241-C Tank Farm Geologic and Stratigraphic Analysis

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Abstract: This document provides stratigraphic and geologic review and analysis of the 241-C Tank Farm area. Available geologic data is compiled, reviewed and correlated. A revised Appendix A includes interpretation of borehole and well logs.

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TERMS

200 East	200 East Area of the Hanford Site
Bf/Eo	Backfill/Eolian
BGS	below ground surface
CRBG	Columbia River Basalt Group
elev.	elevation
H1	Informal facies sub-units of Hanford formation H1 gravel dominated
H2	Informal facies sub-units of Hanford formation H2 sand dominated
H3	Informal facies sub-units of Hanford formation H3 mixed sand and gravel lower portion of Hanford deposits
PUREX	Plutonium-Uranium Extraction
TOB	top of basalt

241-C TANK FARM GEOLOGIC AND STRATIGRAPHIC ANALYSIS

1.0 INTRODUCTION

This report presents the results of geologic investigation of the 241-C Tank Farm area. The C Tank Farm was constructed between 1943 and 1944 and first received metal waste and first-cycle waste from B Plant beginning in 1946. The single shell C Farm tanks are located in the 200 East Area of the Hanford Site, Richland, Washington (Figure 1) and consist of 16 underground waste storage tanks set approximately 609.6 meters (2,000 feet) north of the Plutonium-Uranium Extraction (PUREX) Plant in the east-central part of 200 East.

This report describes the geology of the 241-C Tank Farm area and is based on available geologic logs and geologic reports, specifically, data from the Pacific Northwest National Laboratory (geologic logs) and Kennedy/Jenks Consultants staff personal and project files for the 200 East area.

The following sections are included as part of this report.

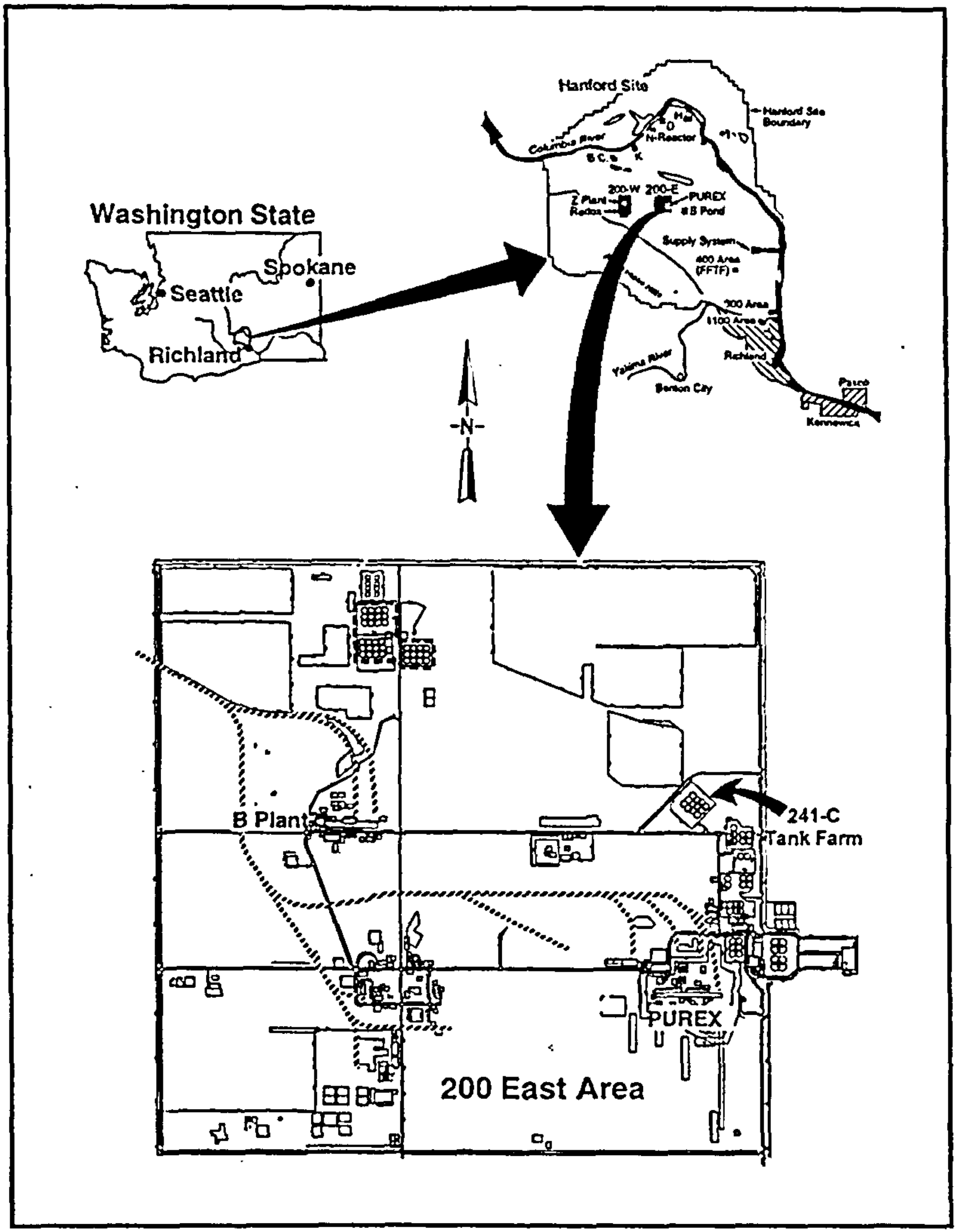
- Regional Geologic Setting
- Site-Specific Geology
- Conclusions
- Borehole/Well Logs (Appendix A)

2.0 REGIONAL GEOLOGIC SETTING

The regional geology, geologic structure, and stratigraphy identified in the Pasco Basin, and presented in this section, are based on various reports (DOE 1998a; Wood et al. 2000; Caggiano and Goodwin 1991; Lindsey et al. 1992, 1994a; Myers et al. 1979; Reidel et al.1989; Tallman et al. 1979).

The Hanford Site is located in the Pasco Basin, which is a physical and structural depression in the Columbia Plateau. The basin was created by tectonic activity and folding of Columbia River basalt and intercalated and overlying Miocene-Pliocene sediments. The Pasco Basin is bounded on the north by the Saddle Mountains; on the east by the Palouse Slope; on the west by the Umtanum Ridge, the Yakima Ridge, and the Rattlesnake Hills; and on the south by Rattlesnake Mountain and the Rattlesnake Hills. All these uplifts are major structural anticlines within the basalt bedrock. The eastern boundary of the Pasco Basin is a structural monocline with the bedrock dipping to the west and covered with the sediment that constitutes the Palouse Slope.

Figure 1. General Site Location Map.



The Hanford Site is underlain by Miocene Age basalt of the Columbia River Basalt Group and Miocene-to-recent (Holocene) suprabasalt sediments (Figure 2).

2.1 GEOLOGIC STRUCTURE OF THE PASCO BASIN

The Pasco Basin, one of the largest structural basins on the Columbia Plateau, lies near the junction of the Yakima Fold Belt and the Palouse sub-provinces. The Yakima Fold Belt is distinguished by a series of segmented, narrow, asymmetrical, generally east-west trending anticlines. The northern limbs of these anticlines are generally steeply dipping and some are vertical or overturned. The southern limbs are generally of shallow dip or low angle. Broad synclines or basins that may contain thick accumulations of sediment separate the anticlinal ridges. The Umtanum-Gable Mountain anticline divides the Pasco Basin into the Wahluke and Cold Creek synclines. The Cold Creek syncline is asymmetrical and is a relatively flat-bottomed structure. The Hanford Site 200 Areas are located on the northern limb of the Cold Creek syncline where the bedrock dips to the south at an angle of approximately 5 degrees. The Gable Mountain and Rattlesnake Mountain anticlines, located to the north and south of the Cold Creek syncline, are topographic high areas with outcropping basalt.

2.2 STRATIGRAPHY OF THE PASCO BASIN

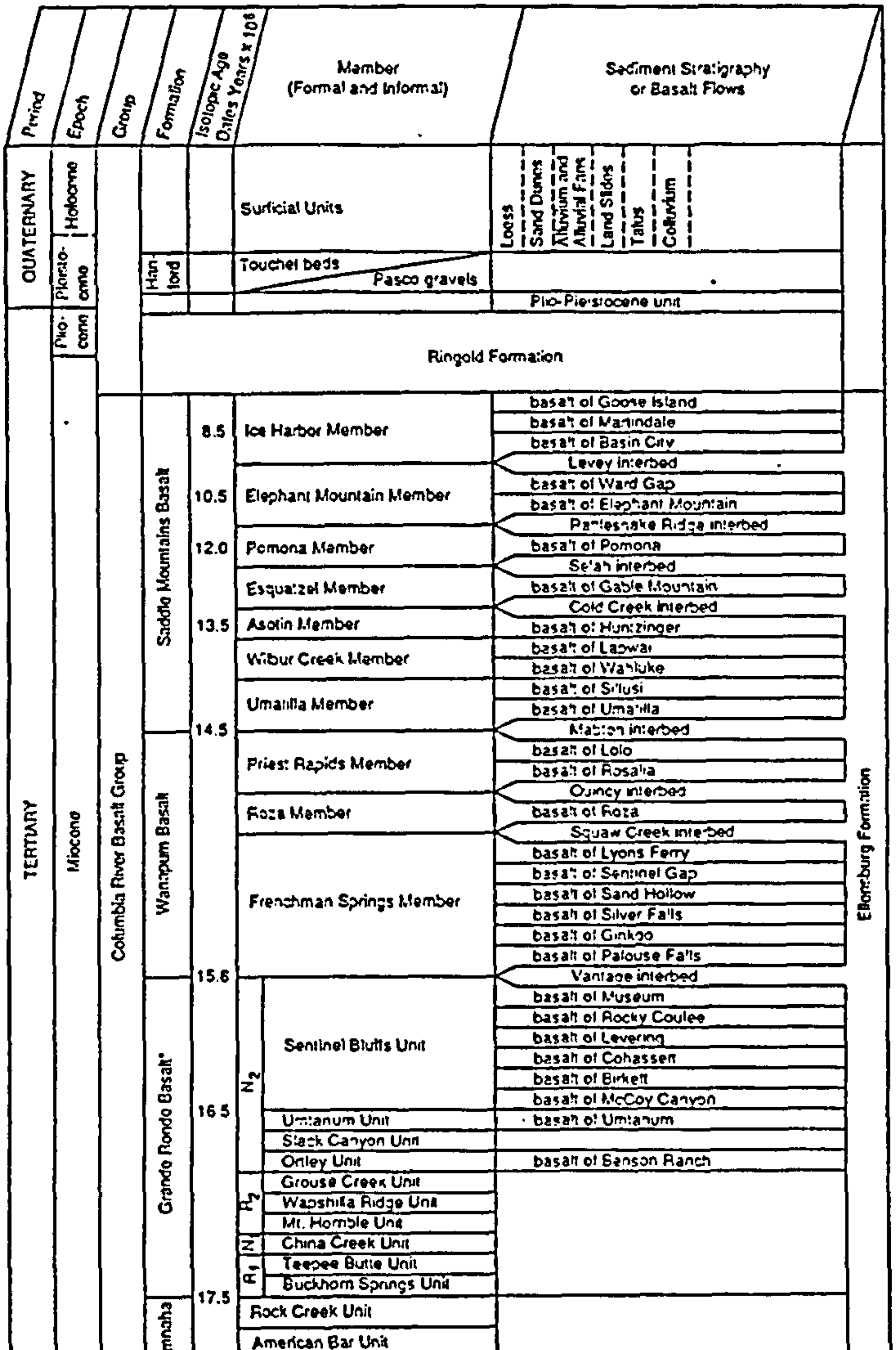
Sections 2.2.1 through 2.2.3 below discuss the stratigraphic units present in the Pasco Basin in order from oldest to youngest (Figures 2 and 3).

2.2.1 Columbia River Basalt Group

The Columbia River Basalt Group (CRBG) consists of a series of flood-basalt flows (up to 300 individual flows) deposited between 17.5 to 6.5 million years ago. The CRBG covers an area of over 164,000 km^2 (63,000 mi^2) in Washington, Oregon, and western Idaho and has a total estimated volume of over 174,000 km^3 (41,700 mi^3) (Tolan et al. 1989). Data from geophysical surveys and deep hydrocarbon exploration wells indicate that there is a maximum thickness of more than 3.2 km (2 mi) near Pasco, Washington, (Reidel et al. 1982, 1989). CRBG basalt flows erupted from 10 to 50 km (6 to +30 mi) long, north-northwest trending linear fissure systems located in eastern Washington, northeastern Oregon, and western Idaho. Several of these fissure systems are found in eastern and central Franklin County (Swanson et al. 1979b).

Detailed regional study and mapping of the CRBG show that differences in lithology, geochemistry, and paleomagnetic polarity exist among flows and groups of flows. These differences have enabled the definition of a sequence of units (or formations) within the CRBG that can be reliably identified and mapped on a regional basis (e.g., see Swanson et al. 1979a, 1979b; Beeson et al. 1985, 1989; Reidel et al. 1989; Beeson and Tolan, 1990, 1996). Each of these formations is subdivided into a number of individual members. The Saddle Mountains Basalt is the uppermost basalt underlying the Hanford Site (Reidel and Fecht 1981).

Figure 2. Stratigraphy of the Pasco Basin.



*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named. N_2, R_2, N_1 and R_1 are magnetostratigraphic units.

2.2.2 Ringold Formation

The Ringold Formation consists of variably indurated clay, silt, pedogenically altered mud and sand, fine- to coarse-grained sand, and multi-lithologic, granule-to-cobble conglomerate (Goodwin 1993; Grolier and Bingham 1971, 1978; Newcomb et al. 1972; Myers et al. 1979; WPPSS 1981; DOE 1988; Lindsey 1995, 1996). Ringold sediments are best described on the basis of the types of sediment, or sediment facies associations that comprise them. These facies associations are defined on the basis of unique combinations of lithology, stratification, and pedogenic (or soil) alteration (Lindsey and Gaylord 1990; Lindsey 1995, 1996). Ringold facies associations, described in detail in Lindsey et al. (1994b) and Lindsey (1995, 1996), are summarized below:

- Fluvial (or river) gravel consist of non-indurated to well indurated (or cemented), river deposited, pebble-cobble conglomerate with a sand matrix. Minor, local interbeds of sand and silt are found in the association.
- Fluvial (or river) sand consists of fine to coarse sand with minor interbedded gravel and silt.
- Overbank-paleosol deposits (ancient flood plains and soils) consist of laterally discontinuous to widely distributed silt and clay displaying evidence of river flooding and soil forming processes.
- Lacustrine strata consist of interbedded clay, silt, and sand forming laterally continuous beds deposited in lakes.
- Alluvial fan deposits are characterized by mud-rich, basaltic gravel deposited by streams that flowed off upland surfaces.

