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Environmental Protection
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UCID-21688

Remedial Investigation of Landfill Pit 9 Lawrence Livermore National Laboratory Site 300

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July 1989

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LAWRENCE LIVERMORE NATIONAL LABORATORY
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Certification

We certify that the work presented in this report was performed under our supervision. To the best of our knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.

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Contents

Remedial Investigation of Landfill Pit 9 Lawrence Livermore National Laboratory Site 300

Introduction

This report documents our investigation of the geology and hydrogeology beneath inactive landfill Pit 9 at Lawrence Livermore National Laboratory (LLNL) Site 300. Site 300 is located about 15 miles east of Livermore, California, in rugged, rural terrain on the east side of the Altamont Hills (Fig. 1); this remote facility is used for explosives and materials testing to support LLNL's national defense programs. The landfill is located in San Joaquin County near the center of Site 300 (Figs. 2 and 3). In mid-1988, we began this investigation to determine if ground water quality had been degraded by wastes within the pit. This report presents our results and conclusions.

Summary and Conclusions

Pit 9 contains potentially hazardous waste generated during explosives experiments. We have assessed the potential impact of landfill Pit 9 on vadose zone and ground water chemistry. We have studied the geology and ground water flow characteristics at the Pit 9 site. Ground water flow direction, gradient, and velocities have been determined by well installation and monitoring and hydraulic testing.

No elevated levels of tritium, metals, or uranium have been detected in borehole core samples, except for one sample that contained tritium at twice the detection limit of 1,000 pCi/L. We believe this analysis to be spurious because ground water sampled from this zone is free of tritium at the limit of detection.

We have performed two rounds of sampling and analysis for a full suite of chemical parameters designed to assess whether the landfill has impacted ground water chemistry beneath and adjacent to the landfill. Although the landfill is not a Resource Conservation and Recovery Act (RCRA) landfill, this suite of assessment parameters meets or exceeds sampling and analysis performed to comply with RCRA or Solid Waste Assessment Test (SWAT) guidance.

In the two rounds of sampling completed, no chemical parameters were detected above State Action Levels (SAL), Maximum Contaminant Levels (MCL), or Soluble Threshold Limit Concentrations (STLC). No tritium was detected in ground water samples; no metals or other radiologic parameters were detected at greater than background levels. No organic compounds were detected, except for 2 mg/L of carbon disulfide and 17 μg/L of phenolics in a ground water sample from one well; we believe this report may be spurious. Further sampling and analysis will provide resolution.

The present assessment monitoring program will continue through the end of 1989. At present there is no evidence of landfill impacts on vadose zone or ground water chemistry.

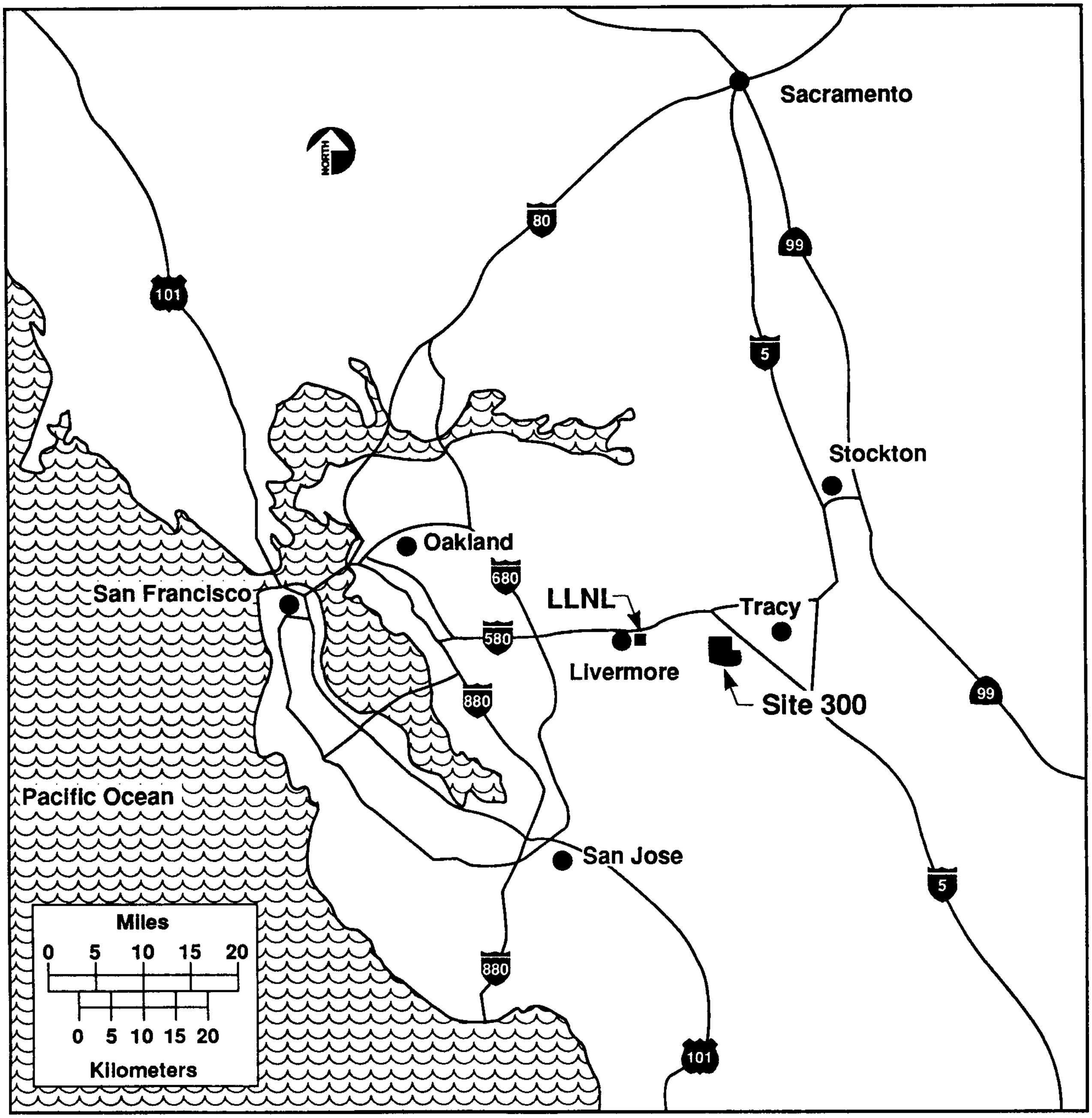


Figure 1. Regional setting of LLNL Livermore site and Site 300.

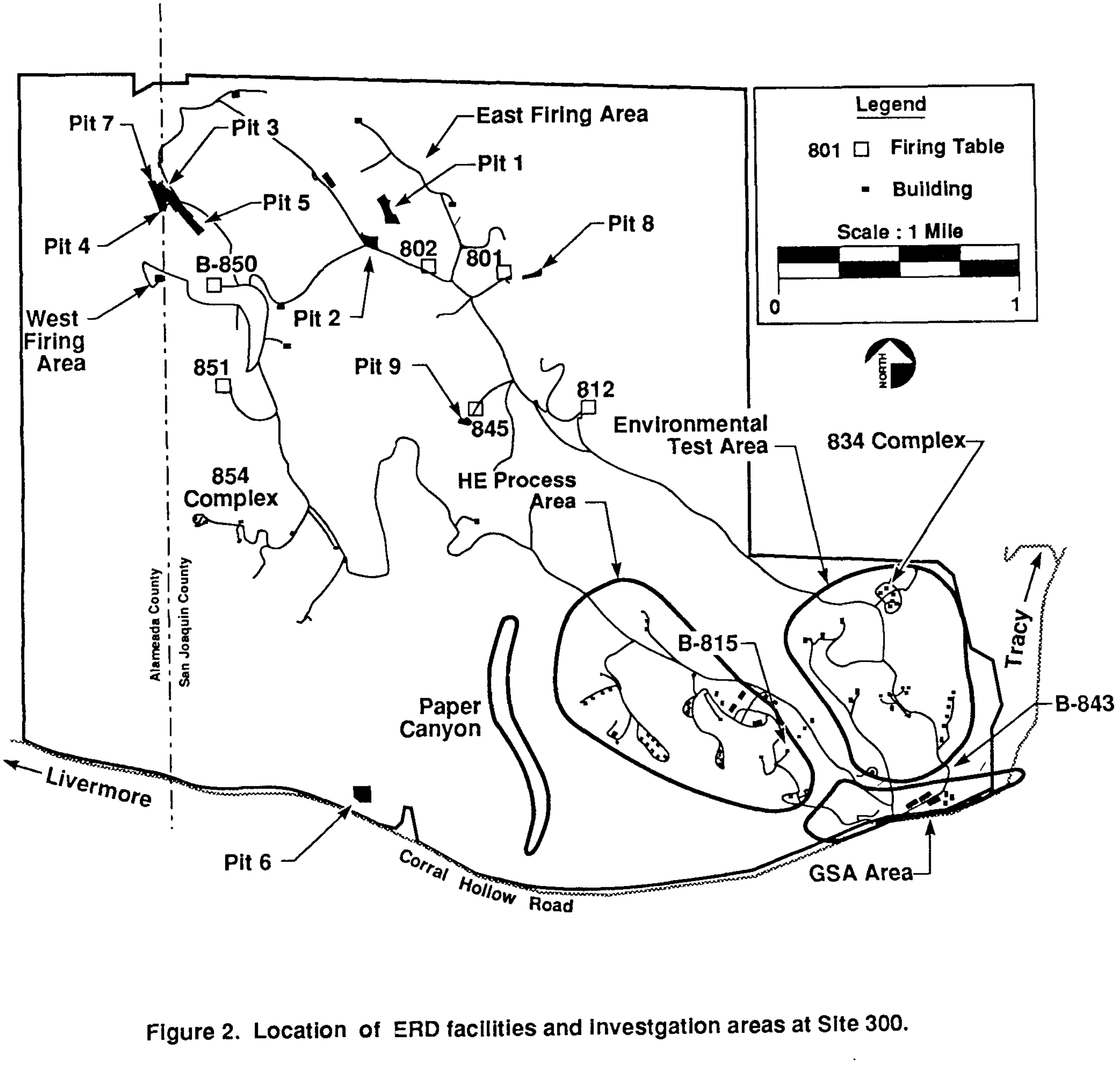


Figure 2. Location of ERD facilities and investgation areas at Site 300.

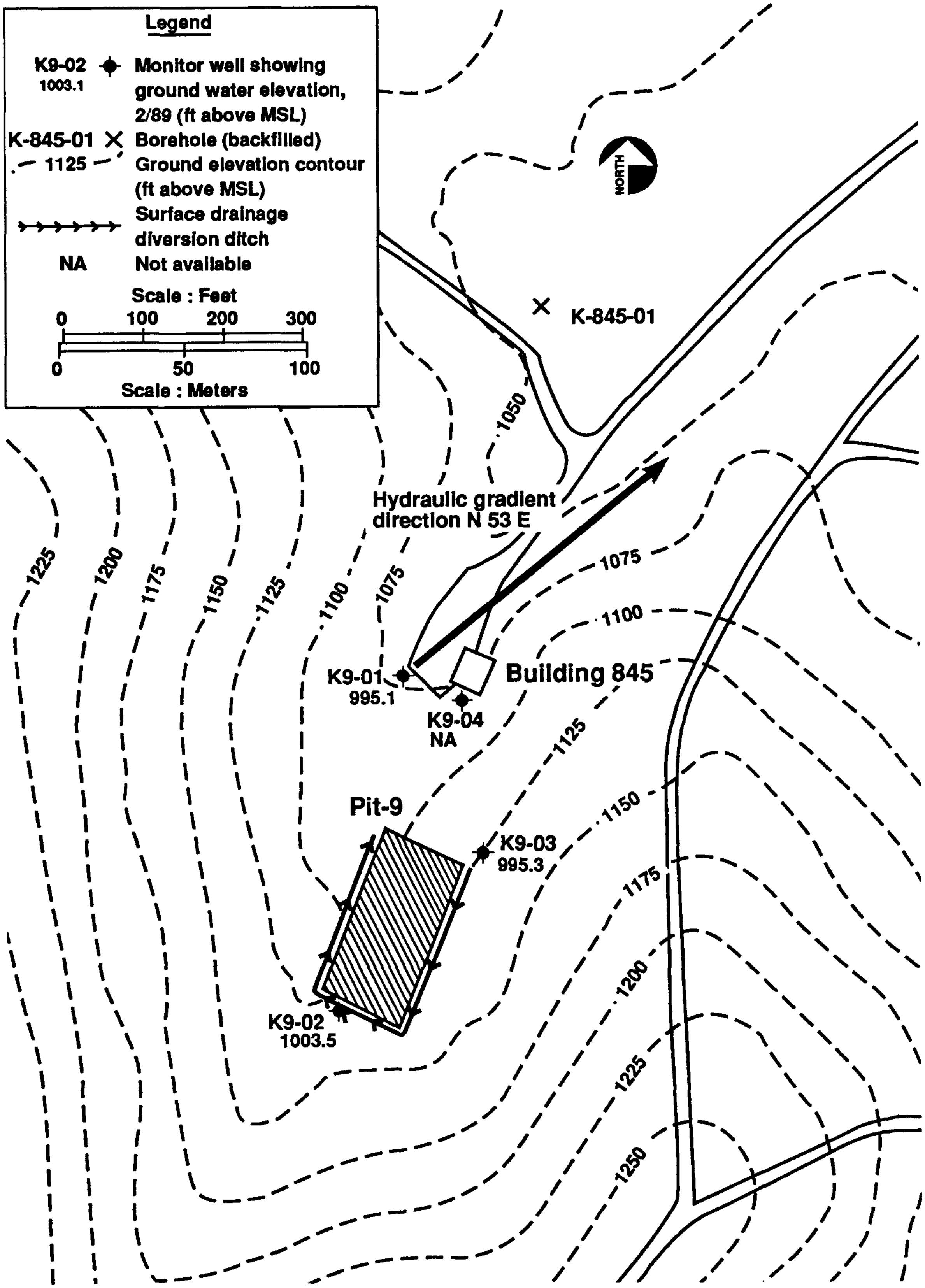


Figure 3. Topography, monitor wells, and general features of the Pit 9 area.

Background

History of the Pit 9 Site

Pit 9 is located adjacent to the Building 845 firing table, where explosives experiments were conducted from 1958 to 1963. Debris from the firing table was disposed of in the pit during this time and may contain tritium, uranium-238, lead, beryllium, and barium. The bulk volume of the landfill material is less than 40 cubic yards; the debris was originally placed on the ground surface and was later levelled and compacted by bulldozer. It was covered with less than 4 ft of locally obtained silty soil with clay, sand, and gravel. As-built plans were not prepared for the landfill because the volume of waste was small. A drainage ditch (Fig. 3) has been constructed around the landfill to protect the cover from erosion and to prevent run-on. The landfill is not lined.

Physical Setting

Pit 9 is located on the east side and upslope of the bottom of a canyon (Fig. 3). Access to the pit is from a dirt road extending to the southwest past Building 845. With the exception of this building, there are no program facilities in the ravine or the general area. Soils at the landfill site vary in thickness from 1 ft, high on ravine slopes, to 30 ft in the ravine bottom.

Field Work

We mapped geology, drilled and installed monitor wells, monitored potentiometric surface elevations and ground water chemistry, and performed hydraulic tests to characterize the hydrogeology at the Pit 9 site.

Geologic mapping was done at a scale of 1 in. to 200 ft over a 1/2-square mile area. A Brunton compass was used to measure bedding strikes and dips. Examination of outcrops allowed deduction of the distribution of lithologic units. Contacts were inferred beneath alluvial cover and were correlated with geologic data from the boring logs and geologic cross sections.

Four monitor wells (K9-01 through K9-04) and one exploratory borehole (K-845-01) were drilled for this study (Fig. 3). Table 1 is a summary of well and borehole details. Boring logs of well completions and geology are presented in Appendix A. Analytical results of borehole core analyses are tabulated in Appendix B, Table B-1.

Exploratory borehole K-845-01 was drilled several hundred feet northeast of Pit 9 in September 1982 as part of the original Site 300 hydrogeologic assessment (Raber and Carpenter, 1983; Carpenter and Peifer, 1983). No ground water was encountered to the borehole total depth at 62.0 ft. No core samples were collected for chemical analysis.

Downgradient monitor well K9-01 was drilled 200 ft north of Pit 9 in February 1987. Ground water was first encountered in sandstone of Neroly Formation unit Tnbs$_1$ (see the section titled Geology for a discussion of this unit) extending from 115 to 124.5 ft in depth. Ground water subsequently rose to a depth of 81 ft, indicating confinement of the water-bearing zone. Several soil and rock cores were collected for tritium analysis. The well was screened in the 115- to 125-ft interval; a sump extends to 127 ft. After development, the maximum sustainable yield of this well is in excess of 1 gallon per minute (gpm).

We drilled monitor well K9-02 during the third quarter of 1988, upgradient and 20 ft south of the pit. Moisture was first encountered in fractured siltstone of unit Tnbs$_1$ at 143.5 ft; a continuous water-bearing zone extends to 158.5 ft. Confined conditions exist as the water has risen above 135 ft in depth. The major water-bearing stratum, a medium-to-high primary permeability

Table 1. Pit 9 borehole and well installation data.

Well	Type[a]	California Coordinates		Shiner Elevation (MSL ft)	Point of Measurement Elevation (MSL ft)	Depth of Screened Interval[b] (ft)	Depth of Sandpack Interval[b] (ft)	Well Diam.[c] (in.)	Casing Depth[b] (ft)	Pump Intake Depth (ft)	Pump Type	HP/Voltage	Completion Date
		Northing	Easting										
K9-01	M W	423427.6	1700873.2	1072.51	1075.51	115.0–125.0	113.0–127.0	4.50	127.0	122.00	GRUNDFS SP1-9	1/2HP/220V	2/26/87
K9-02	M W	422973.2	1700809.5	1133.39	1135.39	153.6–158.5	147.0–158.5	4.50	158.5	155.00	GRUNDFS 5S03-9	1/2HP/220V	8/29/88
K9-03	M W	423254.5	1700954.7	1114.42	1117.08	156.0–160.7	149.2–161.7	4.50	160.7	156.34	GRUNDFS 5S03-9	1/2HP/220V	11/2/88
K9-04	M W	423354.6	1700922.1	1081.95	1084.62	138.1–143.1	131.0–143.4	4.50	143.1	141.00	GRUNDFS 5S03-9	1/2HP/220V	2/22/89
K-845-01	BH	N/A	N/A	N/A	N/A	N/A	N/A	N/A	62.0[d]	N/A	N/A	N/A	N/A

[a] MW = monitor well; BH = borehole.

[b] Depths are measured from ground surface.

[c] Inside diameter.

[d] Total depth of borehole.

sandstone, occurs from 153.5 to 158.5 ft depth. Soil and rock core samples were collected and analyzed for EP Toxicity metals, uranium isotopes, and tritium. The well is screened from 153.6 to 158.5 ft. After development the well yield is about 1 gpm.

Well K9-03 was installed downgradient and approximately 30 ft northeast of the landfill. Ground water was first encountered at 148.1 ft in moderate-to-high primary permeability sandstone of unit $Tnbs_1$. A continuous water-bearing zone extends to 159.6 ft within the porous sandstone and fractures near the base of this zone. Moisture and core samples were collected for analysis for tritium and EP Toxicity metals, respectively. The well is screened from 156 to 160.7 ft. The water level has risen above 120 ft, which indicates that, as in the two other wells, confined conditions exist. After well development, the yield is in excess of 1 gpm.

Downgradient well K9-04 was drilled immediately south of Building 845 between wells K9-01 and K9-03. Ground water was first encountered at 134 ft above a zone of slickensided fault gouge within unit $Tnbs_1$, which extends from 136 to 146 ft. Below this zone, to the total depth of the borehole at 169.1 ft, no additional saturation was encountered. Borehole cores were collected and analyzed for tritium. The well is screened from 138.1 to 143.1 ft within the fault zone and a moderately permeable sandstone stratum that extends from 140.4 to 141.3 ft. The water-bearing zone screened at this location did not exhibit confinement during drilling and completion, but now appears to slowly recover to levels above 100 ft below the ground surface. The well yield is less than 0.2 gpm.

Water-elevation measurements are collected monthly from the four Pit 9 monitor wells. This has been done since the installation of well K9-01 in December 1987. Since the fourth quarter of 1988, we have collected ground water samples for analysis of a full suite of chemical assessment parameters. These parameters include tritium, Title 22 metals, Title 22 organic compounds, (EPA Method 624) volatile organic compounds, uranium isotopes, radium, gross alpha and beta radioactivity, high explosives (HE) compounds, total organic halogen, total organic carbon, ammonium nitrogen, alkalinity, chloride, fluoride, nitrate, nitrite, phenolics, sodium, sulfate, and total Kjedahl nitrogen. Ground water from well K9-01 was sampled and analyzed quarterly for organic compounds listed in EPA Methods 601 or 624 and 602 or 625 during the interval of the fourth quarter of 1987 through the fourth quarter of 1988. Since the first quarter of 1989, all finally developed Pit 9 wells have been sampled for the suite of ground water assessment parameters. Parameters and sampling dates are summarized in Table 2.

Hydraulic tests were performed to determine hydraulic conductivities (and ground water flow velocities) and to assess impacts of faults and fractures on ground water flow in the area. An observation well pump test was performed on each of wells K9-01, K9-02, and K9-03. Results are discussed in the Hydrogeology section of this report.

Table 2. Groundwater sampling at Pit 9.

Wells	Date Sampled	Analytes
4th Quarter 1987		
K9-01	12/8/87	EPA Methods 624 and 625
	12/8/87	General mineral
1st Quarter 1988		
K9-01	3/10/88	EPA Methods 601 and 602
2nd Quarter 1988		
K9-01	6/27/88	EPA Method 601
4th Quarter 1988		
K9-01	11/17/88	EPA Method 601
	11/17/88	General mineral
1st Quarter 1989		
K9-01	2/15/89	Assessment parameters[a]
K9-02	2/16/89	Assessment parameters[a]
K9-03	2/21/89	Assessment parameters[a]
	2/21/89	EPA Method 601
2nd Quarter 1989		
K9-01	4/6/89	Assessment parameters[a]
K9-02	4/6/89	Assessment parameters[a]
K9-03	4/6/89	Assessment parameters[a]
K9-04	5/3/89–5/5/89[b]	Assessment parameters[a]

[a] Assessment parameters include chemical and physical analyses; quadruplicate samples and analyses of electrical conductivity, total organic carbon, and total organic halogen; EPA Method 624 and Title 22 organic compounds; gross alpha and beta radioactivity; uranium isotopes; radium; tritium; high explosives compounds; and Title 22 metals.

[b] This well required several days to sample due to low sustainable yield.

Geology

Geology of Site 300

Site 300 is located within a series of steep canyons and hills overlain by Quaternary alluvium. Bedrock is composed of Plio-Miocene volcaniclastic rock, Cretaceous sedimentary rock, and underlying Jurassic-Cretaceous basement. Alluvium in the area is predominantly terrace deposits, colluvium, and ravine fill. Structure is complex, as several faults and minor folds exist beneath the site. Figure 4 is a geologic map of Site 300; Plate 1 is a geologic map of the Site 300 area and surroundings. Knowledge of the geology of Site 300 is based on the regional geologic mapping of Huey (1948), Raymond (1969), and Dibblee (1980a, b, c, and d) and was refined by recent LLNL studies (Raber and Carpenter, 1983; Buddemeier et al., 1985; Carpenter et al., 1988).

Unconsolidated deposits in the Site 300 area consist of Pleistocene to Holocene colluvium, alluvium and ravine fill (Qa), terrace alluvium (Qoa), and landslide debris (Qls). The colluvium, alluvium, and ravine fills vary from silty clays to silty gravels of variable thickness of 1 in. to over 30 ft. Terrace deposits are most extensive in the southern portion of Site 300 and consist of sandy silts and clays grading downwards to sand and locally coarse cobble-and-boulder-bearing gravels. An unnamed Pliocene unit (Tps) consists of non-marine conglomerates with cobbles of angular graywacke and chert, sandstones, and green-to-gray clays. This unit occurs on isolated hilltops as remnants of a once continuous blanket of sediment. A small patch of Tulare Formation (Qtl) sandstone crops out immediately west of the site.

The bedrock underlying most of Site 300 consists chiefly of the continental and estuarine, largely volcaniclastic, sedimentary rock of the Miocene Neroly Formation (Tn). The Neroly Formation is up 450 ft thick and is composed of distinctive blue weathering sandstones and siltstones, coarse conglomerates of well-rounded andesitic and basaltic cobbles, and interbedded tuffaceous shales. Fractures are common. The Neroly Formation is generally conformably underlain by the interbedded, coarse-grained, friable sandstones, carbonaceous brown shales, and tuffs of the continental and marine, early Miocene Cierbo Formation (Tmss). Sandstones of the Cierbo Formation commonly appear blue-gray to tan-yellow in borehole cuttings, and cores are characterized by a high degree of sorting and the presence of well-rounded chert pebbles and are micaceous, quartz-rich, and pyritic.

The Tesla Formation (Tts) unconformably underlies the Cierbo Formation, is exposed southwest of Site 300 along the southern margin of the site, and probably underlies other portions of the site at depth. The Tesla Formation is a heterogenous sequence of brackish and marine sedimentary rocks of late Paleocene to early Eocene age.

The Upper Cretaceous Great Valley Sequence underlies Site 300 at depth and is comprised of the Moreno (Km) and Panoche (Kps) Formations. These rocks are exposed only in the northern part of the site. The Moreno Formation is composed of poorly bedded, crumbly, green-to-gray clay, shale, or mudstone of marine origin and conformably overlies the Panoche Formation. The thickness of the Moreno Formation in the vicinity of Site 300 is inferred to be in excess of 1,000 ft. The Panoche Formation is a very thick turbidite sequence of intercalated arkosic sandstone, micaceous shale, and local lenses of cobble conglomerate. Its thickness in the area of Site 300 is unknown (Dibblee and Darrow, 1981).

The Jurassic-Cretaceous Franciscan Assemblage (fc/fs) is exposed in the Diablo Range southwest of Site 300 and is composed of graywacke, chert, and lesser amounts of shale and phyllite. In places, beds are intensely folded, fractured, and sheared. The Franciscan Assemblage forms the basement beneath Site 300.

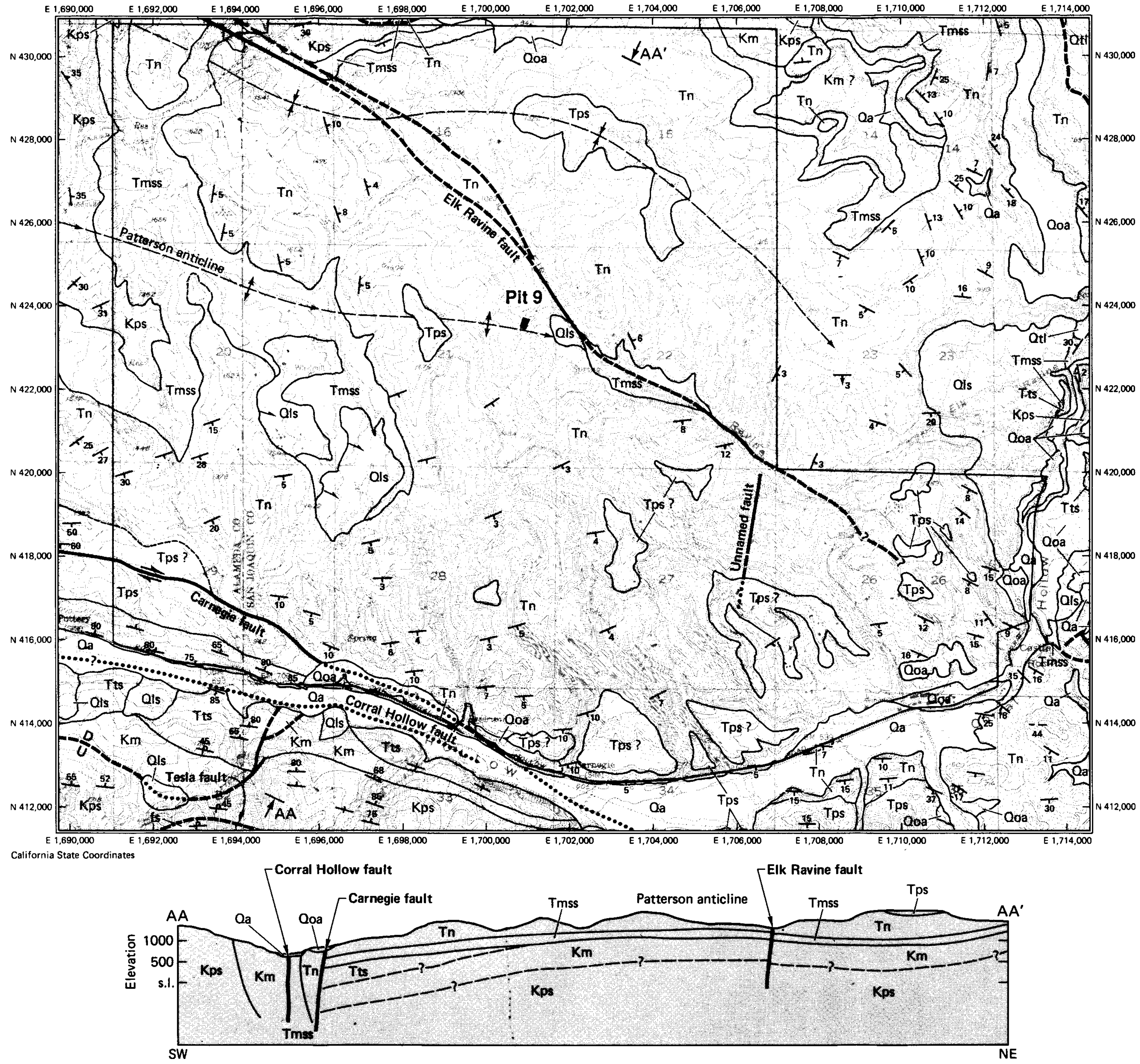


Figure 4. Topographic and geologic map of Site 300 and geologic cross-section AA-AA' (modified from Dibblee, 1980a, Raymond, 1969, and Raber and Carpenter, 1983).

Legend

Qa	Alluvium	Holocene	Quaternary
Qls	Landslide debris		
Qoa	Older alluvium	Pleistocene	
Qtl	Tulare Formation		
Tps	Nonmarine sedimentary rocks	Pliocene	Tertiary
Tn	Neroly Formation	Miocene	
Tmss	Cierbo Formation		
Tts	Tesla Formation	Eocene	
Km	Moreno shale	Upper Cretaceous	Jurassic-Cretaceous
Kps	Panoche Formation		
fs	Franciscan assemblage		

Contact

Dashed where gradational or approximately located.

Fault

Dashed where inferred; dotted where concealed; queried where existence doubtful; double arrows indicate strike-slip movement; U — upthrown side, D — downthrown side, relatively.

Axis of fold

anticline

syncline

Arrow on axis indicates direction of plunge.

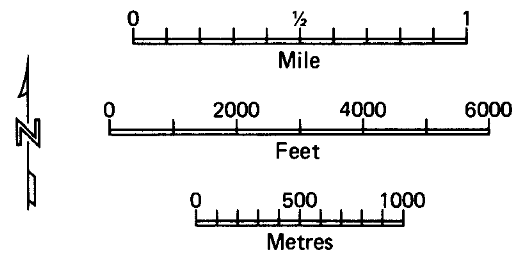
Strike and dip of strata

inclined

inclined (approximate)

vertical

overturned



As shown in Figure 4 and Plate 1, bedrock structure is dominated by the Patterson Anticline, which crosses Site 300 near mid-site with a west-northwest/east-southeast trend. South of the anticlinal ridge, the bedrock sequence dips towards Corral Hollow. North of the ridge crest, beds dip toward the northeast an average of 10 degrees into the trough of a subsidiary syncline that crosses the northeastern portion of Site 300. Immediately northeast of the trough, beds dip southwest for a short distance before resuming a northeasterly dip. The synclinal axis plunges southeast.

Two principal faults are mapped within Site 300: the Elk Ravine Fault, in the north-central part of the site, and the Carnegie Fault, which crosses the southwestern portion of Site 300. The Carnegie Fault merges to the northwest with the Tesla-Ortigalita Fault and with the Corral Hollow Fault southeast of Site 300 (Dibblee, 1980b). Neither the Elk Ravine nor Carnegie Faults show evidence of Holocene displacement (Raber and Carpenter, 1983; Hoffman, 1988). Localized cross-faults and fault splays have recently been identified by trenching and field mapping in the East Firing Area (EFA) (Taffet et al., 1989).

Geology of the Pit 9 Area

Figure 5 is a geologic and topographic map of the Pit 9 area. The pit is located in a canyon that slopes an average of 30 degrees to the northeast. Parallel ridges rise 150 ft west and 100 ft east of the valley bottom. Soils vary from 1 ft thick on the ridge slopes to 30 ft thick in the ravine bottom. Soils in the area are mapped as Linne Adobe Clay (Ln) and Linne Adobe Clay Loam-Rock outcrop Phase (Lcr) (Cole et al., 1943). These soil types are typically dark brownish gray and calcareous. These soils have good erosion resistance but do experience shrinkage cracking due to clay desiccation. Soils are variably composed of gravel, silt, and sandy silt in the valley bottom, grading to clayey and sandy silt on the slopes. Blue sandstone and interbedded siltstones and claystones of the upper section of the Neroly Formation immediately underlie the landfill area. The landfill is several hundred feet north of the Patterson Anticline; beds strike an average of N20W and dip about 5 to 10 degrees northeast. A generalized stratigraphic section for the Pit 9 area is presented below.

Unconsolidated Sediments (Qa), Holocene. These materials consist chiefly of brown to dark brown sandy and clayey silt, grading to silt, sand and gravel. Fill occurs in the area of the landfill as gravel, sand, and silt. Thicknesses of these materials in the Pit 9 area range from less than 1 to greater than 30 ft; greatest thicknesses occur in the valley bottom and decrease up the slopes.

Neroly Formation (Tn), Miocene. This formation is composed of volcaniclastic sedimentary rocks.

Upper Blue Sandstone ($Tnbs_2$). This unit immediately underlies most of the landfill site and is composed of massive blue sandstone with conglomerate interbeds and thin interbeds of pebbles, siltstone, and claystone. The sandstone is locally medium to coarse grained and contains claystone rip-up clasts. Conglomerate beds are generally several feet thick and are composed of pebbles and small cobbles of andesite and basalt and rock fragments, including chert, in a fine sand matrix. Thickness of the unit varies from 30 to 80 ft. Sandstones are moderately permeable and porous.

Middle Claystone ($Tnsc_1$). This unit is composed of predominantly well-lithified, light gray to pinkish gray silty claystone; fine-grained blue weathering sandstone; and thin interbeds of siltstone. This unit crops out in a narrow band immediately north of Building 845. The sandstone tends to be more common at the base of the unit. Sandstone beds are moderately permeable, and finer beds are lesser so. This unit is an average of 50 to 75 ft thick in the Pit 9 area.

