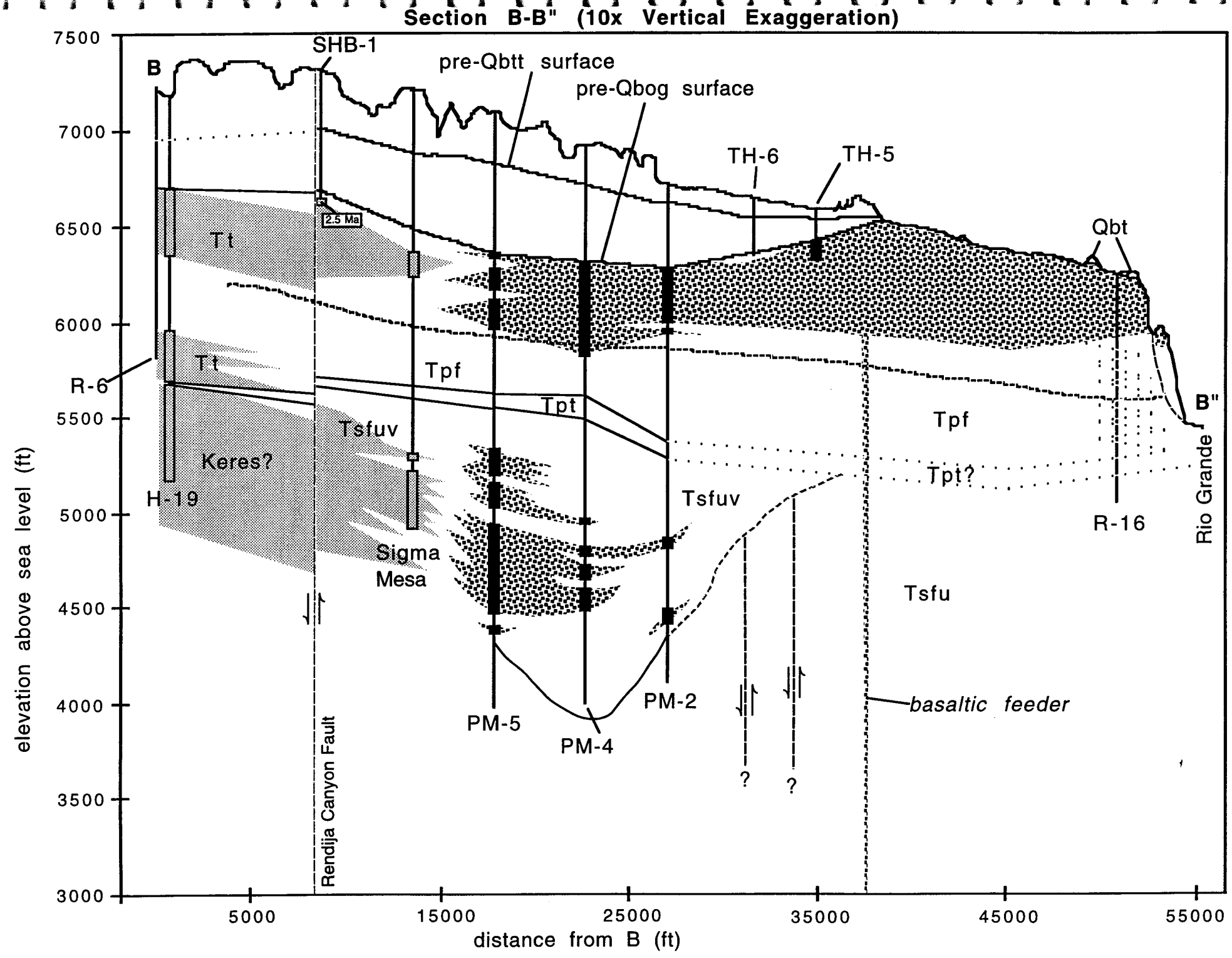
- basalt reported in drill hole
- intermediate lava reported in drill hole

