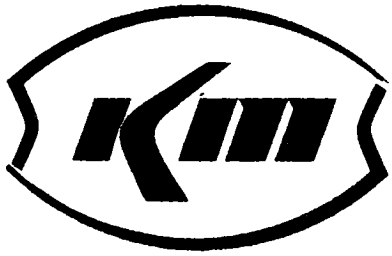
KERR-McGEE CORPORATION



GEOHYDROLOGICAL INVESTIGATION
KERR-McGEE CHEMICAL CORPORATION
HENDERSON FACILITY

JULY, 1985

Engineering Services

HYDROGEOLOGICAL INVESTIGATION

KERR-McGEE CHEMICAL CORPORATION
HENDERSON FACILITY

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SUMMARY

Since November, 1981, the Kerr-McGee Chemical Corporation Henderson Facility has been characterizing the source and extent of chromium contamination in the "Near-Surface" groundwater system present beneath the Facility. The presence of chromium has been detected in the "Near-Surface" groundwater extending northward in the downgradient direction from the Facility. Since the beginning of the investigation in November, 1981, forty groundwater monitoring wells and 13 geological borings have been installed to delineate the horizontal and vertical extent and chemical nature of the chromium containing plume, as well as to determine the geological features that control the occurrence and movement of the groundwater. Geophysical method (EM Survey) was also employed to better define the chromium plume configuration.

The source areas of chromium (contained within process fluids) impact to the "Near-Surface" groundwater have been identified and actions have been taken to eliminate further leakage from these areas.

The stratigraphy directly underlying the site consists of poorly sorted, heterogeneous mixtures of silty sand and gravel (boulders and cobbles common) that vary in thickness from 19.5 to 61.5 feet over the site. Underlying these deposits is the Muddy Creek formation consisting predominantly of a brown silty clay for at least the upper 230 feet of the formation that underlies the Facility. Based upon test drilling and aquifer tests, no water-bearing zones of significant areal extent are present in the upper portion (230 feet) of the Muddy Creek formation. Groundwater found in

isolated water-bearing zones in the upper 230 feet of the Muddy Creek formation have positive head differentials as compared to the "Near-Surface" aquifer. Therefore, water in the "Near-Surface" aquifer cannot migrate vertically to water-bearing zones in the Muddy Creek formation. Developed on the clay surface of the Muddy Creek formation is an extensive ancient drainage system consisting of stream channels and adjacent interfluve (area between streams or rivers) areas that was long ago buried by the alluvial fan sediments. Sediments in the ancient channels consist of reworked (by stream action) sand and gravel referred to as "channel fill" deposits. The deposits adjacent to the "channel fill" deposits consist predominantly of the poorly sorted, heterogeneous alluvial fan sediments.

Groundwater beneath the site is contained within both the upper portions of the Muddy Creek formation and the overlying alluvial sediments and occurs under unconfined conditions. The alluvial sediments are unsaturated over the southern half and the west-central portions of the Facility area and saturated to some depth over the remainder of the Facility. Groundwater is moving through the Muddy Creek formation (under a gradient of about 2.7 percent) at an average velocity of 0.53 feet/day.

Groundwater in the alluvial sediments occurs at depths ranging from about 35 to 5 feet below ground level. The saturated thickness in the alluvium range from 0 to greater than 27.7 feet. Generally, the thicker zones of saturation occur over the buried "channel fill" deposits. The groundwater is moving through these alluvial sediments (under an average gradient of about 1.5 percent) between 0.5 to 16 feet/day. The higher flow velocities

occur in the "channel fill" deposits and the lowest typically occur in interfluve areas where poorly sorted alluvial fan deposits occur. The elevation of the water-table surface remains relatively stable with annual fluctuations of about 2 feet common.

Site studies show a strong correlation between the location of the buried stream channels and the migration of the chromium plume. The movement of the plume is largely controlled by the presence of these channels in the alluvial deposits. The chromium plume also moves through the upper part of the Muddy Creek formation in areas where the overlying alluvial deposits remain unsaturated. This type of movement is near the source of the chromium leakage and the chromium plume remains fairly concentrated. Where the chromium plume moves through the saturated portions of the alluvial fan deposits, natural attenuation of the plume by dilution and dispersion occurs at fairly high rates.

The chromium plume has migrated at least 4,000 feet downgradient from areas of past leakage and is typically narrow in its configuration owing to the fact that it moves principally through the narrow, buried stream "channel fill" deposits.

CONCLUSIONS

The major conclusions of this report are:

1) The presence of chromium in groundwater above background values has been detected and extends from areas of past leakage northward at least 4,000 feet.