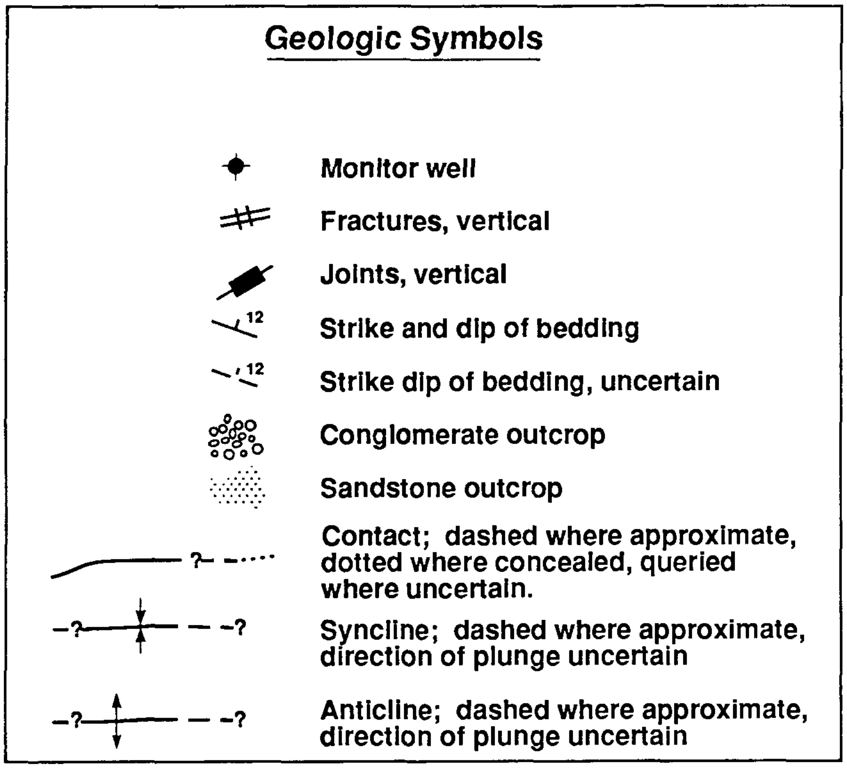
Lower Conglomerate (Tngl$_1$). This unit occurs as a lentil within the upper half of unit Tnbs$_1$ in other portions of northern Site 300. At Pit 9, this unit averages 35 ft in thickness and overlies unit Tnbs$_1$. This unit contains well-rounded andesite and basalt cobbles in a well-cemented sand matrix. It contains sandstone interbeds and tends to interfinger into the underlying Tnbs$_1$ sandstone. Thickness is variable as the conglomerate occurs as channel fill. The conglomerate has low primary permeability; fractures are often present and are often healed.

Lower Blue Sandstone (Tnbs$_1$). This unit consists of a section of massive blue sandstone and thin interbeds of siltstone, claystone, and pebbly sandstone generally about 100 ft thick. The sandstones commonly display large scale cross-bedding and evidence of soft sediment deformation (slump structures and convolute bedding). Sandstone beds are fine to medium grained, well cemented, and moderately permeable. The unit is fractured in places.

Basal Claystone (Tnsc$_0$). The lowermost part of the Neroly Formation is dominated by a predominantly bluish-green to yellow brown and gray weathering claystone-siltstone unit that is typically 25 to 30 ft thick. Minor interbeds of sandstone occur. The only significant permeability in this unit is provided by fractures.

Figure 6 shows the locations of two geologic cross sections through the Pit 9 area. Figure 7 (A–A') is a geologic cross section approximately parallel to the regional strike; as a result, dips are depicted approximately flat. The section shows the greater thicknesses of alluvium (Qa) and conglomerate (Tngl$_1$) within the valley center. The most interesting feature is the shear zone within the lower half of unit Tnbs$_1$ and unit Tnsc$_0$ in the vicinity of well K9-04. Fault breccia and slickensides were recovered from this zone below a depth of 136 ft and are indicative of a series of high-angle shears with a possible strike-slip component. The fact that this zone abruptly ends at a depth of 136 ft, within unit Tnbs$_1$, suggests that the horizontal surface defined by this break in deformation is a local unconformity. This shear zone appears to be narrow as it was not observed in the other boreholes. Curiously, the main water-bearing sandstone within unit Tnbs$_1$ is absent in the area of well K9-04; this is likely due to high-angle vertical offset along the shear planes. This offset would have to be in excess of 12 ft to account for the absence of the water-bearing sandstone.

Geologic Symbols



Monitor well

Fractures, vertical

Joints, vertical

Strike and dip of bedding

Strike dip of bedding, uncertain

Conglomerate outcrop

Sandstone outcrop

Contact; dashed where approximate, dotted where concealed, queried where uncertain.

Syncline; dashed where approximate, direction of plunge uncertain

Anticline; dashed where approximate, direction of plunge uncertain

Legend

Lithologic Units

Quaternary Sediments

Qa	Alluvium, fill: silt, clay, sand and gravel

Tertiary Sedimentary Rocks

Neroly Formation (miocene)

Tngl$_2$	Upper Conglomerate; pebble-cobble sized clasts of andesite, and basalt, chert in matrix of well cemented silt and sand. Contains lenses of blue weathering sandstone.
Tnbs$_2$	Upper Blue Sandstone; massive blue sandstone, contains pebble beds, claystone rip-up clasts and thin interbeds of claystone and siltstone. May contain thin lenses of conglomerate as channel fills in Pit 9 area.
Tnsc$_1$	Middle Claystone; interbedded gray silty claystone, siltstone and silty sandstone.
Tngl$_1$	Lower Conglomerate; cobble size clasts of andesite and basalt within a matrix of dense, well-cemented sand. Occurs as a lentil within unit Tnbs$_1$ in other parts of the site.
Tnbs$_1$	Lower Blue Sandstone; fine-medium grained well-cemented blue sandstone and interbeds of siltstone, claystone and pebbly sandstone.

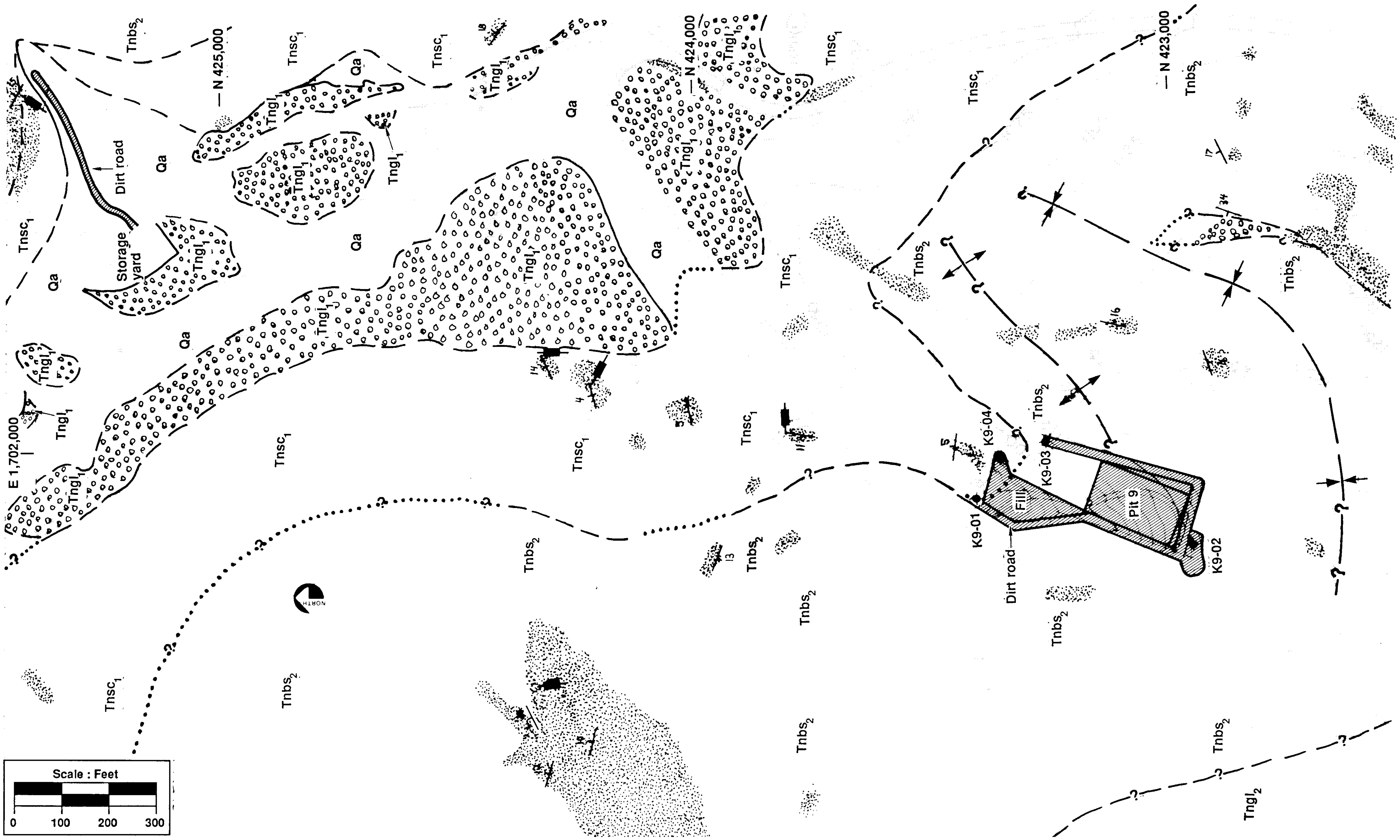


Figure 5. Geologic map of Pit 9 Complex.

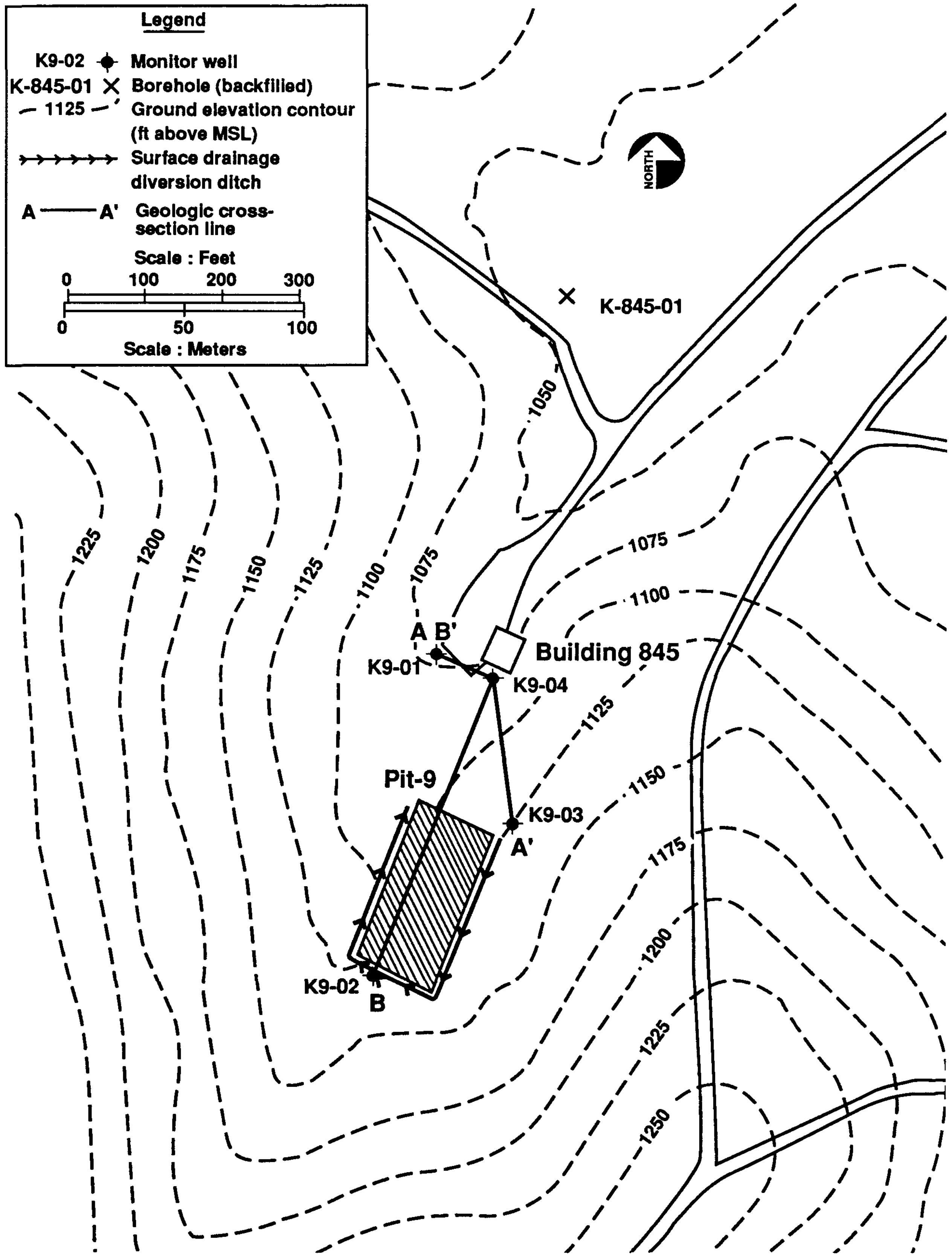


Figure 6. Location of Geologic cross-sections A-A' and B-B' (Figures 7 and 8).

Legend

Lithologic Units

Quaternary Sediments

Qa	Alluvium, fill; silt, clay, sand and gravel

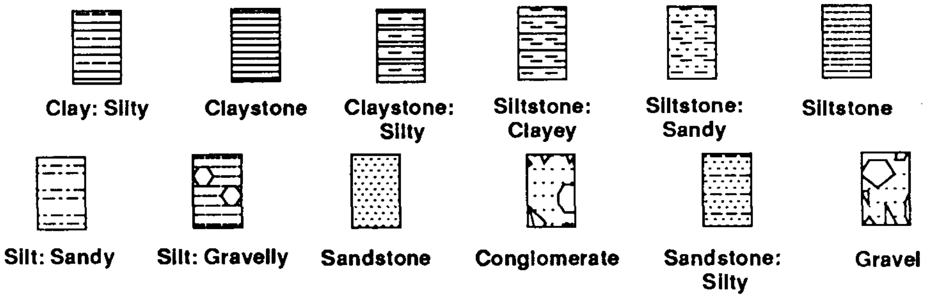
Tertiary Sedimentary Rocks

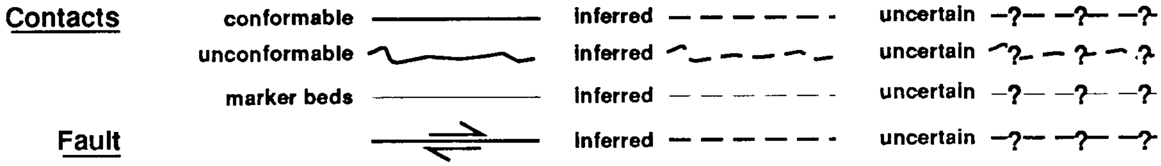
Neroly Formation (Miocene)

Tnbs$_2$	Upper Blue Sandstone; massive blue sandstone, pebble beds and thin interbeds of claystone and siltstone.
Tnsc$_1$	Middle Claystone; interbedded gray silty claystone, siltstone and silty sandstone.
Tngl$_1$	Lower Conglomerate; andesite and basalt cobbles in a sand matrix.
Tnbs$_1$	Lower Blue Sandstone; blue sandstone and interbeds of siltstone, claystone and pebbly sandstone.
Tnsc$_0$	Basal claystone; blue-green claystone and interbeds of clayey siltstone and minor silty sandstone.

Geologic Symbols

Lithologic patterns



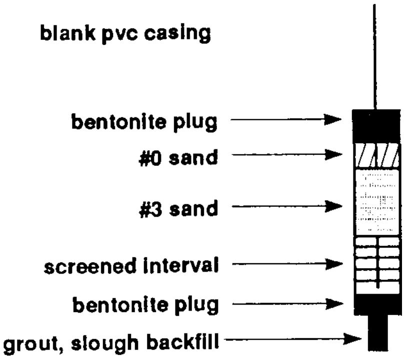


arrows indicate relative sense of movement

Static Water Levels

▽ 11/88
▼ 5/89

Well Construction



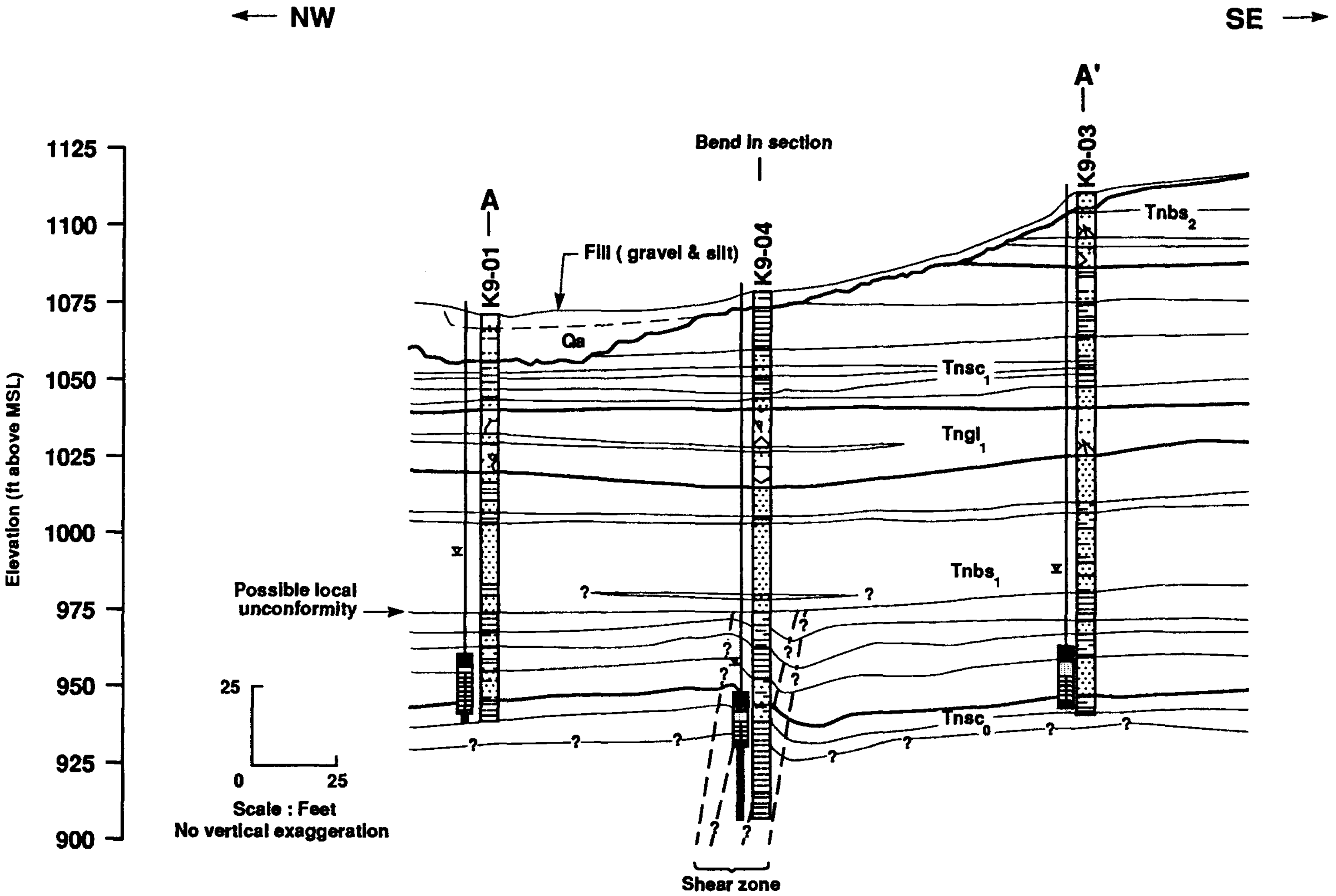


Figure 7. Geologic cross-section A-A'.

Figure 8 (B–B') is a geologic cross section oriented approximately parallel to the average regional dip. Dips shown are approximately true, albeit vertically exaggerated. Geology is consistent to that shown in Figure 7, including the shear zone.

Pit 9 occurs just north of the crest of the Patterson Anticline. Beds on the northeast limb dip to the northeast. No surface evidence for the shear zone encountered in well K9-04 has been observed in field mapping. The Elk Ravine Fault is inferred to pass approximately 1500 ft northeast of the landfill although its orientation and trend in this area are unknown. A small anticline appears to exist northeast of the pit and trends southwest-northeast. A parallel syncline appears to occur south and southeast of the landfill. Strikes and dips vary from the regional values only in the immediate vicinity of these local structures.

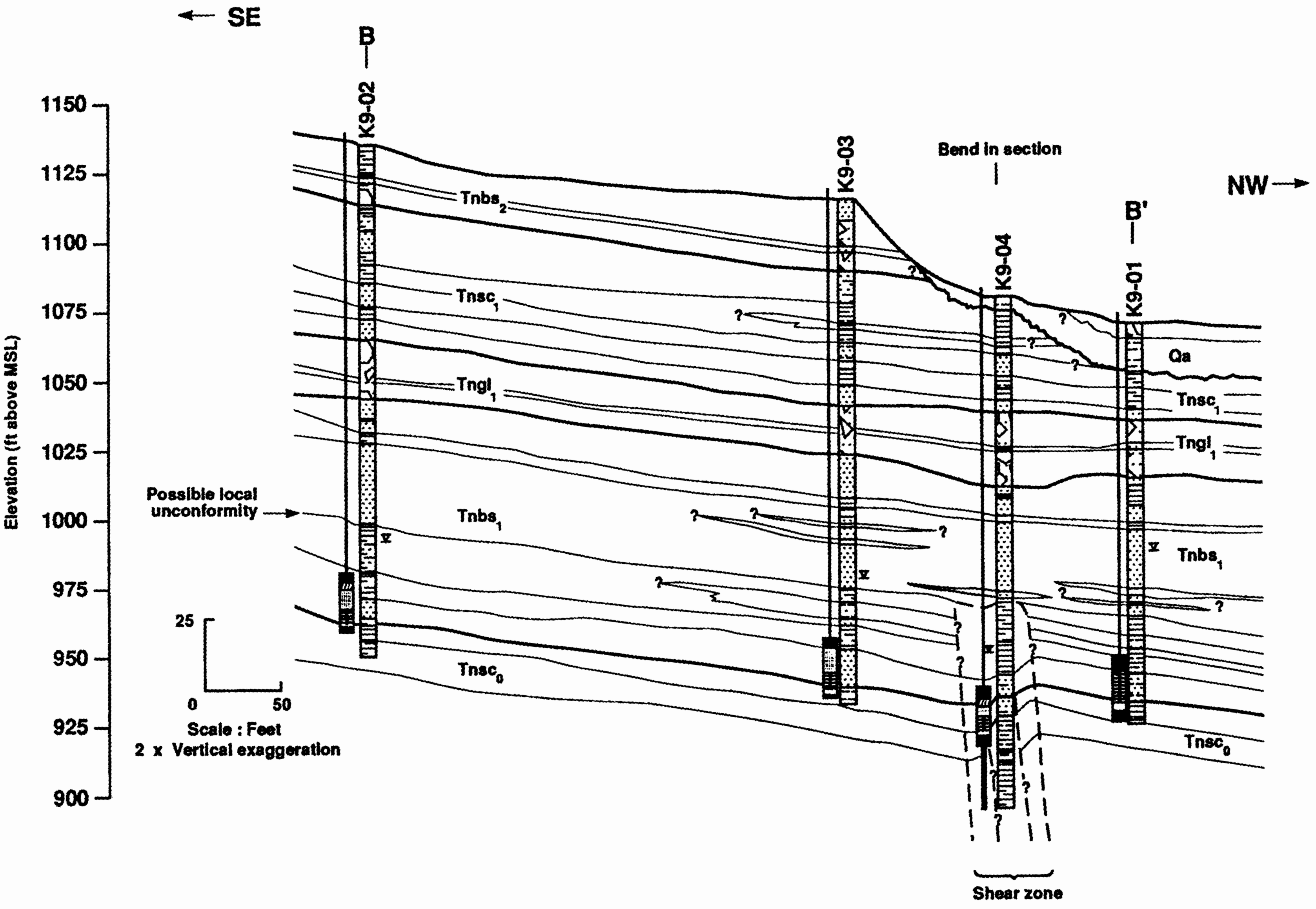


Figure 8. Geologic cross-section B-B'.

Hydrogeology

Hydrogeology of Site 300

First ground water at Site 300 is generally found within unit Tnbs_1. In portions of the site, the first water-bearing zone is perched and of low yield (less than 1 gpm); in other portions, yields may exceed several gallons per minute and conditions are often confined. Depth to ground water varies from 25 ft to in excess of 300 ft. Ground water flow often follows geologic structure in that it often flows along the dip of bedding. Thus, north of the Patterson Anticline, ground water tends to flow northeast. South of the anticline, ground water tends to flow southeast. Faulting also appears to affect ground water flow, causing ground water mounding and possibly conduit flow in shear zones (Taffet et al., 1989). Fractures often convey flow in otherwise impermeable, fine-grained lithologies.

Hydrogeology of Pit 9

Water-Bearing Zones

Depth to ground water beneath Pit 9 varies from 80 to 150 ft below the ground surface. Water-elevation data are tabulated in Appendix C, Table C-1. The first water-bearing zone is confined; it occurs within a zone of sandstone and silty sandstone averaging 10 ft thick, below a conglomerate stratum at the base of unit Tnbs_1. These sandstones, although moderately permeable, are also fractured. The rocks containing this first water-bearing zone can be correlated with the strata of the "main water-bearing zone" observed farther north in the EFA and described in previous reports (Buddemeier, et al., 1987; Ruggieri et al., 1988; Taffet et al., 1989). Unit Tnsc_0 claystone and silty claystone appear to act as aquitard materials except where fractured, as in the shear zone.

Wells K9-01, K9-02, and K9-03 are all completed within the main water-bearing zone. Hydraulic tests, discussed in the next section, indicate that fracture flow is important, if not dominant, in this zone. Well K9-04 is completed in the vertical shear zone where the main water-bearing zone is absent. Here a very low yield perched zone containing water apparently under some confining pressure exists within fractured claystones and siltstones of unit Tnsc_0.

It is worth noting that although ground water appears to occur in two discrete zones, major ion chemistry in ground water from well K9-01 is similar to that of ground water from well K9-04 (Appendix B). Ground water samples collected from both of these wells are sodium sulfate dominant and have similar concentrations of dissolved solids.

Rates and Directions of Movement

The ground water flow gradient was 0.03 in the direction N53E during the first quarter of 1989, as determined from the slope of the potentiometric surface within the three first water-bearing zone wells. This gradient has been approximately constant during the monitoring period that began during the last quarter of 1988. The gradient bearing has varied somewhat, but the direction is generally northeast. This may be due to well equilibration effects.

Pump tests were performed on these three wells to determine ground water flow velocities. These tests were also performed to see if the shear zone beneath the landfill affects ground water flow and whether there is a hydraulic connection between the shear zone monitored by well K9-04 and the extensive water-bearing zone monitored by the other three wells. Details of the hydraulic tests are presented in Table 3. Testing protocols are presented in Buddemeier et al. (1987);

Table 3. Pit 9 hydraulic test details.

Pumping wells	K9-01	K9-02	K9-03
Number of steps	3	1	3
Duration of pumping (min)	308	204	214
Duration of monitored recovery (min)	1040	1213	826
Maximum Q (gpm)	1.7	0.45	1.1
Average Q (gpm)	1.4	0.45	0.90
Total volume pumped (gal)	420	92	186
Maximum drawdown in pumping well (ft)	39.2	24.5	30.7
Response in observation wells (ft)			
K9-01	—	None[a]	3.8[b]
K9-02	0.30[b]	—	0.10[b]
K9-03	10.00	None[a]	—
K9-04	None[a]	None[a]	None[a]
Specific capacity (gpm/ft)	0.05–0.07	0.02	0.04–0.05
Saturated thickness (ft)	10	7	11
Laminar flow component at Q_1, Q_{max} (%)	74–53	—	67–60

[a] Water elevation in observation well rose during test; potential communication masked.

[b] Substantial delayed response.

mathematical methods are presented in Buddemeier et al. (1987), and Weiss Associates (1988). Pore-water flow velocities were determined by Darcy's Law:

$$V_p = \frac{dh}{dl} \frac{k}{n_e}$$

where dh/dl = the hydraulic gradient (0.03),

k = the hydraulic conductivity , determined by dividing transmissivity by aquifer thickness (L/T), and

n_e = the effective porosity (about 0.20).

Hydraulic conductivities calculated using the various methods listed in Table 4 were averaged to determine the mean linear pore water velocity discussed below. The mean linear pore-water velocity for the main-water-bearing zone in the Pit 9 area is 1.04 m/yr.

Table 4. Pit 9 hydraulic test results.

Analytical Solution	Test Phase	Transmissivity (gpd/ft)	Hydraulic Conductivity (gpd/ft^2)	Hydraulic Conductivity (cm/sec)	Corrected for Well Losses (Y/N)	Fit
Pumping Well: K9-01						
Birsoy-Summers	Drawdown	25	2.5	1.2×10^{-4}	N	Excellent
Cooper-Jacobs	Recovery	25	2.5	1.2×10^{-4}	N	Excellent
Hantush	Drawdown	144	14	6.8×10^{-4}	N	—
Specific discharge approximation	Drawdown	144	14	6.8×10^{-4}	Y	—
Pumping Well: K9-02						
Cooper-Jacobs	Drawdown	6.0	0.86	4.1×10^{-5}	N	Good
Cooper-Jacobs	Recovery	5.9	0.84	3.9×10^{-5}	N	Good
Pumping Well: K9-03						
Birsoy-Summers	Drawdown	15	1.4	6.4×10^{-5}	N	Good
Cooper-Jacobs	Recovery	13	1.2	5.6×10^{-5}	N	Fair
Hantush	Drawdown	110	10	4.7×10^{-4}	N	—
Specific discharge approximation	Drawdown	80	7.2	3.4×10^{-4}	Y	—

Well K9-04, which is screened in the shear zone, did not show response during any of the three pumping tests. The rising trend in water levels seen in this well as pump testing was performed at adjacent wells appears to be long-term recovery from routine sampling performed early in May 1988.

Wells K9-01 and K9-03 seem to be in excellent horizontal hydraulic communication. This suggests that the shear zone screened by well K9-04 does not act as a hydraulic barrier. This is not surprising, as the shear zone is deeper in the subsurface. What is surprising is that this water-bearing zone is not present at the location of well K9-04.

Delayed response was seen in several observation wells where there was drawdown occurring after pumping ceased. This is possibly the result of a pressure front moving through a circuitous pathway. The drawdown seen in well K9-02 during the pumping of wells K9-01 and K9-03 is appreciably less than that predicted by a distance drawdown plot. This raises the possibility that there may be a hydraulic barrier between wells K9-02 and K9-03. The nature of this barrier is unknown, but it may be related to the shear zone or restricted ground water flow paths. The S-shapes of many of the recovery curves suggest porous flow into fractures.

Analytical Results

Soil and Rock Core Samples

Core samples were collected from boreholes K9-01, K9-03, and K9-04. No elevated levels of metals, radionuclides, or organic compounds were detected in any samples (Appendix B, Table B-1). One rock core sample, from boring K9-03 at 161.3 ft, contained 2000 pCi/L ± 1000 of tritium. This sample was taken from sandstone within the water-bearing zone at this location. No other core samples contained detectable levels of tritium. The low tritium activity, twice the detection limit, and the fact that ground water sampled from this zone continues to be free of tritium suggest that this result is spurious.

Ground Water Samples

Ground water analytical results are tabulated in Appendix B, Table B-2. Ground water samples have been collected quarterly from well K9-01 since its completion during the fourth quarter of 1987. EPA Methods 624 and 625 analyses (December 8, 1987), EPA Methods 601 and 602 analyses (March 10, 1988), and EPA Method 601 analyses (June 27 and November 27, 1988) all showed no organic compounds present in ground water above detection limits of 0.5 to 1 ppb (Appendix B, Tables B-2 to B-5). Beginning in the first quarter of 1989, we sampled and analyzed ground water from the three monitor wells (K9-01, K9-02,and K9-03) screened in the main water-bearing zone for the assessment parameters previously listed.

During the first quarter of 1989, analytical results for general physical and chemical parameters, specific conductance, and total organic carbon were all within the ranges observed in natural shallow ground water (Hem, 1985). No total organic halogen, EPA Method 624 or Title 22 organic compounds, or HE compounds were detected. Radiological activities and metals concentrations were all well within the ranges in natural shallow ground water (Appendix B, Table B-6). Thus, no chemicals above SALs, MCLs, or STLCs were detected. These regulatory criteria are outlined in Title 40 of the Code of Federal Regulations (CFR) and Title 22 of the CAC.

Well K9-04 was completed and developed during the first quarter of 1989. During the second quarter of 1989, we sampled all four Pit 9 wells for the assessment parameters. Ground water samples from well K9-01, K9-02, and K9-03 contained no detectable tritium or HE or organic compounds. General physical and chemical parameters, radionuclides, gross radioactivity, and metals concentrations were within the ranges expected in natural shallow ground water. Ground water samples from well K9-04 were reported to contain 2 µg/L of carbon disulfide and 17 µg/L of phenolics. There are no federal or state SALs, MCLs, or STLCs for carbon disulfide or phenolics; there is a drinking-water taste and odor threshold of 1 µg/L for phenolics; this standard applies to chlorinated systems (CAC, 1988). We believe that these results may be spurious or laboratory artifacts. There is no record of use of these in firing table 845 activities. These compounds have never been found previously in Pit 9 ground water samples. We will continue this sampling program and determine if these chemicals are present.

No other organic compounds were detected in analyses for EPA Method 624 and Title 22 organic compounds. No total organic halogen, HE compounds, or tritium was detected. Results of the other assessment parameter analyses (including general physical and chemical parameters, gross radioactivity, uranium isotopes, radium, and Title 22 metals) indicate these parameters were not detected or were well within the ranges typical of natural shallow ground water (Hem, 1985). No chemical parameters were detected above SALs, MCLs, or STLCs. For the remainder of 1989, we will continue quarterly sampling for the suite of assessment parameters. Based on the results, we will determine if Pit 9 has impacted area ground water and whether further ground water sampling is necessary.

Discussion

We have completed a remedial investigation of hydrogeology at landfill Pit 9. We have identified the geology and ground water hydraulics in the Pit 9 area. Depth to water varies from 80 to 130 ft below the ground surface; landfill leachate, if present, would have to travel to these depths to reach ground water. The presence of confining layers and shallower low-permeability strata would retard this process. Hydraulic test results indicate low ground water flow velocities.

No evidence exists for landfill impacts on vadose zone or saturated zone chemistry. Chemical analyses of soil and rock core samples revealed only one sample that may have contained slightly elevated tritium activity. No other core samples contained measurable tritium, metals, or radiologic species at elevated levels.

In two quarterly rounds of ground water sampling at Pit 9 during 1989, only the two, likely spurious, results from well K9-04 samples were observed. None of the compounds disposed of in the landfill were detected at elevated levels. No tritium or beryllium has been detected in ground water samples. Radioactive parameters and metals concentrations of lead, arsenic, and barium were all well within the ranges of natural ground water or were not detected. No other organic compounds have been detected. No chemical parameters have been detected at SALs, MCLs, or STLCs.