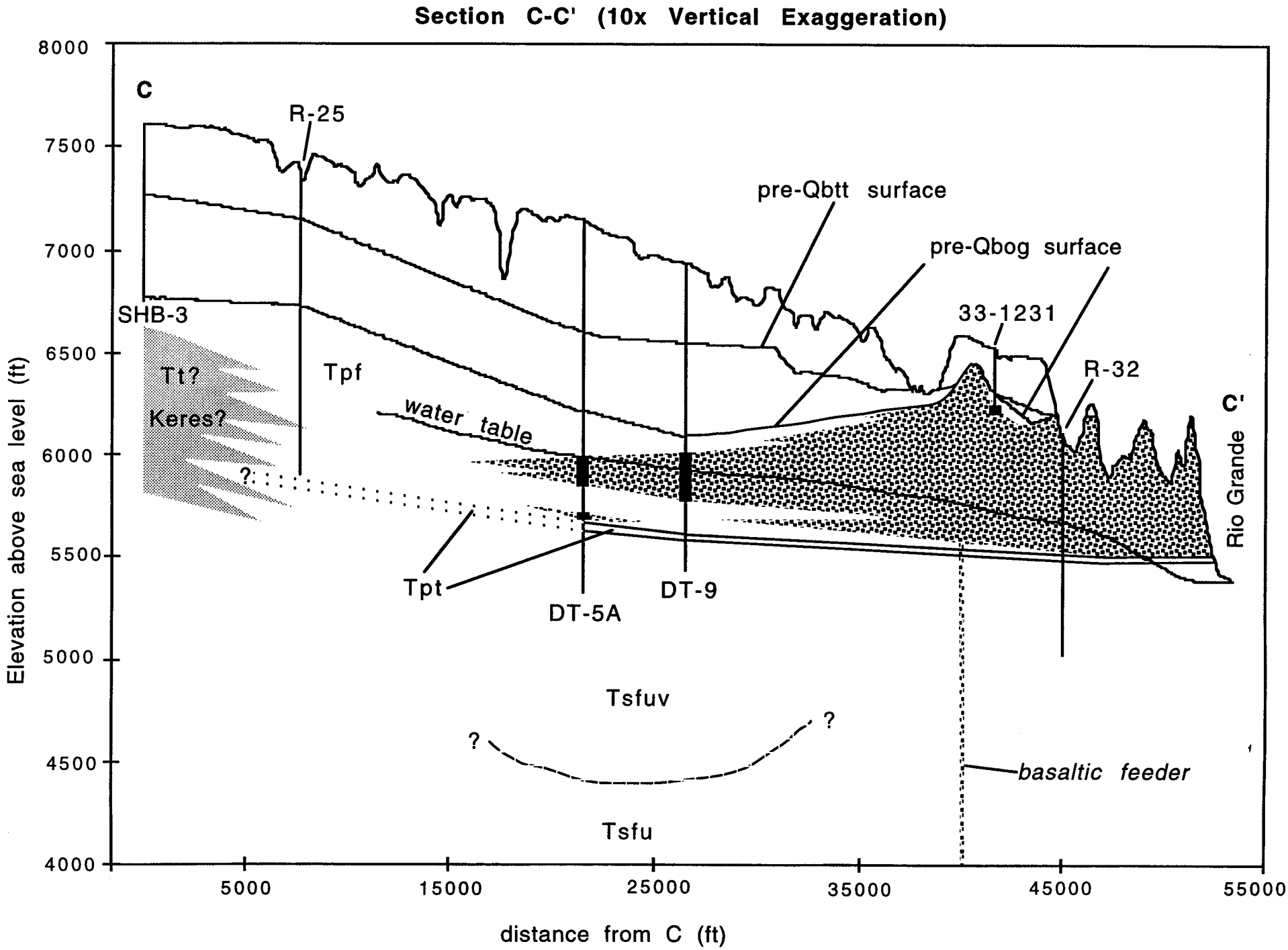
Associated patterns (for basalt and for intermediate lavas) are used between drill holes where further occurrence of basalt or intermediate lava is considered likely. Ages shown for lavas are from Aldrich and Dethier, 1990 (in Section A-A') or from work in progress by G. WoldeGabriel (all other Sections).