The Ringold Formation is divided into three informal members, or map units, each dominated by different facies associations (Lindsey et al. 1994b; Lindsey 1995, 1996):

- The first member, Wooded Island, forms the majority of the Ringold Formation beneath the Hanford Site. The member is dominated by fluvial gravel. Secondary overbank/paleosol and lacustrine deposits that form widespread-to-localized sheets that separate individual fluvial gravel horizons also occur.
- The second member, Taylor Flat, is dominated by fluvial sand and overbank-paleosol deposits. Only thin erosional remnants of this member are found beneath the Hanford Site, predominately beneath the 200 West Area and beneath the Wye Barricade.
- Strata dominated by lacustrine deposits form the third member, Savage Island. The Savage Island member overlies the other Ringold members and may form much of the uppermost Ringold off the Hanford Site. This member is not present in the subsurface beneath the Hanford Site.

The Ringold Formation is the most extensive suprabasalt sedimentary unit at the Hanford Site. The Ringold Formation is absent in the north, areas adjacent to the north, and northeastern portion of the 200 East Area. It also pinches out against structural highs.

2.2.3 Cold Creek Unit

A sequence of laterally discontinuous, fluvial, alluvial, eolian, colluvial, pedogenic carbonate, and lacustrine deposits less than 12 meters (40 feet) thick underlies the Hanford formation and overlies the Ringold Formation beneath parts of the Hanford Site (Myers et al. 1979; DOE 1988; Lindsey 1995, 1996; Slate 1996). Lithologies that have been described in this informal unit include the following.

- Laterally discontinuous pedogenic and groundwater derived white, light gray, and light pink colored calcium carbonate forming irregular partings, fracture fill, nodules, and horizons less than 0.3 m (1 foot) thick.

- Interbedded lenses of reworked loess, basaltic sand and gravel, and felsic sand and gravel with intercalated carbonate.

- Thin planar laminated, interstratified, tan, light brown, and olive colored fine sand, silty sand, and sandy silt with interbedded clayey silt.

- Massive, loess-like sandy silt to silty sand referred to as early Palouse soil and overlying calcium carbonate deposits.

The Cold Creek unit is not present beneath the C Tank Farm.

2.2.4 Hanford Formation

The Hanford formation is the informal name given to all glaciofluvial deposits from cataclysmic ice-age floods found in the Pasco Basin (Myers et al. 1979; DOE 1988). Sources for floodwaters included glacial Lake Missoula, and ice-margin lakes that formed around the margins of the Columbia Plateau and Lake Bonneville (Baker et al. 1991). On average, interglacial conditions lasting about 50,000 years have been separated by major glacial advances, also averaging about 50,000 years. To date, ice-age flood deposits from only four of the major glacial events that occurred between 1 million and 13,000 years ago are identified within the Pasco Basin (Baker et al. 1991; Reidel and Fecht 1994). Evidence to support the other major glacial cycles in the Pasco Basin either are masked or have been destroyed by subsequent ice-age floods.

The Hanford formation consists of mostly unconsolidated sediments that cover grain sizes from pebble to boulder gravel, fine- to coarse-grained sand, silty sand, and silt. The formation is further subdivided into gravel-, sand-, and silt-dominated facies, which transition into one another laterally with distance from the main, high-energy, flood channels. The three Hanford formation facies are generally characterized as follows.

- **Gravel-Dominated (Coarse-Grained) Facies.** This facies generally consists of coarse-grained basaltic sand and granule to boulder gravel. These deposits display an open framework texture, massive bedding, plane- to low-angle bedding, and large-scale planar cross bedding in outcrop. Gravel-dominated beds sometimes grade upward into sand- and silt-dominated facies. Gravel clasts are predominantly basalt, with lesser amounts of Ringold Formation clasts, granite, quartzite, and gneiss (Lindsey et al. 1992). The gravel-dominated facies was deposited by high-energy floodwaters in, or immediately adjacent to the main cataclysmic flood channels.

- **Sand-Dominated (Transitional) Facies.** Well stratified, fine-to-coarse grained sand and granule gravel dominate the facies (Lindsey et al. 1994b). The sands typically have a high-basalt content and are commonly referred to as black, gray, or "salt-and-pepper" sands. They may contain small pebbles, rip-up clasts, and pebble-gravel interbeds. They often grade upward into zones of silt-dominated facies less than 1 m (3 foot) thick. This facies commonly displays plane lamination and bedding and, less commonly, channel cut-and-fill sequences. The sand-dominated facies was deposited adjacent to main flood channel ways during the waning stages of flooding. The facies is transitional between the gravel-dominated facies and the silt-dominated facies.

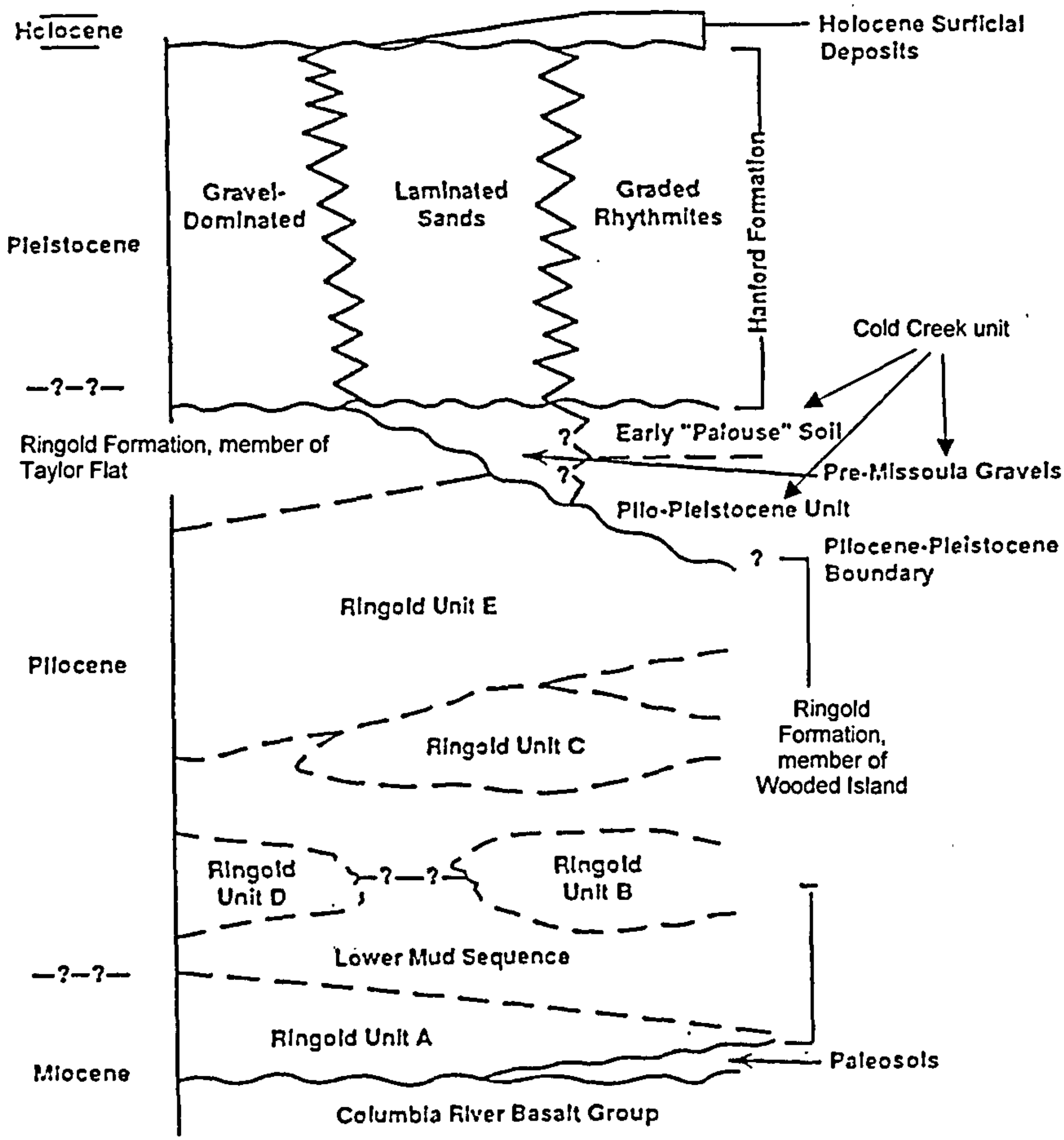
- **Silt-Dominated (Rhythmite) Facies.** This facies consists of thin-bedded, plane-laminated, and ripple cross-laminated silt and fine- to coarse-grained sand. Beds are typically a few to several tens of centimeters (1 to 10+ inches) thick and commonly display normally graded bedding. Sediments of this facies were deposited under slackwater conditions and in back-flooded areas (DOE 1988; Baker et al. 1991).

Beneath much of the Hanford Site the Hanford formation has been locally subdivided into several informal subunits. In the 200 East and West Areas Lindsey et al. (1994b) subdivide the Hanford formation into 3 basic units, H1, H2, and H3. H1 is described as consisting of a gravel facies-dominated interval in the upper part of the formation throughout much of the 200 East and West Areas. Unit H2 is described as a predominantly sand facie-dominated unit, which increases in predominance within the formation from north to south across the same area. The H3 unit is generally described as a mixed sand and gravel facies unit found comprising the lower part of the formation in much of the 200 East Area, and possibly locally in the 200 West Area.

2.2.5 Clastic Dikes

Clastic dikes are found in the Hanford formation and locally in other sedimentary units (Black 1979; Fecht and Weeks 1996; Fecht et al. 1998, 1999). Clastic dikes are vertical to sub-horizontal fissures filled by multiple layers of unconsolidated sand, silt, clay, and minor gravel aligned parallel to sub-parallel to dike walls. Clastic dikes range in vertical extent from.3 m to 55 meters (1 foot to 180 feet). In cross-section, clastic dikes range from 1 millimeter to 1.8 meter (0.04 in. to 6 feet) in thickness, and in plan view clastic dikes extend up to 100 meters (328 feet) along strike. Clastic dikes form a branching pattern that in plan view forms polygons many feet across. Where the dikes intersect the ground surface a feature known as patterned ground is observed. Patterned ground features are most abundant when Hanford formation sand-dominated and silt-dominated facies are at or near ground surface. Fecht et al. (1998) summarize the location at Hanford where clastic dikes have been identified. Clastic dikes are inferred to be present beneath the single-shell tank farms, and at least locally, they cross-cut the Plio-Pleistocene boundary (Singleton and Lindsey 1994).

Figure 3. Generalized Suprabasalt Stratigraphy of the Hanford Site.



2.2.6 Holocene Surficial Deposits

Holocene surficial deposits consist of silt, sand, and gravel that form a thin layer across much of the Hanford Site. These sediments were deposited by a combination of eolian and alluvial processes. During construction of the 241-C Tank Farm, these deposits were largely removed from the area (Price and Fecht 1976).

2.3 SITE-SPECIFIC GEOLOGY

The purpose of this section is to describe the vadose zone geology of the 241-C Tank Farm (the tank farm). This section is based on interpretations of geologic logs and, where available, geophysical logs, drilled within and near the tank farm. Figure 4 shows the locations of boreholes used to interpret site-specific geology. Interpreted borehole logs used in this investigation are reproduced in Appendix A.

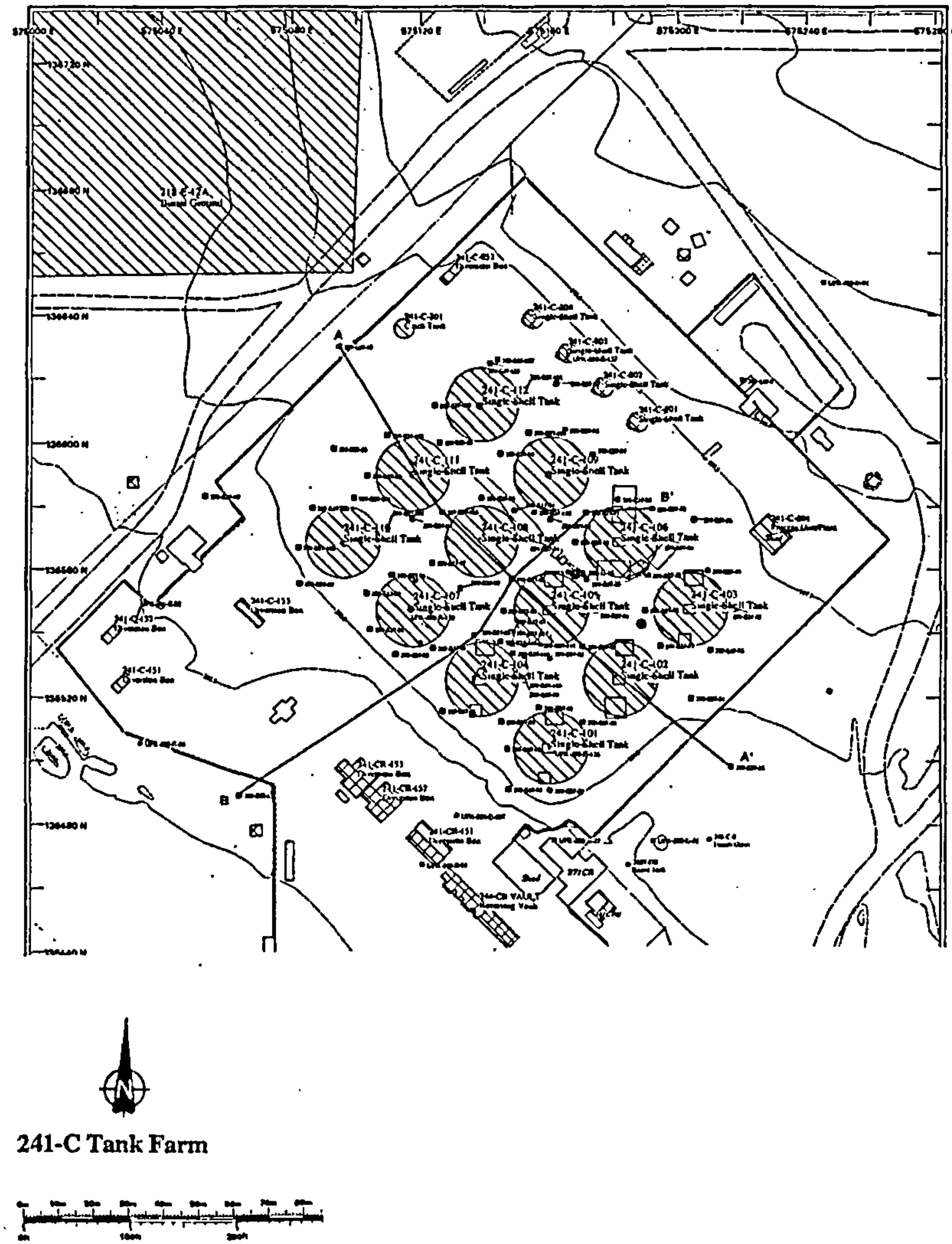
The majority of the borehole logs (geologic and geophysical) used in this investigation are from dry wells constructed for tank leak detection. These wells are typically less than 47 meters (155 feet) deep and geologic logs for them, prepared by drillers, are usually generalized. Logs from a series of groundwater monitoring wells located around the periphery of the tank farm are also used in this investigation. Geologic information on these well logs was recorded by a well site geologist and usually more detailed than the logs for the leak detection wells.