Assessment monitoring of water levels and ground water chemistry will continue on a quarterly basis through the end of 1989. This will allow determination as to whether Pit 9 is altering area ground water chemistry. Results of this investigation will be reported in future Site 300 Environmental Investigation Quarterly Reports. At present, it appears that Pit 9 landfill materials have not affected vadose zone or saturated zone water chemistry.

Acknowledgments

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T. Cederwall of LLNL provided data base management.

S. Gregory and J. Swardenski of Brown and Caldwell collected ground water samples.

J. Clarkson and J. Cupps of LLNL performed analyses of high-explosives compounds.

J. Rego of LLNL performed the tritium analyses.

K. Heyward of LLNL prepared the graphics.

C. Corey of LLNL/TID edited the manuscript.

D. Harms of LLNL and J. Tweed of Bendix provided editorial and clerical support.

K. Toney of Brown and Caldwell prepared geologic boring logs.

J. Chiu of Weiss Associates conducted hydraulic tests.

E. Draney, J. Lane, and M. Gonzalez of LLNL provided coordination and operational support at Site 300.

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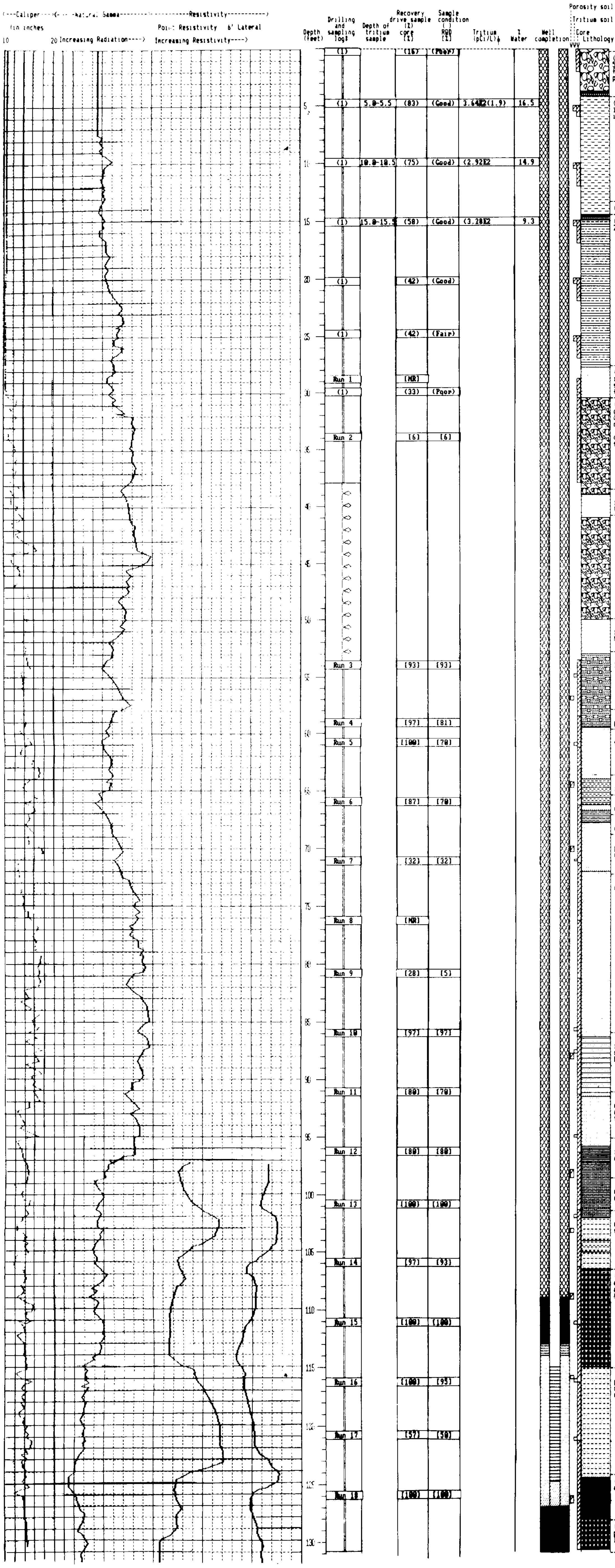
Appendix A

Well and Borehole Logs

LOG: MONITOR WELL K9-1



Drilling and sampling log‡	Depth of tritium sample	Recovery drive sample (%) core [%]	Sample condition ( ) RQD [%]	Tritium (pCi/L)‡	% Water
(1)		(16)	(Poor)		
(1)	5.0-5.5	(83)	(Good)	3.64E2(1.9)	16.5
(1)	10.0-10.5	(75)	(Good)	<2.92E2	14.9
(1)	15.0-15.5	(58)	(Good)	<3.28E2	9.3
(1)		(42)	(Good)		
(1)		(42)	(Fair)		
Run 1		[NR]			
(1)		(33)	(Poor)		
Run 2		[6]	[6]		
Run 3		[93]	[93]		
Run 4		[97]	[81]		
Run 5		[100]	[70]		
Run 6		[87]	[70]		
Run 7		[32]	[32]		
Run 8		[NR]			
Run 9		[28]	[5]		
Run 10		[97]	[97]		
Run 11		[80]	[70]		
Run 12		[80]	[80]		
Run 13		[100]	[100]		
Run 14		[97]	[93]		
Run 15		[100]	[100]		
Run 16		[100]	[95]		
Run 17		[57]	[50]		
Run 18		[100]	[100]		

Lithologic descriptions and/or remarks‡‡

(0-3.7) GRAVEL: SANDY, [GM], light brown and light gray, dense, 50-60% well rounded to rounded pebbles to 3 inches, 20-30% very fine to very coarse sand, 10-20% silt, moderate estimated permeability

(3.7-14.5) SILT: SANDY, [ML], dark brown, damp, medium stiff, 10-30% very fine to fine sand, 5% well rounded pebbles to ¼ inch, low estimated permeability

at 13 feet: becomes dry and light brown

(14.5-130.8) TERTIARY SEDIMENTARY ROCKS

(14.5-27.8) SILT: CLAYEY, [ML], light brown, dry, very stiff, 20-40% clay, low estimated permeability, locally lithified

(27.8-30.5) SANDSTONE: black and dark brown, damp, poorly indurated, friable, pooorly sorted, fine to medium grained, sparse pebbles, moderate estimated permeability, upper contact from driller

(30.5-39) CONGLOMERATE: PEBBLE-COBBLE, dark brown, red, and gray-blue, well to very well indurated, moderately to well cemented, very poorly sorted very well rounded andesitic and chert pebbles and cobbles to 5+ inches,

clast supported, matrix consists of very fine to very coarse sand, silt, and clay, moderate to low estimated permeability

at 32 feet: lost circulation; at 35 feet: regain circulation

(39-41) SANDSTONE: brown and black, poorly to moderately indurated, moderately sorted, fine to medium grained, moderate to high estimated permeability, contacts from driller

(41-50) CONGLOMERATE: PEBBLE-COBBLE, as above

(50-53) SANDSTONE: black and brown, moderately to poorly indurated, poorly sorted, fine to medium grained, moderate to high estimated permeability, contacts from driller

(53-59) SILTSTONE: GRAVELLY, light brown, angular rip-up clasts 1/8 to 2 inches, inversely graded

[DL, 53.0-53.5/breccia zone(?); 59.0/33°/lower contact]

(59-59.5) SILTSTONE: light gray, well indurated, low estimated permeability

(59.5-64) SANDSTONE: dark gray, poorly indurated, moderately sorted, very fine grained, moderate estimated permeability

at 59.7, 60.5, and 66.0 feet: leaf fossils
[DL, joints: 60.7/45°/fresh; 65.9/8°/smooth and coated with Mn-oxide]

(64-66.2) SILTSTONE: CLAYEY, light gray, moderately to well indurated, moderately sorted, low estimated permeability

(66.2-66.7) SANDSTONE: black, moderately to poorly indurated, moderately sorted, fine grained, moderate estimated permeability

(66.7-67.8) SILTSTONE: very light brown, well indurated, moderately sorted, low estiamted permeability, leaf fossils

(67.8-72) SANDSTONE: gray brown, well indurated, moderately to poorly sorted, fine to medium grained, moderate to high estimated permeability, bottom contact from gamma log

at 70.5 feet: becomes poorly indurated

(72-86.3) SANDSTONE: as above, medium to coarse grained, with orange-brown staining, moderate to high estimated permeability

at 76 feet: no apparent production after blowing hole dry

(86.3-91.5) SANDSTONE: CLAYEY, light brown, moderately indurated, pooorly sorted, medium to coarse grained, 10-20% clay, sparse red chert grains, low estimated permeability, bottom contact from gamma log

[DL, 87.5/45°/fresh joint; 90.2/15°/irregular fresh fracture]

(91.5-95.8) SANDSTONE: gray brown, with orange stained blebs, moderately to poorly indurated, moderately sorted, medium to coarse grained, <10% fines, abundant red chert grains, moderate to high estimated permeability

at 96.3 feet: no apparent production after blowing hole dry

(95.8-97.2) CLAYSTONE: light brown and light purple, well indurated, moderately sorted, low estimated permeability, numerous open and healed fractures, some leaf fossils

[DL, 96.8-98.0/84°/silica(?) filled fracture]

(97.2-102) SILTSTONE: light blue-gray, well indurated, moderately sorted, 10-20% clay, sparse chalcopyrite, low estimated permeability

(102-106.5) SANDSTONE: SILTY, light blue-gray, well indurated, moderately sorted, very fine grained, 20-40% silt, becomes less silty with depth, low estimated permeability

104.0-105.0 feet: alternating laminae of sandy siltstone and very fine sandstone, no apparent water production
[DL, 104.0-105.0/12°/bedding; 104.4-106.3/85°/open fracture partially healed with silica(?)]

(106.5-115) CLAYSTONE: SILTY, light brown gray, well indurated, moderately sorted, 20-40% silt, leaf and wood fossils, low estimated permeability, numerous vertical and subvertical healed hairline fractures

[DL, 109.0-110.0/0-90°/intense fracture zone]

(115-124.5) SANDSTONE: SILTY, dark blue, very well indurated, poorly sorted, very fine to medium grained, 10-20% silt, red chert grains, dispersed pyrite pseudomorphs, moderate to low estimated permeability

[DL, 116.9-117.0/30°, 30°/intersecting and partially filled with pyrite; ≈117/20°/bedding; 124.5/undulant lower contact]

at 121.3 feet: hole produces water, water level rises above 91 feet

(124.5-128) SILTSTONE: light blue-gray, very well indurated, moderately sorted, low estimated permeability

[DL, 125.0/80°/hairline fracture healed with silica; 126.0/70°/healed joint]

(128-130.8) CLAYSTONE: SILTY, light purple-gray, moderately to poorly indurated, moderately to poorly sorted, 20-40% silt, low estimated permeability

Monitor Well K9-1

Geologic Logging:
T. Howard, Weiss Associates, Oakland, CA

Hole Location:
On access road northwest of Bunker 845

Coordinates:
N: 428,487.1
E: 1,698.880.6

Ground Elevation: 1124.10 feet

Geophysical Logging:
Geo-Hydro Data Inc., Tehachapi, CA

Drilling:
G. Hickmor, P. C. Exploration Inc.,
Roseville, CA

Date Drilled: 2/18-26/87

Drilling Method:
4 1/4-inch air-mist rotary 0-37.9
5-inch blade rotary 37.9-53.5 feet
4 1/4-inch air-mist rotary 53.5-130.8 feet
9 7/8-inch tri-cone rotary, ream 0-131 feet

‡ Key: Drilling and Sampling Log

5-inch blade rotary

(1) 2½-inch diameter sample taken with a Modified California Sampler hydraulically advanced. Samples taken from core, placed in glass jar, sealed with watertight tape, and frozen later that day.

Run # Core obtained using Christensen HG (97 mm) Wireline Punch Core System. Samples taken from core, placed in glass jar, sealed with watertight tape, and frozen later that day.

‡ Tritium concentrations are given in exponential notation with the counting uncertainty (2 std. dev.) in parentheses:
6.24E2(1.9) = (6.24 ± 1.9) $\times 10^2$ pCi/L.
If the tritium concentration is less than the uncertainty, then the tritium is reported as less than the uncertainty:
<2.92E2

NA Not analyzed

‡‡ Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

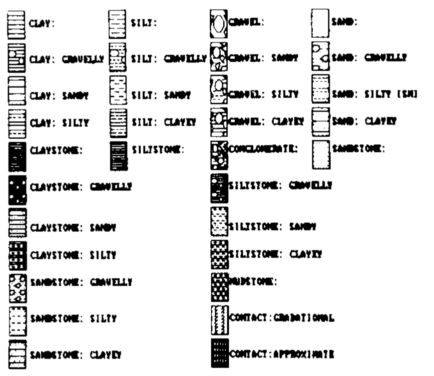
Discontinuity Log,
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

Ground Water: 78 feet

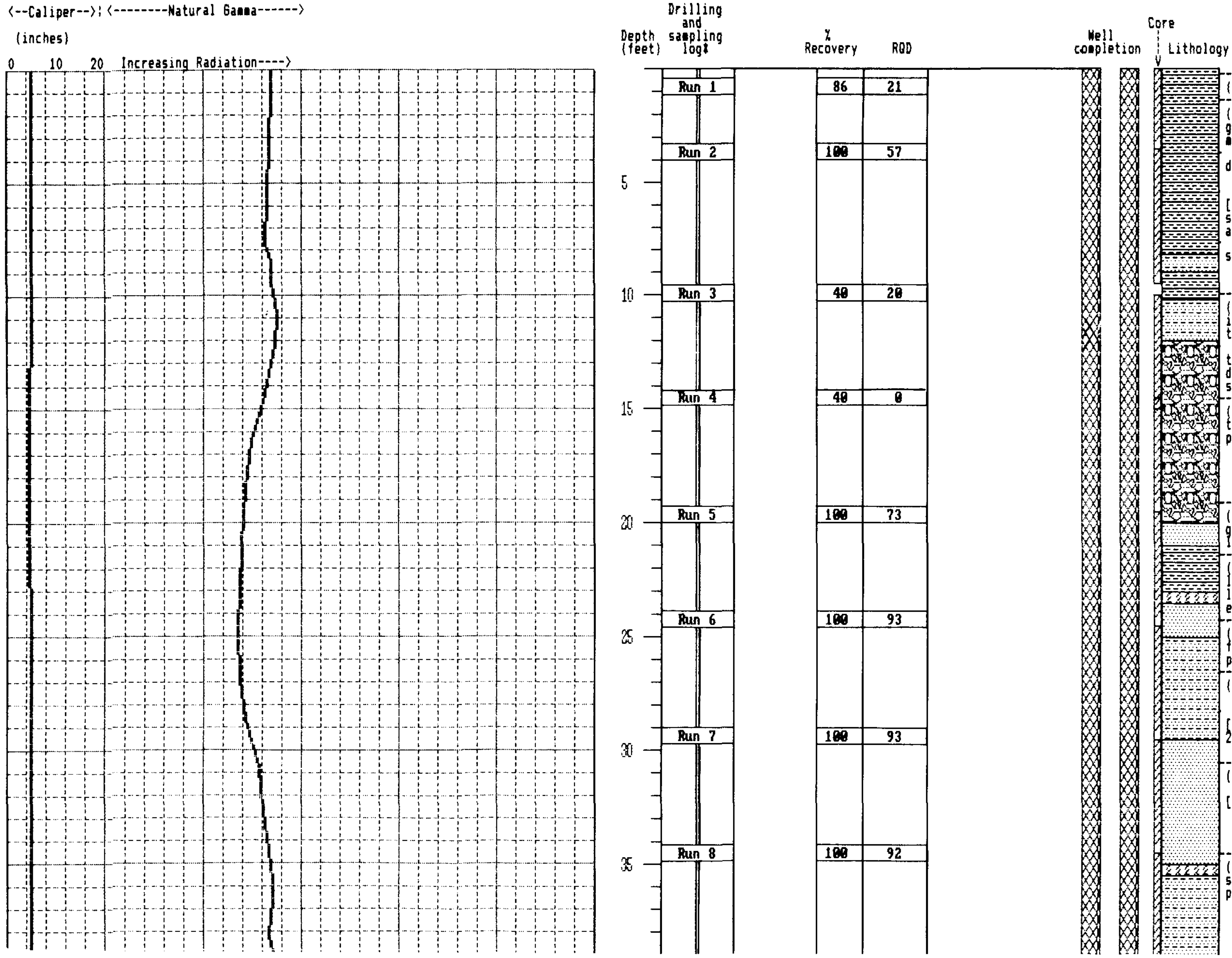
Monitor well Completion:

- ☐ **CASING: 4.5 inch I.D. threaded PVC**
- ▤ **SCREEN: 4.5 inch I.D. threaded PVC**
- ░ **FINE SAND: #0 Sand**
- ▒ **SAND PACK: #3 Sand**
- ■ **BENTONITE SEAL**
- ▩ **ANNULAR SEAL: Cement Grout**
- ▓ **SLOUGH:MATERIAL**

INDEX TO LITHOLOGIC SYMBOLS



LOG: MONITOR WELL K9-02



Drilling and sampling log*	% Recovery	RQD
Run 1	86	21
Run 2	100	57
Run 3	40	20
Run 4	40	0
Run 5	100	73
Run 6	100	93
Run 7	100	93
Run 8	100	92

Lithologic descriptions and/or remarks**

(0-169.5) TERTIARY SEDIMENTARY ROCKS

(0-10.2) SILTSTONE: CLAYEY, brown, dry, dries light brown to gray-brown, poorly to moderately indurated, 20-30% clay, abundant micas, tight, low porosity, low estimated permeability

damp to moist at 4-9 feet

[DL, intense fracture zone at 4-7 feet with horizontal and subvertical fractures with white (caliche ? and silica ?) coatings and open fractures]

silty sandstone interbed with 15-25% silt at 8.2-9 feet

(10.2-12) SANDSTONE: SILTY, brown to blue-brown, damp, moderately indurated, very fine grained, 15-25% silt, 5-10% clay, well sorted, tight, low porosity, low estimated permeability

three round Fe-oxide stained (fossils ?) to 1/12 inch at 10.4 feet; dark blue-brown, dries blue-gray, micaceous, and local Fe-oxide stains below 11 feet

(12-20) CONGLOMERATE: brown to blue-brown, damp to dry, moderately to well indurated, subrounded volcanic pebbles to 3 inches, low porosity, low estimated permeability

(20-21) SANDSTONE: brown, damp to moist, moderately indurated, fine grained, <10% silt, flat claystone fragments to 1/10 inch dip 5-8°, low to moderate porosity and estimated permeability

(21-23) SILTSTONE: to SILTSTONE: CLAYEY, brown, damp to moist, dries light-brown, moderately indurated, 5-20% clay, <3% very fine sand, local rounded Fe-oxide stained (fossils ?), low porosity, low estimated permeability

(23-25) SANDSTONE: brown, damp to moist, moderately indurated, very fine to fine grained, 5-10% silt, some micas, low to moderate porosity and estimated permeability

(25-29.5) SANDSTONE: SILTY, very fine grained, 20-30% silt, 10-15% clay

[DL, fractures: 21.2/10-43°/open, 23.8/subhorizontal/stained yellow, 24.5/2°/Fe-oxide and yellow stains, and 28.4/41°/Fe-oxide spots]

(29.5-35) SANDSTONE: as above at 23-25 feet

[DL, 30-34.5/6-11°/dark gray silt cross laminations]

(35-40) SANDSTONE: SILTY, brown, damp, moderately indurated, well sorted, 15-25% silt, <5% clay, tight, low porosity, low estimated permeability

Monitor Well K9-02

Geologic Logging:
M. Wade, Weiss Associates, Oakland, CA

Well Location:
Southwest of Well K9-01 and Pit 9, Site 300

Coordinates:
N: 422,973.2
E: 1,700,809.5

Elevation: Shiner 1133.39 feet
Top of Protective Casing (TOSP) 1135.39 feet

Geophysical Logging:
Geo-Hydro Data Inc., Tehachapi, CA

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

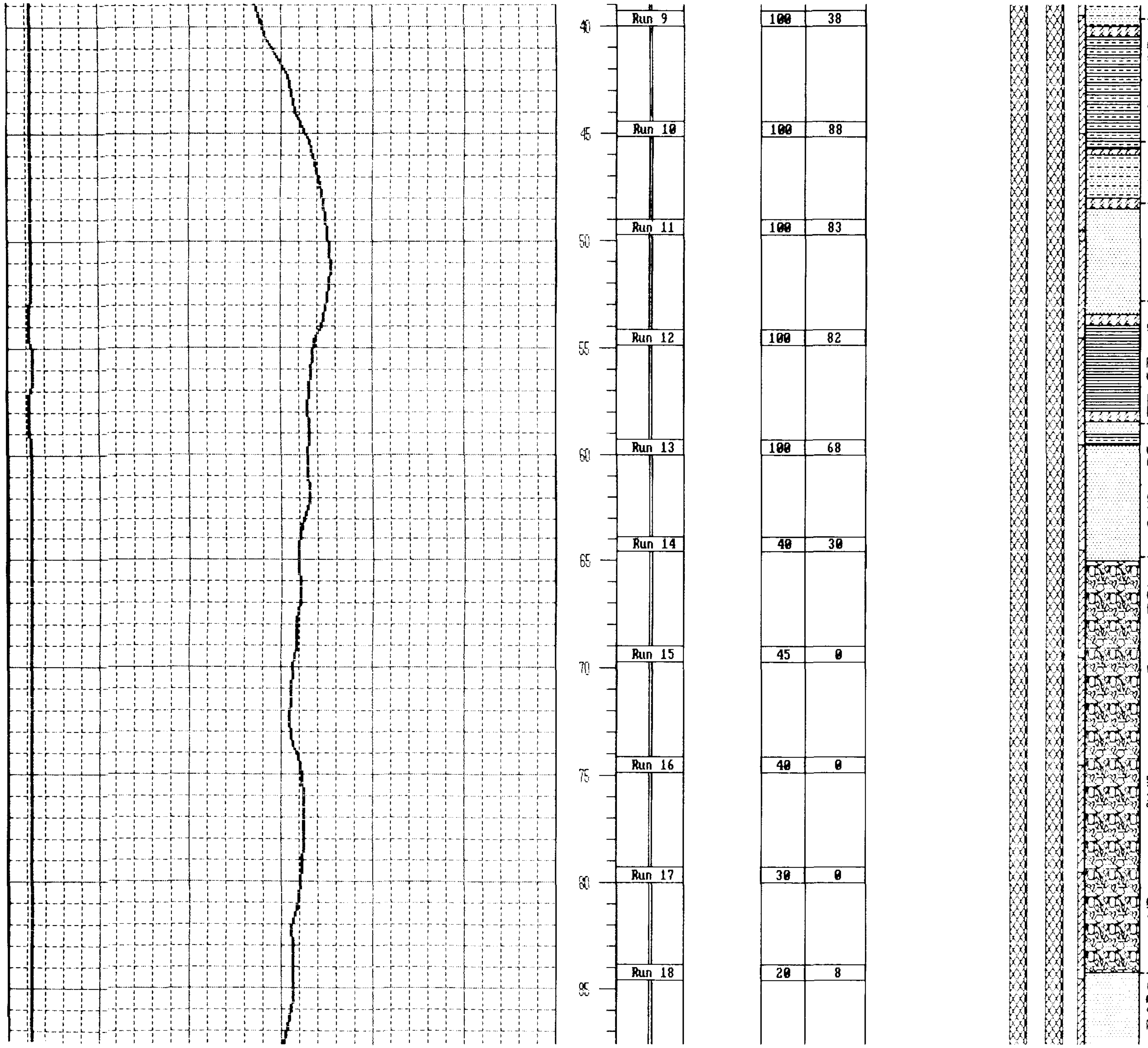
Dates Drilled: 8/16 to 8/26/88

Drilling Method:
4 1/4-inch air-mist rotary, 0-169.5 feet
9-inch tri-cone rotary, ream, 0-169.5 feet
install 4 1/2-inch PVC casing with
0.015-inch slots at 153.6-158.5 feet

* Key: Drilling and Sampling Log

Run 1 Core obtained using Christensen HQ
║ (92 mm) Wireline Coring System.
No soil or rock samples submitted
for chemical analysis.

LOG: MONITOR WELL K9-02 (CONTINUED)



(40-45.7) CLAYSTONE: to CLAYSTONE: SILTY, brown, dry to damp, moderately to well indurated, 5-20% silt, <5% very fine sand, low porosity, low estimated primary permeability, moderate estimated fracture permeability

[DL, fractures: 41.2/2°/with black (Mn-oxide ?) stains and 43.7/0-3°/with yellow-orange stains; intense fracture zone at 44-45 feet with yellow-orange stains]

(45.7-48) SANDSTONE: to SANDSTONE: SILTY, brown, damp to moist, 5-20% silt, <5% clay, local Fe-oxide stains, low to moderate porosity, low estimated permeability

(48-53.4) SANDSTONE: blue-gray, damp to moist, dries medium and light blue-gray, moderately indurated, fine to medium grained, 10% silt, low to moderate porosity and estimated permeability

(53.4-57.9) CLAYSTONE: brown, dry, moderately indurated, 5-15% silt, subhorizontal bedding, tight, low porosity, low estimated permeability

Fe-oxide stained (fossil ?) at 54.2 feet; Fe-oxide stained vertical worm tube at 57.2 feet

[DL, 57.7 and 58/subhorizontal/open fractures with orange-yellow and black (Fe- and Mn-oxide ?) stains]

(57.9-65) SANDSTONE: dark brown and black-brown, moist, moderate to well indurated, poorly sorted, fine to coarse grained, <3% silt, moderate to high porosity, moderate estimated permeability

silty claystone interbed at 59-59.5 feet; sandstone grades coarser towards base; sandstone contains subrounded pebbles to 2 inches at 64.8 feet

(65-84.2) CONGLOMERATE: red-brown, locally light gray, damp, well indurated, subrounded volcanic pebbles to 4 inches, minor chert and diabase clasts, abundant micas, low porosity, low estimated permeability

rounded volcanic pebbles to 3 inches at 69.5-71.7 feet

subrounded to well rounded pebbles to 3.2 inches, local siltstone lenses to 3 inches thick, and abundant Fe-oxide stained pebble rims at 74.5-76.5 feet

minor interbeds of cemented sandstone to 1.5 inches thick at 79.5-80.5 feet

(84.2-95.2) SANDSTONE: black to dark gray, damp to locally moist, moderately to well indurated, poorly sorted, fine to coarse grained, <1% silt, homogenous, moderate porosity, moderate estimated permeability

**** Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.**

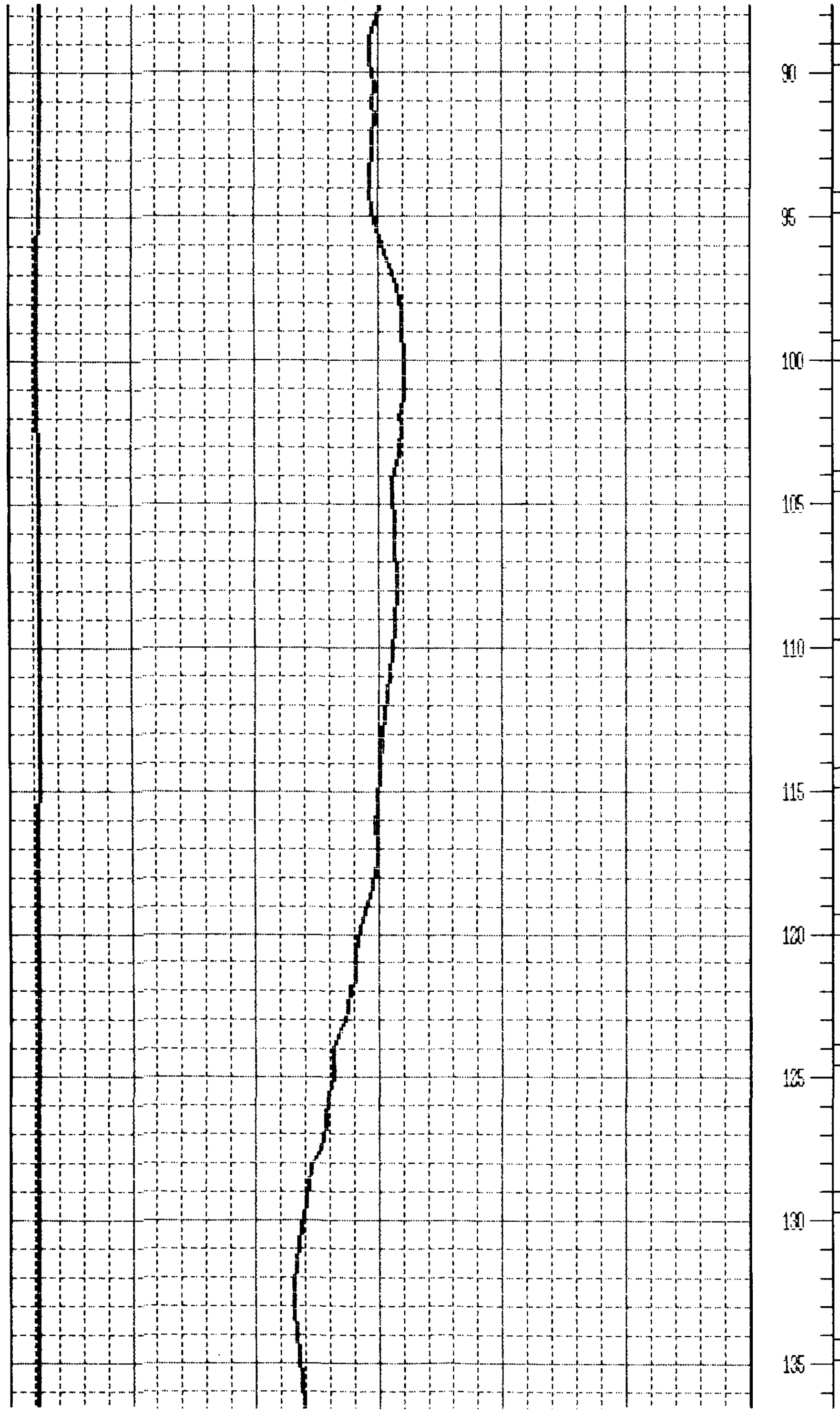
Discontinuity Log,
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

Ground Water:
Water was first encountered at 143.5 feet.
11/2/88 water was 132.16 feet below TOSP

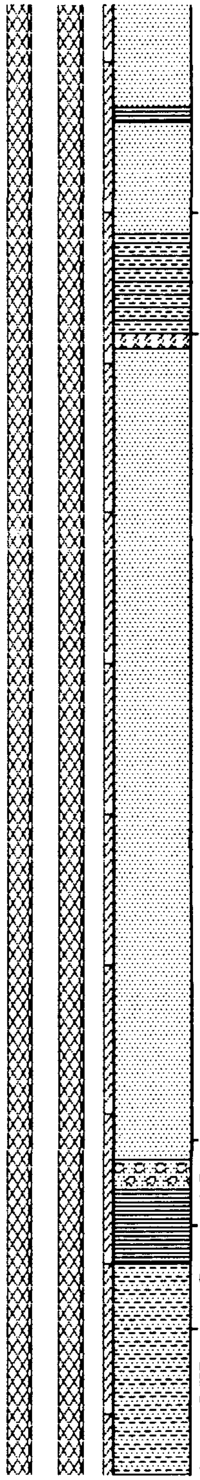
Well Completion:

- ☐ **CASING: 4.5 inch I.D. PVC**
- ▤ **SLOTTED CASING**
- ▒ **FINE SAND: #0 Sand**
- ░ **SAND PACK: #3 Sand**
- ■ **BENTONITE**
- ▩ **ANNULAR SEAL: Cement Grout**
- ▨ **SLOUGH:MATERIAL**

LOG: MONITOR WELL K9-02 (CONTINUED)



Run 19	100	58
Run 20	80	63
Run 21	90	80
Run 22	50	30
Run 23	72	58
Run 24	70	30
Run 25	90	68
Run 26	90	50
Run 27	90	40
Run 28	88	68



local Fe-oxide staining at 90-94 feet; brown, dry, claystone interbed at 91-91.5 feet

[DL, 91/22°/bedding contact; 91.4/18°/closed fracture with yellow stains]

(95.2-98.5) MUDSTONE: brown, dry to damp, moderately indurated, 40-50% silt, 40-50% clay, <3% very fine sand, low porosity, low estimated permeability

Fe- and Mn-oxide stained fossil leaves and stems to 2 inches at 95.7, 96.1, and 97.7 feet

---

(98.5-126) SANDSTONE: black to dark brown, damp to moist, dries blue-gray, poorly sorted, fine to coarse grained, <3% silt, (subhorizontal ?) bedding

[DL, 97.7/subhorizontal/fracture with yellow stains; 100-101/31-43°/Fe-oxide stained veins to 1/20 inch thick]

local orange-brown (Fe- and/or Mn-oxide) stains at 105-113.2 feet; homogenous at 109.5-113 feet

moist (to wet ?) at 116.5-118 feet

[DL, fractures: 120-120.2/2°/stained with Mn-oxide, 121.6/35-37°/3 fractues healed with Fe-oxide, and 125.5/26°/open with Fe-oxide stains]

brown sandstone interbed at 125.1-125.6 feet

(126-127) SANDSTONE: GRAVELLY, dark brown to black, moist, moderately indurated, medium to coarse grained, very coarse grained at base, moderate to high porosity and estimated permeability

---

(127-129.5) CLAYSTONE: light brown, dry to damp, well indurated, intensely fractured with fractures dipping 3-17°, locally blue-gray with yellow and black stains, low porosity, low estimated primary permeability, high estimated fracture permeability