2) The source areas responsible for past leakage of chromium containing process fluids were identified and actions have been taken to eliminate further leakage from these areas.

3) The chromium plume shows a northern migration at rates from 0.5 to 16 feet/day and moves first through the upper part of the Muddy Creek formation and then the overlying saturated alluvial fan sediments.

4) The alluvial fan sediments are unsaturated over the southern half and west-central portions of the Facility. Groundwater moves through the upper parts of the Muddy Creek formation in these areas. The saturated zone extends into the more permeable alluvial fan sediments in the northern and east-central portions of the Facility.

5) The surface of the Muddy Creek formation is eroded by buried stream channels that eroded and are entrenched into the Muddy Creek formation. The "channel fill" sediments that occupy these ancient stream channels are much more permeable than interfluve areas adjacent to the streams. These "channel fill" deposits largely control the migration of the chromium plume present in the saturated portions of the alluvial fan desposits.

6) A large buried channel system occurs in an area extending northward from the Plant AP ponds to at least the area of well M-23, where the chromium plume is largely contained.

7) Groundwater from the "Near-Surface" aquifer (and its dissolved components) cannot migrate into deeper aquifer systems that may underlie the Facility at depth due to the presence of upward or positive head exhibited by these deeper aquifers over the "Near-Surface" aquifer.

8) Aquifer testing of the "Near-Surface" aquifer revealed a wide range of permeability (6.5 to 1496 gpd/ft^2) and transmissivity (45.2 to 23,786 gpd/ft) values. The lower permeabilities and transmissivities occur in the Muddy Creek clays and interfluve alluvial fan depositional areas. The higher values occur in the buried stream channels which consist of "channel fill" deposits. The storage coefficient is relatively constant over all areas and averages 0.053.

INTRODUCTION

In May and June, 1985, Kerr-McGee Corporate Hydrology Department completed a detailed investigation of the hydrogeological conditions at the Kerr-McGee Chemical Corporation's Henderson Facility. The purpose of this investigation was to provide a detailed evaluation of the chromium contaminant plume present in the "Near-Surface" groundwater as well as provide technical hydrogeological information characterizing aquifer dynamics. Major objectives of this investigation were to: 1) delineate the extent and concentration of the plume area; 2) define aquifer properties; 3) determine conditions that control occurrence and movement of groundwater; 4) characterize the chemical nature of the groundwater; and 5) define contaminate plume hydrodynamics.

LOCATION AND GENERAL SURFACE FEATURES

The Henderson Facility lies in the Basin and Range Physiographical Province (Fenneman, 1931). Features of this province consist of linear and semi-linear north-south trending mountain ranges separated by linear and semi-linear valleys. The Facility is located in portions of sections 12 and 13, Township 22 South, Range 62 East, about 1/2 mile west of Henderson, Nevada (Figure 1).