Table 1 lists the boreholes used in the investigation. Geologic units interpreted to be penetrated by each borehole, the elevations of the tops of these units, and the thicknesses of these units are also given in Table 1. Geologic units interpreted to comprise the vadose zone at the tank farm, and discussed in the following sections, include, from the youngest to the oldest:

- Tank farm backfill
- Eolian deposits
- Hanford formation, units H1, H2, and H3
- Ringold Formation.

The Cold Creek unit, which is common beneath the nearby 200 West Area, is interpreted to be absent beneath the tank farm.

Figure 4. Borehole and Cross-Section Location Map.



2.3.1 Tank Farm Backfill

The shallowest sediments found within the confines of the tank farm are described primarily as basaltic pebble-cobble gravel with a sand and silt matrix. This material is commonly brown in color and contains construction debris, including nails, wood, and cement. These strata are interpreted to be tank farm backfill, which is consistent with previous interpretations of area geology (Price and Fecht 1976; Lindsey and Law 1993). Moisture logs collected in many of the tank farm leak detection borings show increased moisture approximately 12 to 13 meters (40 to 42 feet) below ground surface (bgs). This is interpreted to be moisture accumulating above the compacted base of the original tank farm excavation.

2.3.2 Eolian Deposits

A thin (<5 meter [15-foot] thick) veneer of brown fine sand and silty fine sand is found locally in the area around the tank farm, but not within the tank farm or other heavily built-up areas. This material is interpreted as eolian sand deposits. The absence of these strata from the tank farm proper is due to their removal during tank farm excavation and construction.

2.3.3 Hanford Formation

A thick sequence of gravel, sand, and silt up to 91 meters (300 feet) thick underlies the entire tank farm area. Based on previous reports, including Appendix A of HNF-2603, describing the geology of the eastern part of the 200 East Area (DOE 1988; Last et al. 1989; Caggiano and Goodwin 1991; Lindsey and Law 1993; Lindsey et al. 1998) these strata are assigned to the Hanford formation. For this report, the Hanford formation is subdivided into three units, from the surface downward - H1, H2, and H3, defined on the basis of the dominant facies present. The basic physical characteristics of these units, which are based on geologic logs for selected borings and wells in and near the tank farm and outcrop observations of analogous strata and deposits in the Hanford Site area, are presented below.

Unit H1 consists predominantly of a mix of the gravel and sand facies. Typical lithologies include uncemented, silty sand, medium-to-granular basaltic sand, gravelly basaltic sand, and pebble-to-cobble gravel. Gravel clasts are typically basaltic, although other igneous and metamorphic rock types also are usually present. The gravel deposits also are commonly open framework. Thin (<0.5 m) lenticular silt interbeds are potentially present, although not well represented in existing geologic logs. Bedforms in the unit are probably dominated by broad, tabular lenses consisting of cross-bedded and planar-bedded horizons. However, channel-like scours, abruptly truncating strata also are potentially present, at least locally. The unit is present to the north, west, and east of the tank farm, and absent to the south. It is largely absent beneath the tank farm due to its removal during tank farm excavation.

Unit H2 is a 43 to 85+ meter (140 to 280+ foot-) thick sequence of predominantly medium-to-granular, basalt-rich sand (typical of the sand facies). Unit H2 underlies unit H1 where unit H1 is present, and tank farm backfill where unit H1 was removed during tank farm excavation

(Figures 5 and 6). Outcrops of strata interpreted to be analogous to this interval show these deposits to typically be planar stratified, occasionally cross-bedded, and to contain thin (<0.1 meter [0.5 foot-] thick) silty-to-sandy silt interbeds. These analogous outcrops also suggest bedforms in this material are typified by broad, tabular-to-low-angle sheets, although channel scours may be locally present. Thin interbeds of small-to-medium pebble gravel probably are scattered throughout unit H2. The pebbly and silty interbeds are inferred to be lenticular and of limited lateral extent given the absence of laterally persistent horizons beneath the tank farm suggested by analysis of lithologic and geophysical logs in the area of proposed borehole C4297 (Letter from K. A. Lindsey to K. D. Reynolds, 25 November 2003).

The contact between unit H2 and unit H1 is placed at the base of gravel facies strata over 0.5 to 1 meter (2- to 3-feet) thick. This contact appears to range from approximately 11 to 24 meters (35 to 80 feet) bgs. Where unit H1 is absent, the unit H2/backfill contact is generally placed at a marked downwards transition from gravel to sand at depths of approximately 12 meters (40 feet) at the tank farm. The top of unit H2 generally slopes to the northeast in the vicinity of the tank farm, from an elevation of approximately 204 meters (670 feet) above sea level southwest of the tank farm to approximately 168 meters (550 feet) above sea level northeast of the tank farm (Figure 7). Directly beneath the tank farm this surface is relatively flat and corresponds generally to the base of the tank farm excavation. However, beneath the southern edge of the tank farm the contact is deeper, lying at least 12 meters (40 feet) beneath the base of the tank farm (Figure 7).

At depths ranging from approximately 61 to 91 meters (200 to 300 feet), the sand facies dominated strata of unit H2 transitions downward into a mixed gravel-and-sand facies-dominated interval, which we assign to unit H3. This contact is usually placed at the top of the first gravelly strata greater than 3 meters (10 feet) thick. This contact is generally deeper beneath the tank farm (between 131 to 128 meters [430 and 420 feet] above sea level) and shallower to the north and south of the tank farm (between 146 to 149 meters [480 and 490 feet] above sea level) (Figure 8). We are not aware of direct surface analogous to unit H3 in the 200 East Area. However, lithologic variations identified in borehole logs through this interval are interpreted to indicate the predominant bed forms in it are lenticular.

It seems likely that unit contacts within the Hanford formation are not single, continuous stratigraphic horizons. Instead, based on variations in the elevation of these contacts, the contacts as interpreted in this report are inferred to actually be a series of overlapping, discontinuous surfaces arbitrarily assigned to a unit. If this is the case, facies comprising the units interfinger near the contacts, and the contacts, are irregular.

Figure 7. Structure Contour Map of the Top of Hanford Formation Unit H2.

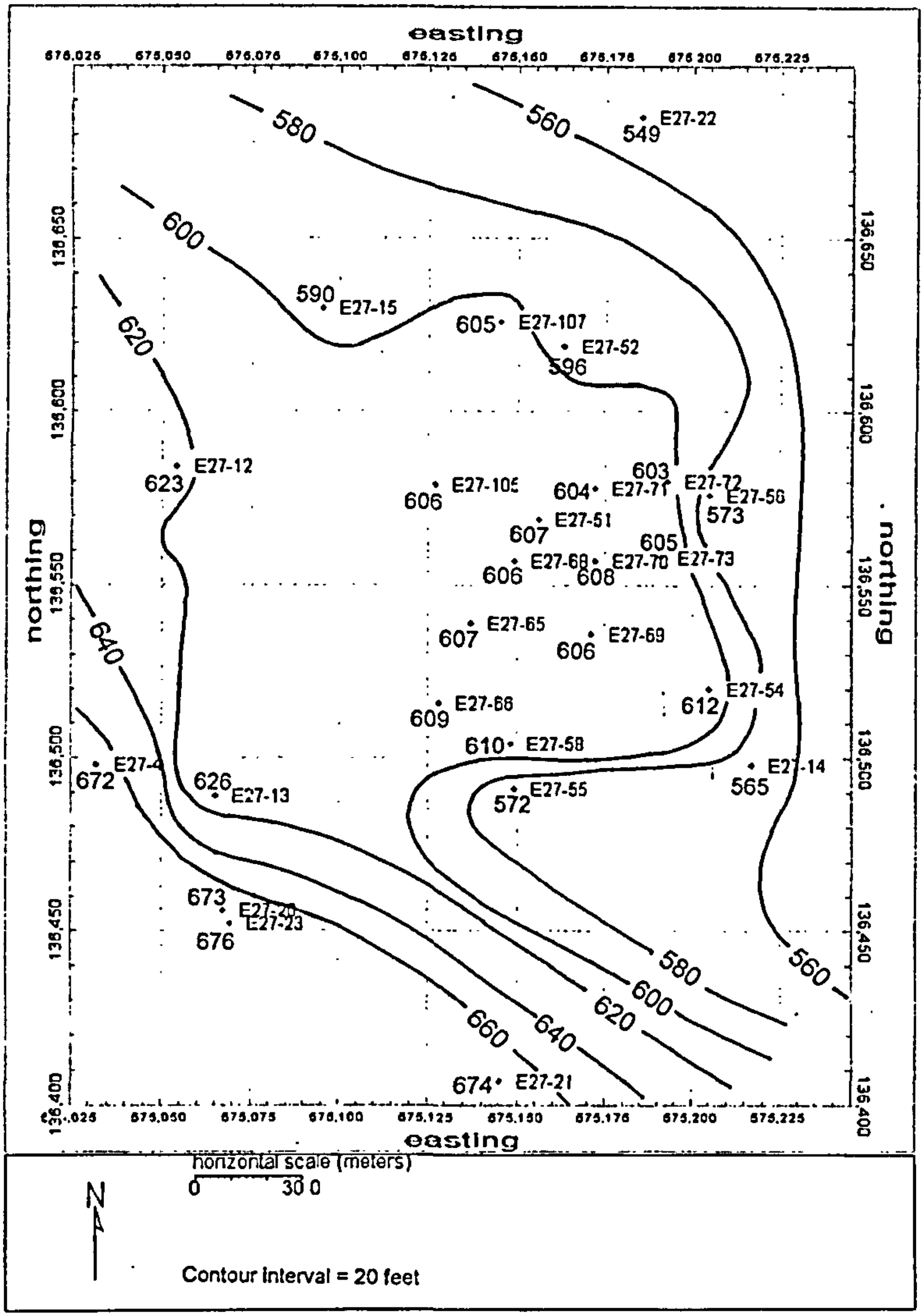
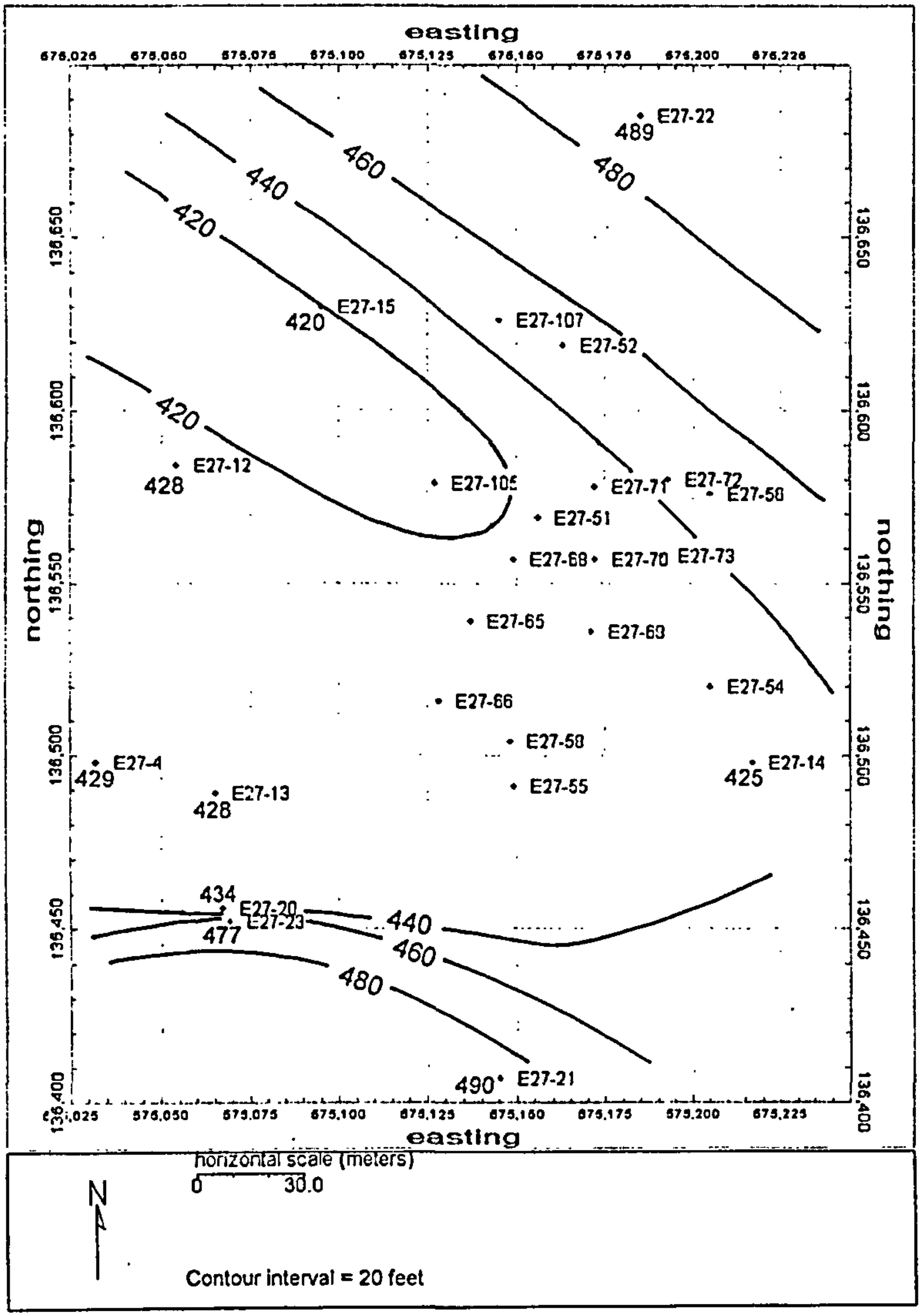


Figure 8. Structure Contour Map of the Top of Hanford Formation Unit H3.