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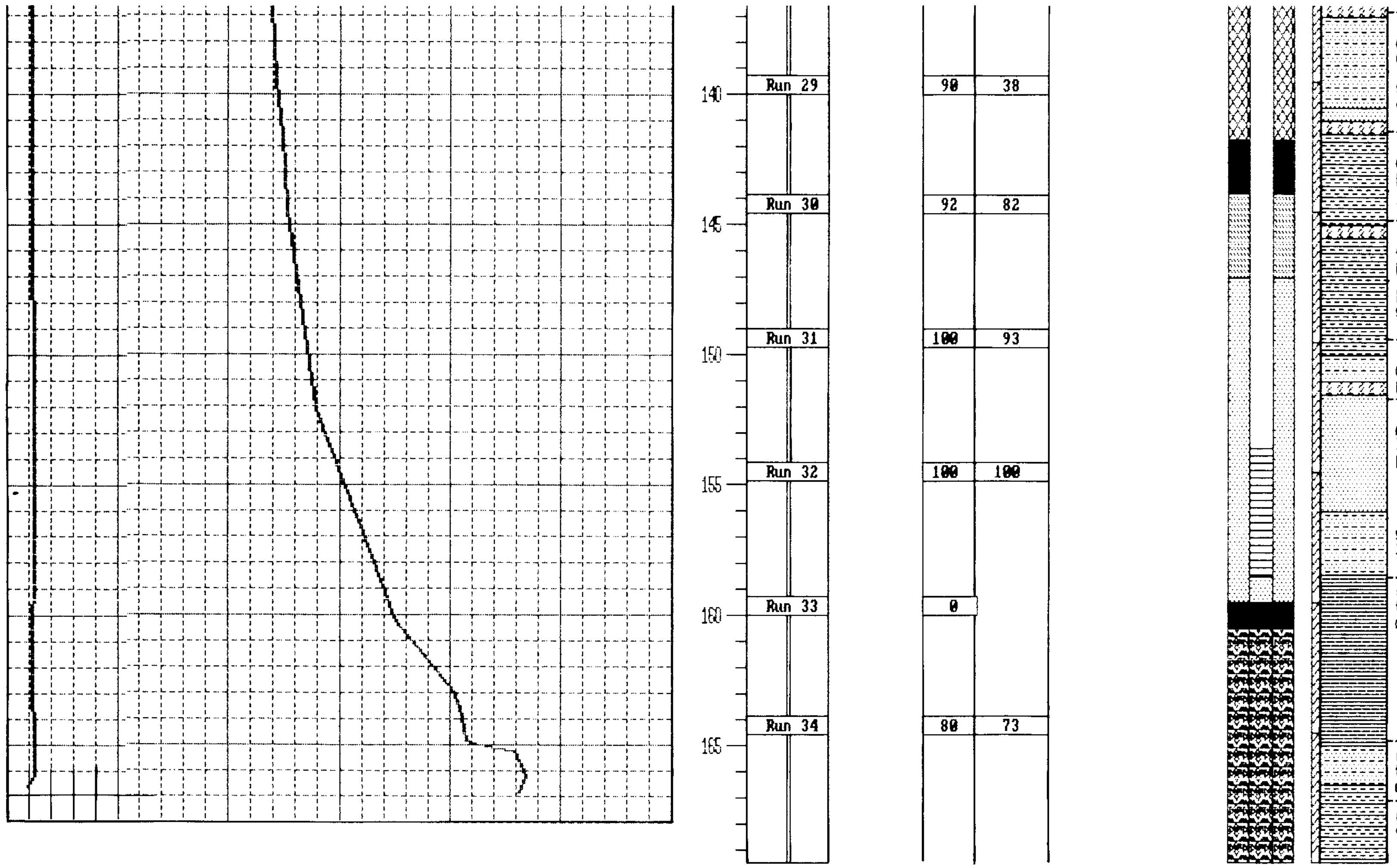
(129.5-136.5) SILTSTONE: SANDY, blue-gray to light blue-gray, damp, moderately indurated, 10-35% very fine sand, <5% clay, minor Fe-oxide stained nodules to 1/5 inch, tight, low porosity, low estimated permeability

[DL, 136.5/4-21° and subvertical/white (caliche and silica ?) veins to 1/10 inch thick; 138-138.6/subhorizontal/open fractures with black (Mn-oxide ?) stains]

LOG: MONITOR WELL K9-02 (CONTINUED)



(136.5-141) SANDSTONE: SILTY, light blue-gray to blue-gray, tight, dry to damp, 20-35% silt, 5-10% clay, tight, low porosity, low estimated permeability

sandstone interbed at 140.5-141 feet with bottom contact dipping 30° and some white caliche and (silica ?) veins dipping 20-30°

(141-145) SILTSTONE: CLAYEY, light blue-gray, dry to damp, 10-30% clay, 5-10% very fine sand, tight, low porosity, low estimated permeability

first water at 143.5 feet

(145-150) MUDSTONE: light blue-gray, dry to damp, 40-55% clay, 40-55% silt, <5% very fine sand, dispersed pryite-sulfides, low porosity, low estimated permeability

[DL, 146.5 and 147/subhorizontal/open fracture with black Mn-oxide stains]

(150-151) SANDSTONE: SILTY, light blue-gray, damp, very fine grained, 15-30% silt, 5-10% clay, low porosity, low estimated permeability

(151-158.4) SANDSTONE: dark blue to blue-brown, moist to wet, moderately indurated, poorly to moderately well sorted, medium to locally coarse grained, <5% silt, homogenous, moderate to high porosity, moderate estimated permeability

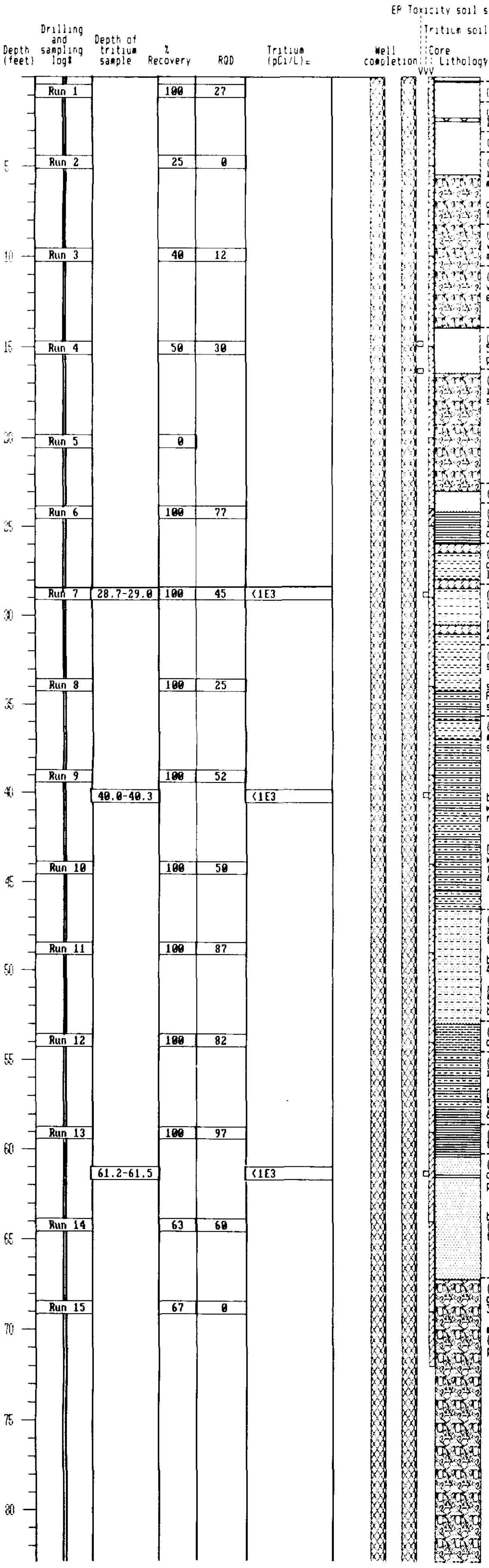
sandstone is wet with silt content increasing from <5% to 15-20% at 156-158.4 feet

(158.4-165) SILTSTONE: to SILTSTONE: SANDY, blue to green-gray, dry to barely damp, dries light blue-gray, 5-20% very fine sand, 5-15% clay, tight, low porosity, low estimated permeability

(165-166.5) SANDSTONE: SILTY, green-brown, dry to damp, moderately to well indurated, 10-25% silt, <5% clay, tight, low porosity, low estimated permeability

(166.5-169.5) SILTSTONE: CLAYEY, green-brown to brown, 20-35% clay, <2% very fine sand, low porosity, low estimated permeability

LOG: MONITOR WELL K9-03



Drilling and sampling log*	Depth of tritium sample	% Recovery	RQD	Tritium (pCi/L)‡
Run 1		100	27	
Run 2		25	0	
Run 3		40	12	
Run 4		50	30	
Run 5		0		
Run 6		100	77	
Run 7	28.7-29.0	100	45	<1E3
Run 8		100	25	
Run 9		100	52	
	40.0-40.3			<1E3
Run 10		100	50	
Run 11		100	87	
Run 12		100	82	
Run 13		100	97	
	61.2-61.5			<1E3
Run 14		63	60	
Run 15		67	0	

Lithologic descriptions and/or remarks**

(0-0.3) QUATERNARY ALLUVIAL DEPOSITS

(0-0.3) SILT: CLAYEY, [ML], dark brown, damp, medium stiff to stiff, local white (caliche ?), low estimated permeability

(0.3-164.5) TERTIARY SEDIMENTARY ROCKS

(0.3-2.5) SANDSTONE: brown, locally yellow-brown, damp, moderately indurated, fine to medium grained, <3% silt, moderate porosity, moderate estimated permeability

conglomerate interbed with volcanic pebbles to 1/2 inch at 2.3-2.5 feet; brown sandstone at 4.4 to 5.3 feet

(2.5-5.5) SANDSTONE: blue to brown-blue, dry, moderately indurated, very fine to fine grained, minor medium grained sand, low to moderate porosity, low estimated permeability

(5.5-14) CONGLOMERATE: brown, well indurated, damp, subrounded volcanic pebbles to 3 inches, sandy matrix, low porosity, low estimated permeability

(14-16.5) SANDSTONE: brown, dry to damp, fine to medium grained, 5-10% silt, horizontal to subhorizontal bedding, low to moderate porosity, low estimated permeability

(16.5-23) CONGLOMERATE: brown to red-brown, dry to damp, well indurated, rounded to subrounded pebbles to 3 inches, clast supported, sandy matrix, minor silt and clay, local yellow stains

(23-24.2) SANDSTONE: brown, damp, horizontal bedding

(24.2-26) CLAYSTONE: brown to light brown, dry, moderately indurated, <5% silt, very thin subhorizontal laminations, minor cross laminations, low porosity, low estimated permeability

(26-28) SILTSTONE: SANDY, brown, dry, moderately indurated, abundant cross laminations to 17°, fine grained sand and dark gray silt layers, low porosity, low estimated permeability

(28-30.6) SANDSTONE: SILTY, brown to dark brown, damp, moderately indurated, moderate porosity, low to moderate estimated permeability

[DL, fractures: 27.5/horizontal/with black (Mn-oxide ?) stains and 28.5-29/subvertical/filled]

(30.6-34.3) SILTSTONE: SANDY, brown, damp, 15-35% very fine to fine sand, 5-15% clay, low to moderate porosity, low estimated permeability

sparse brown claystone interbeds to 1.2 inches at 29-34.3 feet; Fe-oxide stained (fossils ?) at 31 and 37.7 feet; brown, damp sandy siltstone interbed with cross laminations to 16° at 35.9-37 feet

(34.3-46.5) CLAYSTONE: SILTY, brown, locally light brown, dry, moderately indurated, 5-25% silt, very thin horizontal to subhorizontal laminations, low porosity, low estimated permeability

brown, damp to dry, moderately indurated clayey siltstone interbeds with a low estimated permeability at 41-42.4 and 45.5-45.6 feet; rare fossil leaves at 43.8 feet

[DL, black and yellow stained intense fracture zone at 39.6-45 feet with subhorizontal, open, factures at 39.6-43.5 and 0° and 90° fractures at 43.5-45 feet; fractures: 41.8-42.1/subvertical and 45.5, 46, and 46.7/subhorizontal]

(46.5-53) SANDSTONE: SILTY, brown to black-brown, damp, moderately indurated, 5-25% silt, <5% clay, some cross laminations to 7°, low to moderate porosity, low estimated permeability

brown-gray to gray below 49 feet; 15-35% silt and low porosity below 49.3 feet

[DL, subhorizontal fractures: 48.7/with Mn-oxide stains and 50 and 50.6/open with orange (Fe-oxide) stains; 51.2-51.5/48°/closed with black-green and yellow stains]

(53-54.6) SILTSTONE: gray to brown-gray, dry, well indurated, 5-15% clay, 5-10% very fine sand, low porosity, low estimated permeability

(54.6-57.7) CLAYSTONE: SILTY, gray to blue-gray, dry, well indurated, 10-25% silt, low porosity, low estimated permeability

[DL,open fractures with no stains: 54.6-55/47° and 58.5-58.7/90°; 54.6 and 57.7/subhorizontal/unit contacts; bedding: 65.5/3-7° and 66.5/9°]

(57.7-60.4) CLAYSTONE: brown, dry, well indurated, 5-10% silt, waxy, tight, low porosity, low estimated permeability

(60.4-67.2) SANDSTONE: brown, damp, moderately indurated, medium to coarse grained, <2% silt, moderate to high porosity, high estimated permeability

brown claystone interbed at 61.4-61.6 feet; orange and yellow-brown (Fe-oxide) stained zone at 64.5-66.5 feet; claystone rip-up clasts to 1.2 inches at 66.5 feet

(67.2-83.5) CONGLOMERATE: brown and red-brown, locally blue-gray, dry, very well indurated, subrounded volcanic pebbles and cobbles to 3 inches, minor claystone clasts, clast supported, sandy matrix,

minor fines, minor claystone and sandstone interbeds to 3 inches (from driller and cuttings), low porosity, low estimated permeability; lower contact from driller

Monitor Well K9-03

Geologic Logging:
M. Wade, Weiss Associates, Oakland, CA

Well Location:
South of Well K9-01, Pit 9 Area, Site 300

Coordinates:
N: 423,254.5
E: 1,700,954.8

Elevation: Shiner 1114.42 feet
Top of Protective Casing (TOSP) 1117.08 feet

Geophysical Logging: See Wells K9-01 and K9-02

Drilling:
D. Wagster, D. Kelsey, and G. Hickmon,
P. C. Exploration Inc., Roseville, CA

Dates Drilled: 10/13 to 10/31/88

Drilling Method:
- 4 1/4-inch air rotary, wireline coring, 0-10 feet
- 4 1/4-inch air-mist rotary, wireline coring, 10-23 feet
- 4-inch tri-cone rotary, 23-24 feet
- 4 1/4-inch air-mist rotary, wireline coring, 23-72 feet
- 4-inch tri-cone rotary, 72-84 feet
- 4 1/4-inch air-mist rotary, wireline coring, 72-164.5 feet
- 9-inch tri-cone rotary, ream, 0-164.5 feet
- install 4 1/2-inch PVC casing with 0.015-inch slots at 156-160.7 feet

* Key: Drilling and Sampling Log

Run 1 ‖ Core obtained using Christensen HQ (92 mm) Wireline Coring System. Tritium samples taken from core, placed in glass jar, sealed with watertight tape, and frozen later that day.

Analytical Notes:

‡ Tritium activities are given in exponential notation with the counting uncertainty (2 std. dev.) in parentheses:

6.24E2(1.9) = (6.24 ± 1.9) x 10^2 pCi/l.

If the tritium activities is less than the uncertainty, then the tritium is reported as less than the uncertainty:

<2.92E2

The following activities of uranium isotopes were identifed above a counting uncertainty (2 std. dev.) of 0.2 pCi/gm:

28.7 feet:	0.7 pCi/gm 238U
	0.6 pCi/gm 234U
40 feet:	0.9 pCi/gm 238U
	0.7 pCi/gm 234U
85 feet:	1.2 pCi/gm 238U
	1.1 pCi/gm 234U
126.5 feet:	0.7 pCi/gm 238U
	0.8 pCi/gm 234U
154.2 feet:	0.8 pCi/gm 238U
	0.8 pCi/gm 234U

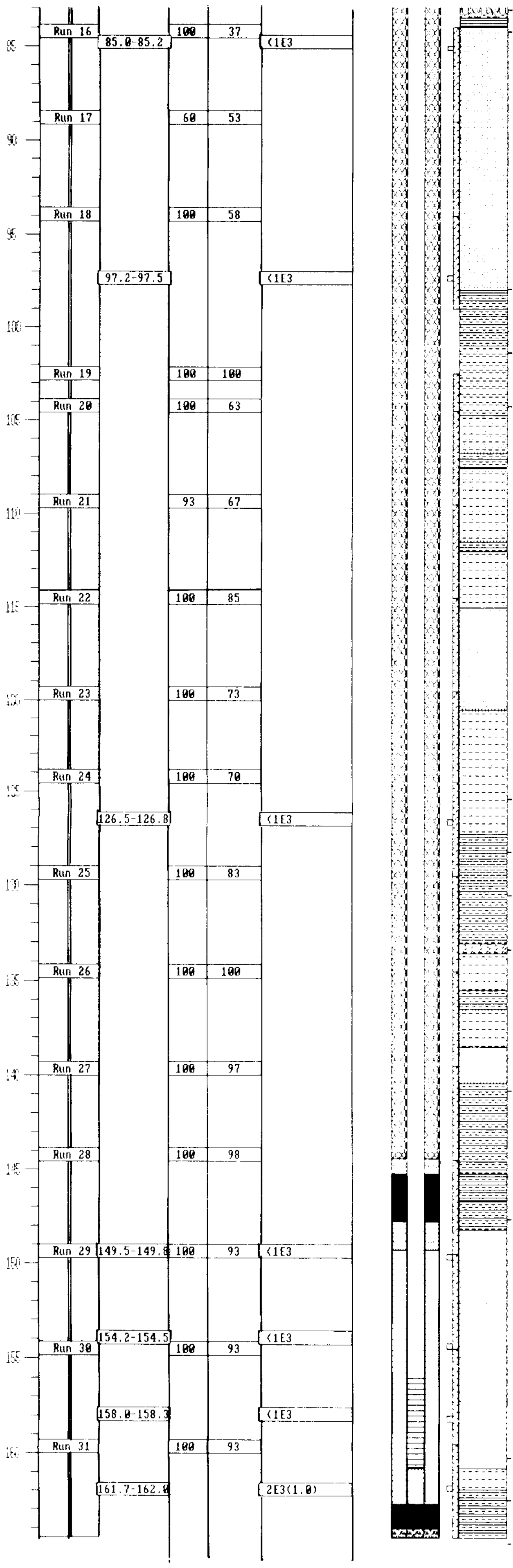
No 235U was identified above the counting uncertainty.

Soil samples from 14.7 and 16.2 feet were analyzed for 9 soluble metals, including beryllium and lead, by the EP Toxicity test. No metals were identified above STLCs in these samples.

** Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

Discontinuity Log,
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

LOG: MONITOR WELL K9–03 (CONTINUED)



(83.5-84) CLAYSTONE: brown, <5% silt; from cuttings

(84-98.3) SANDSTONE: dark brown, damp, locally moist, moderately indurated, fine to medium grained, <5% silt, subhorizontal bedding, abundant Fe-oxide blebs, moderate porosity, moderate estimated permeability

sandstone becomes massive at 89 feet

becomes medium to coarse grained at 95 feet; claystone interbed at 98-98.3 feet; Fe-oxide stained leaf fossil at 98.3 feet; (caliche ?) veinlets at 98.3 feet

[DL, 98-98.3/subhorizontal/fracture]

(98.3-101) SILTSTONE: CLAYEY, brown-gray, dry, moderately indurated, 15-30% clay, 5-15% very fine sand, tight, low porosity, low estimated permeability

siltstone becomes yellow-brown at 100.5 feet

(101-104.7) SILTSTONE: SANDY, yellow-brown, damp, moderately indurated, 5-25% very fine sand, 5-15% clay, local Fe-oxide stains, tight, low porosity, low estimated permeability

(104.7-127.3) SANDSTONE: SILTY, dark brown, dries blue-gray, damp, moderately indurated, fine to medium grained, locally coarse grained, 5-20% silt, subhorizontal bedding, cross laminations dip to 9°, low to moderate porosity and estimated permeability

[DL, subhorizontal fractures with Mn- and Fe-oxide stains at 105.4, 105.7, 105.9, and 109 feet; 107.4/90°/open fracture with Mn-oxide stains]

light brown clayey siltstone interbed at 106.8-107.6 and 111.5-112 feet

[DL, fractures: 111.5-112/subvertical/with Mn-oxide stains and 115-116.6/vertical/closed with Fe-oxide stains; 111.5/11°/bedding]

coarse grained sandstone at 112.5-114.3 feet; sandstone is massive with <3% silt at 115-120.5

becomes damp to moist, very thinly bedded, with a high porosity and moderate to high estimated permeability at 120.5-124.5 feet

[DL, 120.5-124.5/6°/bedding; fractures: 125-127.3/69-97°, 125-125.5/69°/with black, brown, and yellow stains, and 127.7-128.6/90°/with green-yellow, black, and orange stains]

(127.3-128.6) CLAYSTONE: SILTY, brown, dries light brown, dry to damp, moderately to well indurated, 5-20% silt, <5% very fine sand, subhorizontal bedding, cross laminations to 9°, low porosity, low estimated permeability; undulating upper contact

(128.6-130) SILTSTONE: local clayey siltstone, brown, dries light blue-gray, damp, moderately indurated, 5-20% clay, 5-15% very fine sand, low porosity, low estimated permeability

(130-133.1) SILTSTONE: CLAYEY, blue-green and gray-green, dries blue-gray, damp, moderately indurated, 15-25% clay, 5-20% very fine sand, abundant sulfides, low porosity and estimated permeability

(133.1-140.4) SANDSTONE: SILTY, blue-green to blue-gray, dries light blue-gray, dry to damp, moderately indurated, 15-30% silt, 0-10% clay, rare subhorizontal carbonate veins, subhorizontal bedding, low porosity, low estimated permeability

[DL, fractures: 129-129.4/64°/open with yellow-green and Mn-oxide stains, 129.3/24°/closed, and 136/subvertical; subhorizontal fractures with black and brown stains at 140.4, 140.7, 140.2, 144, 145.3, and 145.5 feet]

clayey siltstone at 135.5-136.5 feet; subhorizontal sandstone interbed at 138.5-140.4 feet

(140.4-148.2) SILTSTONE: CLAYEY, light blue-gray to blue-brown, dry, moderately to well indurated, 25-40% clay, <5% very fine sand, disseminated sulfides, very thinly laminated, bedding dips 4°, low porosity, low estimated permeability

dry silty claystone interbed at 145.2-146.7 feet

(148.2-160.8) SANDSTONE: dark brown to blue-brown, dries light blue-gray, moist to wet, moderately indurated, moderately well sorted, fine to coarse grained, <5% silt, semi-massive, moderate to high porosity and estimated permeability

first water at 148.2 feet

[DL, bedding: 153-154/14° and 157-159/21°; 162.5/subhorizontal/fracture with black Mn-oxide stains]

moist to wet sandstone lenses to 2 inches thick at 153-154 feet; local moist silty sandstone with 5-15% silt at 158.4-159.5 feet; carbonate ring to 4/5 inch at 162.7 feet; abundant sulfides at 164 feet

(160.8-161.9) SANDSTONE: SILTY, blue-green to locally blue-gray, dry to damp, well indurated, 15-30% silt, <5% clay, cross laminations to 8°, tight, low porosity, low estimated permeability

(161.9-164.5) CLAYSTONE: SILTY, blue-green, locally blue-gray, dry, well indurated, 15-25% silt, waxy, tight, low porosity, low estimated permeability

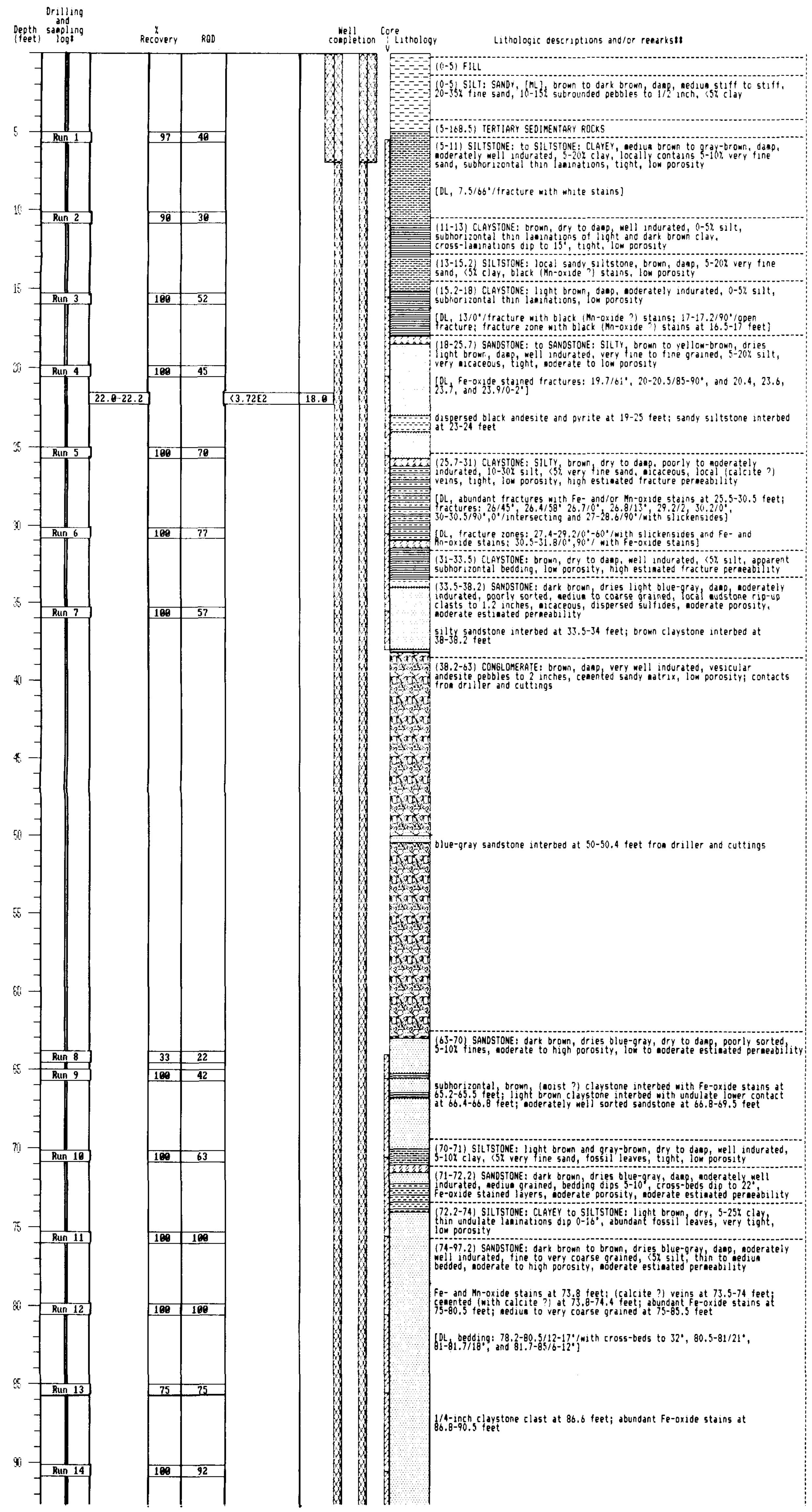
Ground Water:

Water was first encountered at 148.2 feet.
11/2/88 water was 120.3 feet below G.L.
4/5/89 water was 121.9 feet below TOSP.

Well Completion:

□ **CASING: 4.5 inch I.D. PVC**
☰ **SLOTTED CASING**
▒ **FINE SAND: #0 Sand**
░ **SAND PACK: #3 Sand**
■ **BENTONITE**
▩ **ANNULAR SEAL: Cement Grout**
▦ **SLOUGH:MATERIAL**

LOG: MONITOR WELL K9-04



Drilling and sampling log‡	% Recovery	RQD
Run 1	97	40
Run 2	90	30
Run 3	100	52
Run 4	100	45
Run 5	100	70
Run 6	100	77
Run 7	100	57
Run 8	33	22
Run 9	100	42
Run 10	100	63
Run 11	100	100
Run 12	100	100
Run 13	75	75
Run 14	100	92

(0-5) FILL

(0-5) SILT: SANDY, [ML], brown to dark brown, damp, medium stiff to stiff, 20-35% fine sand, 10-15% subrounded pebbles to 1/2 inch, <5% clay

(5-168.5) TERTIARY SEDIMENTARY ROCKS

(5-11) SILTSTONE: to SILTSTONE: CLAYEY, medium brown to gray-brown, damp, moderately well indurated, 5-20% clay, locally contains 5-10% very fine sand, subhorizontal thin laminations, tight, low porosity

[DL, 7.5/66°/fracture with white stains]

(11-13) CLAYSTONE: brown, dry to damp, well indurated, 0-5% silt, subhorizontal thin laminations of light and dark brown clay, cross-laminations dip to 15°, tight, low porosity

(13-15.2) SILTSTONE: local sandy siltstone, brown, damp, 5-20% very fine sand, <5% clay, black (Mn-oxide ?) stains, low porosity

(15.2-18) CLAYSTONE: light brown, damp, moderately indurated, 0-5% silt, subhorizontal thin laminations, low porosity

[DL, 13/0°/fracture with black (Mn-oxide ?) stains; 17-17.2/90°/open fracture; fracture zone with black (Mn-oxide ?) stains at 16.5-17 feet]

(18-25.7) SANDSTONE: to SANDSTONE: SILTY, brown to yellow-brown, dries light brown, damp, well indurated, very fine to fine grained, 5-20% silt, very micaceous, tight, moderate to low porosity

[DL, Fe-oxide stained fractures: 19.7/61°, 20-20.5/85-90°, and 20.4, 23.6, 23.7, and 23.9/0-2°]

dispersed black andesite and pyrite at 19-25 feet; sandy siltstone interbed at 23-24 feet

(25.7-31) CLAYSTONE: SILTY, brown, dry to damp, poorly to moderately indurated, 10-30% silt, <5% very fine sand, micaceous, local (calcite ?) veins, tight, low porosity, high estimated fracture permeability

[DL, abundant fractures with Fe- and/or Mn-oxide stains at 25.5-30.5 feet; fractures: 26/45°, 26.4/58° 26.7/0°, 26.8/13°, 29.2/2, 30.2/0°, 30-30.5/90°,0°/intersecting and 27-28.6/90°/with slickensides]

[DL, fracture zones: 27.4-29.2/0°-60°/with slickensides and Fe- and Mn-oxide stains; 30.5-31.8/0°,90°/ with Fe-oxide stains]

(31-33.5) CLAYSTONE: brown, dry to damp, well indurated, <5% silt, apparent subhorizontal bedding, low porosity, high estimated fracture permeability

(33.5-38.2) SANDSTONE: dark brown, dries light blue-gray, damp, moderately indurated, poorly sorted, medium to coarse grained, local mudstone rip-up clasts to 1.2 inches, micaceous, dispersed sulfides, moderate porosity, moderate estimated permeability

silty sandstone interbed at 33.5-34 feet; brown claystone interbed at 38-38.2 feet

(38.2-63) CONGLOMERATE: brown, damp, very well indurated, vesicular andesite pebbles to 2 inches, cemented sandy matrix, low porosity; contacts from driller and cuttings

blue-gray sandstone interbed at 50-50.4 feet from driller and cuttings

(63-70) SANDSTONE: dark brown, dries blue-gray, dry to damp, poorly sorted, 5-10% fines, moderate to high porosity, low to moderate estimated permeability

subhorizontal, brown, (moist ?) claystone interbed with Fe-oxide stains at 65.2-65.5 feet; light brown claystone interbed with undulate lower contact at 66.4-66.8 feet; moderately well sorted sandstone at 66.8-69.5 feet

(70-71) SILTSTONE: light brown and gray-brown, dry to damp, well indurated, 5-10% clay, <5% very fine sand, fossil leaves, tight, low porosity

(71-72.2) SANDSTONE: dark brown, dries blue-gray, damp, moderately well indurated, medium grained, bedding dips 5-10°, cross-beds dip to 22°, Fe-oxide stained layers, moderate porosity, moderate estimated permeability

(72.2-74) SILTSTONE: CLAYEY to SILTSTONE: light brown, dry, 5-25% clay, thin undulate laminations dip 0-16°, abundant fossil leaves, very tight, low porosity

(74-97.2) SANDSTONE: dark brown to brown, dries blue-gray, damp, moderately well indurated, fine to very coarse grained, <5% silt, thin to medium bedded, moderate to high porosity, moderate estimated permeability

Fe- and Mn-oxide stains at 73.8 feet; (calcite ?) veins at 73.5-74 feet; cemented (with calcite ?) at 73.8-74.4 feet; abundant Fe-oxide stains at 75-80.5 feet; medium to very coarse grained at 75-85.5 feet

[DL, bedding: 78.2-80.5/12-17°/with cross-beds to 32°, 80.5-81/21°, 81-81.7/18°, and 81.7-85/6-12°]

1/4-inch claystone clast at 86.6 feet; abundant Fe-oxide stains at 86.8-90.5 feet

Monitor Well K9-04

Geologic Logging:
M. Wade, Weiss Associates, Oakland, CA

Well Location:
Southeast of Well K9-01 and northwest of
Well K9-03, Pit 9 Area, Site 300

Coordinates:
N: 423,354.6
E: 1,700,922.2

Elevation: Shiner 1081.95 feet
Top of Protective Casing (TOSP) 1084.62 feet

Geophysical Logging: See Wells K9-01 and K9-02

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 2/2 to 2/22/89

Drilling Method:
4 1/4-inch air-mist rotary, wireline coring 0-38 feet
4 1/4-inch tricone rotary, 38-64 feet
4 1/4-inch air-mist rotary, wireline coring 64-168.5 feet
backfill with bentonite, 145-168.5 feet
9-inch tri-cone rotary, ream 0-145.1 feet
install 4 1/2-inch PVC casing with 0.015-inch slots at 138.1-143.1 feet

‡ Key: Drilling and Sampling Log

Run 1 ‖ Core obtained using Christensen HQ (92 mm) Wireline Coring System. Tritium samples taken from core, placed in glass jar, sealed with watertight tape, and frozen later that day.

ǂ Tritium activities are given in exponential notation with the counting uncertainty (2 std. dev.) in parentheses:
6.24E2(1.9) = (6.24 ± 1.9) x 10^2 pCi/l.
If the tritium activity is less than the uncertainty, then the tritium is reported as less than the uncertainty:
<2.92E2

‡‡ Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates. Unless stated otherwise the estimated primary and fracture permeability are low.