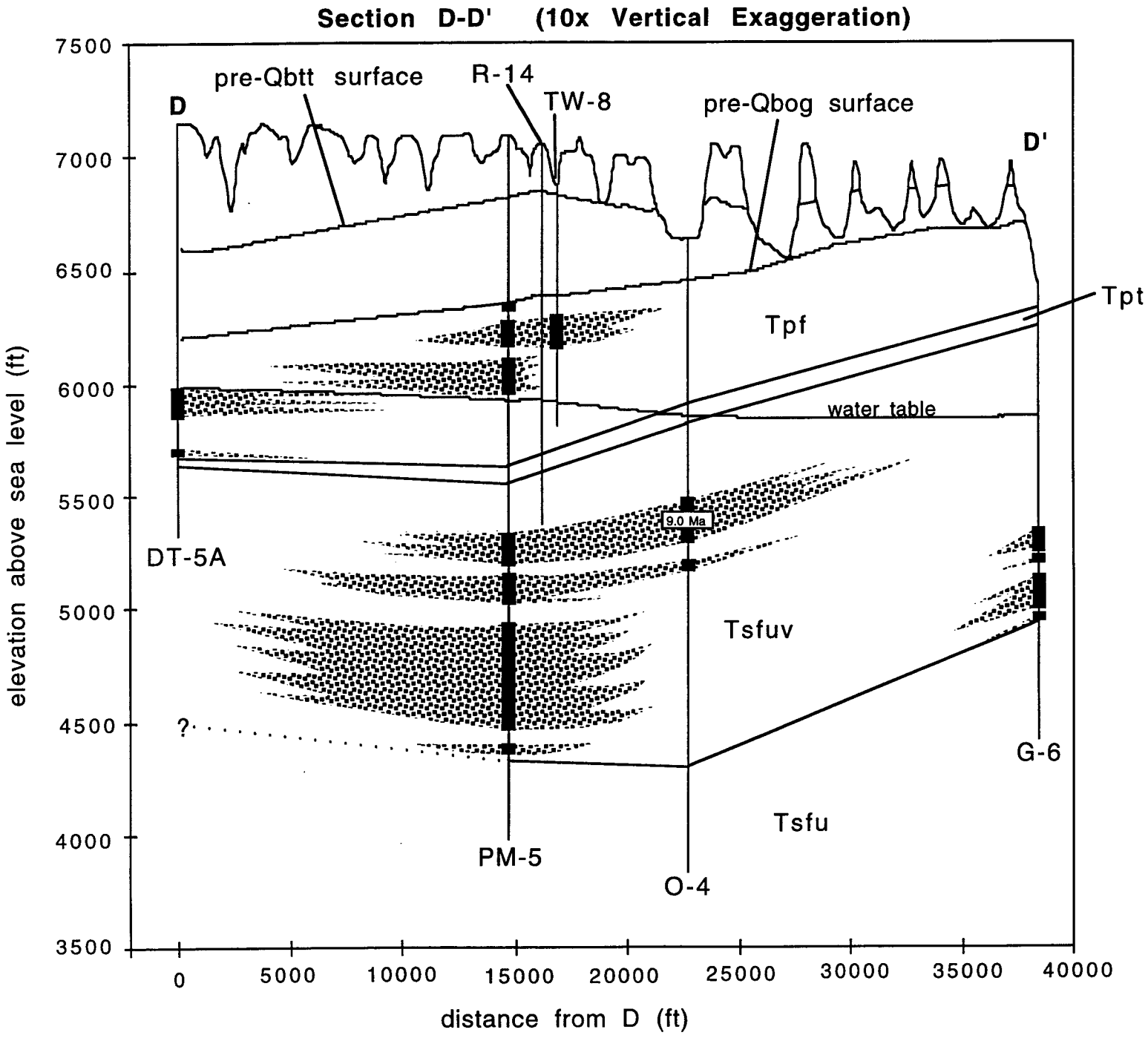

G-5
G-4
G-3
G-1A
(R-1)
(G-6)
D'
G-2
(G-1) A'
TW-4
H-19
21-2523
LADP-4
(R-6)
B
O-4
Sigma
Mesa
(LA-4)
B'
O-1
R-9
TW-8
R-14
PM-5
SHB-1
PM-3
R-25
SIMO
PM-4
PM-2
(SHB-3)
C
Rio Grande
B"
TH-6
TH-5
R-28
R-16
(DT-5A)
D
(DT-9)
A"
R-32
33-1231
Rio Grande
C'