2.3.4 Ringold Formation

At depths between 69 to 96 meters (227 and 316 feet) (111 to 124 meters [365 to 408] feet msl) silty sandy gravel that appears to differ from overlying strata is encountered. Borehole log descriptions indicate the following about this silty sand gravel.

- It is less basaltic than overlying strata.
- It contains staining and coloration in shades of brown, yellow, and red.
- It displays more induration than overlying strata.

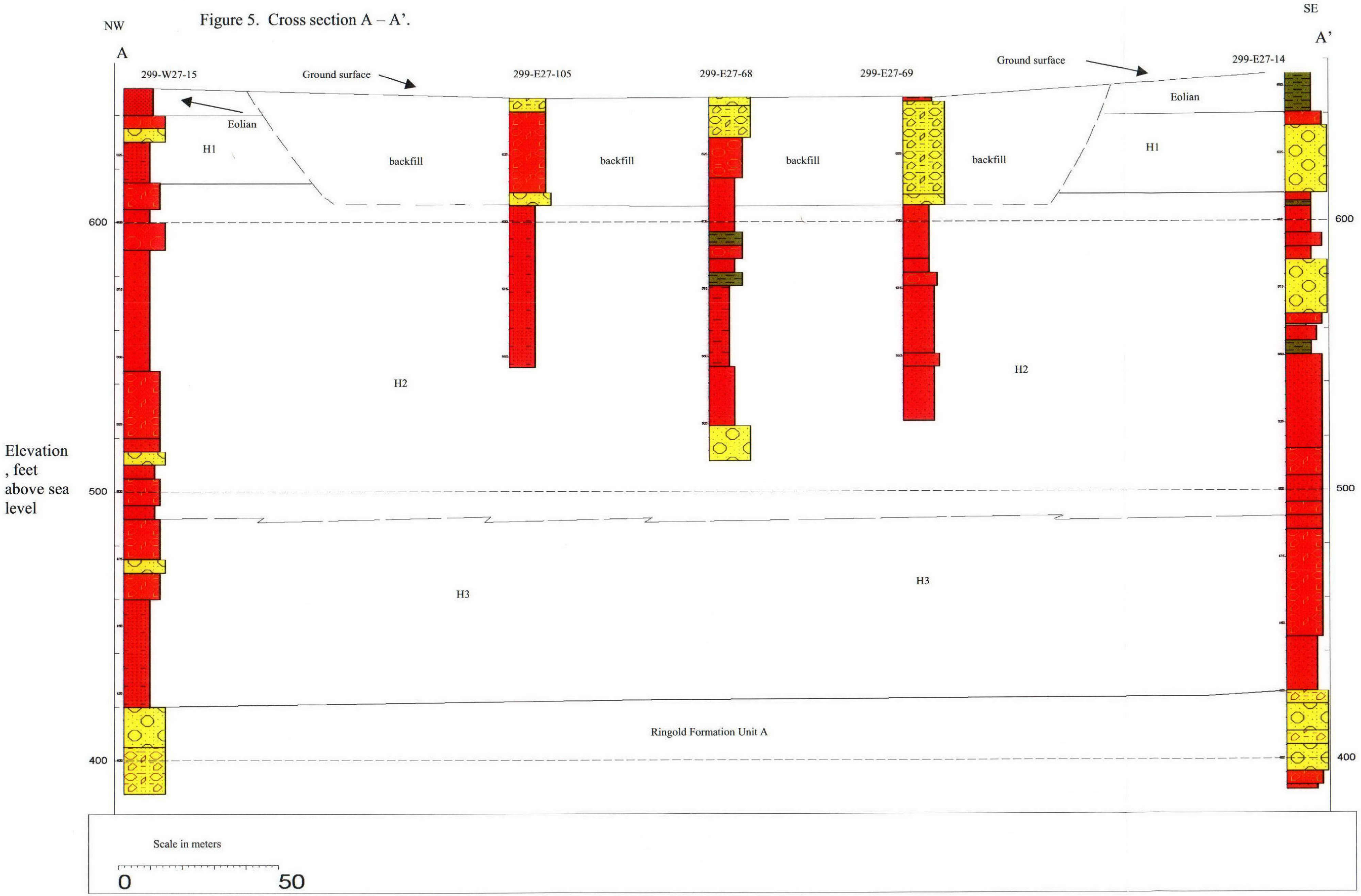
These deposits are inferred to be part of the Ringold Formation, member of Wooded Island. Only two boreholes used in the investigation go deep enough to intersect the unit so it is not clear if the unit completely underlies the tank farm or if it is at least locally absent. Only one of the two boreholes, 299-E27-22, fully penetrates the unit, intersecting underlying basalt. In this borehole the Ringold is 12 meters (41 feet) thick. Because only one borehole intersects basalt beneath the tank farm, the shape of this basalt surface at this site is not known.

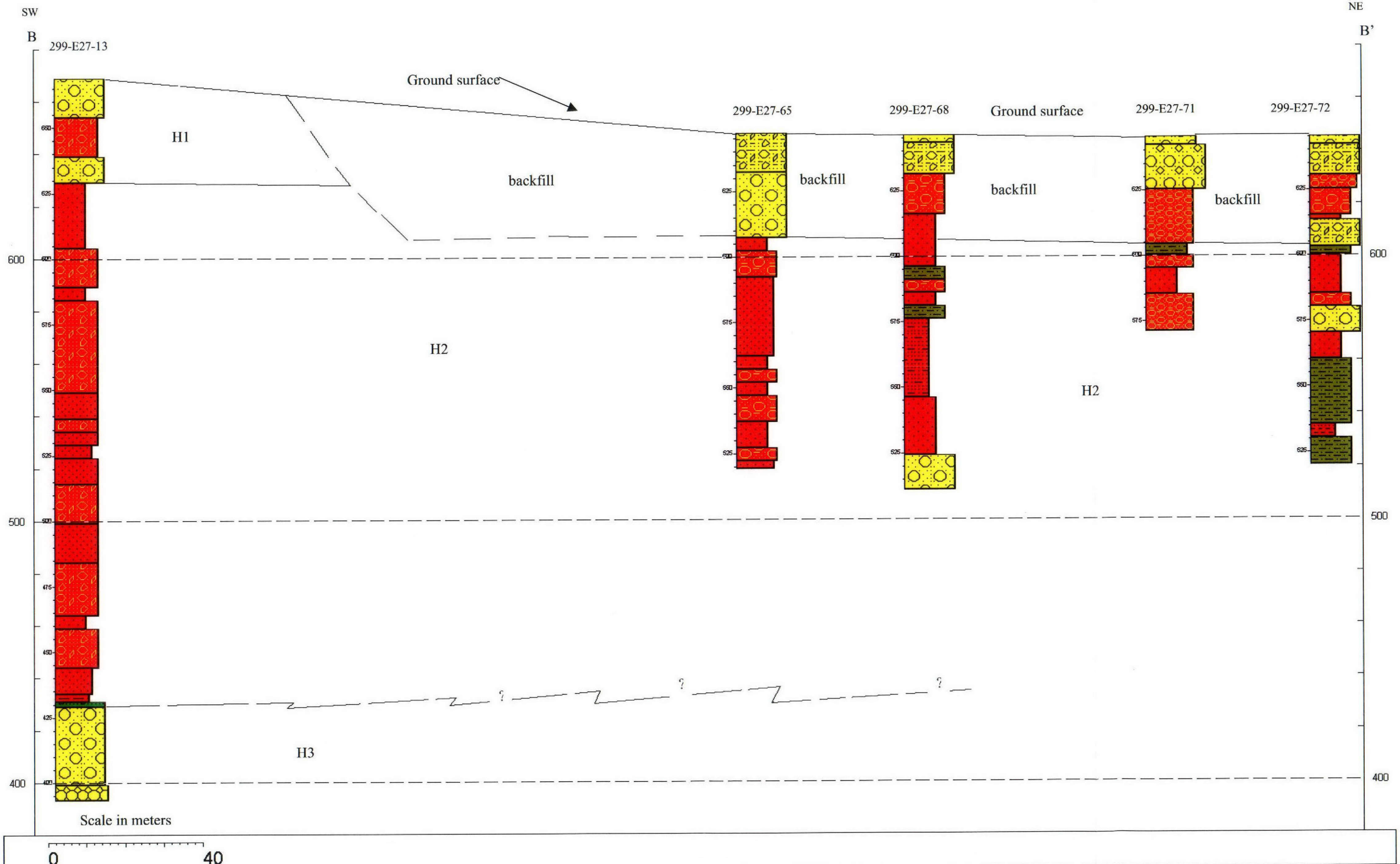
Table 1. Structure Contour and Isopach Data.[a]

Borehole #	elev[c]	easting	northing	Bf/Eo[d] top[b]	Bf/Eo thick	H1 top[b]	H1 thick	H2 top[b]	H2 thick	H3 top[b]	H3 thick	Ringold top[b]	Ringold thick	TOB[e] elev
E27-105	646	575127	136579	646	40		0	606	>60					
E27-107	645	575145	136626	645	40		0	605	>60					
E27-12	657	575054	136584		0	35	35	622	195	427	>40			
E27-13	666	575065	136489		0	40	40	626	198	428	>38			
E27-14	655	575217	136498	655	15	75	75	565	140	425	>37			
E27-15	649	575095	136630	649	10	50	50	589	170	419	>32			
E27-20	674	575067	136455	674	1		0	673	239	434	>38.5			
E27-21	674	575145	136407	674	1		0	673	184	489	120	369	>13	
E27-22	634	575185	136685	634	1	633	80.5	552	63.5	489	82	407	41	366
E27-23	677	575069	136452	677	1.5		0	676	198.5	477	>118			
E27-4	674	575032	136497	674	2		0	672	243	429	>66			
E27-51	646	575156	136569	646	40		0	606	>110					
E27-52	645	575163	136619	645	40	605	10	595	>100					
E27-54	651	575205	136520	651	40		0	611	>115					
E27-55	652	575149	136491	652	40	612	41	571	>73					
E27-56	639	575205	136576	639	40	599	26	573	>79					
E27-58	647	575148	136504	647	37		0	610	>63					
E27-65	647	575137	136539	647	40		0	607	>88					
E27-66	649	575128	136516	649	40		0	609	>105					
E27-68	646	575149	136557	646	40		0	606	>95					
E27-69	646	575171	136536	646	40		0	606	>80					
E27-70	645	575172	136557	645	41		0	604	>89					
E27-71	645	575172	136578	645	41		0	604	>33					
E27-72	645	575193	136580	645	42		0	603	>83					
E27-73	644	575191	136558	644	40		0	604	>50					

[a]All data in feet.
[b]Tops in feet above sea level.
[c]Elev = elevation in feet above sea level.
[d]Bf/Eo = Backfill/Eolian.
[e]TOB = top of basalt.

Figure 5. Cross section A – A'.




SW
B
299-E27-13
Ground surface
NE
B'
299-E27-65
299-E27-68
Ground surface
299-E27-71
299-E27-72
H1
backfill
backfill
backfill
backfill
H2
H2
H3
600
500
400
600
500
400
?
?
?
Scale in meters
0
40

3.0 CONCLUSIONS

The vadose zone directly underlying the tank farm is interpreted to consist almost entirely of Hanford formation sand facies in unit H2, overlying a mix of Hanford formation sand and gravel facies, unit H3. Sand facies strata throughout unit H2 are inferred to display predominantly planar-tabular bedforms with minor cross-bedding and scour cut-and-fill features. Interbedded, probably lenticular, silt and pebble gravel layers rarely greater than 0.3 to 0.6 meter (1 to 2 feet) thick are interpreted to be present in unit H2 beneath the tank farm. All of these strata may gently dip to the east-southeast, down the general paleo-depositional gradient on the Cold Creek bar (although this interpretation is speculative and not supported by direct evidence observed in borehole logs).

The contacts between units H1 and H2, and H2 and H3 are irregular. This is interpreted to be because these contacts are defined on the basis of facies changes that are probably reflective of the presence of lenticular sediment bodies, and not single, continuous, stratigraphic horizons or layers. The contacts as interpreted here are therefore better characterized as being defined by a series of overlapping lenses, accounting for the irregularities seen in these contacts.

Ringold Formation conglomerate, interpreted to be unit E of the member of Wooded Island, probably underlies most, if not all, of the tank farm. However, given that only two boreholes are interpreted to intersect this unit beneath the immediate area of the tank farm, the lateral continuity of the unit, and the elevation of the Ringold/Hanford contact cannot be determined with any certainty.