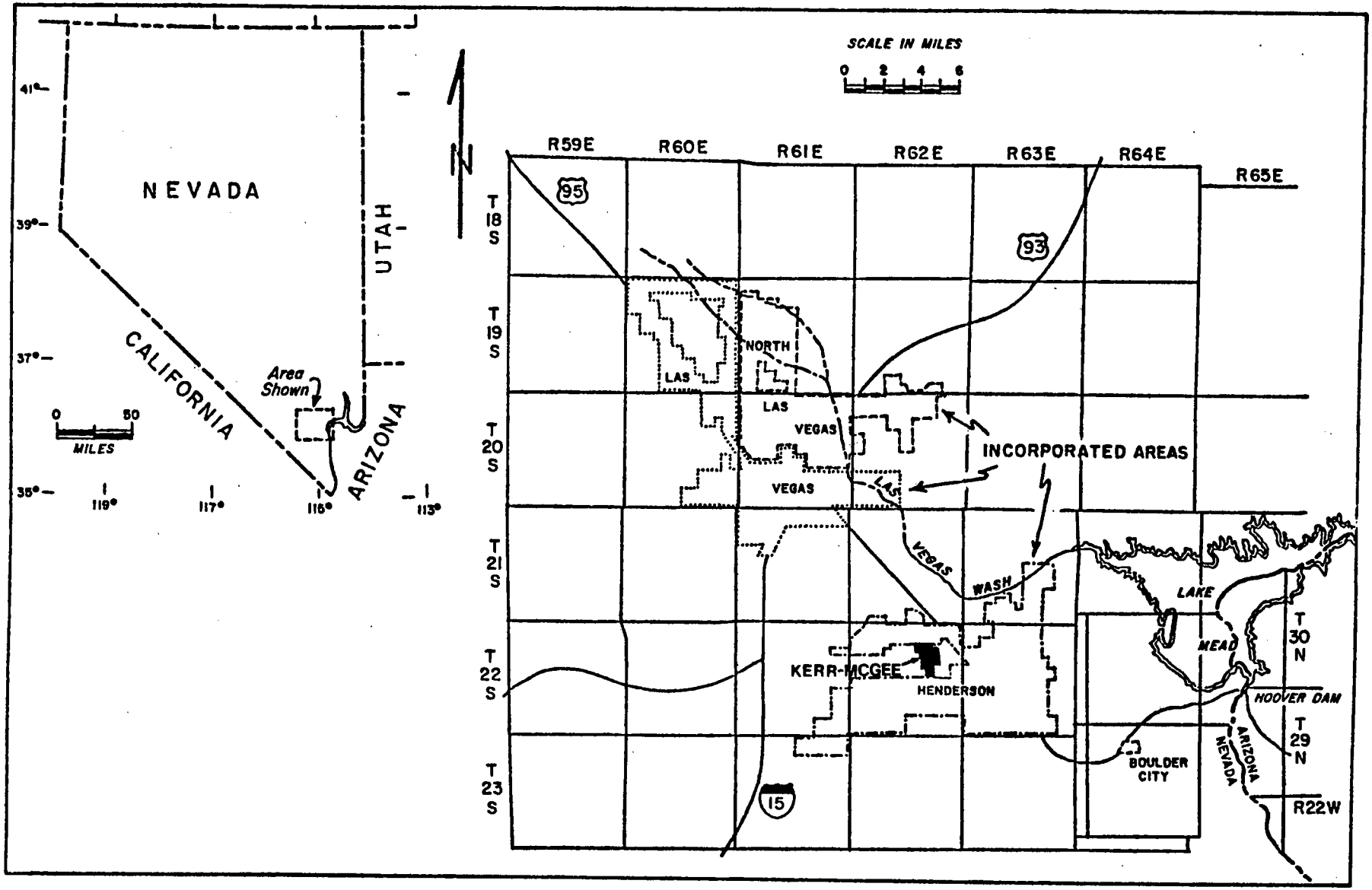

FIGURE 1. INDEX MAP OF THE REPORT AREA.

The Henderson Facility (Figure 2) is located within the Las Vegas Valley (southern edge), a valley that is about 40 miles long and up to 20 miles wide. The Valley trends south-southwest, and its floor ranges in altitude from 1500 to 3000 feet. This Valley is a tributary to the Colorado River. The Las Vegas Valley is bounded on the west by the Spring Mountains; on the east by Frenchman and Sunrise Mountains; on the north by the Desert, Sheep and Las Vegas Ranges; and on the south by the River Mountains and the McCullough Range.

The mountain ranges in the region are generally composed of exposed bedrock which have steep, often bare surfaces. They rise abruptly above the gently-sloping valley floor and are surrounded by flat-lying alluvial deposits extending to the central part of the Valley.

Las Vegas Wash is the major drainage in the area and represents the base level of Las Vegas Valley. The Wash is 3 miles north at its nearest approach to the Henderson Facility. Prior to 1920, Las Vegas Wash carried no continuous streams of surface water. However, an occasional flash flood flowed down the Wash. Just after World War I, artesian wells were drilled in the upper reaches of the Wash. Uncontrolled water from these wells seeped into the alluvial material and reappeared as springs farther down the Wash. Presently, several points of artificial discharge into Las Vegas Wash keep it flowing year round and discharging into Lake Mead (Colorado River). Several tributary drainages flow into Las Vegas Wash from the northeast, west, and southeast. All of these drainages are intermittent.