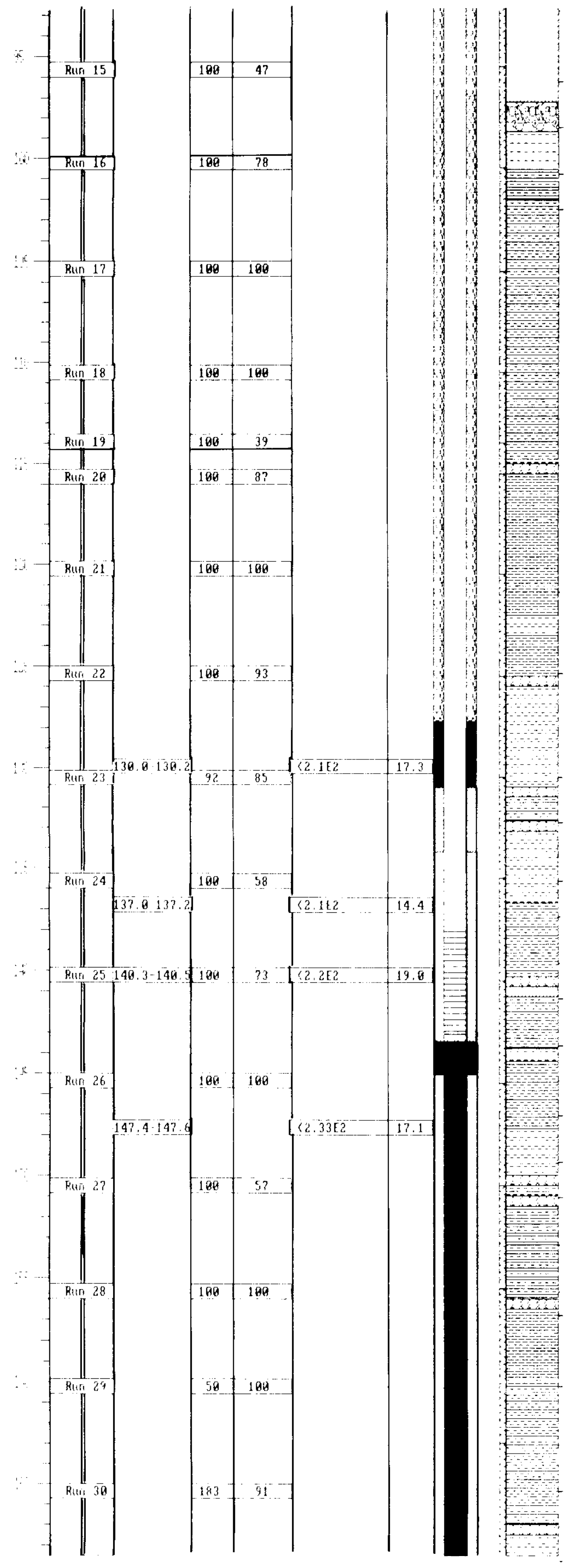
Discontinuity Log,
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

Ground Water:
Water was first encountered at 119 feet.
11/2/88 water was 120.3 feet below G.L.
5/10/89 water was 130.66 feet below TOSP

Well Completion:

- ☐ **CASING: 4.5 inch I.D. PVC**
- ▤ **SLOTTED CASING**
- ▦ **FINE SAND: #0 Sand**
- ░ **SAND PACK: #3 Sand**
- ■ **BENTONITE**
- ▩ **ANNULAR SEAL: Cement Grout**
- ▧ **SLOUGH:MATERIAL**

LOG: MONITOR WELL K9-04 (CONTINUED)



[DL, 90.5-95.5/subhorizontal bedding; 94.6/3°/orange Fe-oxide stained fracture; 96.2/40-45°/orientation of Fe-oxide stains]

very coarse grained with abundant claystone rip-up clasts oriented parallel to bedding at 93.5-95.5 feet

(97.2-98.7) BRECCIA: brown, dry to damp, moderately indurated, abundant claystone and siltstone rip-up clasts oriented parallel to bedding, thin sandstone layers to 0.8 inch thick, low porosity

(98.7-100.6) SANDSTONE: SILTY, brown to gray-brown, damp, moderately indurated, 15-30% silt, some Fe- and Mn-oxide stains, tight, low to moderate porosity

(100.6-102.1) CLAYSTONE: to CLAYSTONE: SILTY, light brown, dry, poorly indurated, 5-20% silt, low porosity, high estimated fracture permeability

(102.1-115) SILTSTONE: CLAYEY, blue- to green-gray, dry to damp, 20-40% clay, <5% very fine sand, bedding dips from 11° to subhorizontal, tight, low porosity

[DL, fractures with abundant Fe- and Mn-oxide stains: 99-99.7/90° and 101.7-102.1/several 0-10°/open; fractures with green stains: 102.7/4° and 103.2/0°; 107.2/23°/healed fracture (with calcite ?)]

fossil leaves at 101-101.8 feet; cemented at 101.7-102.3 feet; locally cemented at 102.3-105.1 feet; 15-20% sand at 104.5-105.5 feet; abundant randomly oriented white (calcite ?) veins to 0.1 inch thick at 108.1-110.3 feet

[DL, fractures with Mn-oxide stains and fossil leaves: 113.5/30° and 113.8/26°; 114.5-114.5/subhorizontal/fracture with Mn-oxide stains]

wood fragments to 0.3 inch at 112.3 feet; green to green-gray at 114.4-114.8 feet; cemented, 10-20% clay, and 5-15% very fine sand at 114.8-115.5 feet

(115-125.5) SILTSTONE: light blue-gray, dry to locally damp, cemented, 5-15% very fine sand, 5-15% clay, bedding dips 0-6° with cross-laminations dipping to 14°, low porosity

[DL, fractures: 117/3°/with Mn-oxide stains, 118.2-118.9/85°/open with white (calcite ?), 120.5/0°/with Mn-oxide stains, and 120.7/90°/open with minor slickensides; fracture zone with Mn-oxide stains at 118.8 feet]

leaf and wood fossils at 120.3 feet; very fine grained silty sandstone interbed with 25-30% silt and 5-10% clay at 122.5-123.5 feet

[DL, 122.1/0°/healed fracture (with calcite ?); 122.5-123.5/5-12°/bedding in silty sandstone interbed]

(125.5-131) SILTSTONE: SANDY, light blue-gray, minor green and purple, damp, locally cemented, 20-35% very fine to fine sand, 5-15% clay, subhorizontal bedding, abundant red grains, low porosity

(131-132.7) SILTSTONE: to SILTSTONE: CLAYEY, green-gray to purple-gray, dry to damp, very well indurated, 5-20% clay, <5% very fine sand, subhorizontal bedding, low porosity

(132.7-136.7) interbedded SANDSTONE: SILTY (30-40% silt) and SILTSTONE: SANDY (30-40% fine to medium sand), light gray and purple green-gray, dry to damp, locally cemented, subhorizontal bedding, low (to moderate ?) porosity

(136.7-140.3) SILTSTONE: CLAYEY, green, damp, poorly to moderately indurated, 15-35% clay, 5% fine sand, low porosity

[DL, fracture zone with slickensides and gouge at 136.7-138.5 feet; 142.4-142.6/79°/possible water-bearing fracture with slickensides; fault zone at 136-146 feet]

medium sand content increases from 15% to 25% at 139.5-140.3 feet; no apparent production at drilling depth 140.3 feet

(140.3-141.3) SANDSTONE: green, damp (to wet ?), poorly indurated, crumbles easily, locally cemented, medium to coarse grained, <5% silt, high porosity, moderate estimated permeability

(141.3-147.7) SILTSTONE: CLAYEY, green to gray-green, damp, very well indurated, 20-30% clay, 15% very fine to fine sand, micaceous, low porosity

damp, medium to coarse grained silty sandstone interbed at 143.8-144.4 feet

(147.7-150) SILTSTONE: SANDY, green, damp, well indurated, 20-35% very fine to fine sand, 5-15% clay, local sulfides, medium grained mica flakes, low porosity

(150-151) SILTSTONE: CLAYEY, green to gray-green, dry to damp, well indurated, waxy, 25-35% clay, 5-10% very fine sand, low porosity

(151-156) CLAYSTONE: SILTY, green, locally brown and gray-brown, dry to damp, poorly to moderately indurated, 20-35% silt, <2% very fine sand, low porosity, moderate estimated fracture permeability

[DL, fractures with slickensides (suggesting dextral movement): 150.3/34°/closed, 153/33°, 153.2-153.6/90°, 153.7/25°, and 154.5-155.4/90°; intense fracture zone with slickensides at 153.7-154.5 feet]

clay content increases below 150.5 feet; blue-green below 155.5 feet

(156-160.2) SILTSTONE: local sandy siltstone, gray-green and blue gray-green, damp, very well indurated, 5-25% fine to medium sand, 5-10% clay, micaceous, abundant chert fragments to 1/4 inch, low to moderate porosity

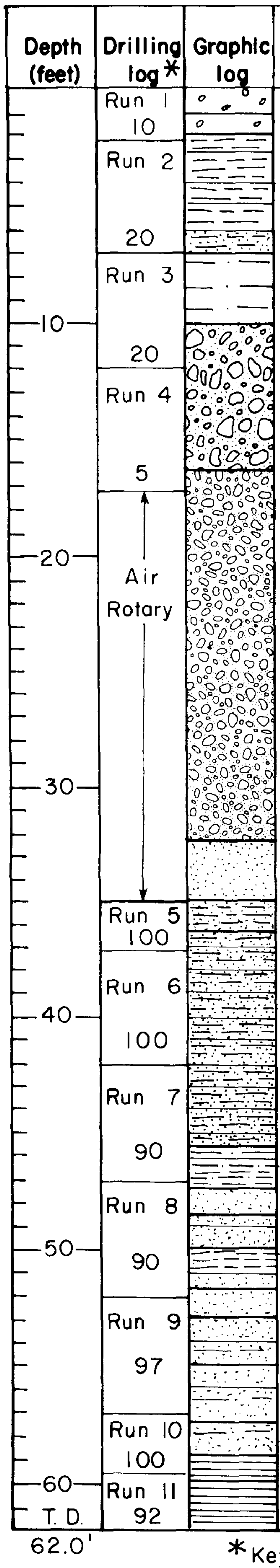
(160.2-167) SILTSTONE: CLAYEY, blue-green, dry to damp, 25-35% clay, 5-10% fine sand, local subrounded green pebbles to 1/4 inch, low porosity

local silty claystone at 163-166 feet

(167-168.5) SILTSTONE: SANDY, gray-green, damp, well indurated, 25-35% fine sand, 5-15% clay, some silica nodules and green claystone clasts, low porosity

[DL, crumbly fracture zone with minor slickensides and a low to moderate estimated fracture permeability at 167.5-168.5 feet]

SUMMARY LOG K 845-1



Geologic Description

0-2 <u>FILL</u>
ANGULAR TO SUBANGULAR FINE <u>GRAVEL</u>, BROWN-GRAY.

2-16.5 <u>ALLUVIAL DEPOSITS</u>
2-10 <u>SILTY CLAY</u> GRADING DOWNWARD TO <u>SANDY SILT</u>, MATERIAL DEVELOPS SHRINKAGE CRACKS ON DRYING.

2-7 DARK BROWN.
7-10 LIGHT BROWN WITH SCATTERED CALICHE.

10-16.5 <u>GRAVEL</u>, SUBROUNDED TO ROUNDED, 1/2" DIA., TRACES OF LIGHT BROWN CLAYEY SAND MATRIX. (POSSIBLE DECOMPOSED CONGLOMERATE).

16.5-62.0 <u>NEROLY FORMATION</u>

16.5-32.5 <u>CONGLOMERATE</u>. ROUNDED PEBBLE AND COBBLE-SIZED CLASTS IN SANDSTONE MATRIX. LOCAL INCREASES IN SAND SUGGESTING PEBBLY SANDSTONE LENSES. HARD DRILLING.

32.5-35.0 <u>SANDSTONE</u>, SCATTERED 1/4-3/4" PEBBLES.

35.0-36.4 <u>SILTY CLAYSTONE</u> GRADING DOWN TO <u>SANDY SILTSTONE</u>. BROWN, DRIES LIGHT GRAY; LEAF FOSSILS ON SUBHORIZONTAL BEDDING PLANES; PROMINENT FE-OXIDE STAINED VOIDS.
35-36 CORE BROKEN ALONG JOINT WITH 80° DIP.
36.4-45.6 <u>SANDSTONE</u> WITH <u>CLAYEY SILTSTONE INTERBEDS</u>. SAND DOMINANTLY FINE, LOCALLY MEDIUM AND COARSE GRAINED, BLACK, DRIES BLUISH GRAY. MOSTLY HARD, COARSER INTERVALS FRIABLE WITH DIFFICULTY. <u>SILTY CLAYSTONE</u> HARD, BROWN TO GRAY, BEDS 0.05-0.5' THICK, DIPS VARY FROM 0-20°.

45.6-47.3 <u>SILTSTONE</u>. MASSIVE, INCREASING SAND DOWNWARD. BROWN, DRIES GRAY. CONTAINS HEALED, LIMONITE STAINED FRACTURE, DIP 70°.
47.3-48.5 <u>SANDSTONE</u>. MEDIUM GRAINED, BLACK, DRIES BLUISH GRAY; VERY IRREGULAR LOWER CONTACT WITH PROMINENT LIMONITE STAIN.
47.5-50.0 CORE BROKEN ALONG NEAR VERTICAL JOINT.
48.5-51.6 <u>SILTSTONE</u> WITH <u>SANDSTONE</u> LENSES. FINE GRAINED, HARD; SHALY, LEAF FOSSILS ON BEDDING PLANES.
51.0-51.6 GRADES CLAYEY, HARD AND WAXY.
51.6-59.0 <u>SANDSTONE</u>. VARIES FROM FINE TO COARSE GRAINED. BLACK TO GRAY BROWN, ABUNDANT FE-OXIDE, DRIES BLUISH GRAY. MOSTLY HARD, LOCALLY FRIABLE WITH DIFFICULTY. BEDDING DIPS 25°, BOTTOM CONTACT HORIZONTAL.
56.5-57.5 CONGLOMERATE, INCLUDES 2.5"+ CLAYSTONE COBBLE.
52-53 HEALED JOINTS, DIP 55° AND 90°.
55' OPEN, INTERSECTING JOINTS, DIP 60°.
59.0-62.0 <u>CLAYSTONE</u> GRADING DOWN TO <u>SANDY SILTSTONE</u>. HARD, LIGHT BROWN, DRIES GRAY, FE-OXIDE STAINS.
60.0 NEAR VERTICAL JOINT.
61.5 JOINT, DIPS 45°, FE AND MN-OXIDE STAINS.

*Key:
Run 5 – Core run number
100 – Percent core recovered

Appendix B

Analytical Results

Table B-1. Analytical results of soil and rock core collected at Pit 9.

Borehole	Date Sampled	Depth (ft)	Parameter(s)	Result
K9-01	2/18/87	5.0	Tritium	3.64E2pCi/L±1.9
		10.0	Tritium	<2.92E2[a]
		15.0	Tritium	<3.28E2[a]
K9-03	10/13/88	14.75	<u>EP-Toxicity Extraction</u>	
			Arsenic	<0.01 mg/L
			Barium	<0.03 mg/L
			Cadmium	<0.02 mg/L
			Chromium	<0.02 mg/L
			Lead	<0.05 mg/L
			Mercury	<0.0005 mg/L
			Selenium	<0.02 mg/L
			Silver	<0.03 mg/L
			Beryllium	<0.001 mg/L
	10/13/88	16.25	<u>EP-Toxicity Extraction</u>	
			Arsenic	<0.01 mg/L
			Barium	<0.045 mg/L
			Cadmium	<0.02 mg/L
			Chromium	<0.02 mg/L
			Lead	<0.05 mg/L
			Mercury	<0.0005 mg/L
			Selenium	<0.02 mg/L
			Silver	<0.03 mg/L
			Beryllium	<0.001 mg/L
	10/13/88	28.8	Tritium	0 pCi/L±1000
			Uranium-238	0.7 pCi/g ± 0.2
			Uranium-235	0 pCi/g ± 0.2
			Uranium-234	0.6 pCi/g ± 0.2
	10/14/88	40.0	Tritium	0 pCi/L ± 1000
			Uranium-238	0.9 pCi/g ± 0.2
			Uranium-235	0 pCi/g ± 0.2
			Uranium-234	0.7 pCi/g ± 0.2
	10/14/88	61.2	Tritium	0 pCi/L ± 1000
	10/17/88	85.0	Tritium	0 pCi/L ± 1000
			Uranium-238	1.2 pCi/g ± 0.2
			Uranium-235	0 pCi/g ± 0.2
			Uranium-234	1.1 pCi/g ± 0.2
	10/17/88	97.5	Tritium	0 pCi/L ± 1000

Table B-1. (Continued.)

Borehole	Date Sampled	Depth (ft)	Parameter(s)	Result
K9-03	10/18/88	126.5	Tritium	0 pCi/L ± 1000
			Uranium-238	0.7 pCi/g ± 0.2
			Uranium-235	0 pCi/g ± 0.2
			Uranium-234	0.8 pCi/g ± 0.2
	10/18/88	149.5	Tritium	0 pCi/L ± 1000
	10/19/88	154.3	Tritium	0 pCi/L ± 1000
			Uranium-238	0.8 pCi/g ± 0.2
			Uranium-235	0 pCi/g ± 0.2
			Uranium-234	0.8 pCi/g ± 0.2
	10/19/88	158.0	Tritium	0 pCi/L ± 1000
	10/19/88	161.3	Tritium	2000 pCi/L ± 1000
K9-04	2/6/89	22.0	Tritium	<372[a]
	2/9/89	130.0	Tritium	<210[a]
	3/10/89	137.0	Tritium	<210[a]
	3/10/89	140.3	Tritium	<220[a]
	3/10/89	147.4	Tritium	<233[a]

[a] These results are reported as less than the limits of sensitivity for the analysis (2 standard deviations). This is equivalent to results reported as 0 ± 2 standard deviations.

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area.

Parameters	Well K9-01
	4th quarter 1987
EPA Method 624	
Date sampled	12/08/87
Date extracted	12/19/87
1, 1, 2, 2-Tetrachloroethane, µg/L	<1
1, 1, 1-Trichloroethane, µg/L	<1
1, 1, 2-Trichloroethane, µg/L	<1
1, 1-Dichloroethane, µg/L	<1
1, 1-Dichloroethylene, µg/L	<1
1, 2-Dichloroethane, µg/L	<1
1, 2-Dichloroethylene (total), µg/L	<1
1, 2-Dichloropropane, µg/L	<1
2-Chloroethylvinylether, µg/L	<1
Bromodichloromethane, µg/L	<1
Bromomethane, µg/L	<1
Bromoform, µg/L	<1
Chlorobenzene, µg/L	<1
Carbon Tetrachloride, µg/L	<1
Chloroethane, µg/L	<1
Chloroform, µg/L	<1
Chloromethane, µg/L	<1
Dibromochloromethane, µg/L	<1
Methylene chloride, µg/L	<1
Tetrachloroethylene, µg/L	<1
Trichloroethylene, µg/L	<1
Trichlorofluoromethane, µg/L	<1
Vinyl chloride, µg/L	<1
trans-1, 3-Dichloropropene, µg/L	<1
Acrolein, µg/L	<10
Acrylonitrile, µg/L	<10
Toluene, µg/L	<1
Benzene, µg/L	<1
Ethylbenzene, µg/L	<1
Toluene, µg/L	<1

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01
	4th quarter 1987 (continued)
EPA Method 625	
Date sampled	12/08/87
Date extracted	12/19/87
1, 2, 4-Trichlorobenzene, µg/L	<1
1, 2-Dichlorobenzene, µg/L	<1
1, 2-Diphenylhydrazine, µg/L	<1
1, 3-Dichlorobenzene, µg/L	<1
1, 4-Dichlorobenzene, µg/L	<1
2, 4, 6-Trichlorophenol, µg/L	<1
2, 4-Dichlorophenol, µg/L	<1
2, 4-Dimethylphenol, µg/L	<1
2, 4-Dinitrotoluene, µg/L	<1
2, 4-Dinitrophenol, µg/L	<10
2, 6-Dinitrotoluene, µg/L	<1
2-Chloronaphthalene, µg/L	<1
2-Nitrophenol, µg/L	<1
2-Chlorophenol, µg/L	<1
2-Methyl-4, 6-dinitrophenol, µg/L	<1
3, 3'-Dichlorobenzidine, µg/L	<1
4-Bromophenylphenylether, µg/L	<1
4-Chloro-3-methylphenol, µg/L	<1
4-Chlorophenylphenylether, µg/L	<1
4-Nitrophenol, µg/L	<20
Bis(2-ethylhexyl)phthalate, µg/L	<100
Bis(2-chloroethyl)ether, µg/L	<1
Bis(2-chloroisopropyl)ether, µg/L	<1
Bis(2-chloroethoxy)methane, µg/L	<1
Butylbenzylphthalate, µg/L	<1
Chrysene, µg/L	<1
Di-n-octylphthalate, µg/L	<1
Dibenzo(a, h)anthracene, µg/L	<1
Dibutylphthalate, µg/L	<1
Diethylphthalate, µg/L	<1
Dimethylphthalate, µg/L	<1
Fluorene, µg/L	<1
Fluoranthene, µg/L	<1
Hexachlorobenzene, µg/L	<1
Hexachlorobutadiene, µg/L	<1
Hexachlorocyclopentadiene, µg/L	<1
Hexachloroethane, µg/L	<1
Indeno(1, 2, 3-c, d)pyrene, µg/L	<1
Isophorone, µg/L	<1
N-Nitrosodi-n-propylamine, µg/L	<1

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01
	4th quarter 1987 (continued)
EPA Method 625 (continued)	
Date sampled	12/08/87
Date extracted	12/19/87
N-Nitrosodimethylamine, µg/L	<1
N-Nitrosodiphenylamine, µg/L	<1
Naphthalene, µg/L	<1
Nitrobenzene, µg/L	<1
Pentachlorophenol, µg/L	<1
Phenanthrene, µg/L	<1
Phenol, µg/L	<1
Pyrene, µg/L	<1
General Mineral	
Date sampled	12/08/87
Date extracted	12/19/87
Hydroxide Alk (as $CaCO_3$), mg/L	<1
Carbonate Alk (as $CaCO_3$), mg/L	<1
Bicarbonate Alk (as $CaCO_3$), mg/L	163
Iron, mg/L	0.25
Manganese, mg/L	0.12
Copper, mg/L	<0.02
Zinc, mg/L	<0.01
Surfactants, mg/L	<0.02
Total dissolved solids (TDS), mg/L	1250
Specific Conductance, umhos/cm	1790
pH, Units	7.4
Nitrate (as NO_3), mg/L	<0.44
Chloride, mg/L	146
Sulfate, mg/L	620
Sodium, mg/L	280
Potassium, mg/L	7.6
Calcium (EDTA Titration), mg/L	80
Magnesium, mg/L	41

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01
	1st quarter 1988
EPA Method 601	
Date sampled	3/10/88
Date extracted	3/23/88
1, 1, 2, 2-Tetrachloroethane, µg/L	<0.5
1, 1, 1-Trichloroethane, µg/L	<0.5
1, 1, 2-Trichloroethane, µg/L	<0.5
1, 1-Dichloroethane, µg/L	<0.5
1, 1-Dichloroethylene, µg/L	<0.5
1, 2-Dichlorobenzene, µg/L	<0.5
1, 2-Dichloroethane, µg/L	<0.5
1, 2-Dichloroethylene (total), µg/L	<0.5
1, 2-Dichloropropane, µg/L	<0.5
1, 3-Dichlorobenzene, µg/L	<0.5
1, 4-Dichlorobenzene, µg/L	<0.5
2-Chloroethylvinylether, µg/L	<0.5
Bromodichloromethane, µg/L	<0.5
Bromomethane, µg/L	<0.5
Bromoform, µg/L	<0.5
Chlorobenzene, µg/L	<0.5
Carbon Tetrachloride, µg/L	<0.5
Chloroethane, µg/L	<0.5
Chloroform, µg/L	<0.5
Chloromethane, µg/L	<0.5
Dibromochloromethane, µg/L	<0.5
Dichlorodifluoromethane, µg/L	<0.5
Methylene chloride, µg/L	<0.5
Tetrachloroethylene, µg/L	<0.5
Trichloroethylene, µg/L	<0.5
Trichlorofluoromethane, µg/L	<0.5
Vinyl chloride, µg/L	<0.5
cis-1, 3-Dichloropropene, µg/L	<0.5
trans-1, 3-Dichloropropene, µg/L	<0.5
Freon 113, µg/L	<0.5

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01
	1st quarter 1988 (Continued)
EPA Method 602	
Date sampled	3/10/88
Date analyzed	3/24/88
Date extracted	3/23/88
Benzene, µg/L	<0.5
Chlorobenzene, µg/L	<0.5
1, 2-Dichlorobenzene, µg/L	<0.5
1, 3-Dichlorobenzene, µg/L	<0.5
1, 4-Dichlorobenzene, µg/L	<0.5
Ethylbenzene, µg/L	<0.5
Toluene, µg/L	<0.5
Total Xylene Isomers, µg/L	<0.5
	2nd quarter 1988
EPA Method 601	
Date sampled	6/27/88
1, 1, 2, 2-Tetrachloroethane, µg/L	<0.5
1, 1, 1-Trichloroethane, µg/L	<0.5
1, 1, 2-Trichloroethane, µg/L	<0.5
1, 1-Dichloroethane, µg/L	<0.5
1, 1-Dichloroethylene, µg/L	<0.5
1, 2-Dichlorobenzene, µg/L	<0.5
1, 2-Dichloroethane, µg/L	<0.5
1, 2-Dichloroethylene (total), µg/L	<0.5
1, 2-Dichloropropane, µg/L	<0.5
1, 3-Dichlorobenzene, µg/L	<0.5
1, 4-Dichlorobenzene, µg/L	<0.5
2-Chloroethylvinylether, µg/L	<0.5
Bromodichloromethane, µg/L	<0.5
Bromomethane, µg/L	<0.5
Bromoform, µg/L	<0.5
Chlorobenzene, µg/L	<0.5
Carbon Tetrachloride, µg/L	<0.5
Chloroethane, µg/L	<0.5
Chloroform, µg/L	<0.5
Chloromethane, µg/L	<0.5
Dibromochloromethane, µg/L	<0.5
Dichlorodifluoromethane, µg/L	<0.5

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01
	2nd quarter 1988 (continued)
EPA Method 601	
Date sampled	6/27/88
Methylene chloride, µg/L	<0.5
Tetrachloroethylene, µg/L	<0.5
Trichloroethylene, µg/L	<0.5
Trichlorofluoromethane, µg/L	<0.5
Vinyl chloride, µg/L	<0.5
cis-1, 3-Dichloropropene, µg/L	<0.5
trans-1, 3-Dichloropropene, µg/L	<0.5
Freon 113, µg/L	<0.5
Radiological results	
Date sampled	6/30/88
Tritium, pCi/L	<222
	4th quarter 1988
EPA Method 601	
Date sampled	11/17/88
1, 1, 2, 2-Tetrachloroethane, µg/L	<0.5
1, 1, 1-Trichloroethane, µg/L	<0.5
1, 1, 2-Trichloroethane, µg/L	<0.5
1, 1-Dichloroethane, µg/L	<0.5
1, 1-Dichloroethylene, µg/L	<0.5
1, 2-Dichlorobenzene, µg/L	<0.5
1, 2-Dichloroethane, µg/L	<0.5
1, 2-Dichloroethylene (total), µg/L	<0.5
1, 2-Dichloropropane, µg/L	<0.5
1, 3-Dichlorobenzene, µg/L	<0.5
1, 4-Dichlorobenzene, µg/L	<0.5
2-Chloroethylvinylether, µg/L	<0.5
Bromodichloromethane, µg/L	<0.5
Bromomethane, µg/L	<0.5
Bromoform, µg/L	<0.5
Chlorobenzene, µg/L	<0.5
Carbon Tetrachloride, µg/L	<0.5

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01
	4th quarter 1988 (continued)
EPA Method 601 (continued)	
Date sampled	11/17/88
Chloroethane, µg/L	<0.5
Chloroform, µg/L	<0.5
Chloromethane, µg/L	<0.5
Dibromochloromethane, µg/L	<0.5
Dichlorodifluoromethane, µg/L	<0.5
Methylene chloride, µg/L	<0.5
Tetrachloroethylene, µg/L	<0.5
Trichloroethylene, µg/L	<0.5
Trichlorofluoromethane, µg/L	<0.5
Vinyl chloride, µg/L	<0.5
cis-1, 3-Dichloropropene, µg/L	<0.5
trans-1, 3-Dichloropropene, µg/L	<0.5
Freon 113, µg/L	<0.5
General Mineral	
Date sampled	11/17/88
Date analyzed	11/27/88
Hydroxide Alk (as $CaCO_3$), mg/L	<1
Carbonate Alk (as $CaCO_3$), mg/L	<1
Bicarbonate Alk (as $CaCO_3$), mg/L	160
Iron, mg/L	0.2
Manganese, mg/L	0.13
Copper, mg/L	<0.08
Zinc, mg/L	0.04
Surfactants, mg/L	<0.02
Total dissolved solids (TDS), mg/L	1200
Specific Conductance, umhos/cm	1420
pH, Units	7.8
Nitrate (as NO_3), mg/L	<0.4
Chloride, mg/L	140
Sulfate, mg/L	590
Sodium, mg/L	300
Potassium, mg/L	7.6
Calcium (EDTA Titration), mg/L	82
Magnesium, mg/L	35

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
	1st quarter 1989			
Chemical and physical analyses				
Date sampled	2/15/89	2/16/89	2/21/89	-
Ammonia Nitrogen (as N), mg/L	0.89	0.7	1.2	-
Carbonate Alk (as $CaCO_3$), mg/L	<1	<1	<1	-
Chloride, mg/L	160	170	160	-
Fluoride, mg/L	0.2	0.3	0.2	-
Nitrate (as N), mg/L	<0.1	<0.1	<0.1	-
Nitrite (as N), mg/L	<0.01	<0.01	<0.01	-
Low Level Phenolics, mg/L	<0.005	0.012	0.01	-
Total suspended solids (TSS), mg/L	<1	<1	<1	-
Sodium, mg/L	230	220	260	-
Sulfate, mg/L	640	560	630	-
Total Kjeldahl Nitrogen, mg/L	1.6	0.8	1.4	-
Quadruplicate Conductivity				
Date sampled	2/15/89	2/16/89	2/21/89	-
Sp Cond, Average, umhos/cm	1910	1850	1920	-
Sp Cond, Std dev, umhos/cm	17	18	81	-
Quadruplicate TOC				
Date sampled	2/15/89	2/16/89	2/21/89	-
TOC, Average, mg/L	1.4	0.9	1.2	-
TOC, Std dev, mg/L	0.14	0.03	0.13	-
Quadruplicate TOX				
Date sampled	2/15/89	2/16/89	2/21/89	-
TOX, Average, mg/L	<0.025	<0.025	<0.025	-
TOX, Std dev, mg/L	0	0	0	-

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
	1st quarter 1989			
EPA Method 624				
Date sampled	2/15/89	2/16/89	2/21/89	-
1, 1, 2, 2-Tetrachloroethane, μg/L	<1	<1	<1	-
1, 1, 1-Trichloroethane, μg/L	<1	<1	<1	-
1, 1, 2-Trichloroethane, μg/L	<1	<1	<1	-
1, 1-Dichloroethane, μg/L	<1	<1	<1	-
1, 1-Dichloroethylene, μg/L	<1	<1	<1	-
1, 2-Dichloroethane, μg/L	<1	<1	<1	-
1, 2-Dichloroethylene (total), μg/L	<1	<1	<1	-
1, 2-Dichloropropane, μg/L	<1	<1	<1	-
2-Chloroethylvinylether, μg/L	<1	<1	<1	-
Bromodichloromethane, μg/L	<1	<1	<1	-
Bromomethane, μg/L	<1	<1	<1	-
Bromoform, μg/L	<1	<1	<1	-
Chlorobenzene, μg/L	<1	<1	<1	-
Carbon Tetrachloride, μg/L	<1	<1	<1	-
Chloroethane, μg/L	<1	<1	<1	-
Chloroform, μg/L	<1	<1	<1	-
Chloromethane, μg/L	<1	<1	<1	-
Dibromochloromethane, μg/L	<1	<1	<1	-
Methylene chloride, μg/L	<1	<1	<1	-
Tetrachloroethylene, μg/L	<1	<1	<1	-
Trichloroethylene, μg/L	<1	<1	<1	-
Trichlorofluoromethane, μg/L	<1	<1	<1	-
Vinyl chloride, μg/L	<1	<1	<1	-
trans-1, 3-Dichloropropene, μg/L	<1	<1	<1	-
Benzene, μg/L	<1	<1	<1	-
Ethylbenzene, μg/L	<1	<1	<1	-
Toluene, μg/L	<1	1	<1	-
EPA Method 601				
Date sampled	2/15/89	2/16/89	2/21/89	-
1, 1, 2, 2-Tetrachloroethane, μg/L	-	-	<0.5	-
1, 1, 1-Trichloroethane, μg/L	-	-	<0.5	-
1, 1, 2-Trichloroethane, μg/L	-	-	<0.5	-
1, 1-Dichloroethane, μg/L	-	-	<0.5	-
1, 1-Dichloroethylene, μg/L	-	-	<0.5	-
1, 2-Dichlorobenzene, μg/L	-	-	<0.5	-
1, 2-Dichloroethane, μg/L	-	-	<0.5	-
1, 2-Dichloroethylene (total), μg/L	-	-	<0.5	-

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
	1st quarter 1989 (continued)			
EPA Method 601 (continued)				
Date sampled	2/15/89	2/16/89	2/21/89	-
1, 2-Dichloropropane, µg/L	-	-	<0.5	-
1, 3-Dichlorobenzene, µg/L	-	-	<0.5	-
1, 4-Dichlorobenzene, µg/L	-	-	<0.5	-
2-Chloroethylvinylether, µg/L	-	-	<0.5	-
Bromodichloromethane, µg/L	-	-	<0.5	-
Bromomethane, µg/L	-	-	<0.5	-
Bromoform, µg/L	-	-	<0.5	-
Chlorobenzene, µg/L	-	-	<0.5	-
Carbon Tetrachloride, µg/L	-	-	<0.5	-
Chloroethane, µg/L	-	-	<0.5	-
Chloroform, µg/L	-	-	<0.5	-
Chloromethane, µg/L	-	-	<0.5	-
Dibromochloromethane, µg/L	-	-	<0.5	-
Dichlorodifluoromethane, µg/L	-	-	<0.5	-
Methylene chloride, µg/L	-	-	<0.5	-
Tetrachloroethylene, µg/L	-	-	<0.5	-
Trichloroethylene, µg/L	-	-	<0.5	-
Trichlorofluoromethane, µg/L	-	-	<0.5	-
Vinyl chloride, µg/L	-	-	<0.5	-
cis-1, 3-Dichloropropene, µg/L	-	-	<0.5	-
trans-1, 3-Dichloropropene, µg/L	-	-	<0.5	-
Freon 113, µg/L	-	-	<0.5	-
Title 22 organics				
Date sampled	2/15/89	2/16/89	2/21/89	-
Date extracted	2/21/89	2/28/89	3/08/89	-
Date analyzed	2/27/89	2/21/89	3/13/89	-
2, 4, 5-TP(Silvex), µg/L	<2	<2	<2	-
2, 4-D, µg/L	<20	<20	<20	-
Endrin, µg/L	<0.01	<0.01	<0.01	-
Lindane, µg/L	<0.4	<0.4	<0.4	-
Methoxychlor, µg/L	<10	<10	<10	-
Toxaphene, µg/L	<0.5	<0.5	<0.5	-

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
	1st quarter 1989 (continued)			
Explosive compounds				
Date sampled	2/15/89	2/15/89	2/15/89	-
RDX, µg/L	<20	<20	<20	-
HMX, µg/L	<20	<20	<20	-
TNT, µg/L	<20	<20	<20	-
Radiological results				
Date sampled	2/15/89	2/15/89	2/15/89	2/10/89
Gross alpha, pCi/L	<2	<4	<3	-
Gross beta, pCi/L	9	31	9	-
Two Std dev	+3	+3	+3	-
Tritium, pCi/L	<228	<228	<228	<228
Uranium 238, pCi/L	<0.3	1.3	0.7	-
Two Std dev		+0.2	+0.2	-
Uranium 235, pCi/L	<0.1	0.07	<0.05	-
Two Std dev		+0.06		-
Uranium 234, pCi/L	<0.3	4.1	1.5	-
Two Std dev		+0.4	+0.4	-
Radium 226, pCi/L	0.2	<0.1	<0.1	-
Two Std dev	+0.1			-
Title 22 Metals				
Date sampled	2/15/89	2/16/89	2/21/89	-
Dateanalyzed	2/23/89	2/25/89	3/02/89	-
Arsenic, mg/L	0.007	0.04	0.014	-
Barium, mg/L	2.1	2.1	<0.1	-
Beryllium, mg/L	<0.03	<0.03	<0.01	-
Cadmium, mg/L	<0.0001	<0.0001	<0.01	-
Chromium, mg/L	<0.0001	0.0007	<0.01	-
Copper, mg/L	<0.001	0.005	<0.02	-
Lead, mg/L	<0.002	<0.002	0.004	-
Mercury, mg/L	<0.0008	<0.0008	<0.0001	-
Selenium, mg/L	<0.004	<0.004	0.001	-
Silver, mg/L	<0.0005	<0.0005	<0.01	-