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APPENDIX A

INTERPRETED BOREHOLE AND WELL LOGS

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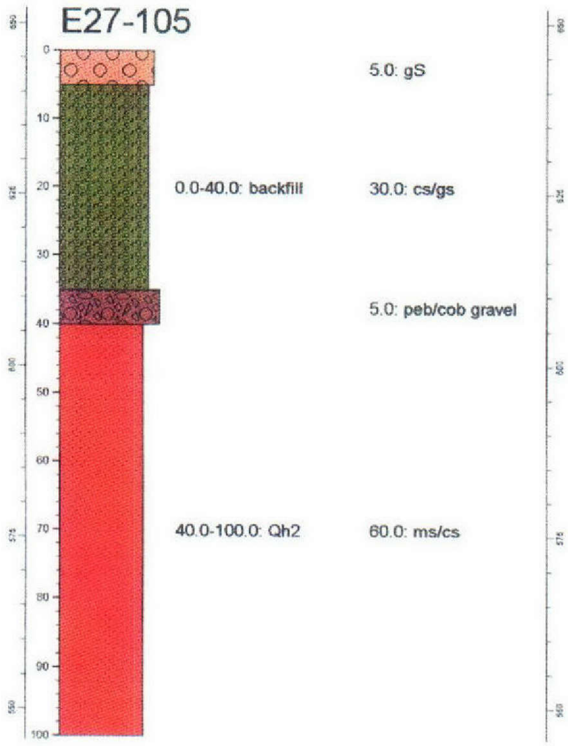


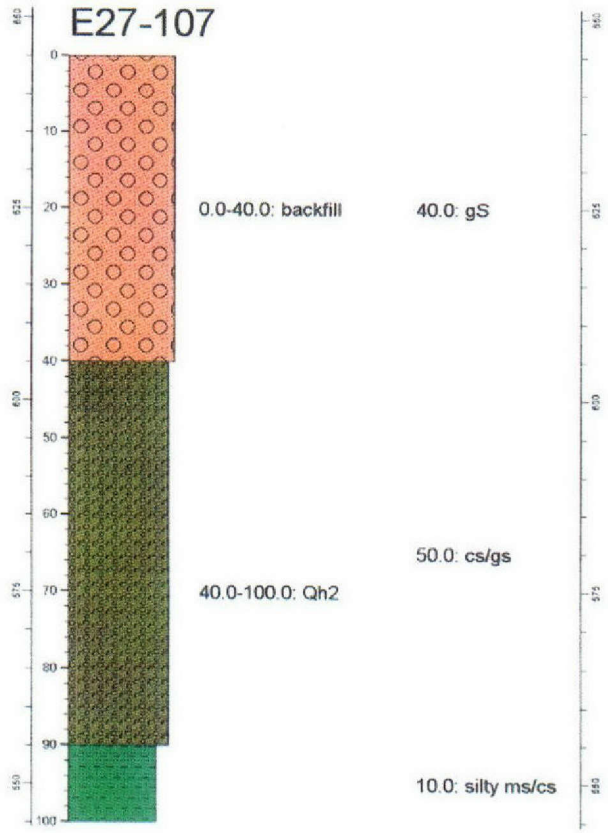
NOTE: In this appendix, all depths and elevations are in feet, the unit names and lithologies are as follows.

Unit names

Qd	eolian deposits
Qh1	Hanford formation, unit H1
Qh2	Hanford formation, unit H2
Qh3	Hanford formation, unit H3
Trwie	Ringold Formation, member of Wooded Island

Lithologies

m	muddy
fs	fine sand
ms	medium sand
cs	coarse sand
s	sand
g	gravel
peb	pebbles
cob	cobbles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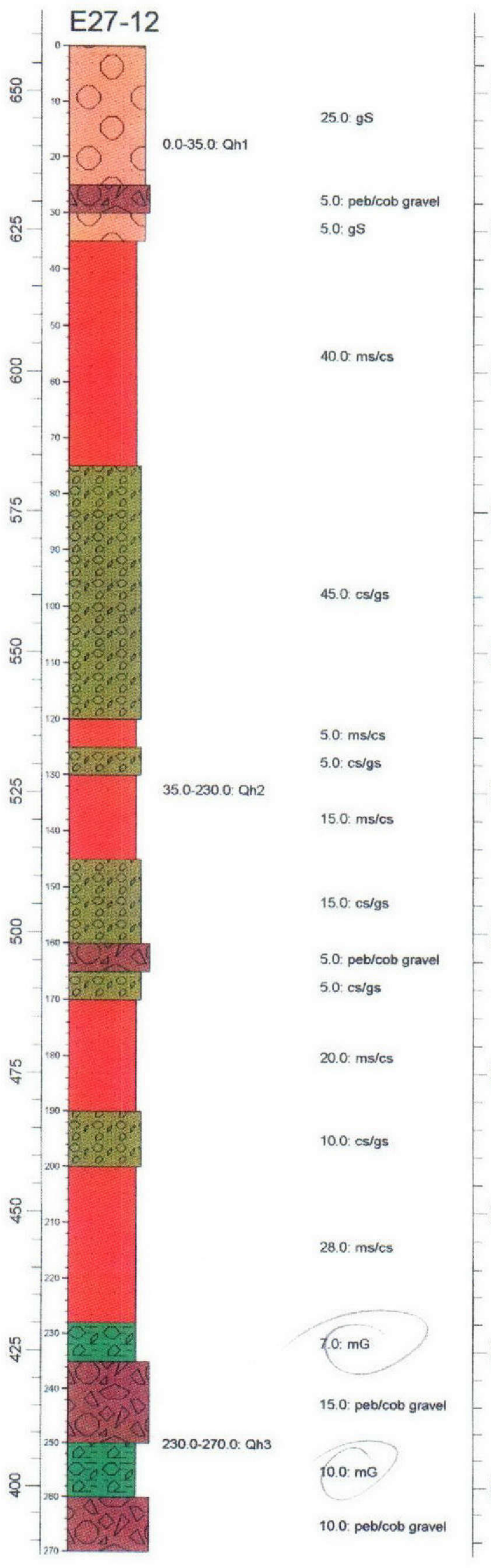
40.0: gS
50.0: cs/gs
10.0: silty ms/cs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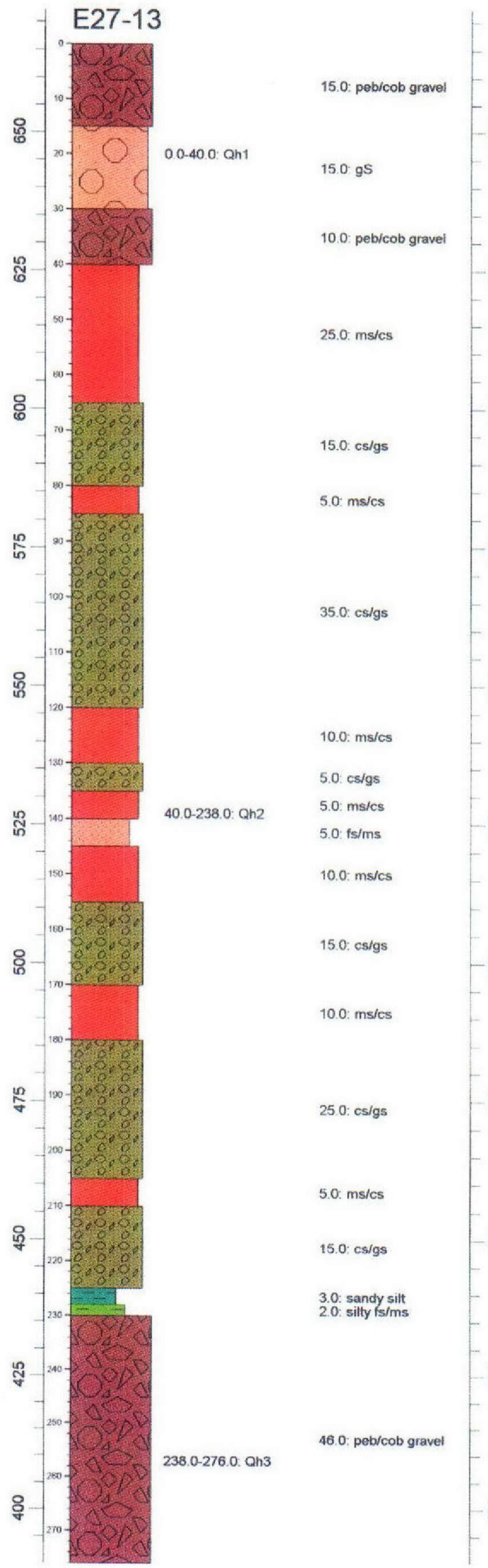
25.0: gS
5.0: peb/cob gravel
5.0: gS
40.0: ms/cs
45.0: cs/gs
5.0: ms/cs
5.0: cs/gs
35.0-230.0: Qh2
15.0: ms/cs
15.0: cs/gs
5.0: peb/cob gravel
5.0: cs/gs
20.0: ms/cs
10.0: cs/gs
28.0: ms/cs
7.0: mG
15.0: peb/cob gravel
230.0-270.0: Qh3
10.0: mG
10.0: peb/cob gravel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40.0-238.0: Qh2
238.0-276.0: Qh3
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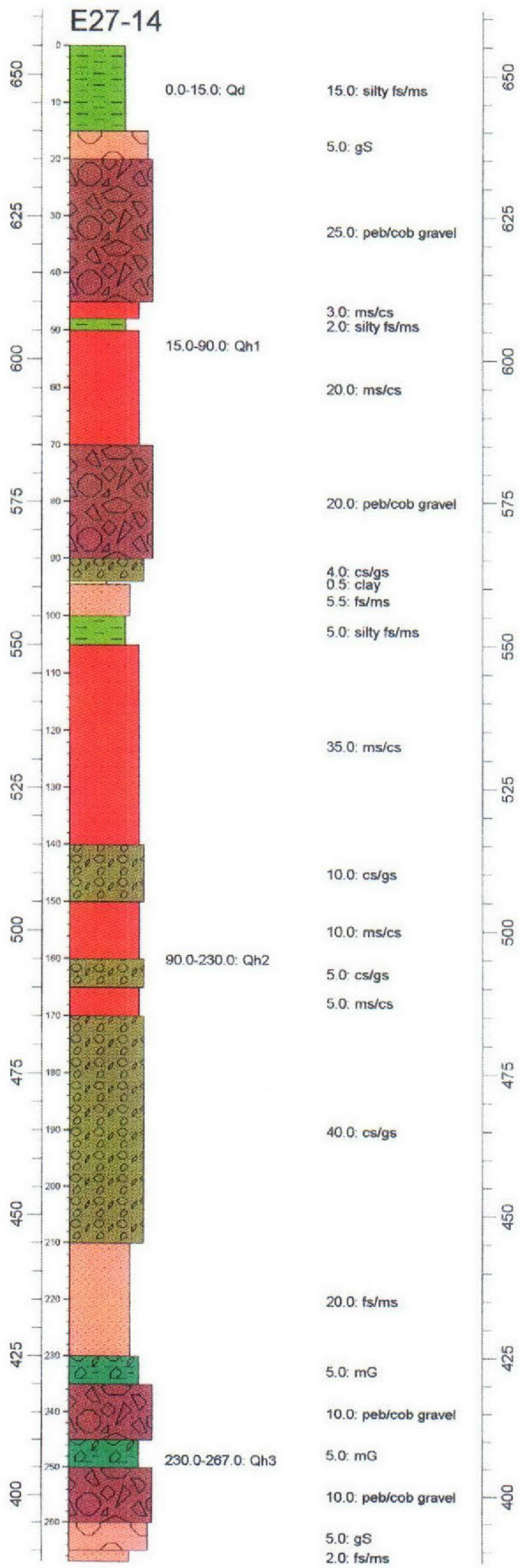
15.0: gS
10.0: peb/cob gravel
25.0: ms/cs
15.0: cs/gs
5.0: ms/cs
35.0: cs/gs
10.0: ms/cs
5.0: cs/gs
5.0: ms/cs
5.0: fs/ms
10.0: ms/cs
15.0: cs/gs
10.0: ms/cs
25.0: cs/gs
5.0: ms/cs
15.0: cs/gs
3.0: sandy silt
2.0: silty fs/ms
46.0: peb/cob gravel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0.0-15.0: Qd
15.0: silty fs/ms
5.0: gS
25.0: peb/cob gravel
3.0: ms/cs
2.0: silty fs/ms
15.0-90.0: Qh1
20.0: ms/cs
20.0: peb/cob gravel
4.0: cs/gs
0.5: clay
5.5: fs/ms
5.0: silty fs/ms
35.0: ms/cs
10.0: cs/gs
10.0: ms/cs
90.0-230.0: Qh2
5.0: cs/gs
5.0: ms/cs
40.0: cs/gs
20.0: fs/ms
5.0: mG
10.0: peb/cob gravel
5.0: mG
230.0-267.0: Qh3
10.0: peb/cob gravel
5.0: gS
2.0: fs/ms
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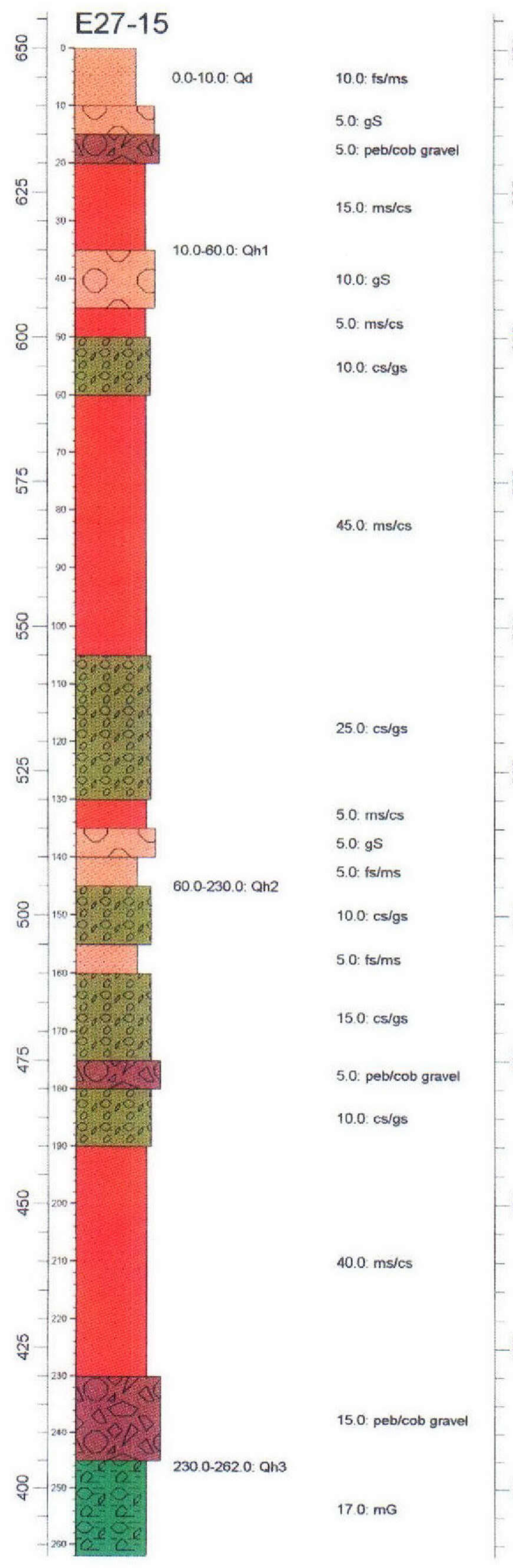
500
475
450
425
400