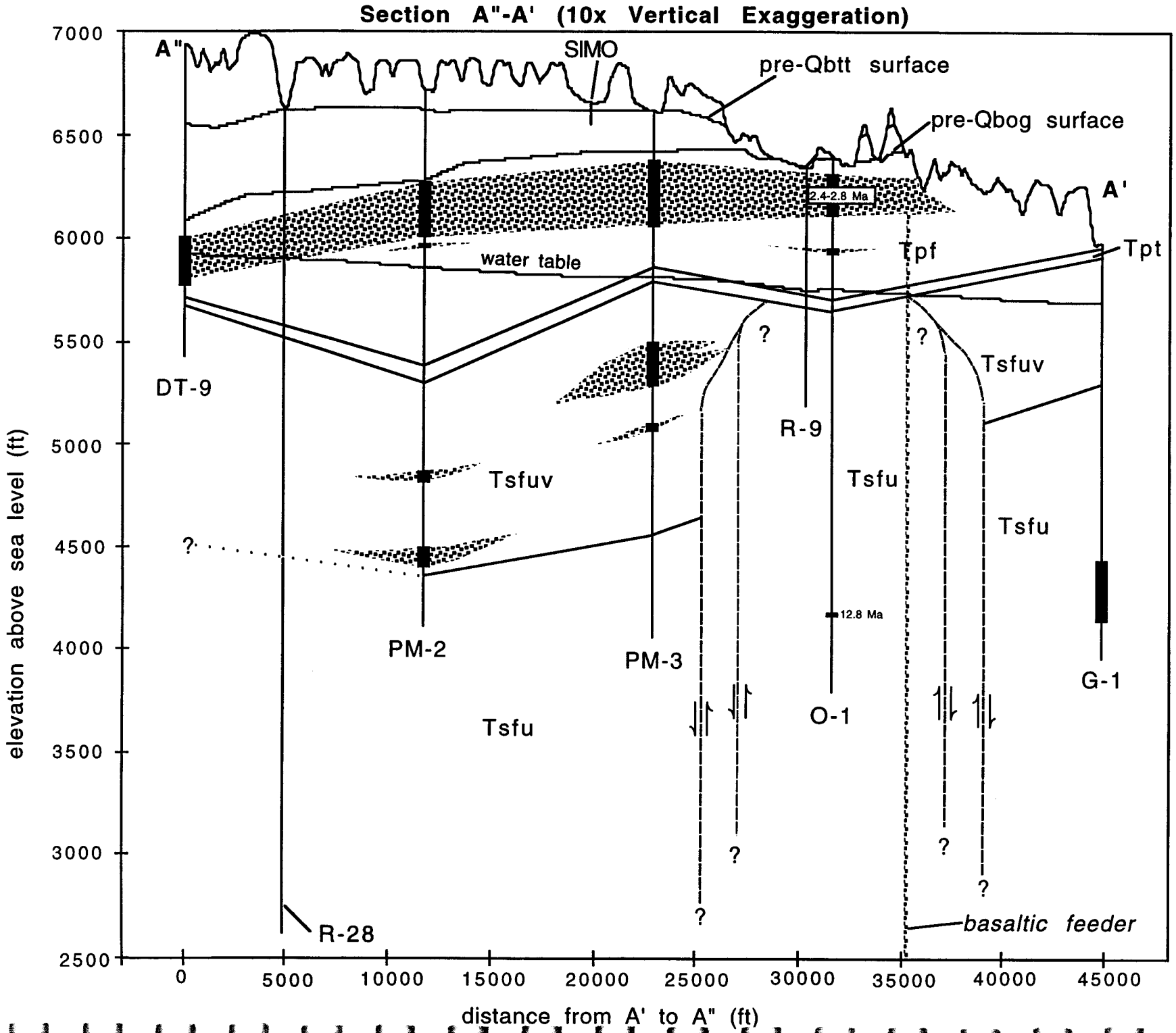

Section A-A' (10x Vertical Exaggeration)
A
A'
Qct
Qbog
Tt
5.0 Ma
Tpf
Tpt
Keres?
water table
Tsfuv
Keres?
Tsfuv
Keres?
Tsfu
Tsfu
?
G-6
G-5
G-4
G-3
G-2
G-1A
G-1
R-1
elevation above sea level (ft)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
0
5000
10000
15000
20000
25000
30000
distance from A (ft)

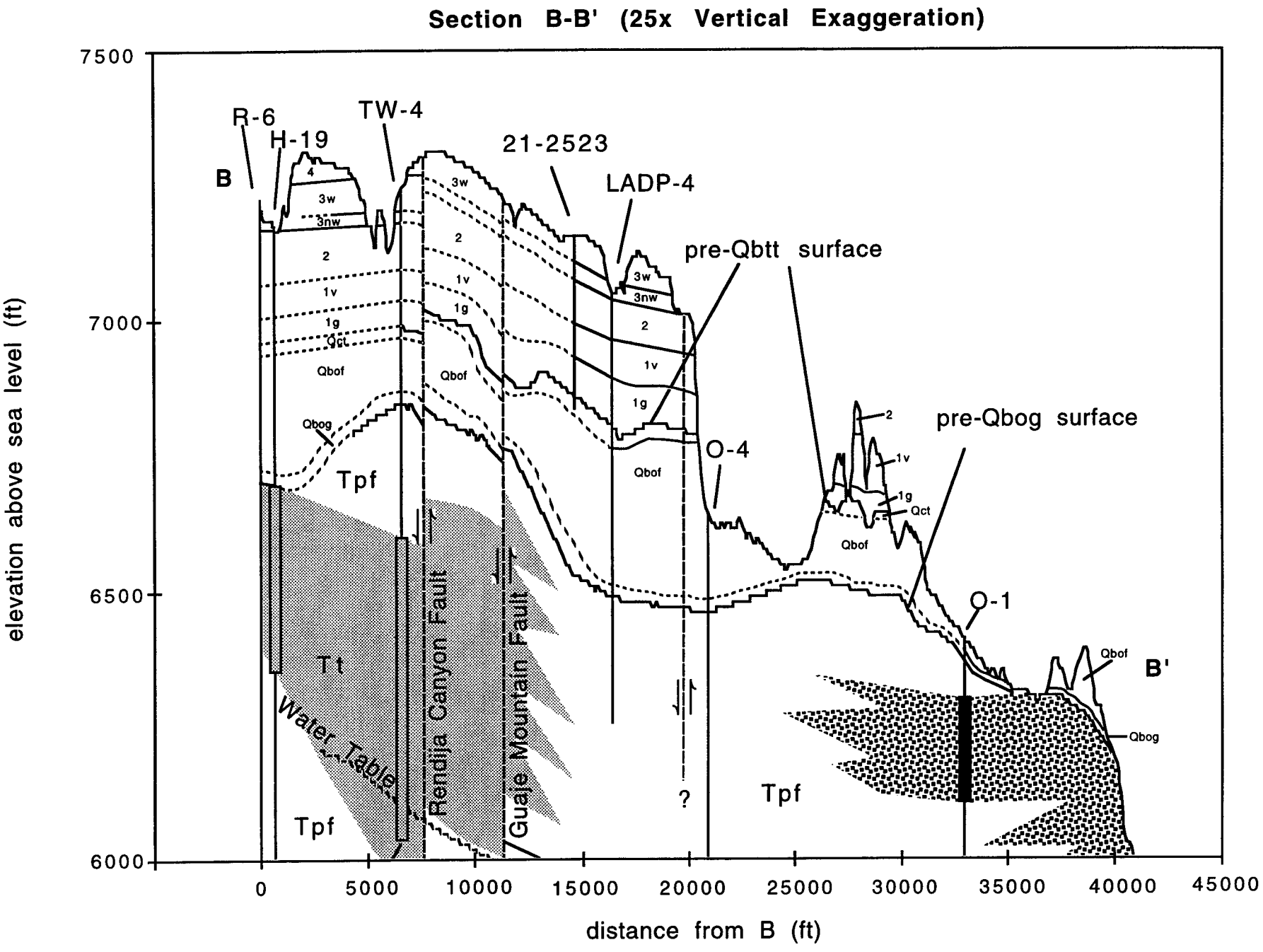

Section B-B' (10x Vertical Exaggeration)
elevation above sea level (ft)
distance from B (ft)
7500
7000
6500
6000
5500
5000
4500
4000
3500
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
B
B'
21-2523
LADP-4
pre-Qbtt surface
pre-Qbog surface
Tt
Tt
Keres?
Tpf
Tpt
water table
TW-4
R-6
H-19
2.4-2.8 Ma
9.0 Ma
12.8 Ma
Tsfuv
Tsfu
Tsfu
Rendija Canyon Fault
Guaje Mountain Fault
O-4
O-1
LA-4
?