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
2nd quarter 1989				
Chemical and physical analyses				
Date sampled	4/06/89	4/06/89	4/06/89	5/04/89
Ammonia Nitrogen (as N), mg/L	1.2	0.98	0.8	-
Carbonate Alk (as $CaCO_3$), mg/L	<1	<1	<1	<1
Chloride, mg/L	150	180	160	160
Total dissolved solids (TDS), mg/L	-	-	-	1200
Fluoride, mg/L	0.4	0.3	0.2	0.4
Nitrate (as NO_3), mg/L	-	-	-	<0.4
Nitrate (as N), mg/L	<0.1	<0.1	<0.1	-
Nitrite (as N), mg/L	<0.01	<0.01	<0.01	-
Low Level Phenolics, mg/L	<0.005	<0.005	<0.005	0.017
Total suspended solids (TSS), mg/L	3	2	8	8
Sodium, mg/L	330	310	320	310
Sulfate, mg/L	620	520	690	590
Total Kjeldahl Nitrogen, mg/L	1.7	1	0.8	-
Quadruplicate Conductivity				
Date sampled	4/06/89	4/06/89	4/06/89	5/04/89
Sp Cond, Average, umhos/cm	1850	1870	1920	1790
Sp Cond, Std dev, umhos/cm	14	85	37	39
QuadruplicateTOC				
Date sampled	4/06/89	4/06/89	4/06/89	5/04/89
TOC, Average, mg/L	2.41	0.8	0.7	1.9
TOC, Std dev, mg/L	0.39	0.11	0.04	0.08
QuadruplicateTOX				
Date sampled	4/06/89	4/06/89	4/06/89	5/04/89
TOX, Average, mg/L	<0.025	<0.025	<0.025	<0.025
TOX, Std dev, mg/L	0	0	0	0

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
	2nd quarter 1989 (continued)			
EPA Method 624				
Date sampled	4/06/89	4/06/89	4/06/89	5/04/89
1, 1, 2, 2-Tetrachloroethane, µg/L	<1	<1	<1	<1
1, 1, 1-Trichloroethane, µg/L	<1	<1	<1	<1
1, 1, 2-Trichloroethane, µg/L	<1	<1	<1	<1
1, 1-Dichloroethane, µg/L	<1	<1	<1	<1
1, 1-Dichloroethylene, µg/L	<1	<1	<1	<1
1, 2-Dichloroethane, µg/L	<1	<1	<1	<1
1, 2-Dichloroethylene (total), µg/L	<1	<1	<1	<1
1, 2-Dichloropropane, µg/L	<1	<1	<1	<1
2-Chloroethylvinylether, µg/L	<1	<1	<1	<1
Bromodichloromethane, µg/L	<1	<1	<1	<1
Bromomethane, µg/L	<1	<1	<1	<1
Bromoform, µg/L	<1	<1	<1	<1
Chlorobenzene, µg/L	<1	<1	<1	<1
Carbon Tetrachloride, µg/L	<1	<1	<1	<1
Chloroethane, µg/L	<1	<1	<1	<1
Chloroform, µg/L	<1	<1	<1	<1
Chloromethane, µg/L	<1	<1	<1	<1
Dibromochloromethane, µg/L	<1	<1	<1	<1
Methylene chloride, µg/L	<1	<1	<1	<1
Tetrachloroethylene, µg/L	<1	<1	<1	<1
Trichloroethylene, µg/L	<1	<1	<1	<1
Trichlorofluoromethane, µg/L	<1	<1	<1	<1
Vinyl chloride, µg/L	<1	<1	<1	<1
trans-1, 3-Dichloropropene, µg/L	<1	<1	<1	<1
Toluene, µg/L	<1	<1	<1	<1
Benzene, µg/L	<1	<1	<1	<1
Ethylbenzene, µg/L	<1	<1	<1	<1
Toluene, µg/L	<1	<1	<1	<1
Title 22 organics				
Date sampled	4/06/89	4/06/89	4/06/89	5/05/89
Date extracted	4/12/89	4/12/89	4/12/89	5/09/89
Date analyzed	4/18/89	4/18/89	4/18/89	5/10/89
2, 4, 5-TP (Silvex), µg/L	<1	<1	<1	<2
2, 4-D, µg/L	<10	<10	<10	<20
Endrin, µg/L	<0.01	<0.01	<0.01	<0.01
Lindane, µg/L	<0.4	<0.4	<0.4	<0.4
Methoxychlor, µg/L	<10	<10	<10	<10
Toxaphene, µg/L	<0.5	<0.5	<0.5	<0.5

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
	2nd quarter 1989 (continued)			
Explosive compounds				
Date sampled	4/06/89	4/06/89	4/06/89	5/03/89
RDX, µg/L	<20	<20	<20	<20
HMX, µg/L	<20	<20	<20	<20
TNT, µg/L	<20	<20	<20	<20
Radiological results				
Date sampled	4/06/89	4/06/89	4/06/89	5/03/89
Gross alpha, pCi/L	<2	<1	<5	<2
Gross beta, pCi/L	8	9	10	9
Two Std dev	+6	+7	+6	+6
Tritium, pCi/L	<217	<186	<196	<186
Uranium 238, pCi/L	<0.1	0.7	0.6	0.3
Two Std dev		+0.2	+0.2	+0.2
Uranium 235, pCi/L	<0.1	<0.2	<0.2	<0.1
Uranium 234, pCi/L	<0.1	4.6	1.8	1
Two Std dev		+0.5	+0.3	+0.3
Radium 226, pCi/L	<0.1	<0.1	<0.1	<0.1
General Mineral				
Date sampled	4/06/89	4/06/89	4/06/89	5/04/89
Date analyzed	4/18/89	4/18/89	4/18/89	5/13/89
Hydroxide Alk (as $CaCO_3$), mg/L	-	<1	<1	<1
Carbonate Alk (as $CaCO_3$), mg/L	<1	<1	<1	<1
Bicarbonate Alk (as $CaCO_3$), mg/L	160	200	160	150
Iron, mg/L	-	-	-	0.59
Manganese, mg/L	-	-	-	0.13
Surfactants, mg/L	-	-	-	-
Total dissolved solids (TDS), mg/L	-	-	-	1200
Specific Conductance, umhos/cm	1850	1830	1960	1730
pH, Units	-	-	-	7.9
Nitrate (as NO_3), mg/L	-	-	-	<0.4
Chloride, mg/L	150	180	160	160
Sulfate, mg/L	620	520	690	590
Sodium, mg/L	330	310	320	310
Potassium, mg/L	-	-	-	7.7
Calcium (EDTA Titration), mg/L	-	-	-	55

Magnesium, mg/L	-	-	-	24

Table B-2. Analytical results reported by June 30, 1989, from the Pit 9 Area. (Continued)

Parameters	Well K9-01	Well K9-02	Well K9-03	Well K9-04
	2nd quarter 1989 (continued)			
Title 22 Metals				
Date sampled	4/06/89	4/06/89	4/06/89	5/04/89
Date analyzed	4/18/89	4/18/89	4/18/89	5/13/89
Arsenic, mg/L	0.003	0.038	0.016	0.004
Barium, mg/L	<0.1	<0.1	<0.1	<0.1
Beryllium, mg/L	<0.01	<0.01	<0.01	0.0002
Cadmium, mg/L	<0.01	<0.01	<0.01	<0.01
Chromium, mg/L	<0.02	<0.02	<0.02	<0.02
Copper, mg/L	<0.02	<0.02	<0.02	<0.02
Lead, mg/L	0.004	<0.001	0.001	0.019
Mercury, mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Selenium, mg/L	<0.001	<0.001	<0.001	<0.001
Silver, mg/L	<0.01	<0.01	<0.01	<0.01
Zinc, mg/L	-	-	-	<0.01

Appendix C

Water Elevations at Pit 9

Table C-1. Water elevation for installations in the Pit 9 Area.

Location	Date of Measurement	Depth to Water (ft)	Water Elevation (ft/MSL)
K9-01			
	12/08/87	80.55	994.96
	06/02/88	80.44	995.07
	07/07/88	80.56	994.95
	08/04/88	80.44	995.07
	09/02/88	80.41	995.10
	10/04/88	80.43	995.08
	11/01/88	83.42	992.09
	11/29/88	80.74	988.77
	01/12/89	80.58	994.93
	02/08/89	80.44	995.07
	04/05/89	80.55	994.96
	05/11/89	80.30	995.21
	06/07/89	80.43	995.08
K9-02			
	12/08/87	131.72	1003.67
	10/04/88	131.99	1003.40
	11/01/88	132.16	1003.23
	11/29/88	132.30	1003.09
	01/12/89	132.24	1003.15
	02/08/89	131.89	1003.50
	04/05/89	131.90	1003.49
	05/11/89	131.54	1003.85
	06/07/89	131.68	1003.71
K9-03			
	12/08/87	121.89	995.19
	11/29/88	122.12	994.96
	01/12/89	121.97	995.11
	02/08/89	121.81	995.27
	04/05/89	121.90	995.18
	05/11/89	121.66	995.42
	06/07/89	121.73	995.35
K9-04			
	05/10/89	130.66	953.96
	06/07/89	102.30	982.32

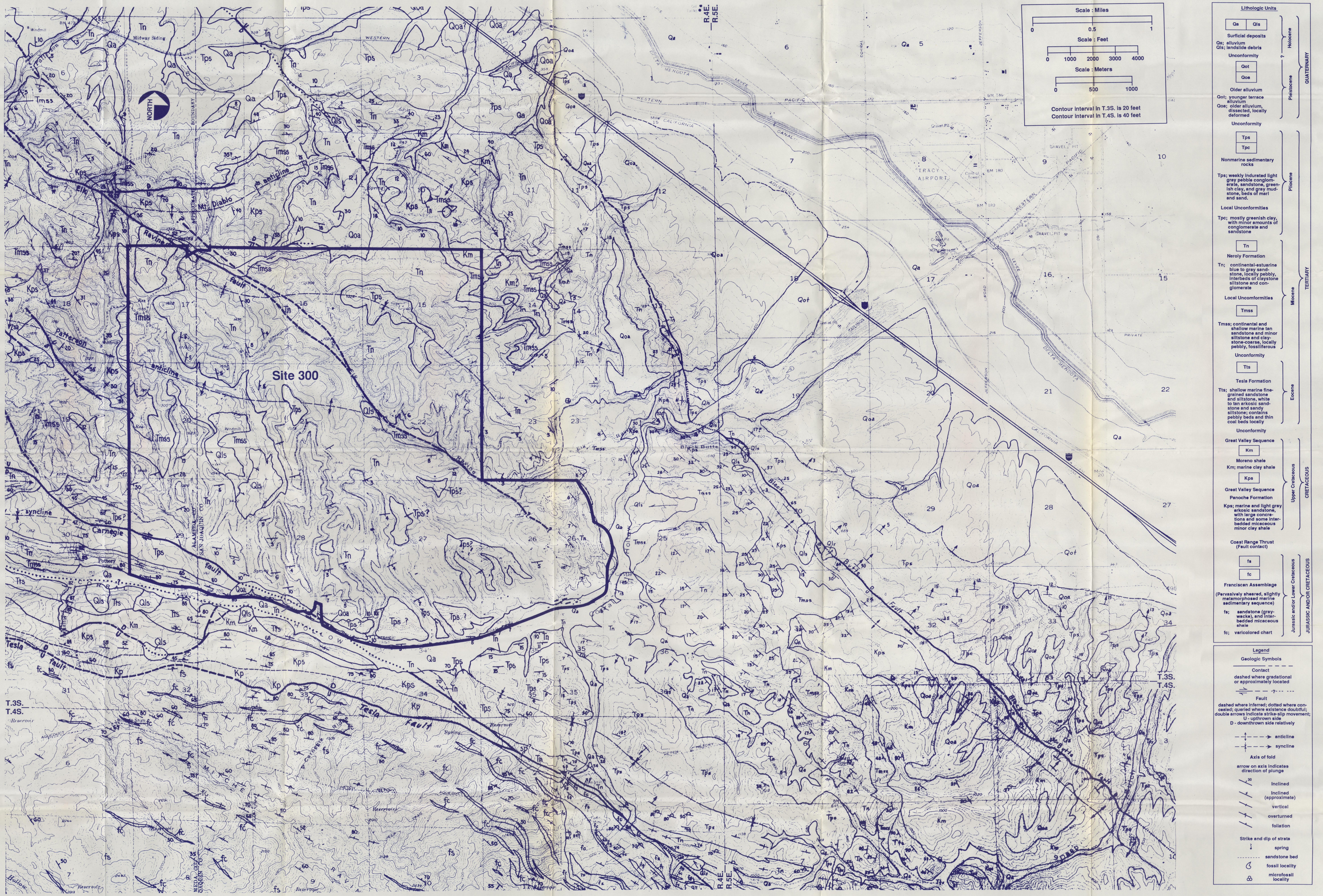
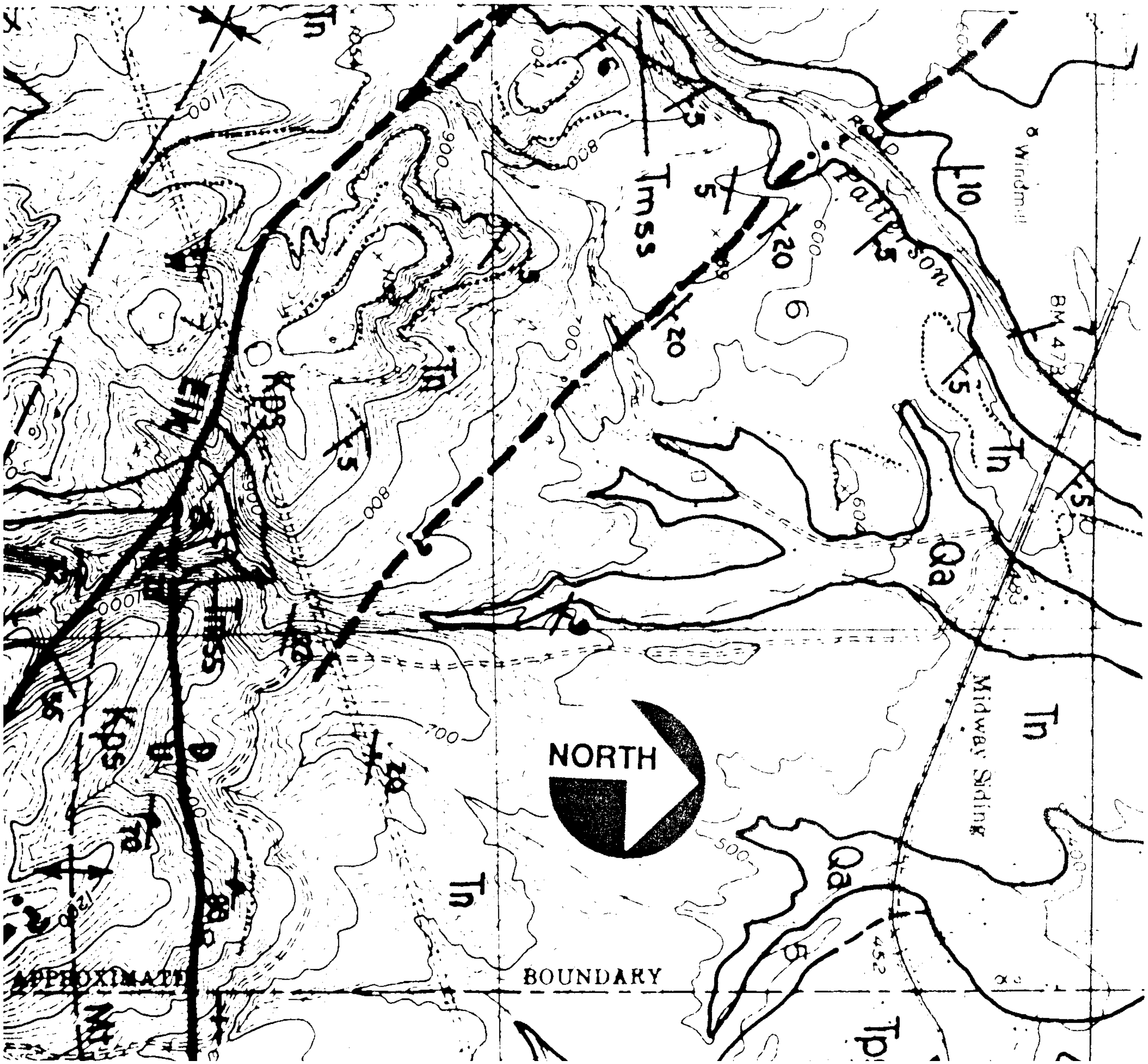
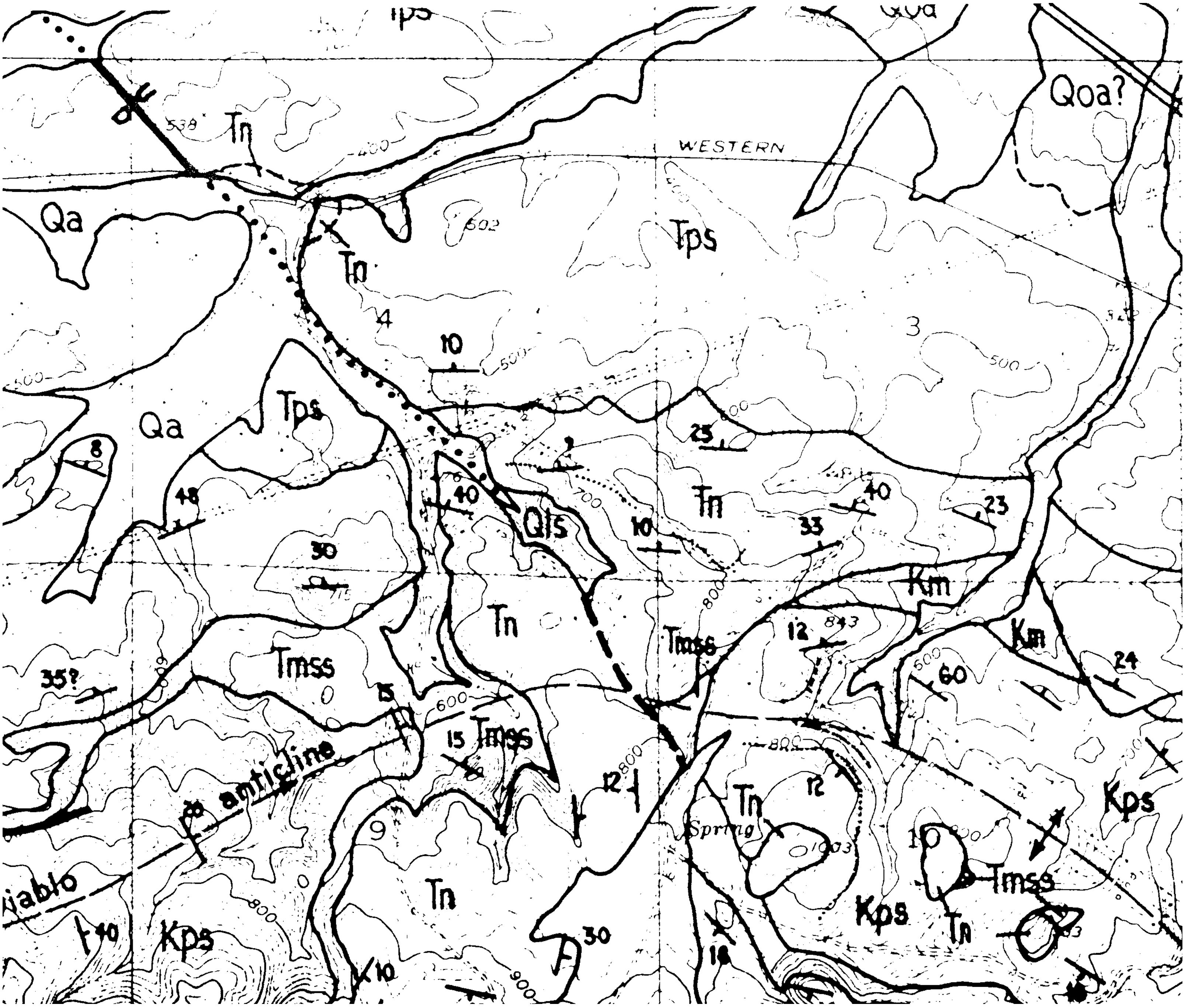
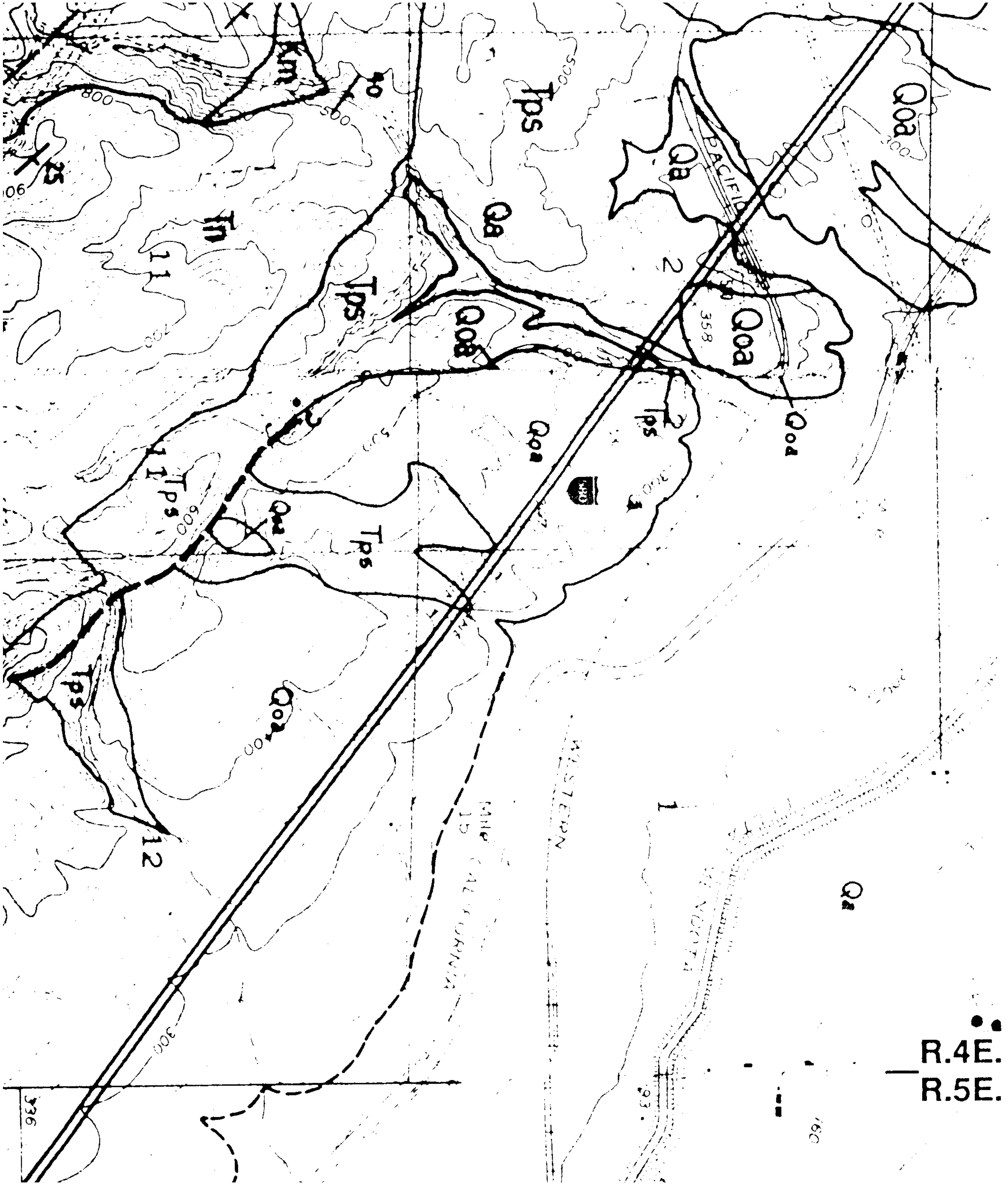
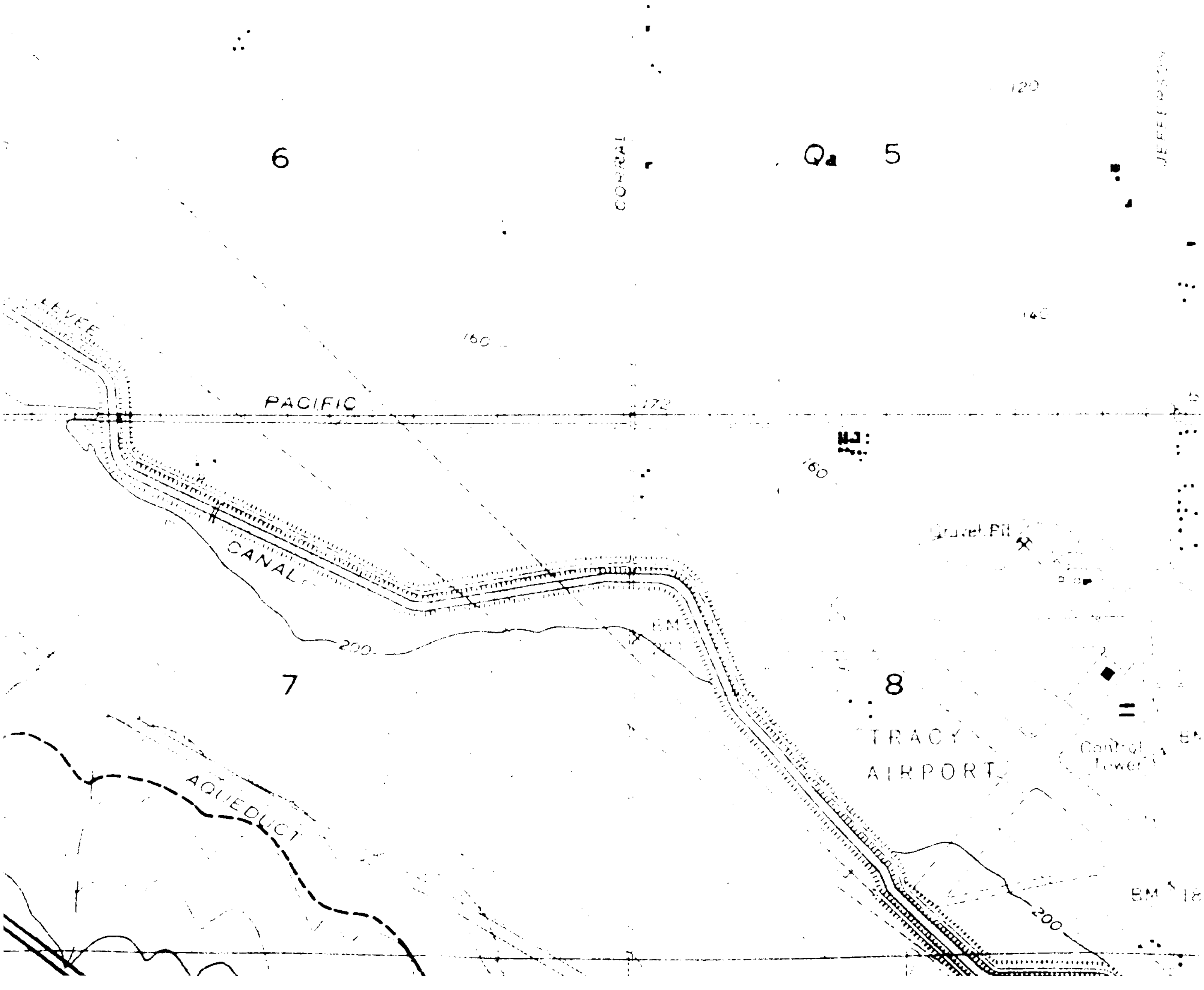


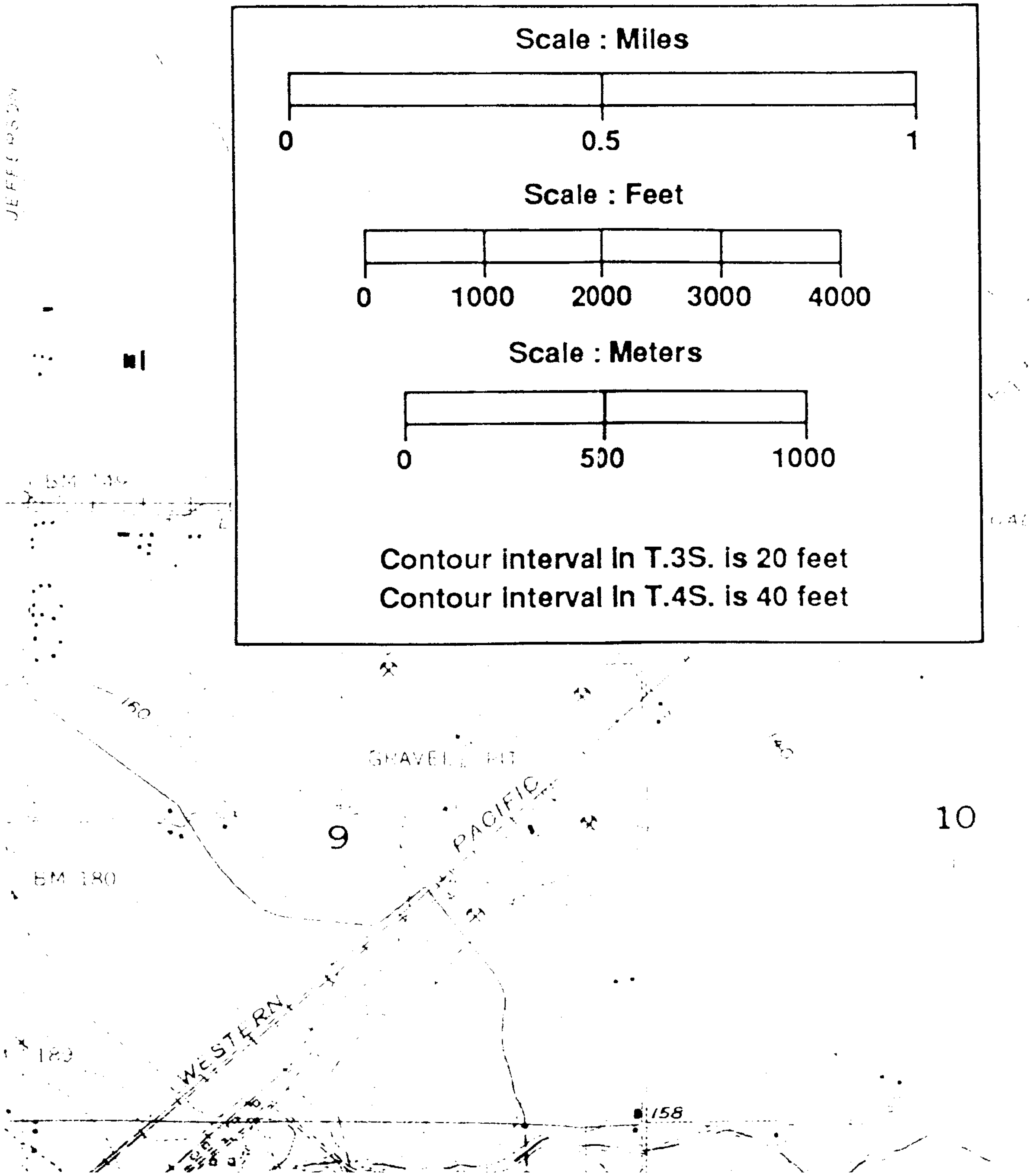
Plate 1. Geologic map of Site 300 and surroundings (modified from Dibblee 1980a, b, c & d).


NORTH
APPROXIMATE
BOUNDARY
Tmss
Tn
Kps
Qa
Tp
Patterson
ROAD
Windmill
Midway Siding
Elk
BM 473
700
800
900
1000
600
500


Tps
Qoa
Qoa?
Tn
538
400
WESTERN
Qa
Tn
602
Tps
4
3
10
500
500
Qa
Tps
8
25
48
40
Qts
700
10
Tn
40
33
23
30
Km
Tn
Tmss
Km
12
843
35?
Tmss
15
600
15
Tmss
60
24
anticline
800
12
12
Tn
Spring
1003
28
9
10
Kps
Tmss
Diablo
Tn
Kps
Tn
40
Kps
800
30
16
10
900


Km
Tps
Tn
Qa
Qoa
PACIFIC
2
11
12
1
358
Qoa
Tps
Qoa
Tps
WESTERN
CALIFORNIA
Mile 15
336
R.4E.
R.5E.