E27-15
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10.0-60.0: Qh1
60.0-230.0: Qh2
230.0-262.0: Qh3
10.0: fs/ms
5.0: gS
5.0: peb/cob gravel
15.0: ms/cs
10.0: gS
5.0: ms/cs
10.0: cs/gs
45.0: ms/cs
25.0: cs/gs
5.0: ms/cs
5.0: gS
5.0: fs/ms
10.0: cs/gs
5.0: fs/ms
15.0: cs/gs
5.0: peb/cob gravel
10.0: cs/gs
40.0: ms/cs
15.0: peb/cob gravel
17.0: mG
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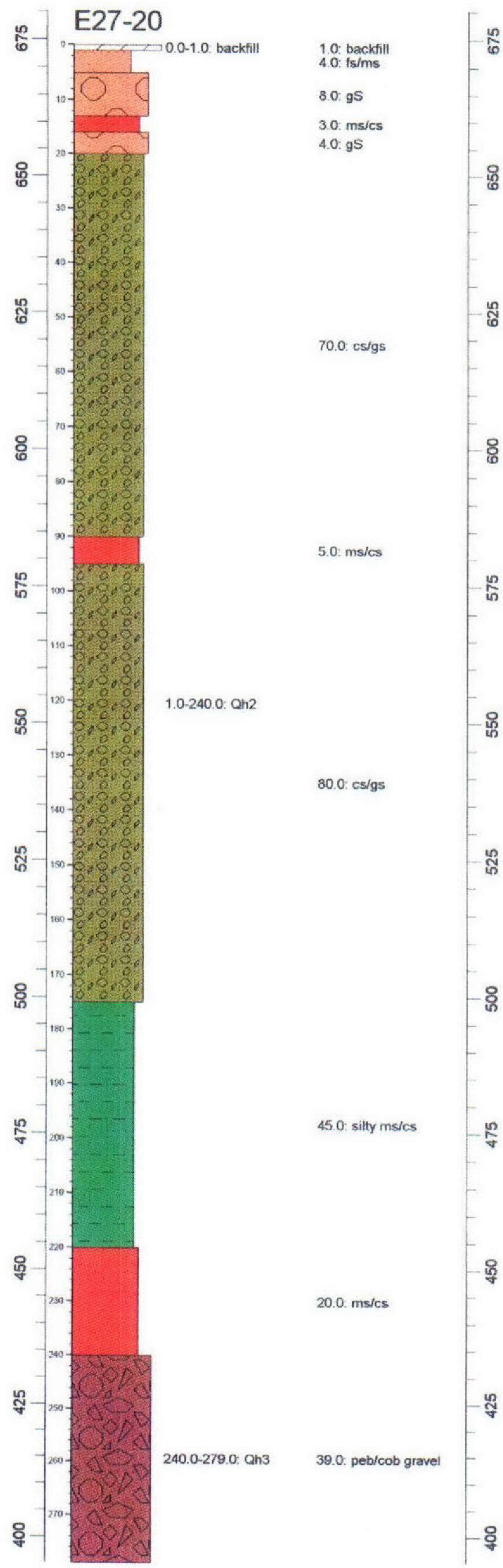
500
475
450
425
400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1.0-240.0: Qh2
240.0-279.0: Qh3
1.0: backfill
4.0: fs/ms
8.0: gS
3.0: ms/cs
4.0: gS
70.0: cs/gs
5.0: ms/cs
80.0: cs/gs
45.0: silty ms/cs
20.0: ms/cs
39.0: peb/cob gravel
675
650
625
600
575
550
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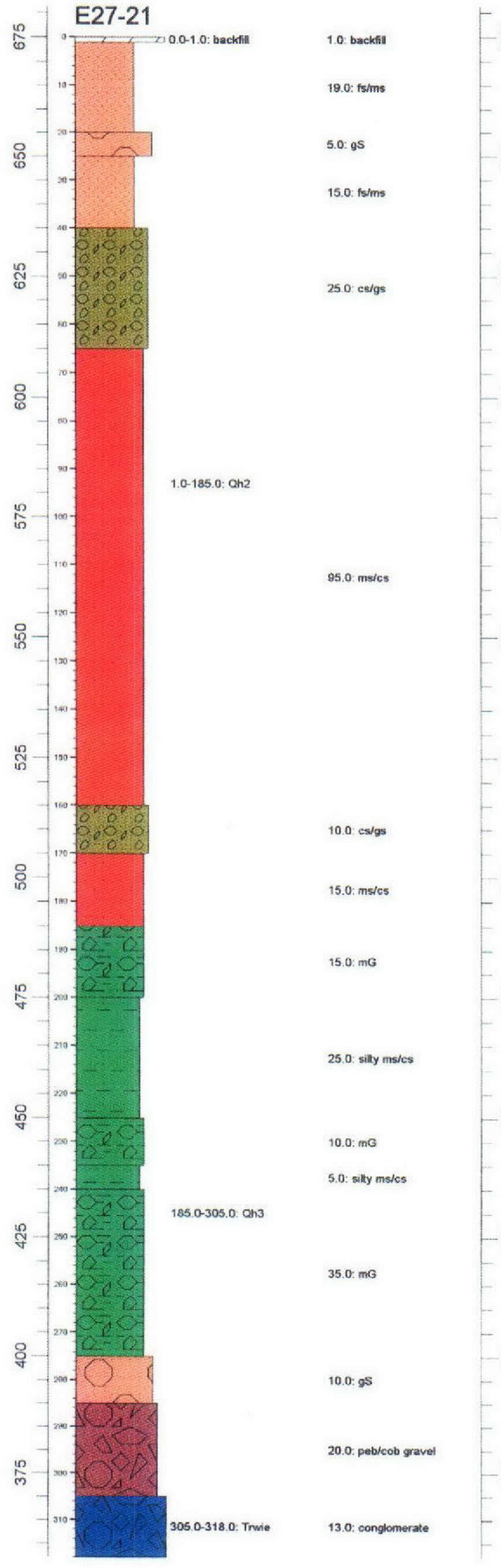
500
475
450
425
400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1.0-185.0: Qh2
185.0-305.0: Qh3
305.0-318.0: Trwie
1.0: backfill
19.0: fs/ms
5.0: gS
15.0: fs/ms
25.0: cs/gs
95.0: ms/cs
10.0: cs/gs
15.0: ms/cs
15.0: mG
25.0: silty ms/cs
10.0: mG
5.0: silty ms/cs
35.0: mG
10.0: gS
20.0: peb/cob gravel
13.0: conglomerate
675
650
625
600
575
550
525
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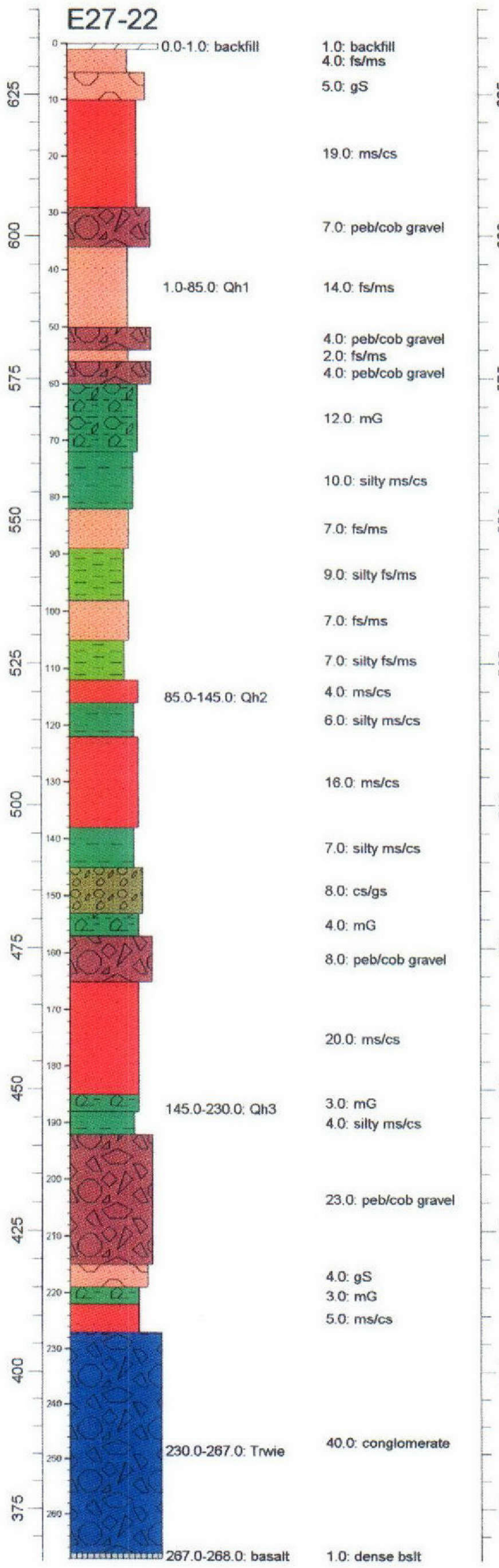
475
450
425
400
375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0.0-1.0: backfill
1.0-85.0: Qh1
85.0-145.0: Qh2
145.0-230.0: Qh3
230.0-267.0: Trwie
267.0-268.0: basalt
1.0: backfill
4.0: fs/ms
5.0: gS
19.0: ms/cs
7.0: peb/cob gravel
14.0: fs/ms
4.0: peb/cob gravel
2.0: fs/ms
4.0: peb/cob gravel
12.0: mG
10.0: silty ms/cs
7.0: fs/ms
9.0: silty fs/ms
7.0: fs/ms
7.0: silty fs/ms
4.0: ms/cs
6.0: silty ms/cs
16.0: ms/cs
7.0: silty ms/cs
8.0: cs/gs
4.0: mG
8.0: peb/cob gravel
20.0: ms/cs
3.0: mG
4.0: silty ms/cs