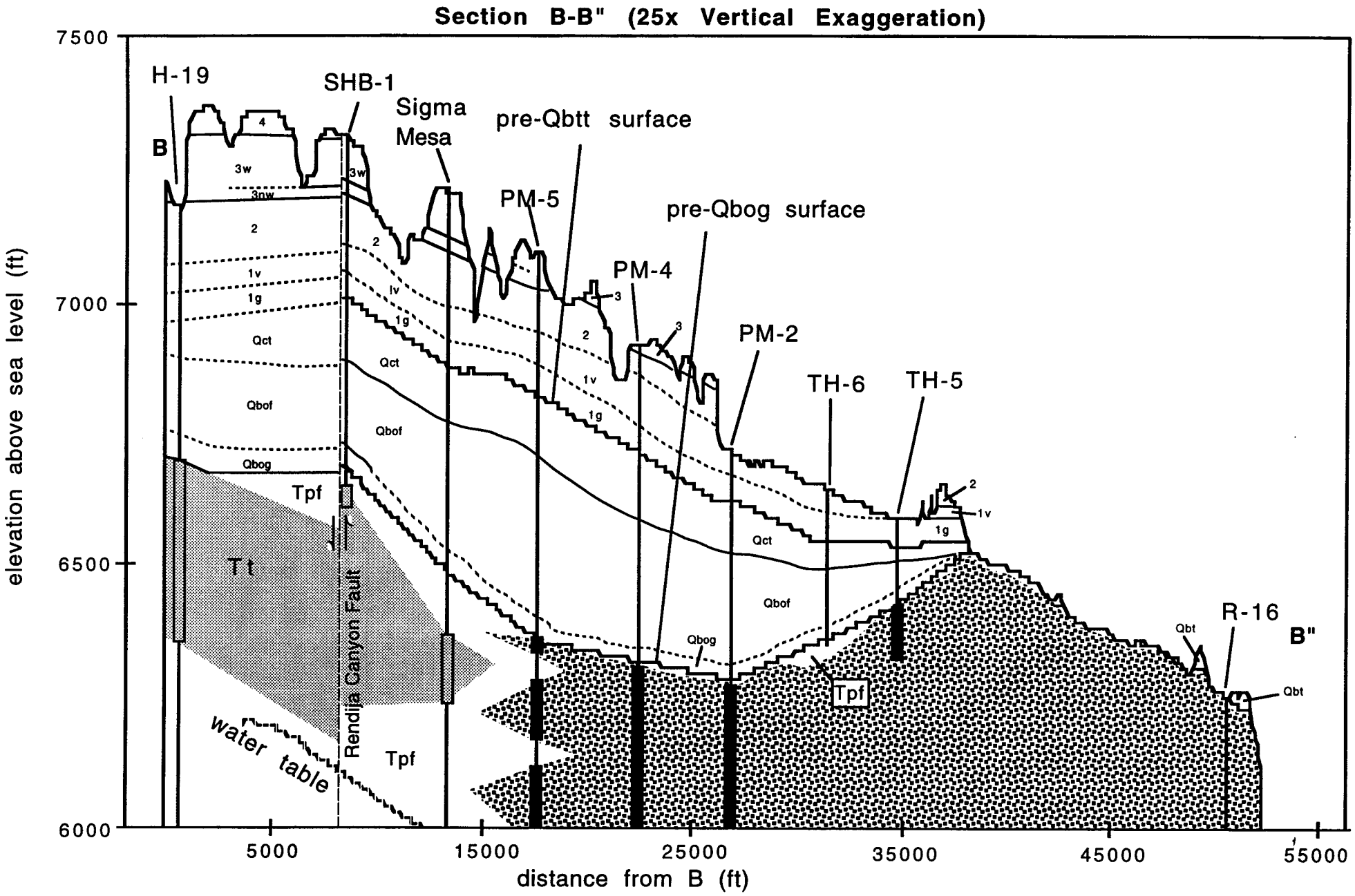

Section B-B" (10x Vertical Exaggeration)
B
SHB-1
pre-Qbtt surface
pre-Qbog surface
TH-6
TH-5
2.5 Ma
Qbt
Tt
Tt
R-6
Tpf
Tpt
Tsfuv
Keres?
H-19
Sigma Mesa
Tsfuv
Tpf
Tpt?
R-16
B"
Rio Grande
Tsfu
basaltic feeder
PM-5
PM-4
PM-2
?
?
Rendija Canyon Fault
elevation above sea level (ft)
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
5000
15000
25000
35000
45000
55000
distance from B (ft)