120
JEFFERSON
CORRAL
6
Qa
5
LEVEE
160
140
PACIFIC
172
160
Gravel Pit
CANAL
200
BM
7
8
TRACY
AIRPORT
Control
Tower
BM
AQUEDUCT
BM 18
200



Qa

Surfici

Qa; alluviu
Qls; landsli

Uncon

Older

Qot; young
alluviu
Qoa; older
dissec
deform

Unco

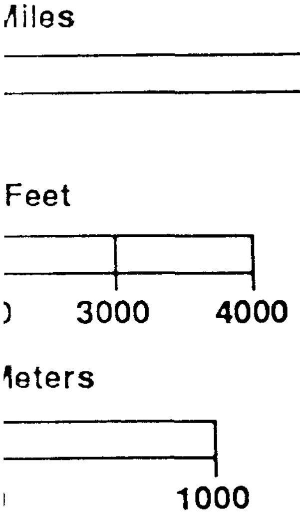
T
T

Nonmarine
r

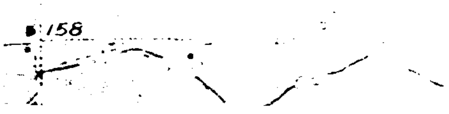
Tps; weakly
gray pet
erate, sa
ish clay,
stone, b
and san

Local Unco

Tpc; mostly
with mi



n T.3S. is 20 feet
n T.4S. is 40 feet



Lithologic Units

Qa | **Qls**

Surficial deposits

Qa; alluvium
Qls; landslide debris

Unconformity

Qot
Qoa

Older alluvium

Qot; younger terrace alluvium
Qoa; older alluvium, dissected, locally deformed

Unconformity

Tps
Tpc

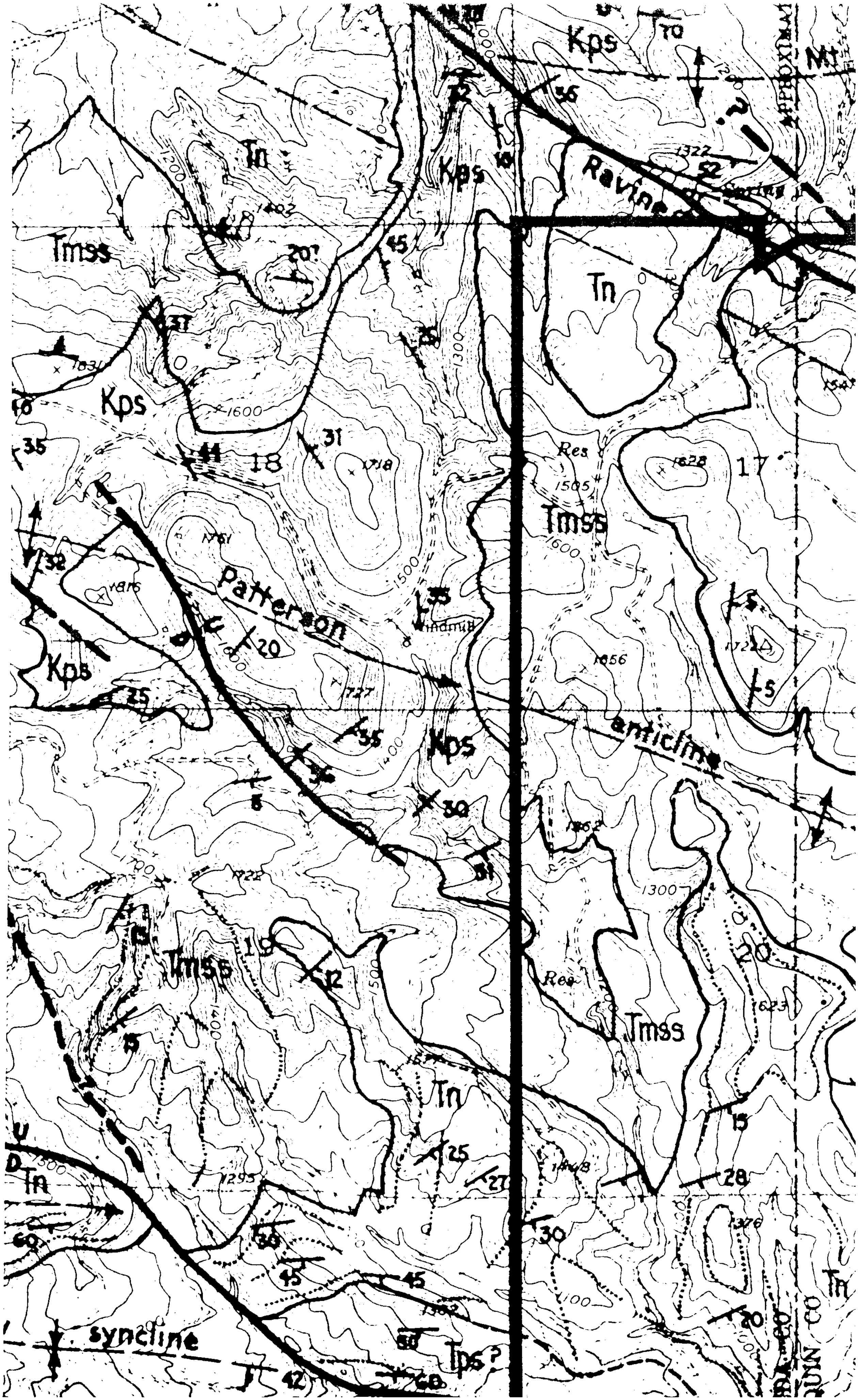
Nonmarine sedimentary rocks

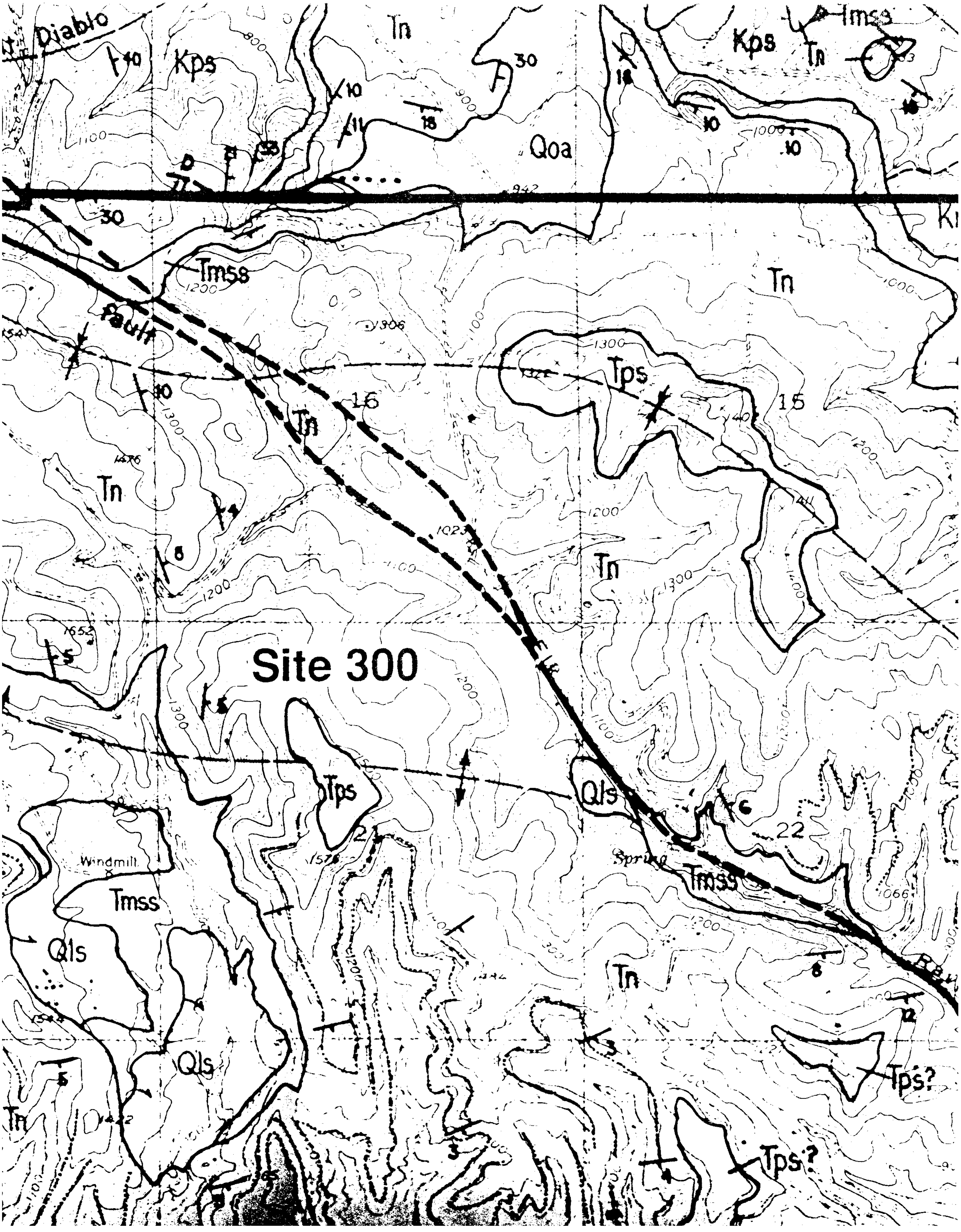
Tps; weakly indurated light gray pebble conglomerate, sandstone, greenish clay, and gray mudstone, beds of marl and sand.

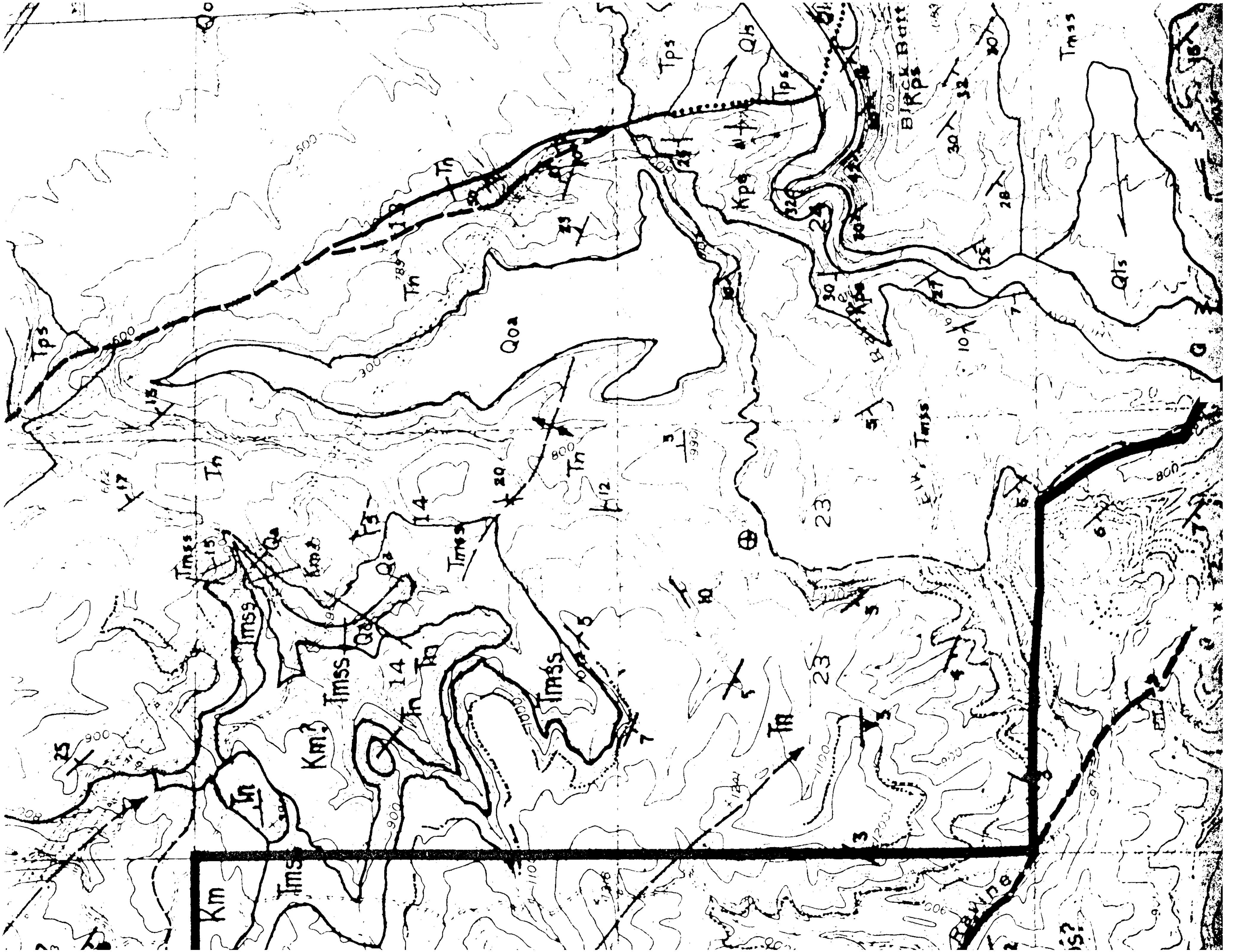
Local Unconformities

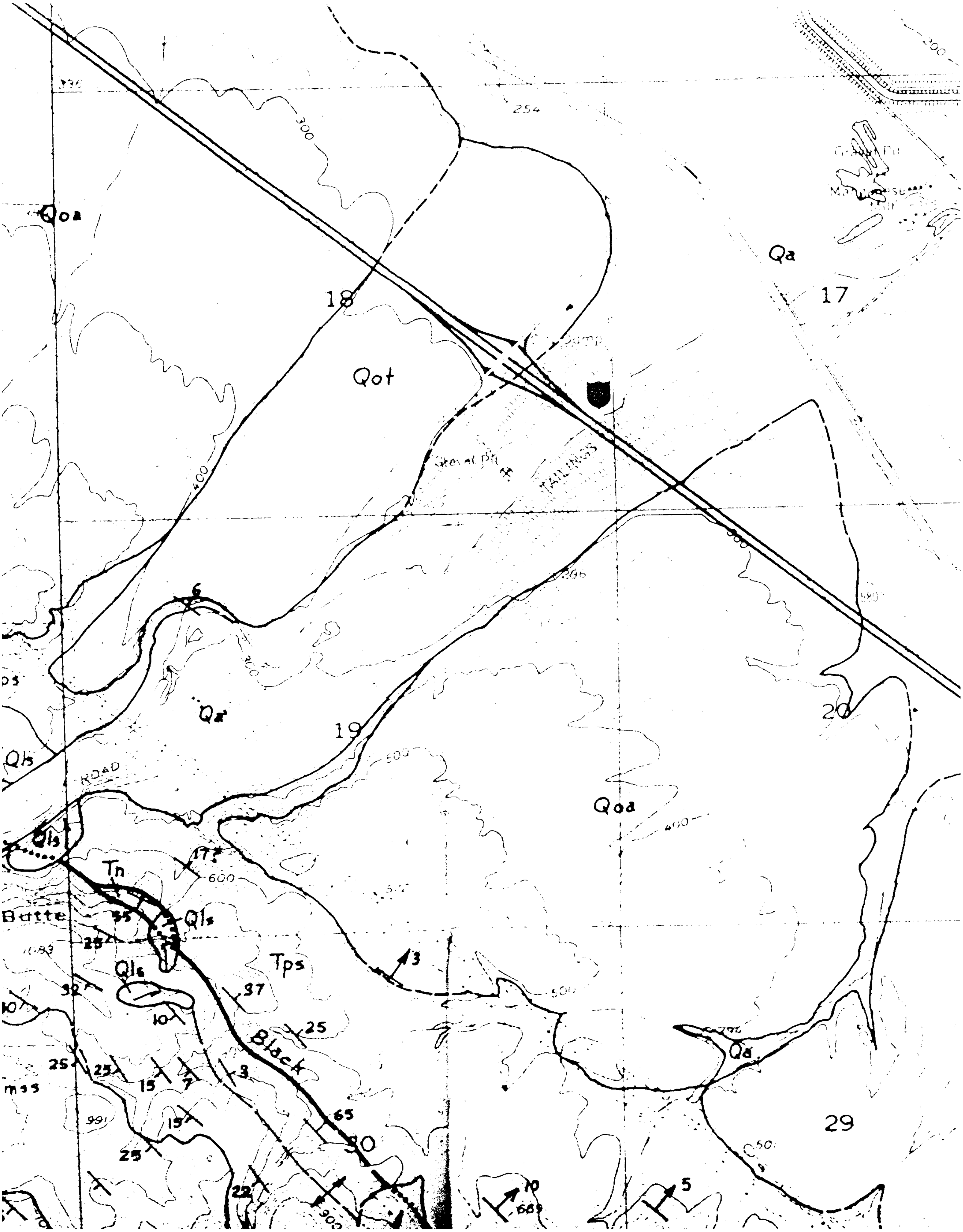
Tpc; mostly greenish clay, with minor amounts of

Holocene
?
Pleistocene
QUATERNARY
Pliocene

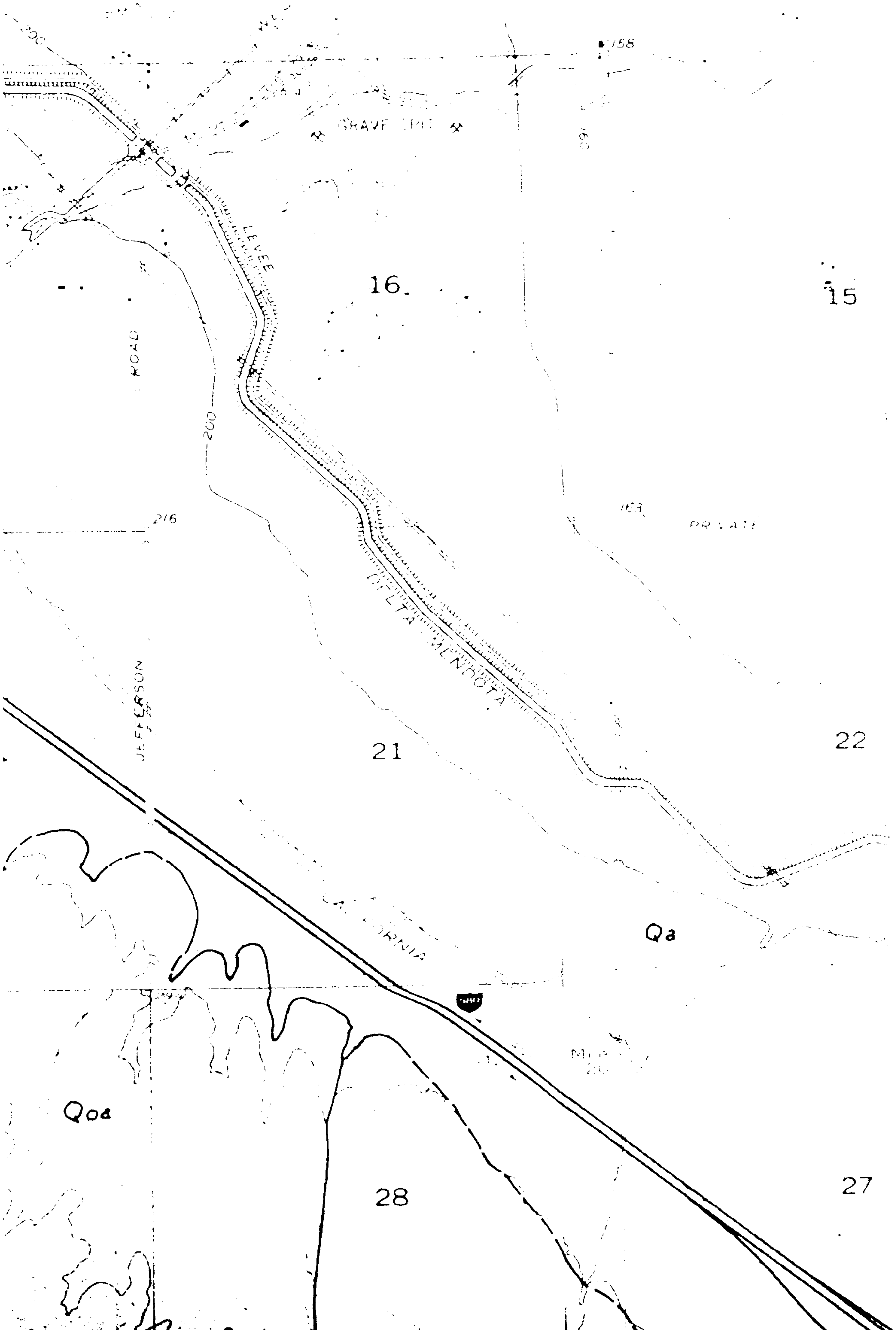

Kps
Tn
Tmss
Ravine
Patterson
anticline
syncline
Tps?
Res
Mt
18
17
19
20
56
52
45
37
31
35
32
25
20
55
30
51
12
15
28
30
36
45
60
42
1322
1402
1600
1718
1761
1816
1727
1505
1628
1656
1722
1500
1400
1300
1295
1648
1623
1376
1722
1552

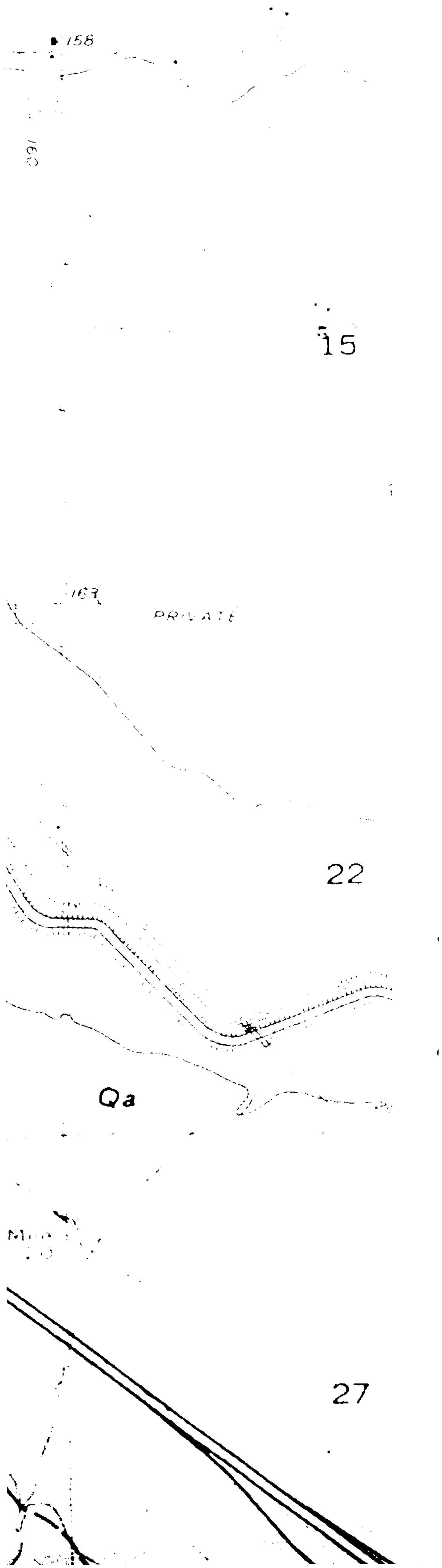

Diablo
Kps
Tn
Tmss
Kps
Tn
Qoa
Tmss
Tn
Fault
Tps
16
15
Tn
Tn
Tn
Site 300
Tps
Qls
22
Spring
Tmss
Windmill
Tmss
Qls
Qls
Tn
Tps?
Tps?
Tn


Tps
Qoa
Qls
Tn
Tmss
Kps
Black Butte
Km
Km?
Qa
Elk
23
14
500
600
300
800
900
1000
1100
1200
Ravine



Qoa
Qa
17
18
Qot
Gravel Pit
TAILINGS
Qa
19
20
Qoa
Qa
29
ROAD
Qls
Tn
Butte
Tps
Black
30
mss
300
400
500
600
254
200


158
GRAVEL PIT
160
LEVEE
16
15
ROAD
200
163
PRIVATE
216
DELTA MENDOTA
JEFFERSON
21
22
Qa
CALIFORNIA
Qoa
28
27



Local Unconformities

Tpc; mostly greenish clay, with minor amounts of conglomerate and sandstone

Tn

Neroly Formation

Tn; continental-estuarine blue to gray sandstone, locally pebbly, interbeds of claystone siltstone and conglomerate

Local Uncomformities

Tmss

Tmss; continental and shallow marine tan sandstone and minor siltstone and claystone-coarse, locally pebbly, fossiliferous

Miocene

Unconformity

Tts

Tesla Formation

Tts; shallow marine fine-grained sandstone and siltstone, white to tan arkosic sandstone and sandy siltstone; contains pebbly beds and thin coal beds locally

Eocene

TERTIARY

Unconformity

Great Valley Sequence

Km

Moreno shale

Km; marine clay shale

Kps

Great Valley Sequence

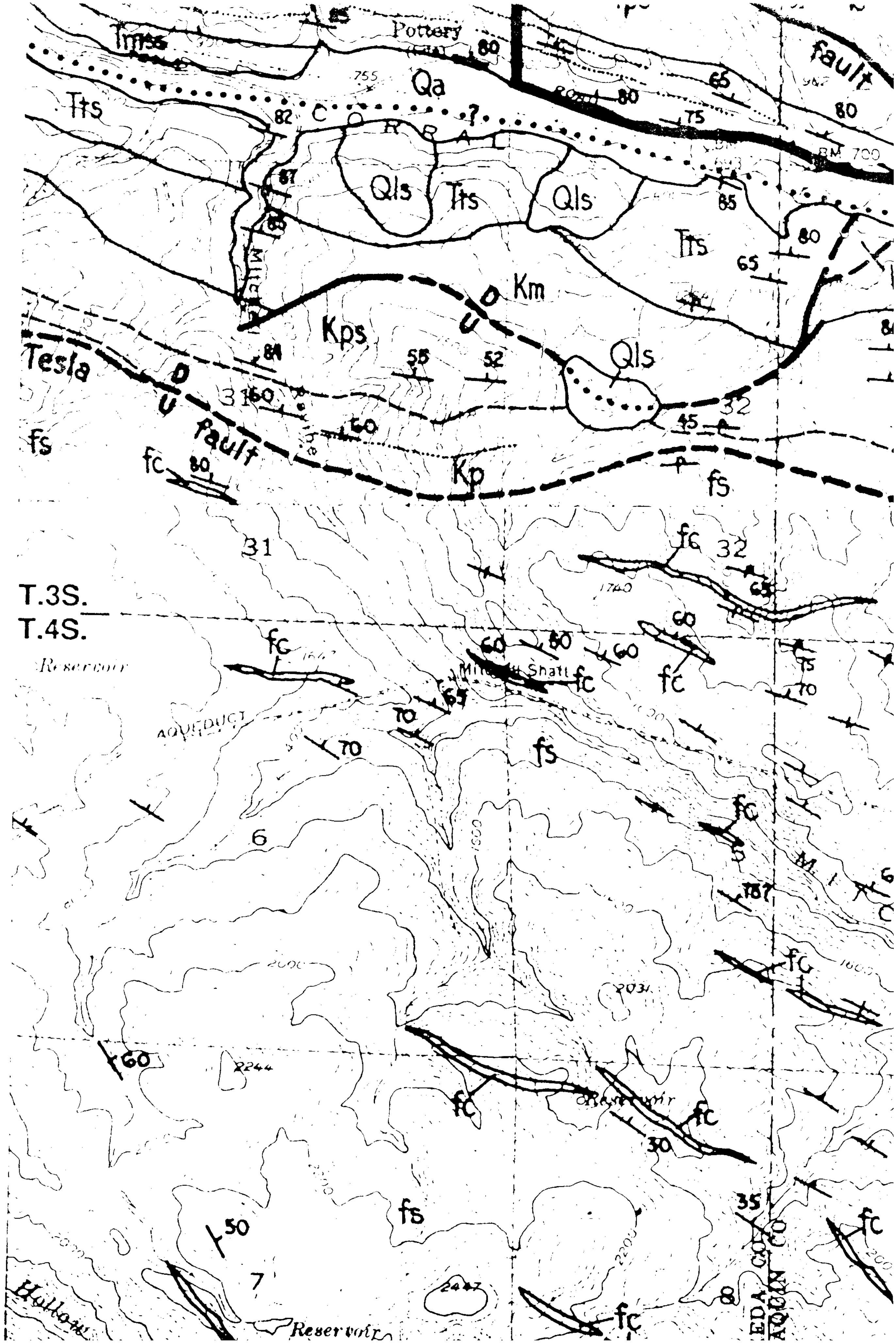
Panoche Formation

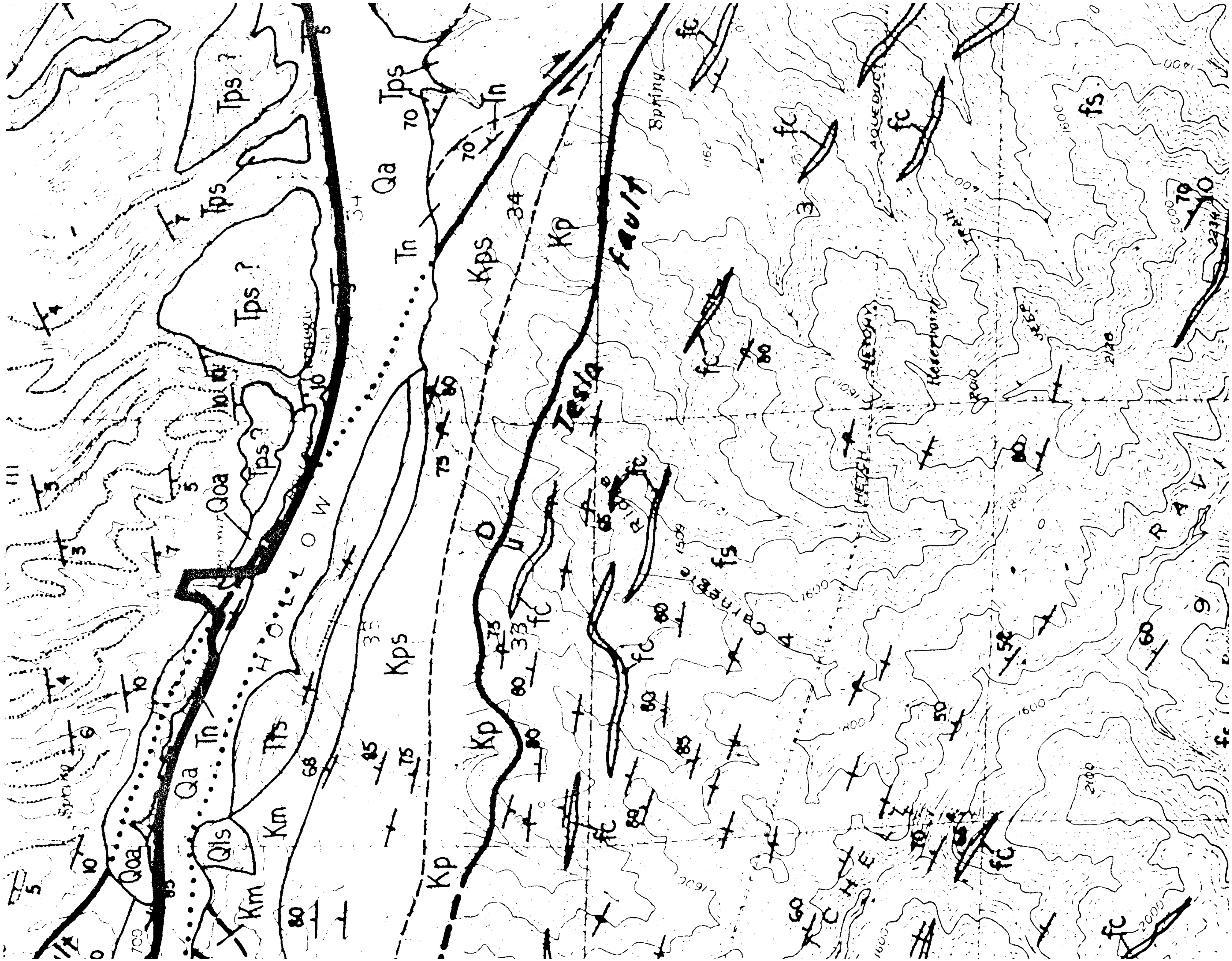
Kps; marine and light gray arkosic sandstone, with large concretions and some interbedded micaceous minor clay shale