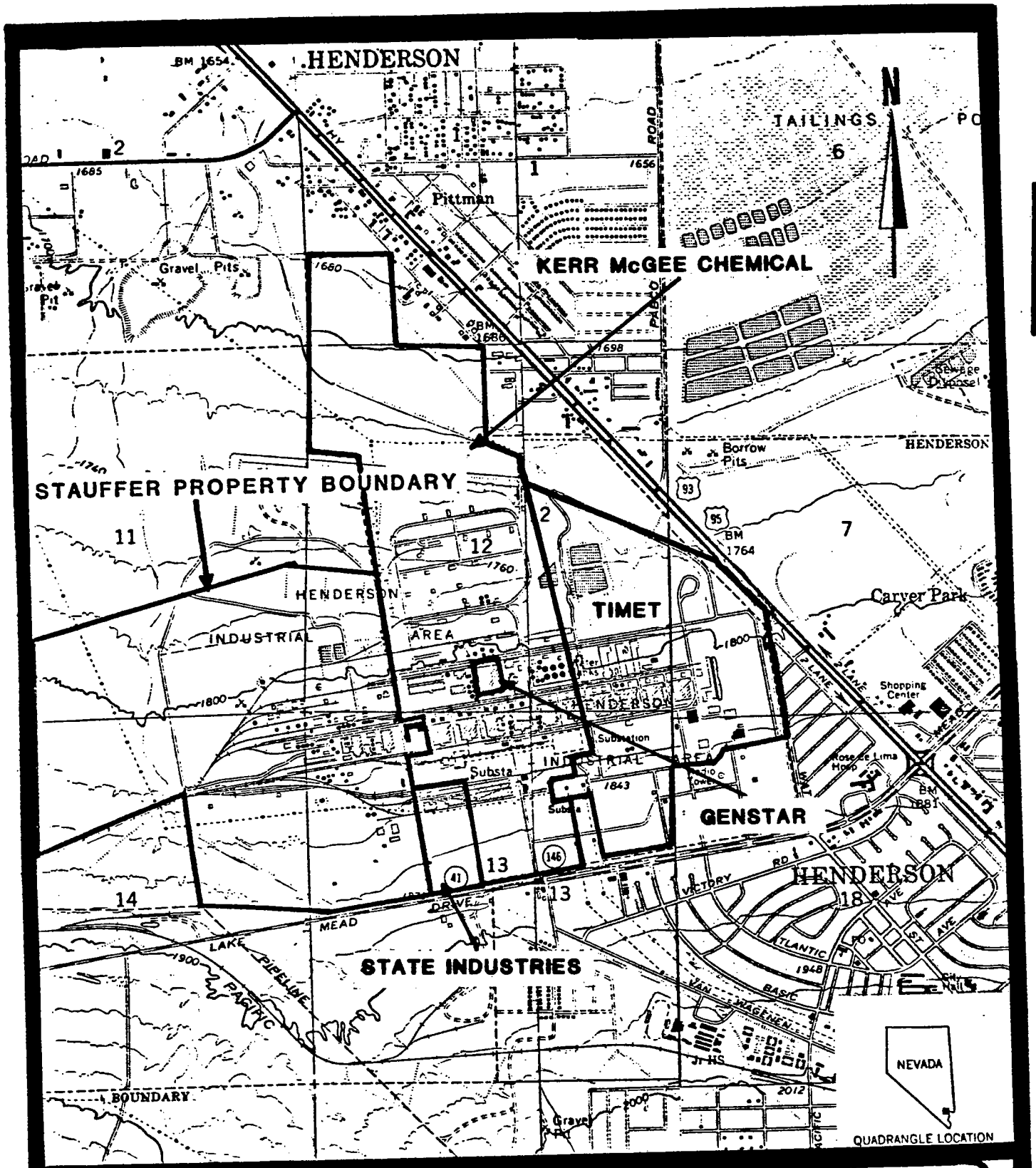

FIGURE 2

KERR-McGEE CHEMICAL COMPANY SITE LOCATION
BMI COMPLEX

HENDERSON, NEVADA

SOURCE: USGS TOPOGRAPHIC MAPS, LAS VEGAS SE QUAD AND HENDERSON QUAD, PR1973,PR1983 SCALE 1:24000

The Henderson Facility is located at the southern edge of the Las Vegas Valley and rests upon alluvial fan sediments from the Black Mountain of the McCullough Range. This alluvial fan forms a gradual northward sloping surface underlying the Facility. The topographic elevation at the Henderson Facility ranges from 1870 (southwest) to 1675 (northwest) feet above mean sea level (MSL). Topographic features for the Facility are presented in Figure 2.

Two small intermittent streams or ditches cross the Henderson Facility (Plate 1). The Beta Ditch crosses the Facility just north of the AP ponds and leaves the property northeast of the C-1 pond. This ditch is tributary to the Las Vegas Wash. The second unnamed ditch crosses the northern portion of the Facility and eventually flows into an abandoned gravel pit. This conducts storm water only.

The principal city in the area is Henderson, Nevada, with a population of 24,363 in 1980. Las Vegas, Nevada is 7.5 miles northwest of the Facility.

SITE DESCRIPTION

The Kerr-McGee Henderson Facility is located in the Henderson Industrial Complex which was the site of the Basic Magnesium Incorporated (BMI) plant operated by the U.S. Government during World War II. The Henderson Facility is involved in the manufacture of industrial chemicals which are: sodium chlorate, ammonium perchlorate, manganese dioxide, boron trichlorate, boron tribromide, elemental boron, and sodium perchlorate. In support of Facility activities, there are currently 10 synthetic lined water-retention and/or

evaporation impoundments situated on the Facility (Plate 1). RCRA impoundments P-1 and S-1 were drained and removed in January, 1983, and are currently undergoing closure. A brief description of each of the above mentioned ponds is presented in Appendix A.