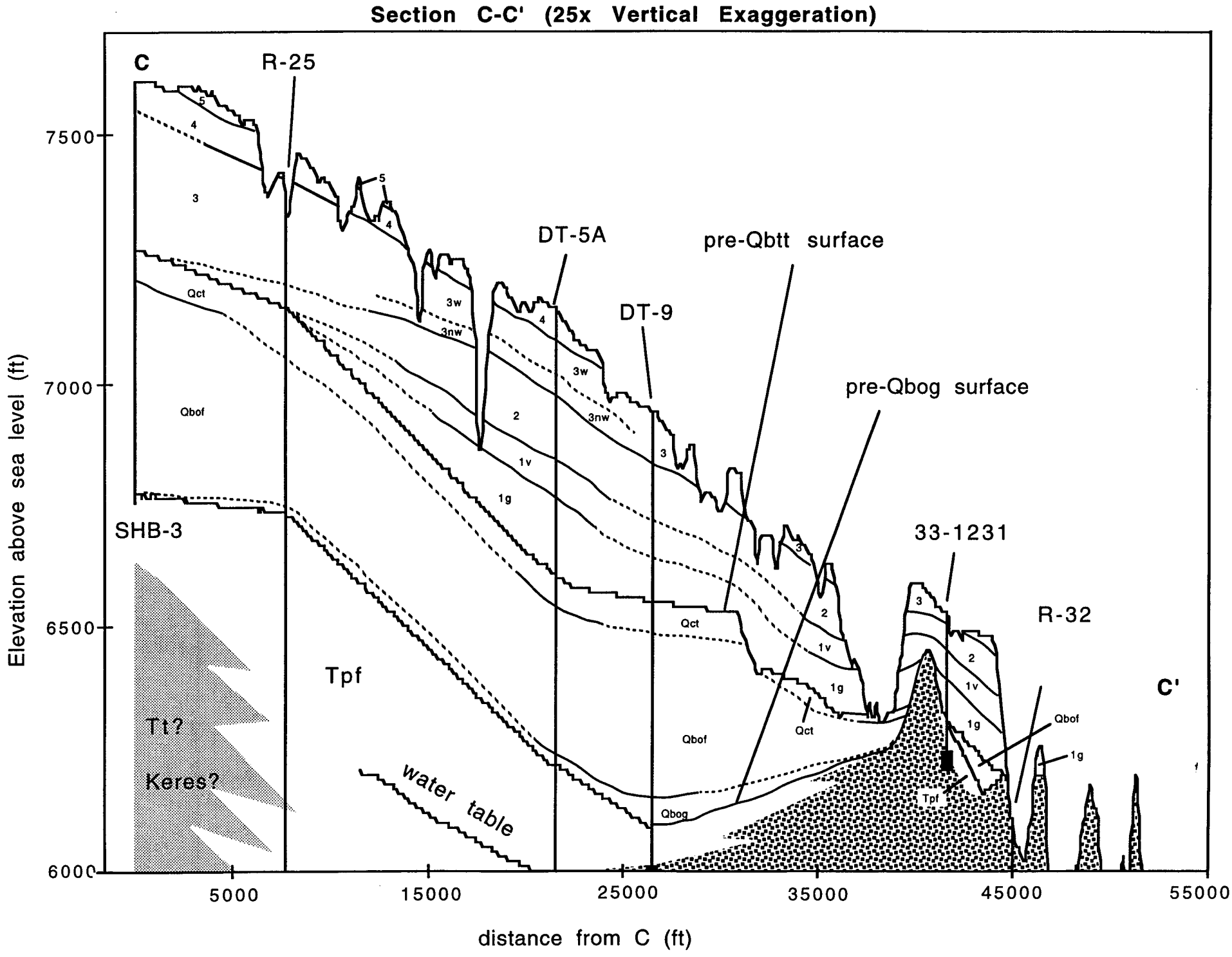

Section C-C' (10x Vertical Exaggeration)
C
C'
R-25
SHB-3
Tt?
Keres?
Tpf
water table
pre-Qbtt surface
pre-Qbog surface
33-1231
R-32
Rio Grande
Tpt
DT-5A
DT-9
Tsfuv
Tsfu
basaltic feeder
Elevation above sea level (ft)
distance from C (ft)
8000
7500
7000
6500
6000
5500
5000
4500
4000
5000
15000
25000
35000
45000
55000