23.0: peb/cob gravel
4.0: gS
3.0: mG
5.0: ms/cs
40.0: conglomerate
1.0: dense bslt
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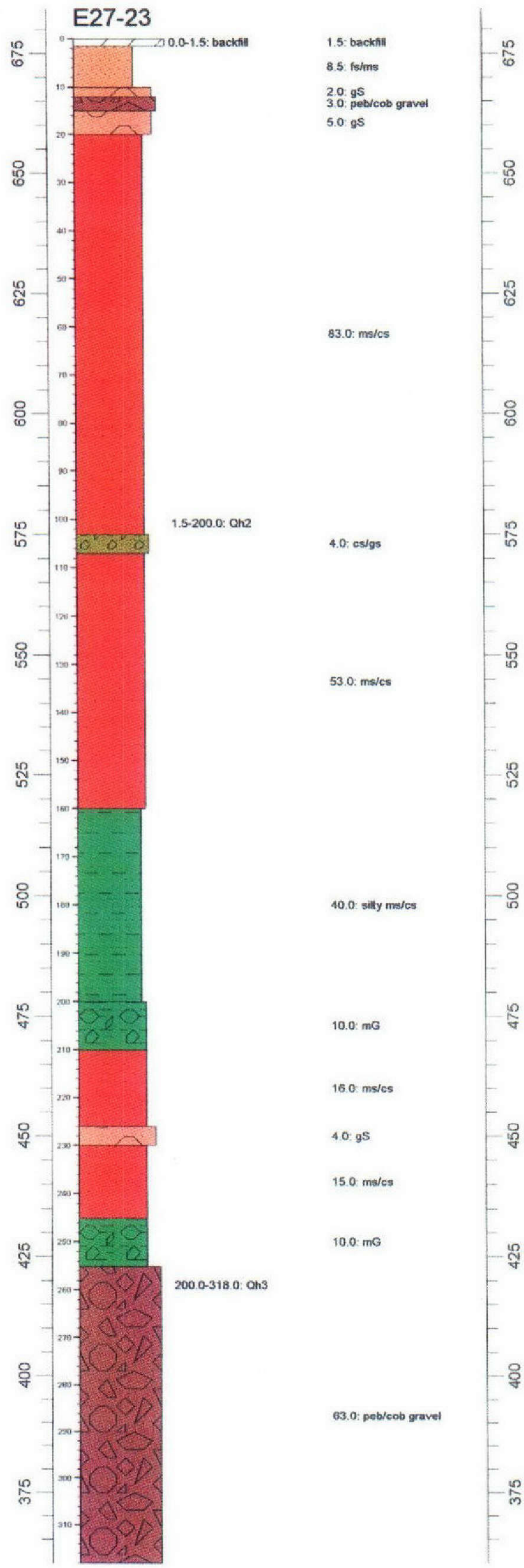
600
575
550
525
500
475
450
425
400
375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1.5-200.0: Qh2
200.0-318.0: Qh3
1.5: backfill
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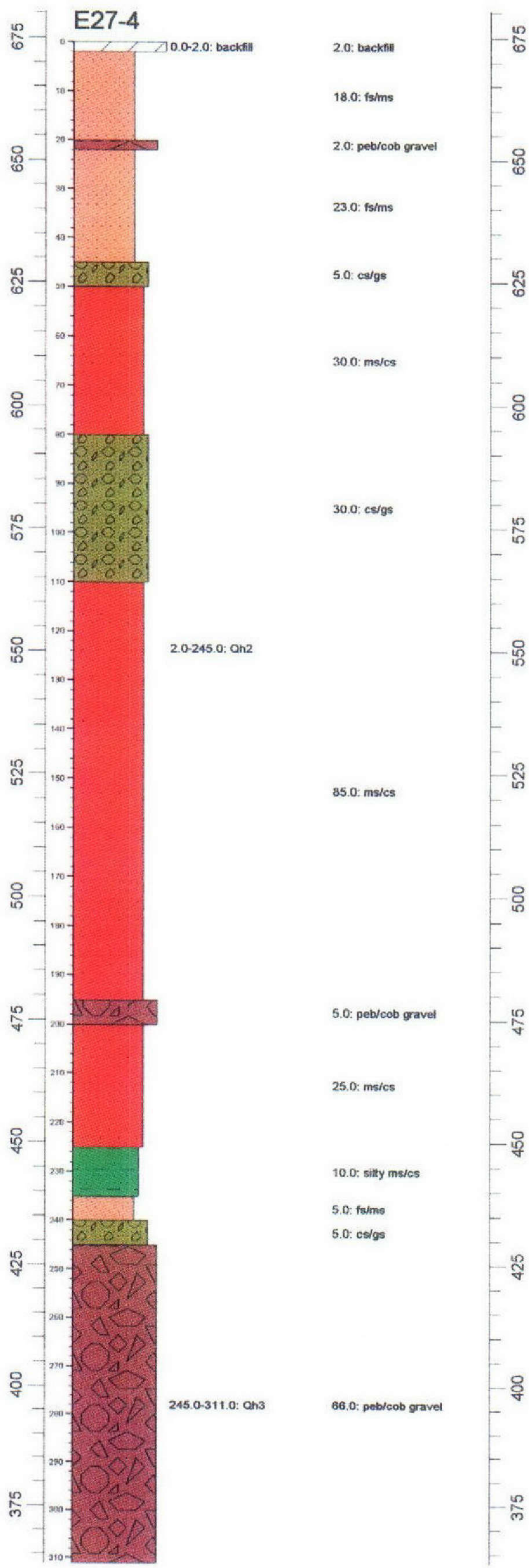
2.0: gS
3.0: peb/cob gravel
5.0: gS
83.0: ms/cs
4.0: cs/gs
53.0: ms/cs
40.0: silty ms/cs
10.0: mG
16.0: ms/cs
4.0: gS
15.0: ms/cs
10.0: mG
63.0: peb/cob gravel
675
650
625
600
575
550
525
500
475
450
425
400
375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2.0-245.0: Qh2
245.0-311.0: Qh3
2.0: backfill
18.0: fs/ms
2.0: peb/cob gravel
23.0: fs/ms
5.0: cs/gs
30.0: ms/cs
30.0: cs/gs
85.0: ms/cs
5.0: peb/cob gravel
25.0: ms/cs
10.0: silty ms/cs
5.0: fs/ms
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66.0: peb/cob gravel
675
650
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600
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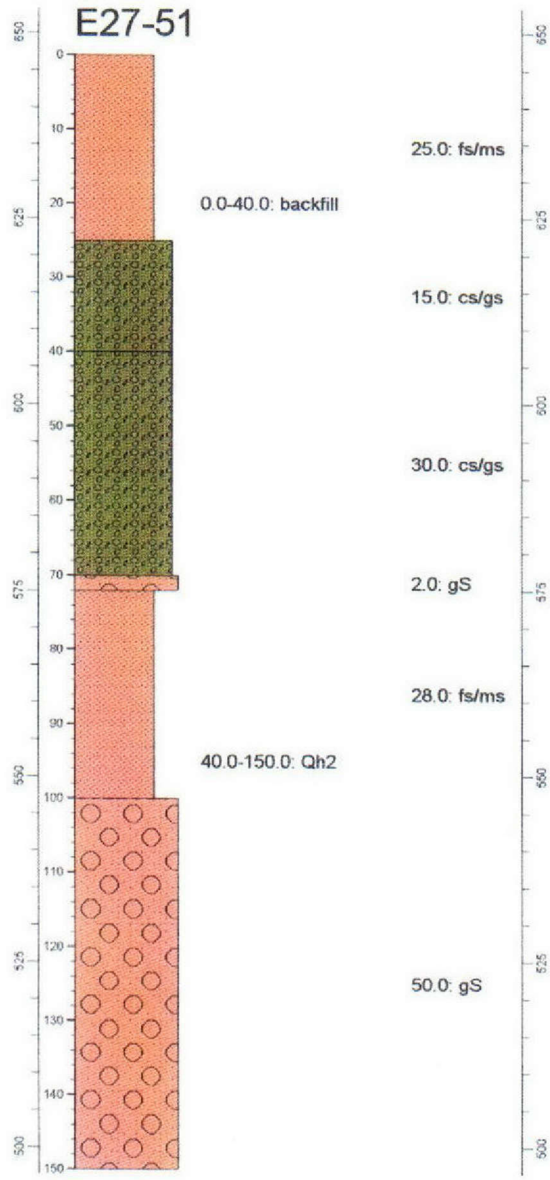
450
425
400
375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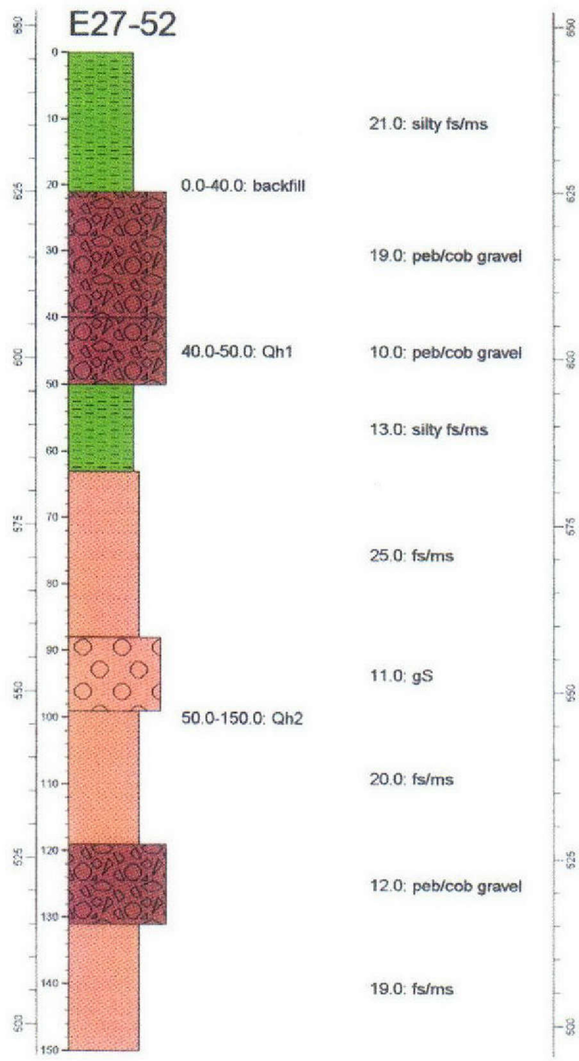
28.0: fs/ms
50.0: gS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40.0-50.0: Qh1
10.0: peb/cob gravel
13.0: silty fs/ms
25.0: fs/ms
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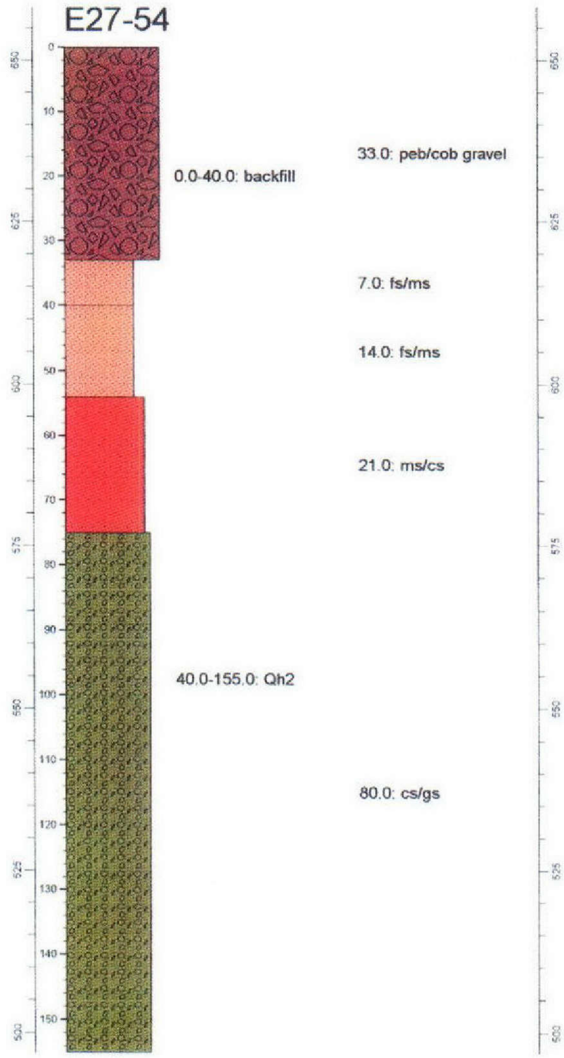
50.0-150.0: Qh2
20.0: fs/ms
12.0: peb/cob gravel
19.0: fs/ms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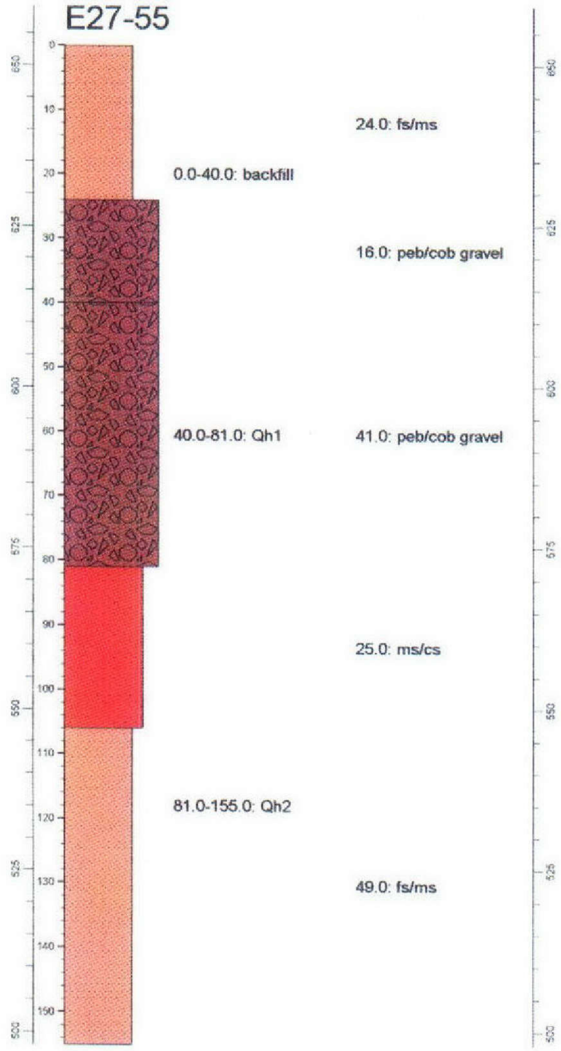
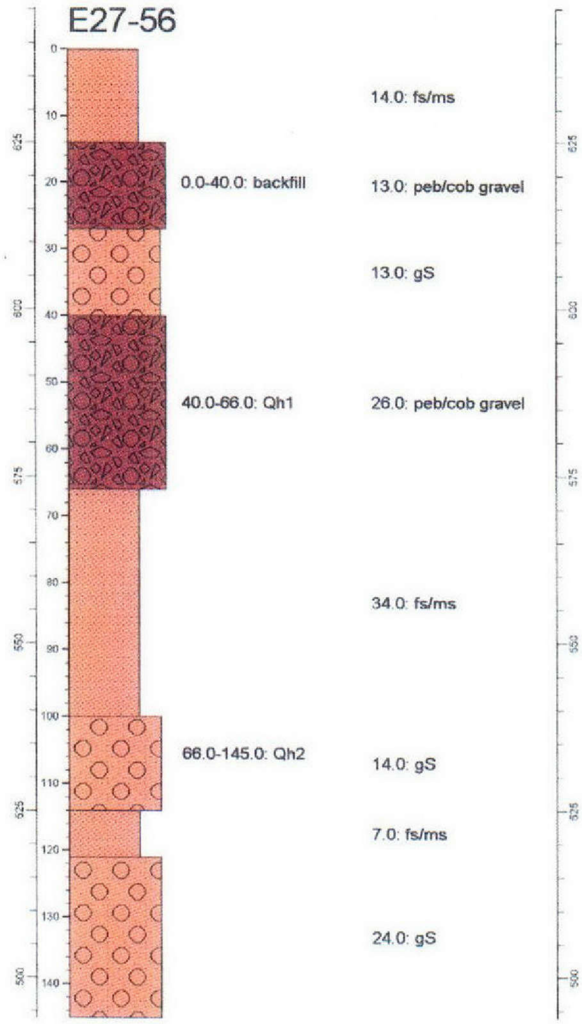
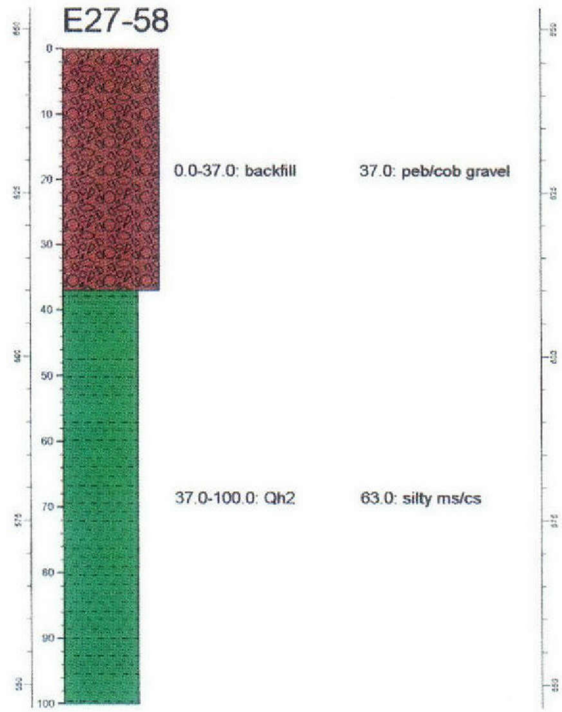
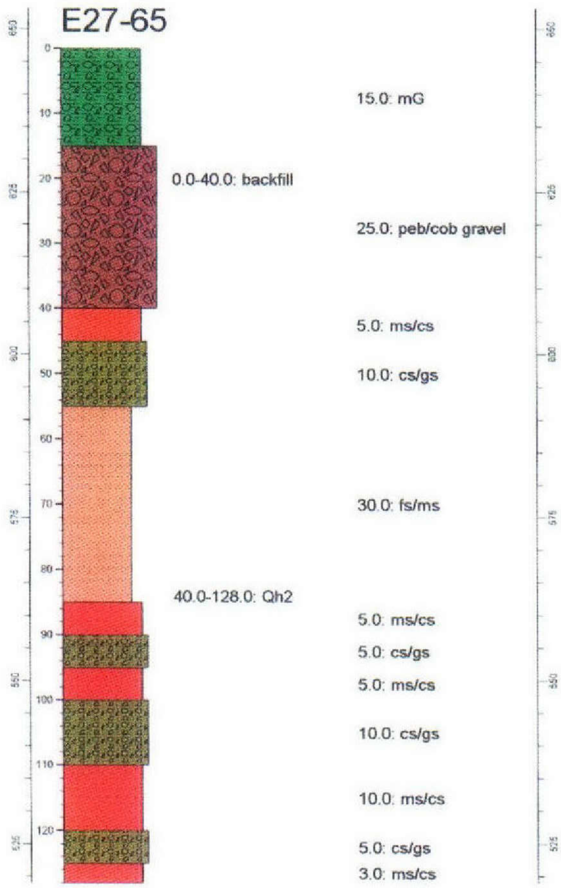
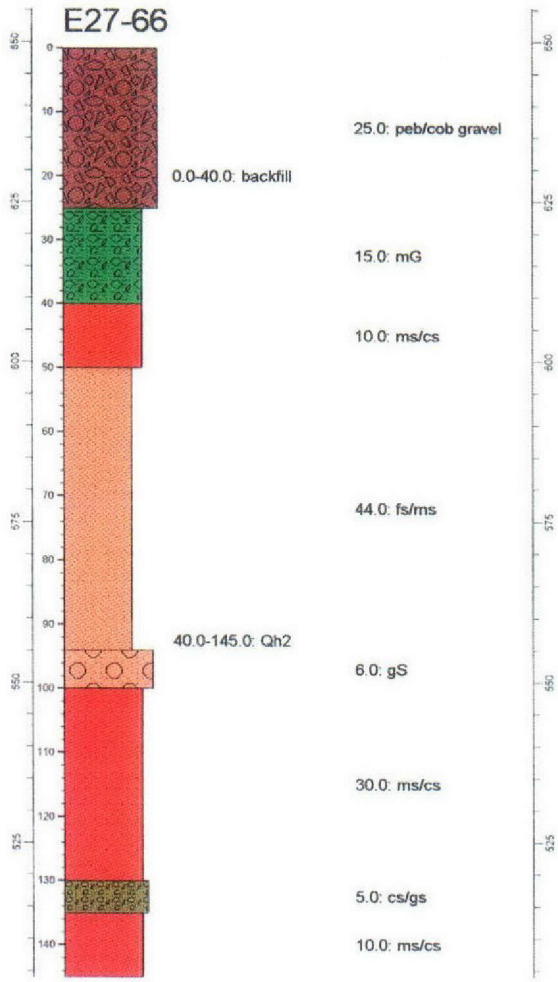
80.0: cs/gs