CLIMATE

The climate in the Henderson, Nevada area is typical of the arid southwest with precipitation falling in two clearly defined rainy seasons. During the winter, frontal storms produce low intensity rainfall over large areas. Some frontal storms also occur during the summer, but most rainfall during this season results from thundershowers occurring during periods of influx of warm, moist tropical air. Over one-third of the four inches of annual average rainfall at Las Vegas McCarran Airport (2162 feet elevation) falls as short term, high intensity rainfall during these thunderstorms, which can be quite severe and result in flash floods. Most documented floods in Las Vegas occurr during July and August.

The mean daily maximum temperature at Las Vegas McCarron Airport ranges from 13.0°C (Celsius) in January to 40.5°C in July; the mean daily minimum temperature for the same months ranges from 0.5°C to 24.5°C.

The potential annual evaporation from lake and reservoir surfaces ranges from 60 to 82 inches, or roughly 15 to 20 times the annual precipitation.

GEOLOGIC SETTING

Regional Stratigraphy

The Henderson Facility is located at the southern edge of the Las Vegas Valley. Las Vegas Valley lies along a boundary separating areas of strikingly different geology. The mountain ranges bounding the east, north, and west sides of the Valley consist primarily of Paleozoic and Mesozoic sedimentary rocks (limestones, sandstones, siltstones, and fanglomerates). The mountains on the south and southeast consist primarily of Tertiary volcanic rocks (basalts, rhyolites, and andesites) that lie directly on Precambrian metamorphic and granitic rocks.

The Las Vegas Valley occupies a deep structural basin that has been filled with a thick sequence of sediments. Beginning in Miocene time, a thick sequence of alluvial and lacustrine sediments began accumulating in the Basin. In the Las Vegas area, the earliest of these deposits are the Thumb and Horse Springs formations of Miocene-age. These formations outcrop in the Frenchman Mountain area, where they consist primarily of limestone, sandstone, siltstone, and conglomerate. These formations occur at depths of at least from 3000 to 3700 feet in the Las Vegas area.

Overlying the Thumb and Horse Springs formations is the Muddy Creek formation. The Muddy Creek formation is a multi-colored, poorly to well-consolidated siltstone, clay, and sand with minor intercalated fanglomeratic horizons. The fine-grained facies is most common in the Las Vegas area, but near the mountains the coarse-grained facies becomes

prominent. The Muddy Creek formation reaches thicknesses of 3000 feet and occurs at depths from 0 to 3000 feet in the Las Vegas area. The Muddy Creek formation is typically flat lying to gently tilted and has been cut by many small faults. The surface configuration of the Muddy Creek formation is often characterized by erosional features which give considerable relief to its surface in some areas.

The Muddy Creek formation is unconformably overlain by Plio-Pleistocene basin fill sediments. These sediments represent semi-continuous sedimentary filling of the Basin that was probably periodically interrupted, either by nondeposition or erosion. Distinct subsurface beds are generally thin, discontinuous, and laterally variable making Basin wide correlation difficult. Three depositional facies are recognized in the Plio-Pleistocene depositional period. These are: 1) coarse-grained piedmont alluvium, 2) fine-grained fluvial and lacustrine basin fill, and 3) "blue" lacustrine clay.

The coarse-grained piedmont alluvium consists of coalescing sequences of alluvial fans (as in the Henderson area) and sediments flanking the mountain ranges of the Valley. These deposits adjacent to the McCullough Range contain almost all volcanic fragments and thin toward the mountain range.

The fine-grained fluvial and lacustrine basin fill crops out along the axis of the Basin and is not present in the Henderson area.

The third facies noted above is the "blue" clay. The "blue" clay is laterally extensive in the center of the Basin, where it is encountered at depths of 480-600 feet.

Figure 3 presents the generalized regional stratigraphic column for the Las Vegas Basin. Figure 4 is a generalized geologic map of the Basin.

Site Stratigraphy

This section describes only the geological units of greatest significance to the Henderson Facility site hydrogeology. The geological units include the upper 200 feet of the Muddy Creek formation and overlying alluvial fan sediments, each of which is discussed below. A detailed site stratigraphic column is presented in Figure 5.

Muddy Creek Formation

The Muddy Creek formation of Pliocene age underlies the Henderson Facility in the subsurface. This formation consists of brown- to reddish-brown silty clay and clayey silt. Thin, discontinuous lenses of fine sand and silt may be present locally.