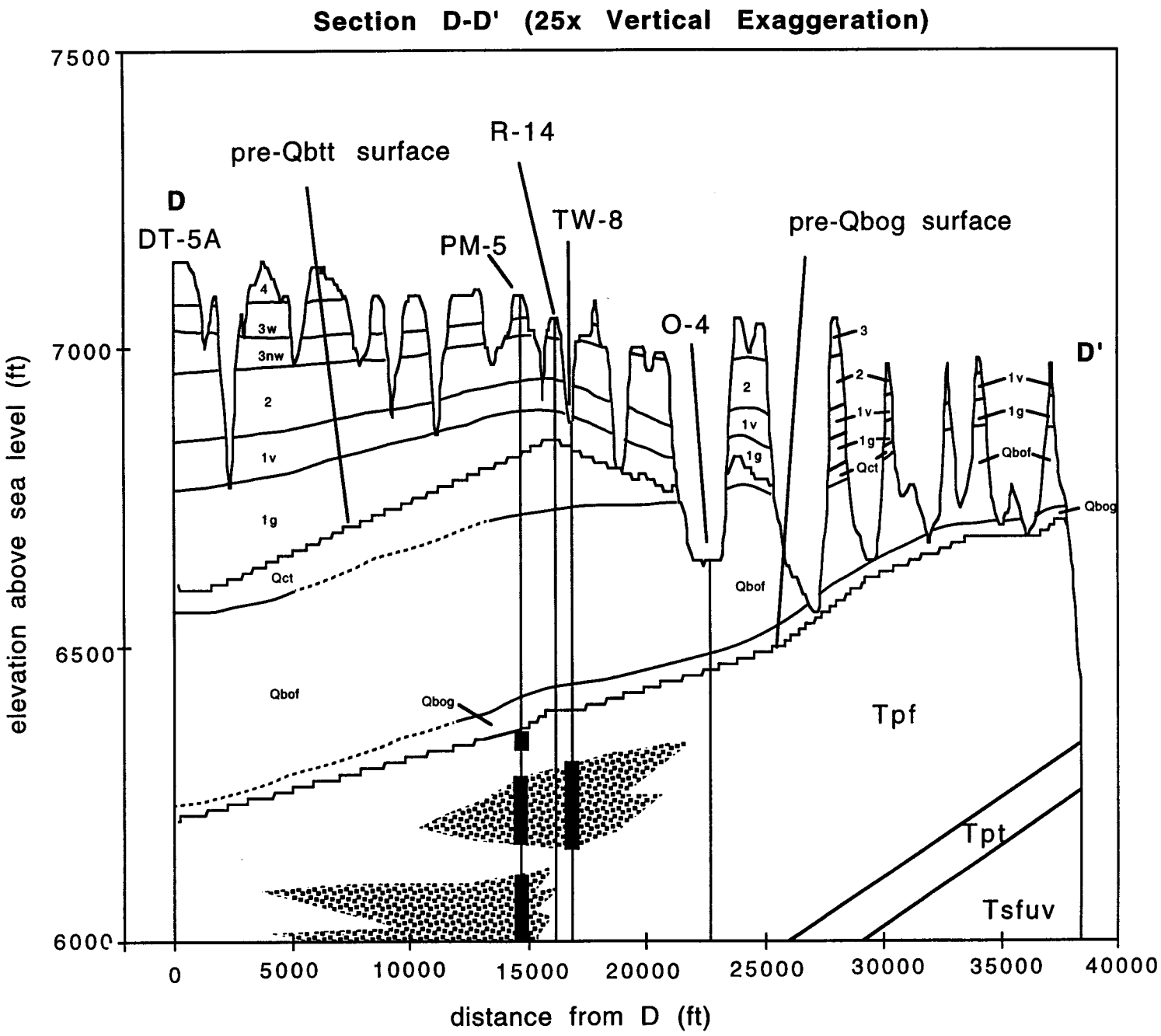

Section D-D' (10x Vertical Exaggeration)
pre-Qbtt surface
R-14
TW-8
pre-Qbog surface
D
D'
Tpt
Tpf
water table
9.0 Ma
DT-5A
Tsfuv
?
G-6
Tsfu
PM-5
O-4
elevation above sea level (ft)
distance from D (ft)
7500
7000
6500
6000
5500
5000
4500
4000
3500
0
5000
10000
15000
20000
25000
30000
35000
40000