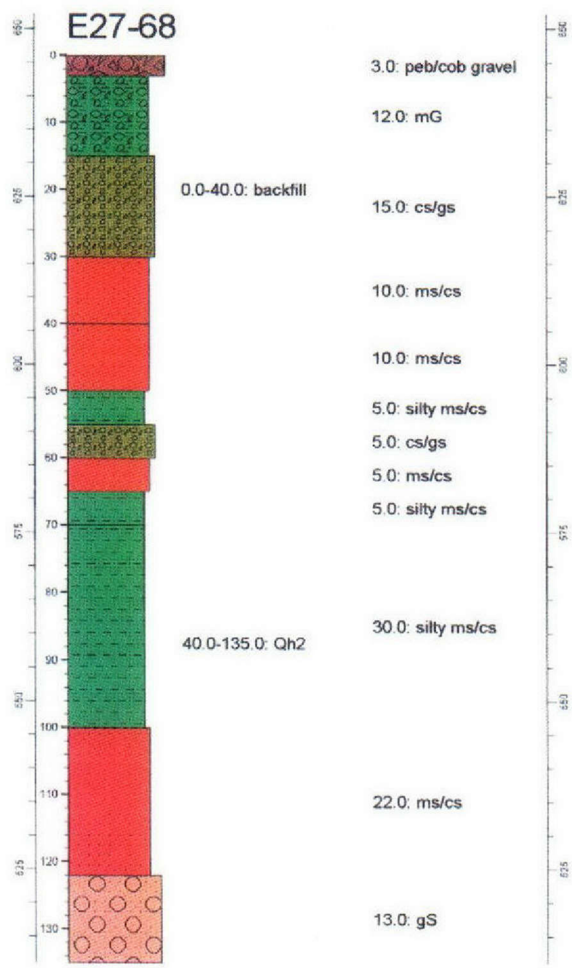

E27-55
0.0-40.0: backfill
40.0-81.0: Qh1
81.0-155.0: Qh2
24.0: fs/ms
16.0: peb/cob gravel
41.0: peb/cob gravel
25.0: ms/cs
49.0: fs/ms

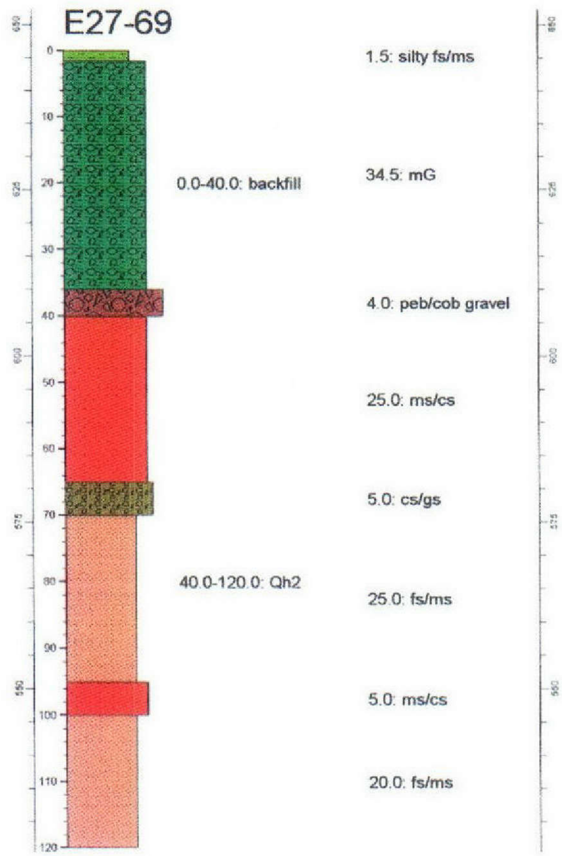

E27-56
0.0-40.0: backfill
40.0-66.0: Qh1
66.0-145.0: Qh2
14.0: fs/ms
13.0: peb/cob gravel
13.0: gS
26.0: peb/cob gravel
34.0: fs/ms
14.0: gS
7.0: fs/ms
24.0: gS

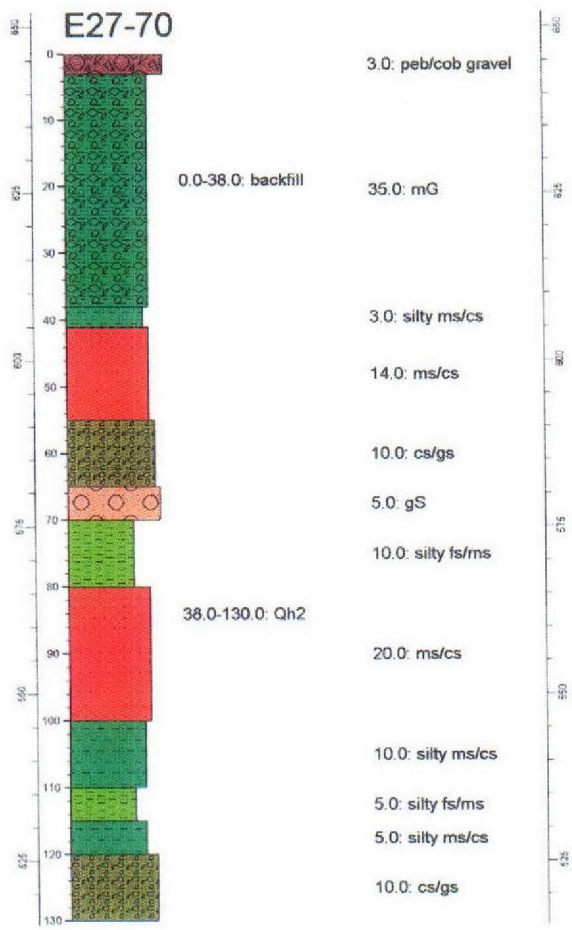

E27-58
0.0-37.0: backfill
37.0: peb/cob gravel
37.0-100.0: Qh2
63.0: silty ms/cs

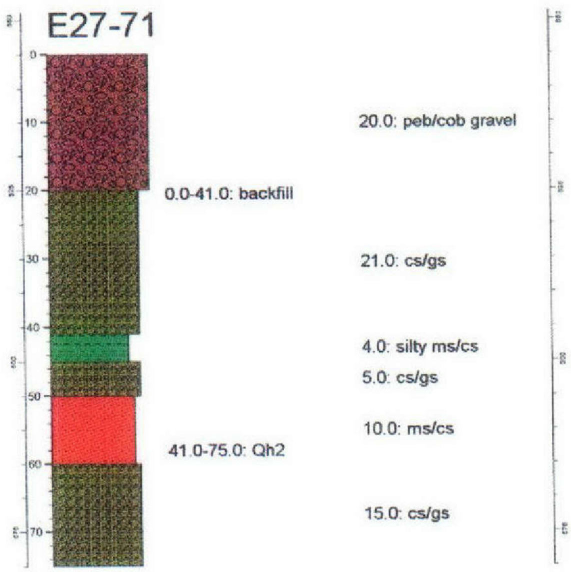

E27-65
15.0: mG
0.0-40.0: backfill
25.0: peb/cob gravel
5.0: ms/cs
10.0: cs/gs
30.0: fs/ms
40.0-128.0: Qh2
5.0: ms/cs
5.0: cs/gs
5.0: ms/cs
10.0: cs/gs
10.0: ms/cs
5.0: cs/gs
3.0: ms/cs

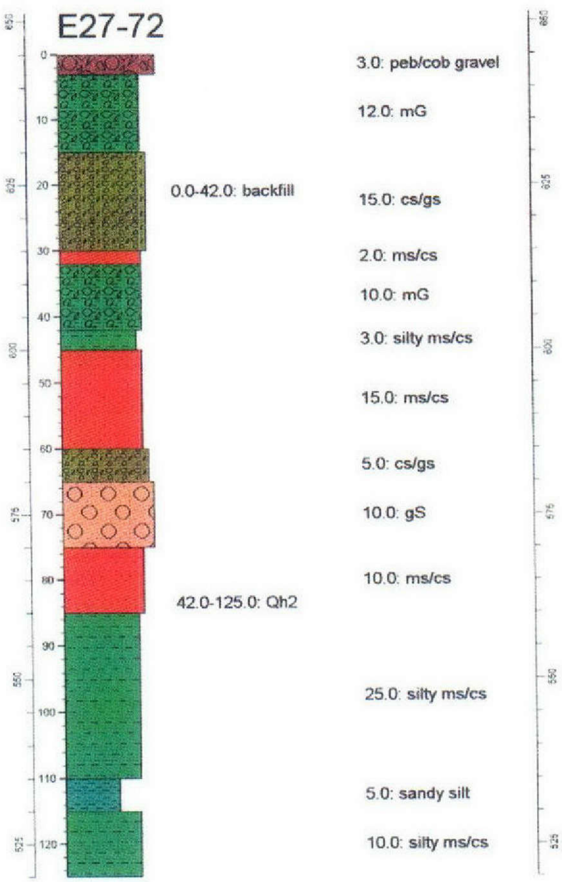

E27-66
25.0: peb/cob gravel
0.0-40.0: backfill
15.0: mG
10.0: ms/cs
44.0: fs/ms
40.0-145.0: Qh2
6.0: gS
30.0: ms/cs
5.0: cs/gs
10.0: ms/cs

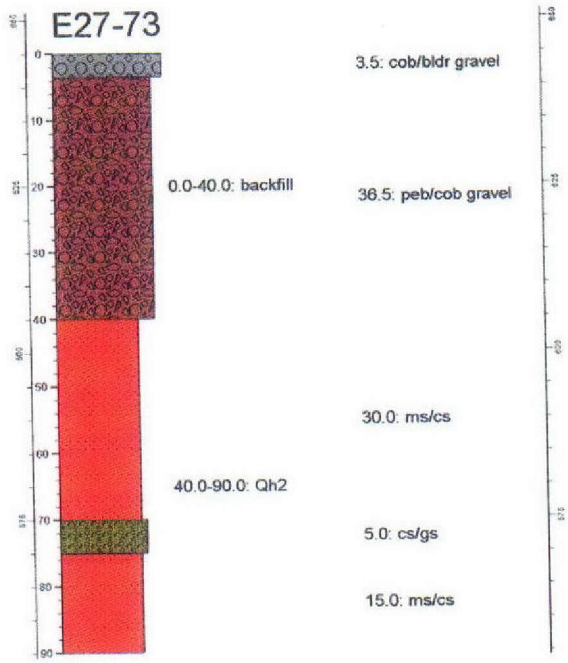

E27-68
0.0-40.0: backfill
40.0-135.0: Qh2
3.0: peb/cob gravel
12.0: mG
15.0: cs/gs
10.0: ms/cs
10.0: ms/cs
5.0: silty ms/cs
5.0: cs/gs
5.0: ms/cs
5.0: silty ms/cs
30.0: silty ms/cs
22.0: ms/cs
13.0: gS


E27-69
0.0-40.0: backfill
40.0-120.0: Qh2
1.5: silty fs/ms
34.5: mG
4.0: peb/cob gravel
25.0: ms/cs
5.0: cs/gs
25.0: fs/ms
5.0: ms/cs
20.0: fs/ms


E27-70
0.0-38.0: backfill
38.0-130.0: Qh2
3.0: peb/cob gravel
35.0: mG
3.0: silty ms/cs
14.0: ms/cs
10.0: cs/gs
5.0: gS
10.0: silty fs/ms
20.0: ms/cs
10.0: silty ms/cs
5.0: silty fs/ms
5.0: silty ms/cs
10.0: cs/gs


E27-71
0.0-41.0: backfill
41.0-75.0: Qh2
20.0: peb/cob gravel
21.0: cs/gs
4.0: silty ms/cs
5.0: cs/gs
10.0: ms/cs
15.0: cs/gs


E27-72
0.0-42.0: backfill
42.0-125.0: Qh2
3.0: peb/cob gravel
12.0: mG
15.0: cs/gs
2.0: ms/cs
10.0: mG
3.0: silty ms/cs
15.0: ms/cs
5.0: cs/gs
10.0: gS
10.0: ms/cs
25.0: silty ms/cs
5.0: sandy silt
10.0: silty ms/cs


E27-73
3.5: cob/bldr gravel
0.0-40.0: backfill
36.5: peb/cob gravel
30.0: ms/cs
40.0-90.0: Qh2
5.0: cs/gs
15.0: ms/cs