The upper 200 feet of the Muddy Creek formation at the Henderson Industrial Complex were extensively investigated by neighboring Stauffer Chemical Company. Five wells were drilled to depths of 230 feet. All of these wells are within 2000 feet of the Kerr-McGee Henderson Facility. Similar geological conditions exist over the entire Henderson Industrial Complex and the logs of these wells are representative for the Henderson Facility. The lithology encountered when drilling these wells indicated that no recognizable sand or gravel (permeable) horizons were encountered in three of the wells and silty clay was the predominant lithology encountered in these wells. Two wells encountered thin sand zones at 127 and 220 feet.

Geologic unit in Las Vegas area	Epoch	Period	Era	Age before present (millions of years)
Recent alluvium	Holocene	Quaternary	Cenozoic	0.01
Plio-Pleistocene Basin Fill	Pleistocene			1.8
Muddy Creek Fm	Pliocene	Tertiary		5.2
Horse Spring Fm Thumb Fm	Miocene			22.5
Intrusive (igeneous), extrusive (volcanic), and sedimentary (continental limestone, sandstone, shale) rocks	pre-Miocene			65
Sedimentary rocks (marine); dominantly sandstones and limestones			Mesozoic	225
Sedimentary rocks (marine); dominantly carbonate rocks with sandstones			Paleozoic	570
Igneous and metamorphic "basement" rocks			Precambrian	

FIGURE 3. REGIONAL STRATIGRAPHIC COLUMN FOR THE LAS VEGAS, NEVADA AREA (After Bell, 1981).