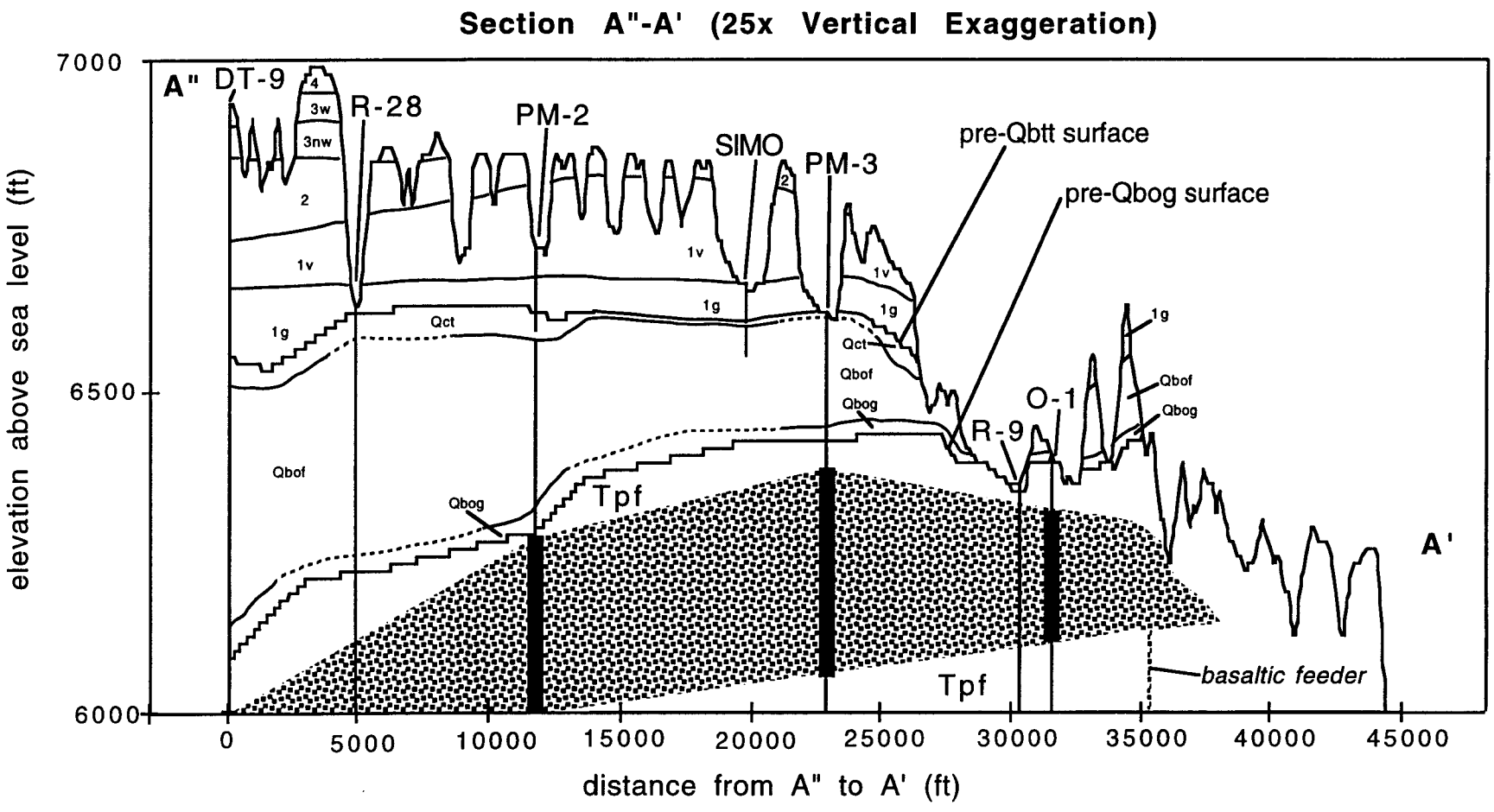

Section A"-A' (10x Vertical Exaggeration)
A"
SIMO
pre-Qbtt surface
pre-Qbog surface
A'
2.4-2.8 Ma
water table
Tpf
Tpt
DT-9
R-9
Tsfuv
Tsfu
12.8 Ma
PM-2
PM-3
O-1
G-1
R-28
basaltic feeder
elevation above sea level (ft)
distance from A' to A" (ft)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
0
5000
10000
15000
20000
25000
30000
35000
40000
45000


Section B-B' (25x Vertical Exaggeration)
elevation above sea level (ft)
distance from B (ft)
7500
7000
6500
6000
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
B
B'
R-6
H-19
TW-4
21-2523
LADP-4
O-4
O-1
pre-Qbtt surface
pre-Qbog surface
4
3w
3nw
2
1v
1g
Qct
Qbof
Qbog
Tpf
Tt
Water Table
Rendija Canyon Fault
Guaje Mountain Fault
?


Section B-B" (25x Vertical Exaggeration)
elevation above sea level (ft)
distance from B (ft)
7500
7000
6500
6000
5000
15000
25000
35000
45000
55000
H-19
SHB-1
Sigma Mesa
pre-Qbtt surface
PM-5
pre-Qbog surface
PM-4
PM-2
TH-6
TH-5
R-16
B
B"
4
3w
3nw
2
1v
1g
Qct
Qbof
Qbog
Tpf
Tt
Rendija Canyon Fault
water table
Qbt


Section C-C' (25x Vertical Exaggeration)
C
R-25
DT-5A
DT-9
pre-Qbtt surface
pre-Qbog surface
33-1231
R-32
C'
SHB-3
Tt?
Keres?
Tpf
water table
Qct
Qbof
Qbog
5
4
3
3w
3nw
2
1v
1g
Elevation above sea level (ft)
7500
7000
6500
6000
5000
15000
25000
35000
45000
55000
distance from C (ft)


Section D-D' (25x Vertical Exaggeration)
7500
7000
6500
6000
elevation above sea level (ft)
0
5000
10000
15000
20000
25000
30000
35000
40000
distance from D (ft)
D
DT-5A
pre-Qbtt surface
R-14
PM-5
TW-8
O-4
pre-Qbog surface
D'
4
3w
3nw
2
1v
1g
Qct
Qbof
Qbog
3
Tpf
Tpt
Tsfuv


Section A"-A' (25x Vertical Exaggeration)
A"
DT-9
R-28
PM-2
SIMO
PM-3
pre-Qbtt surface
pre-Qbog surface
R-9
O-1
A'
4
3w
3nw
2
1v
1g
Qct
Qbof
Qbog
Tpf
basaltic feeder
7000
6500
6000
elevation above sea level (ft)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
distance from A" to A' (ft)

Appendix Section 10.10: Color Key for Geologic Units