Upper Cretaceous

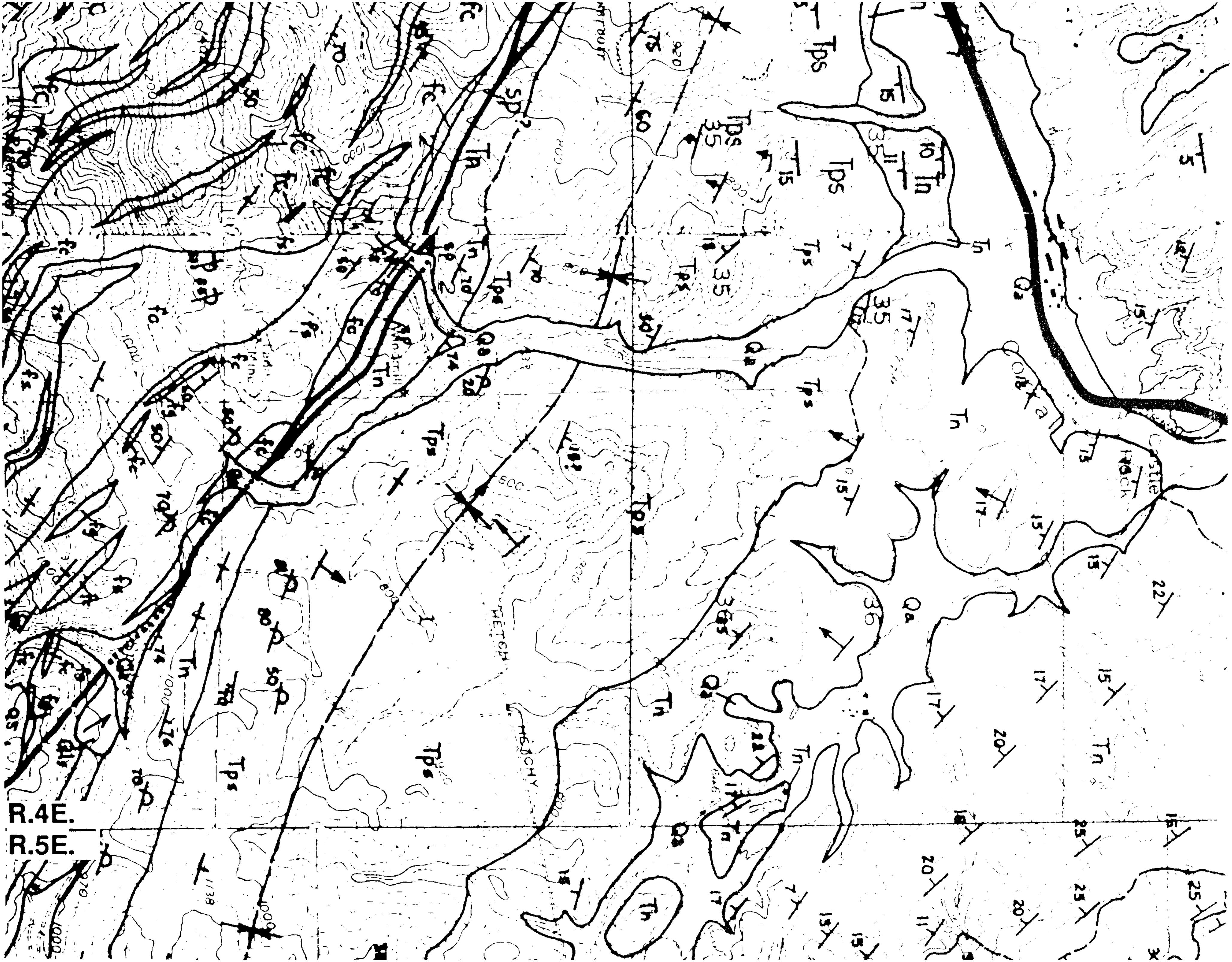
CRETACEOUS

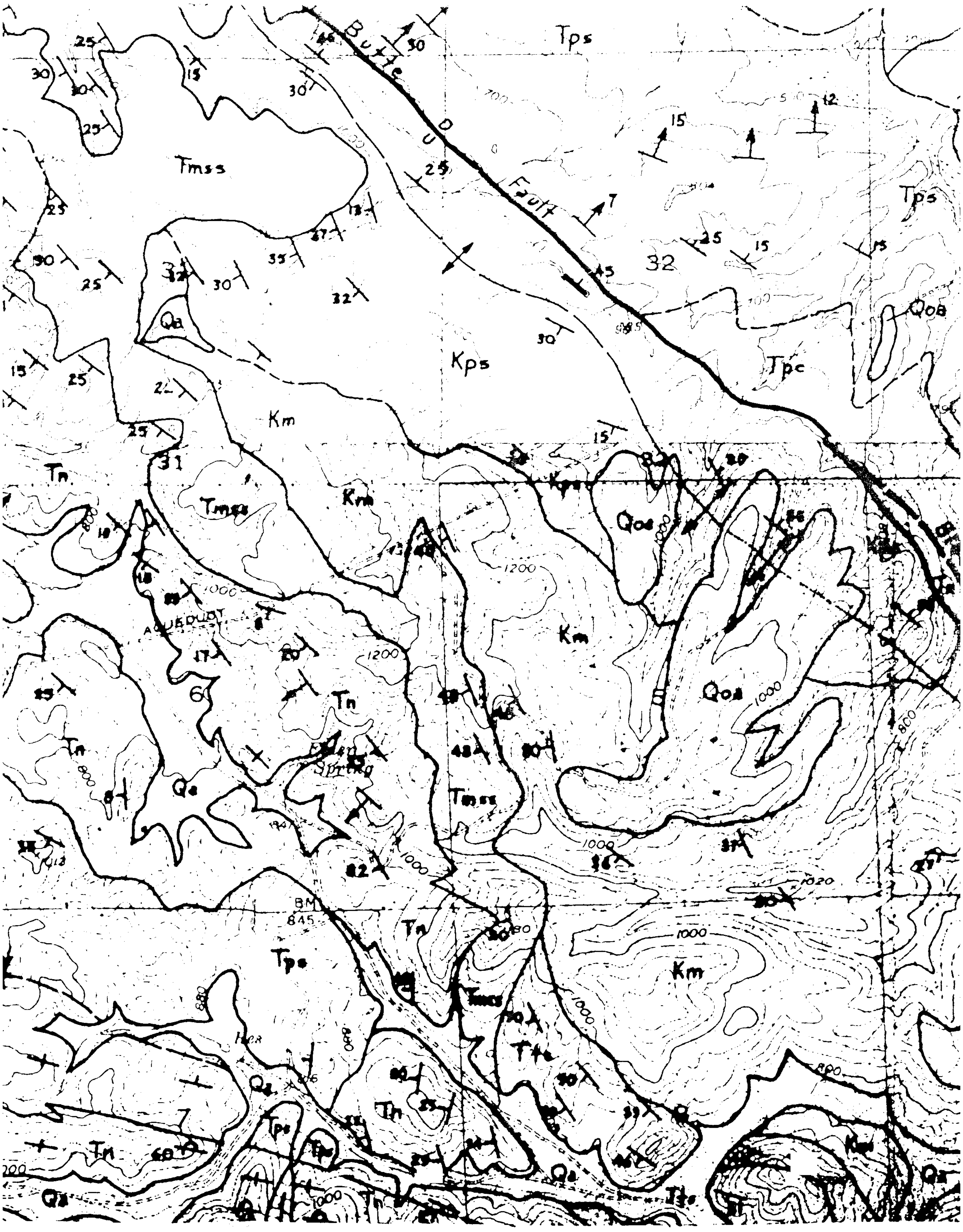
Coast Range Thrust

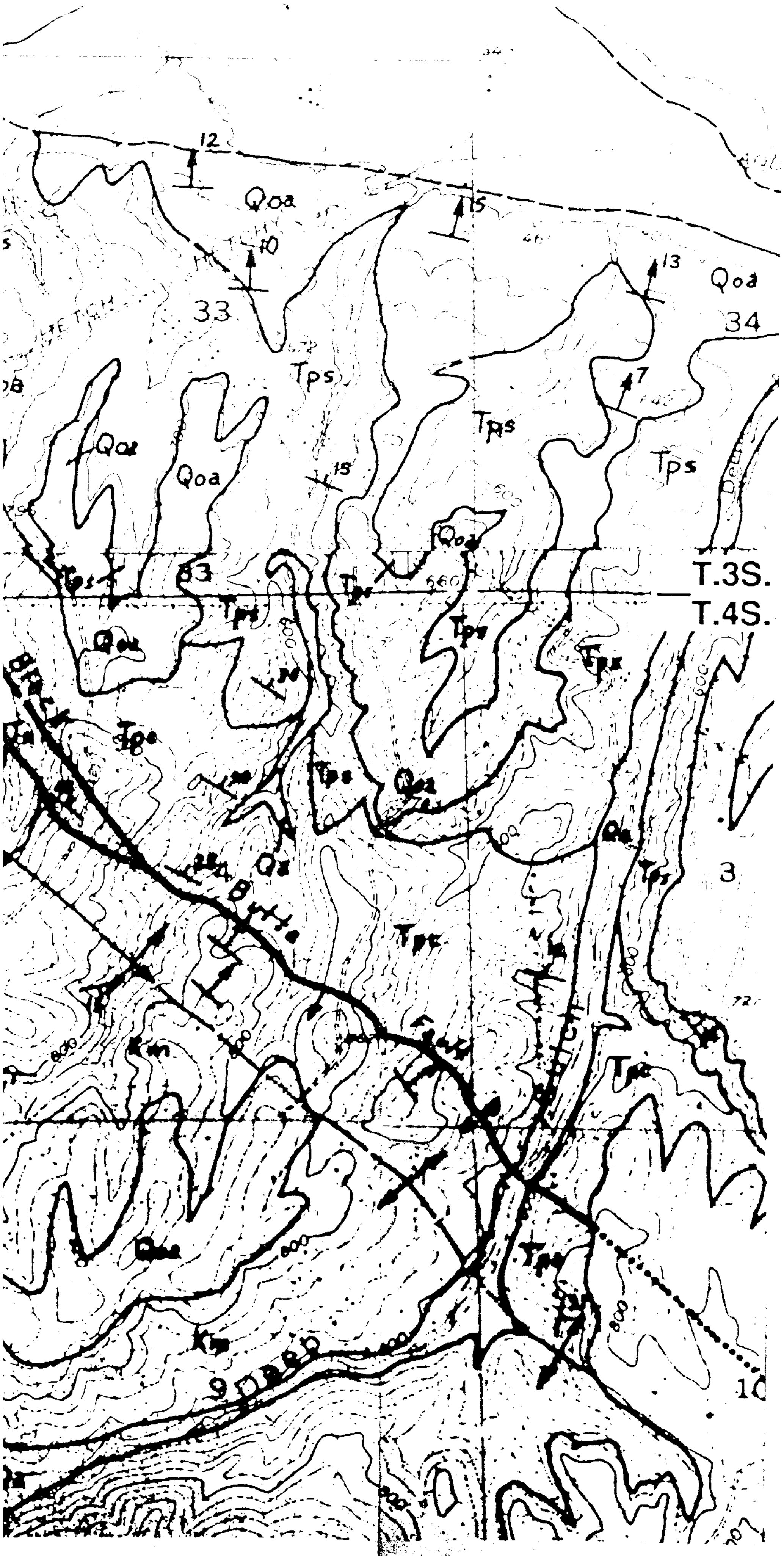

Tmss
Pottery
Qa
Tts
C O R R A L
Qls
Tts
Qls
Tts
Km
D
U
Kps
Qls
Tesla
D
U
fault
31
32
fs
fc
Kp
fs
fault
BM 700
31
fc
32
T.3S.
T.4S.
Reservoir
fc
Mitchell Shaft
fc
fc
AQUEDUCT
fs
fc
6
5
fc
fc
fc
fc
fs
7
8
Hollow
Reservoir
fc
fc
EDA CO.
AQUIN CO.
82
87
85
81
55
52
60
60
80
80
80
65
75
85
80
65
45
60
60
60
60
75
70
65
70
70
60
30
35
50



Tps ?
Tps
Qa
Tn
Qoa
Qls
Km
Kps
Kp
Tesla fault
D
U
fc
fs
HOLLOW
Carnegie
Spring
AQUEDUCT
HETCH HETCHY
Road


R.4E.
R.5E.
Tps
Tn
Qa
fc
fs
SP?
Central
Castle Rock
HETCH
HETCHY
35
36
60
15
17
20
22
25


Butte Fault
D
U
Tps
Tmss
Kps
Km
Qa
Qoa
Tpc
Tn
Tts
32
31
6
7
AQUEDUCT
Spring
BM
845
1000
1200
800



fs

fc

Franciscan Assembla

(Pervasively sheared, sli
metamorphosed mari
sedimentary sequenc

fs; sandstone (gra
wacke), and inte
bedded micace
shale

fc; varicolored char

Legend

Geologic Sym

Contact

dashed where gr
or approximately

Fault

dashed where inferred; d
cealed; queried where exi
double arrows indicate stri
U - upthrown
D - downthrown sid

Axis of fol

arrow on axis in
direction of pl

30

(app

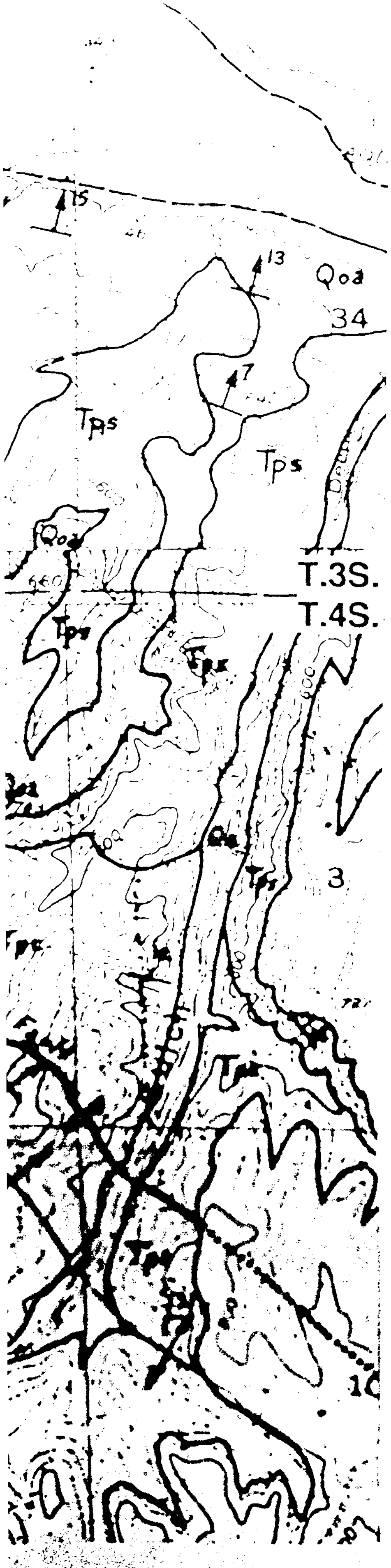
ov

Strike and dip

san

fos

m



fs
fc

Franciscan Assemblage

(Pervasively sheared, slightly metamorphosed marine sedimentary sequence)

fs; sandstone (graywacke), and interbedded micaceous shale

fc; varicolored chart

Jurassic and/or Lower Cretaceous

JURASSIC AND/OR CRETACEOUS

Legend

Geologic Symbols

Contact

dashed where gradational or approximately located

Fault

dashed where inferred; dotted where concealed; queried where existence doubtful; double arrows indicate strike-slip movement;
U - upthrown side
D - downthrown side relatively

anticline

syncline

Axis of fold

arrow on axis indicates direction of plunge

30

inclined

inclined (approximate)

vertical

overturned

foliation

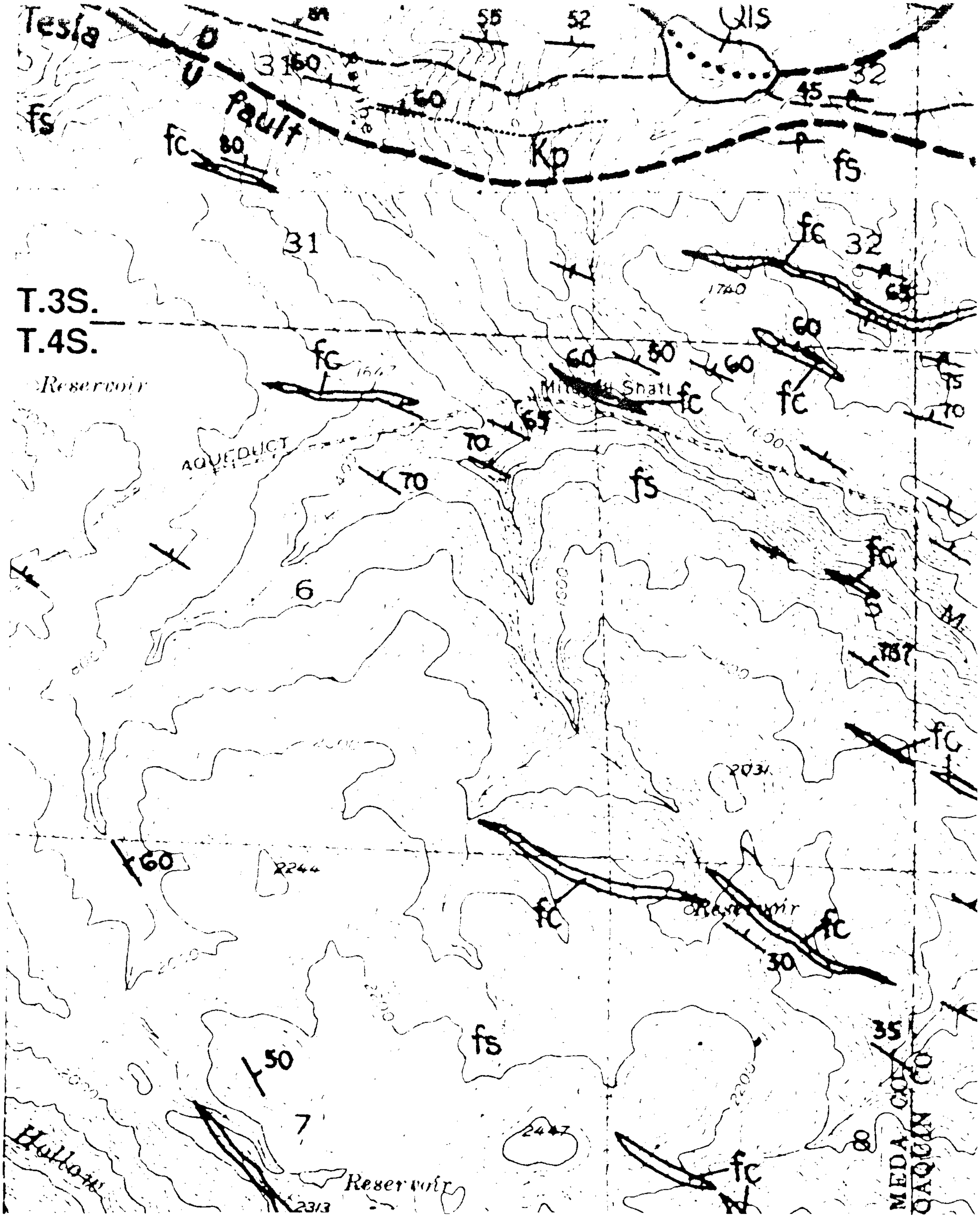
Strike and dip of strata

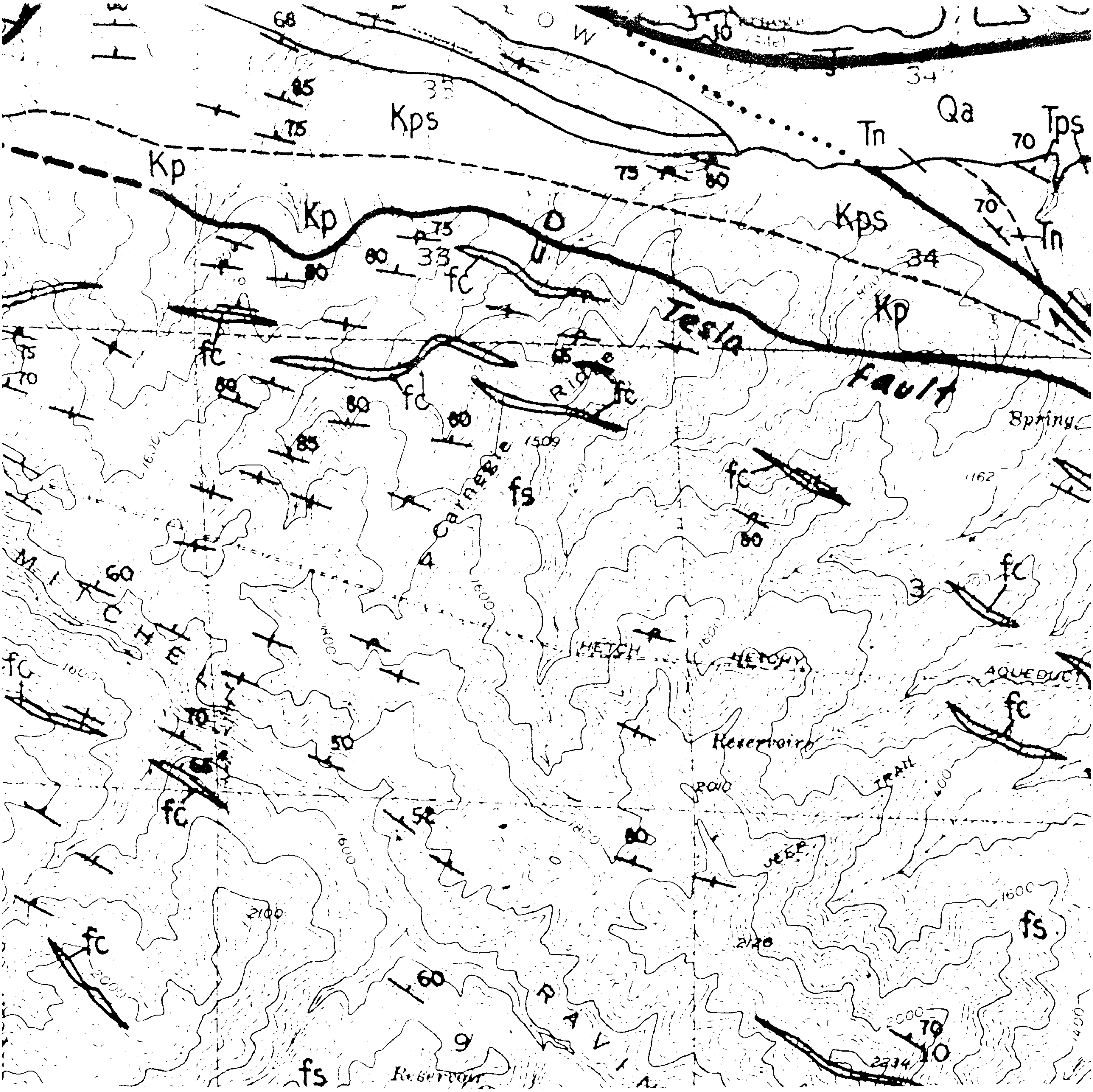
spring

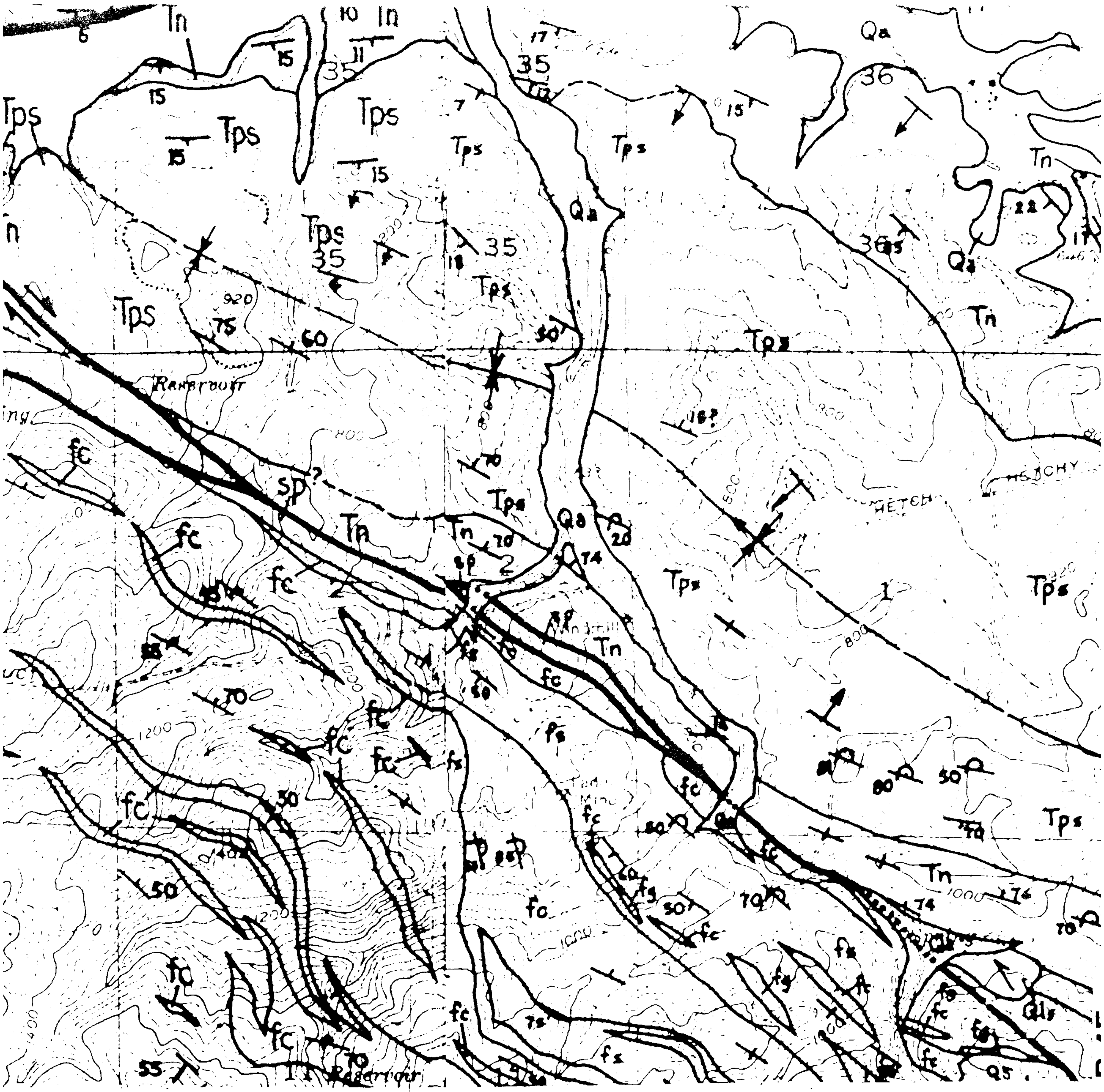
sandstone bed

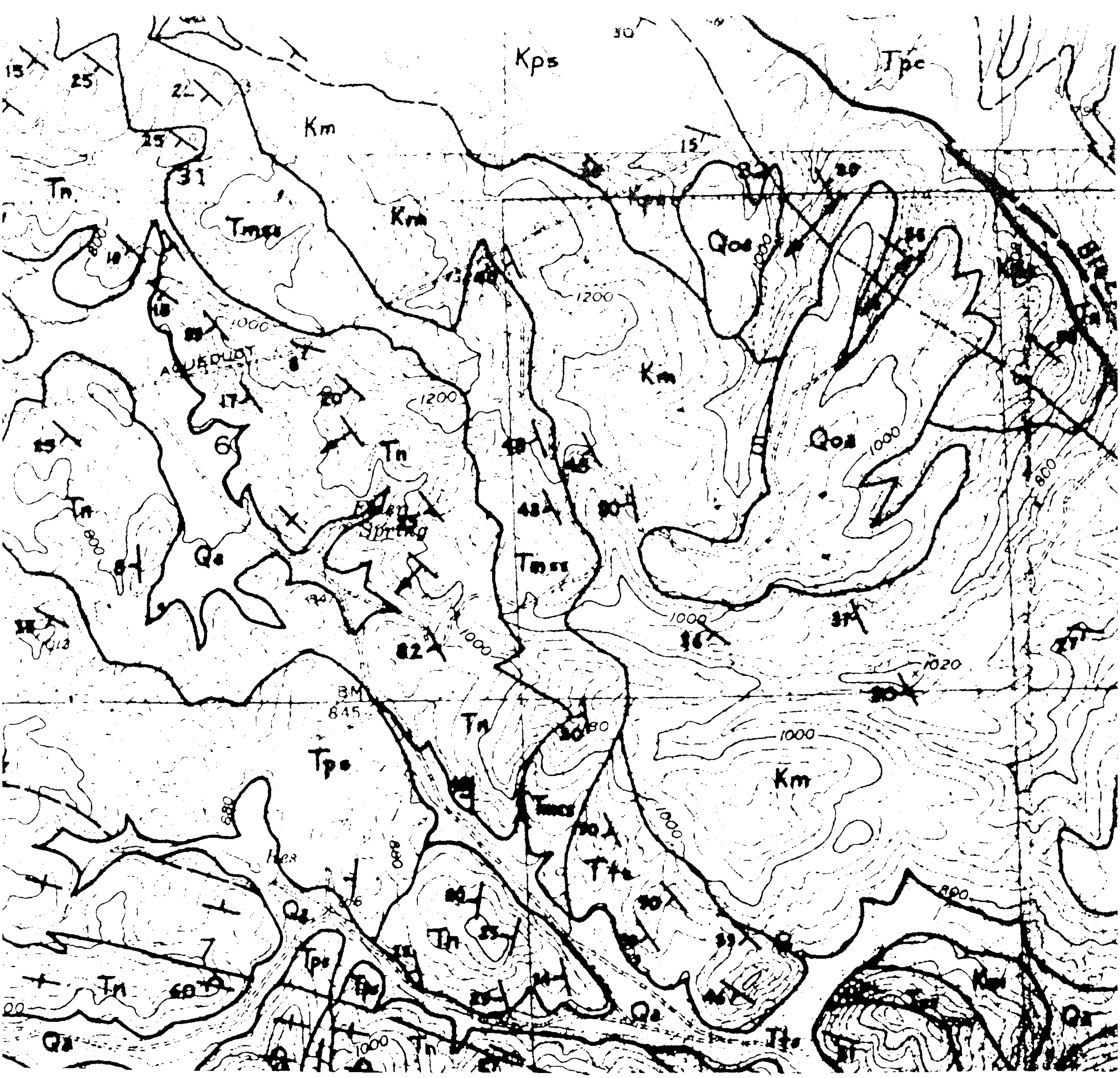
fossil locality

microfossil locality


Tesla
D
U
Fault
fs
fc
80
31
60
60
55
52
Qls
32
45
Kp
fs
31
fc
32
1740
65
T.3S.
T.4S.
Reservoir
fc
1662
60
50
60
60
Mitchell Shaft
fc
fc
75
70
67
70
AQUEDUCT
70
fs
fc
6
787
fc
2031
60
2244
fc
Reservoir
fc
30
35
fs
50
7
2447
fc
8
Hollow
Reservoir
2313
MEDA CO
OAQUIN CO


Tesla Fault
Qa
Tps
Tn
Kps
Kp
fc
fs
U
D
Carnegie
Ridge
HETCH HETCHY AQUEDUCT
Reservoir
Spring
TRAIL
M I T C H E L L
R A V I N
Reservoir
1509
1162
1600
1800
2100
2000
2128
2234
3
4
9
10
34
35
33


Tps
Tn
Qa
Tp s
fc
fs
sp
sp?
Reservoir
HETCH HETCHY
Ql s
Q5
35
36
15
75
60
70
74
50
80
55
800
920
1000
1200



Kps
Tpc
Km
Tn
Tmss
Qoa
Qa
Tpe
Tte
Tn
Aqueduct
Eden Spring
BM 845
1000
1200
1020
800
880

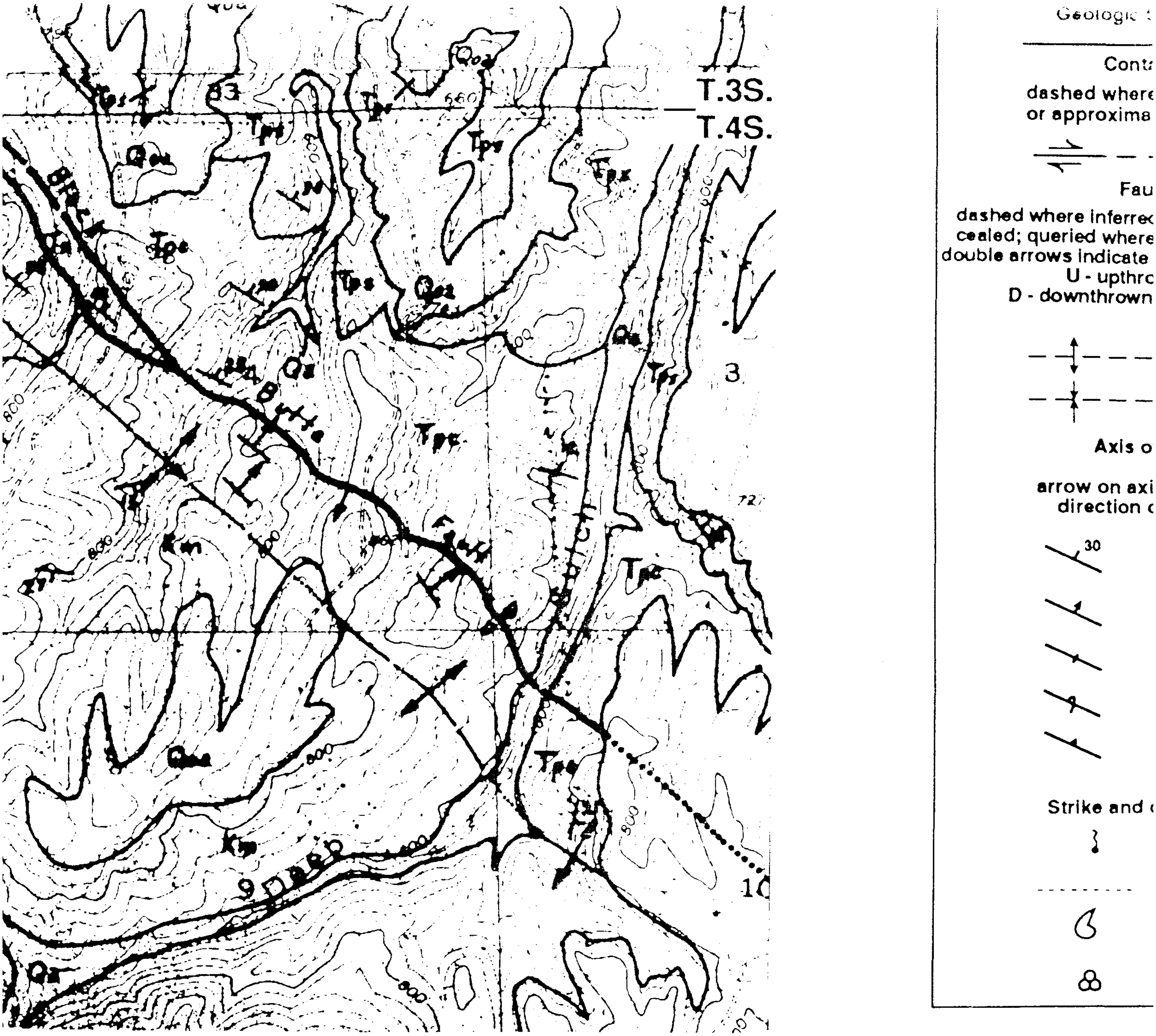
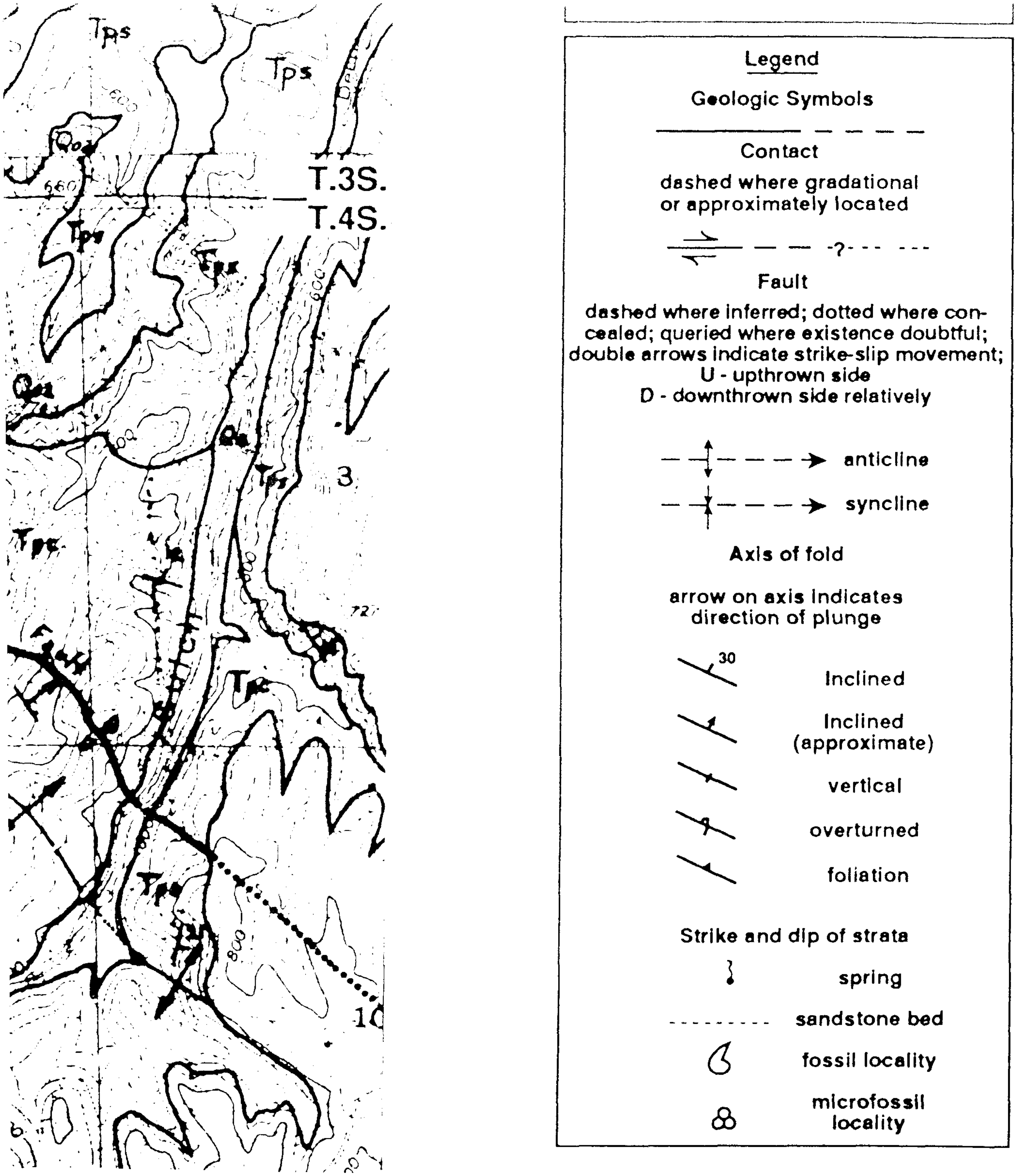


Plate 1. Geologic map of Site 300 and surroundings (modified from Dibblee



Legend

Geologic Symbols

Contact

dashed where gradational
or approximately located

Fault

dashed where inferred; dotted where concealed; queried where existence doubtful;
double arrows indicate strike-slip movement;
U - upthrown side
D - downthrown side relatively

anticline

syncline

Axis of fold

arrow on axis indicates
direction of plunge

Inclined

Inclined
(approximate)

vertical

overturned

foliation

Strike and dip of strata

spring

sandstone bed

fossil locality

microfossil
locality

map of Site 300 and surroundings (modified from Dibblee 1980a, b, c & d).