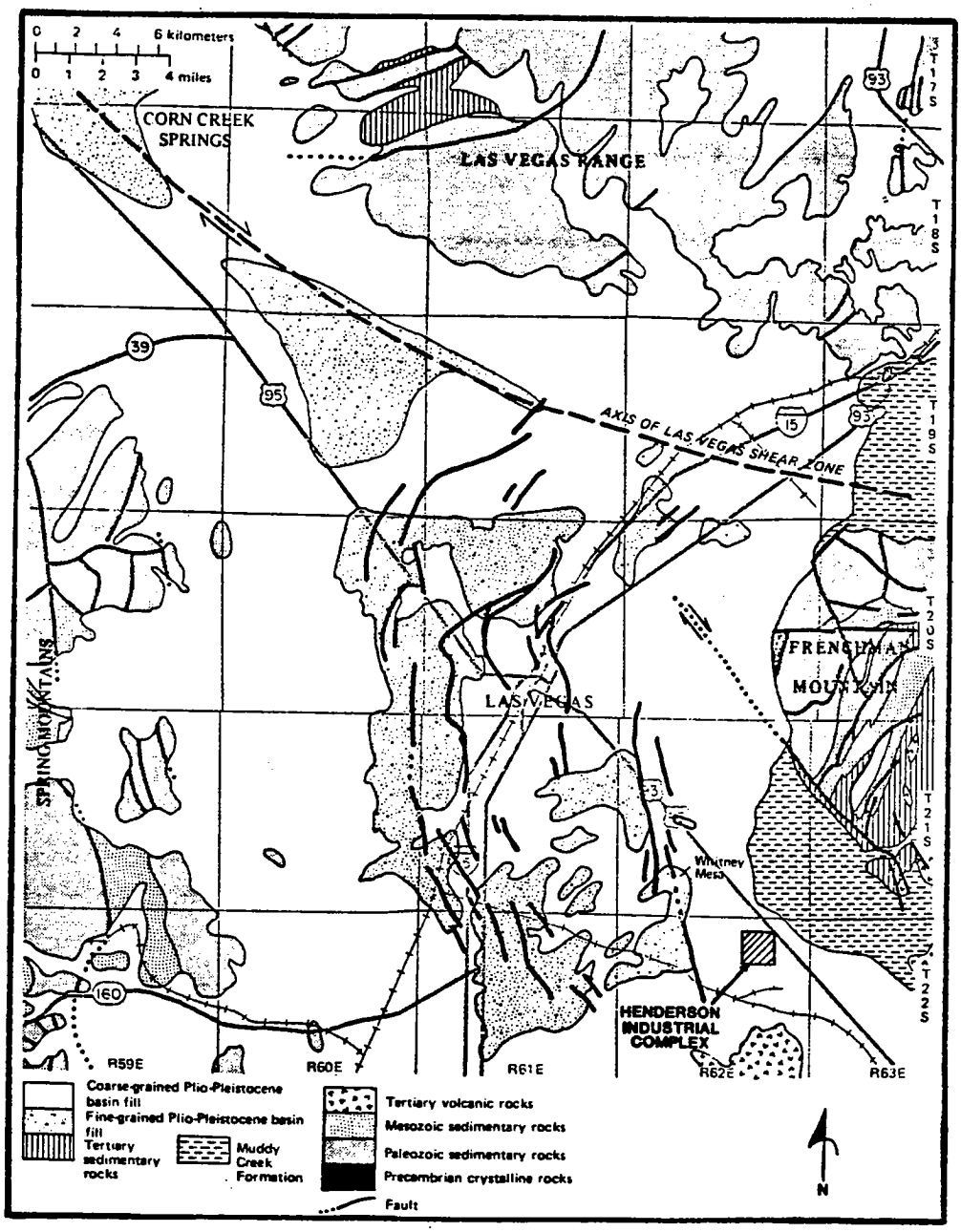

FIGURE 4. GENERALIZED GEOLOGICAL MAP OF THE LAS VEGAS VALLEY AREA (After Bell, 1981).

GEOLOGIC AGE	GEOLOGIC FORMATION	APPROXIMATE THICKNESS, FT	LITHOLOGIC DESCRIPTION
PLEISTOCENE	ALLUVIAL FAN DEPOSITS	19.5 - 61.5	Heterogeneous, poorly sorted, unconsolidated deposits of silty sandy gravels and silty gravelly sands consisting primarily of reworked volcanics and meta-volcanics. Sands and gravels typically multi-colored with reddish-brown the dominant color. Gravels may be locally cemented or slightly cemented by calcium carbonate. Small lenses of a white clayey silt common near the base of this deposit. Boulder and large cobbles are common throughout.
PLIOCENE	MUDDY CREEK FORMATION	500? - 3000	NOTE: This description for upper 200 feet of Muddy Creek. The Muddy Creek is typically a moderately consolidated sandy-silty clay to a clayey silt. The upper 2 feet of the formation is typically a brown clayey silt grading into a brown silty clay. Small discontinuous silt and fine sand lenses may be present locally.

FIGURE 5. SITE SPECIFIC STRATIGRAPHIC COLUMN FOR THE KERR-McGEE HENDERSON FACILITY.

However, Geraghty and Miller (1980), indicate that these sands have limited areal extent because they were not encountered in neighboring wells that penetrated this formation to at least 230 feet. Also, wells completed within these sand horizons indicated that a positive groundwater head differential exists over the groundwater levels noted in the "Near-Surface" aquifer. This pressure differential prevents downward leakage of shallow groundwater to these deeper permeable strata (Geraghty and Miller, 1980).

Over 100 monitoring wells and test borings have been drilled on the Henderson property. Most of these wells penetrate the upper 5 to 20 feet of the Muddy Creek formation. Logs prepared from these wells indicate that the upper 2 feet of the Muddy Creek formation typically consists of a brown clayey silt followed by brown silty clay. Thin, discontinuous fine sand and silt lenses may be locally present. The fine-grained nature of this formation (silty clay) is of utmost importance since it effectively inhibits extensive vertical migration of any contaminant at the site.

The upper surface of the Muddy Creek formation has been modified through erosion. An erosional surface is evident on the top of the Muddy Creek formation and was caused by an ancient drainage system. Referring to Plate 2, the configuration of the top of the Muddy Creek formation is shown beneath the Henderson Facility. The predominant feature of this map is the northward sloping surface of this formation. The surface slopes at gradients that range from 0.80% (42 feet/mile) to 5.4% (285 feet/mile) with an average of 2.5% (132 feet/mile). Five major erosional features are evident upon examination of this map. A buried erosional channel appears to

start near pond AP-5 and strikes north along a line to well M-23. An interfluve area is suggested to exist east of this channel and strike northward. A second interfluve area exists west of this channel and also strikes northward (from wells H-38 to to MC-20). A major buried channel exists (along a line from wells H-23 to MC-56 to MC-50 to H-51) in the northwest corner of the Henderson Facility. Stauffer Chemical Corporation is currently operating a groundwater interception system over the width of this channel. This buried channel trends northeast. A third interfluve area occurs due west and bounds the western side of the channel. Definition of where these buried channels and adjacent interfluves occur is of utmost importance because they greatly control the occurrence and movement of groundwater beneath the Henderson Facility. Typically, the erosional channels contain greater thicknesses of more permeable sands and gravels than the interfluve areas adjacent to these channels. The role of these channels in groundwater occurrence and movement beneath the site is discussed more fully in the section titled Site Hydrogeology.

A map showing depth-to-top of the Muddy Creek formation is presented in Plate 3. The depth-to-top of the Muddy Creek formation varies from 19.5 to 55 feet over the site. Examination of this map shows the presence of interfluve areas (near wells MC-59, M-18, and MC-60) with the intervening buried channel systems (near well M-27, and wells MC-80 to H-51).

The configuration of the Muddy Creek formation is shown more clearly in the geologic cross sections presented in Figures 6, 7, and 8 (Line of section shown on Plate 9). The cross sections in Figure 6 shows very little Muddy Creek relief along section A-A' near Units 4, 5, and 6. Section B-B' shows the existence of an erosional channel from wells M-4 to CLU-1, north of the

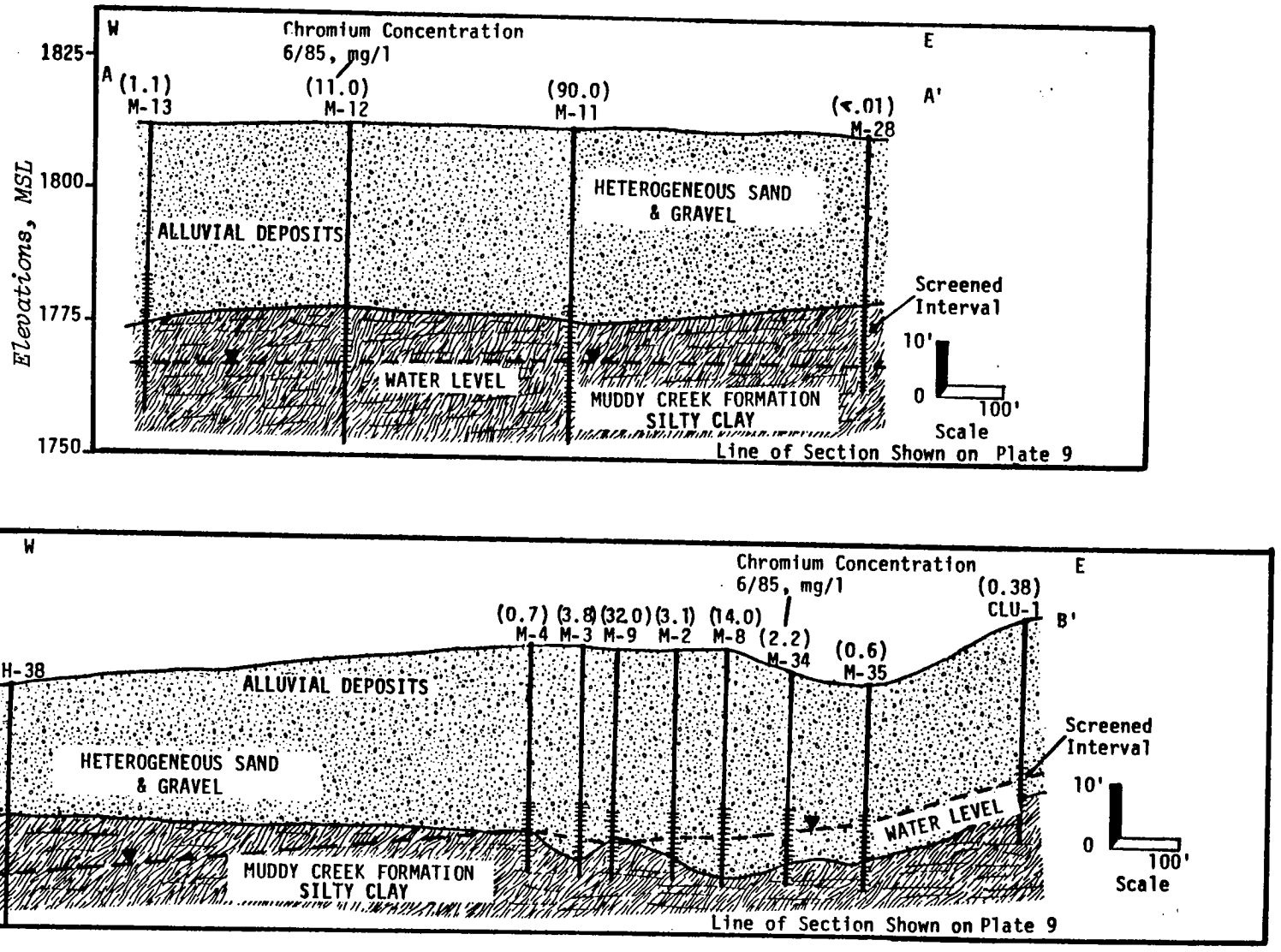

FIGURE 6. EAST-WEST GEOLOGICAL CROSS SECTIONS FOR AREAS DOWNGRADIENT OF THE P- AND S-SERIES IMPOUNDMENTS (B-B') AND UNITS 4, 5, AND 6 (A-A') AT THE HENDERSON FACILITY.

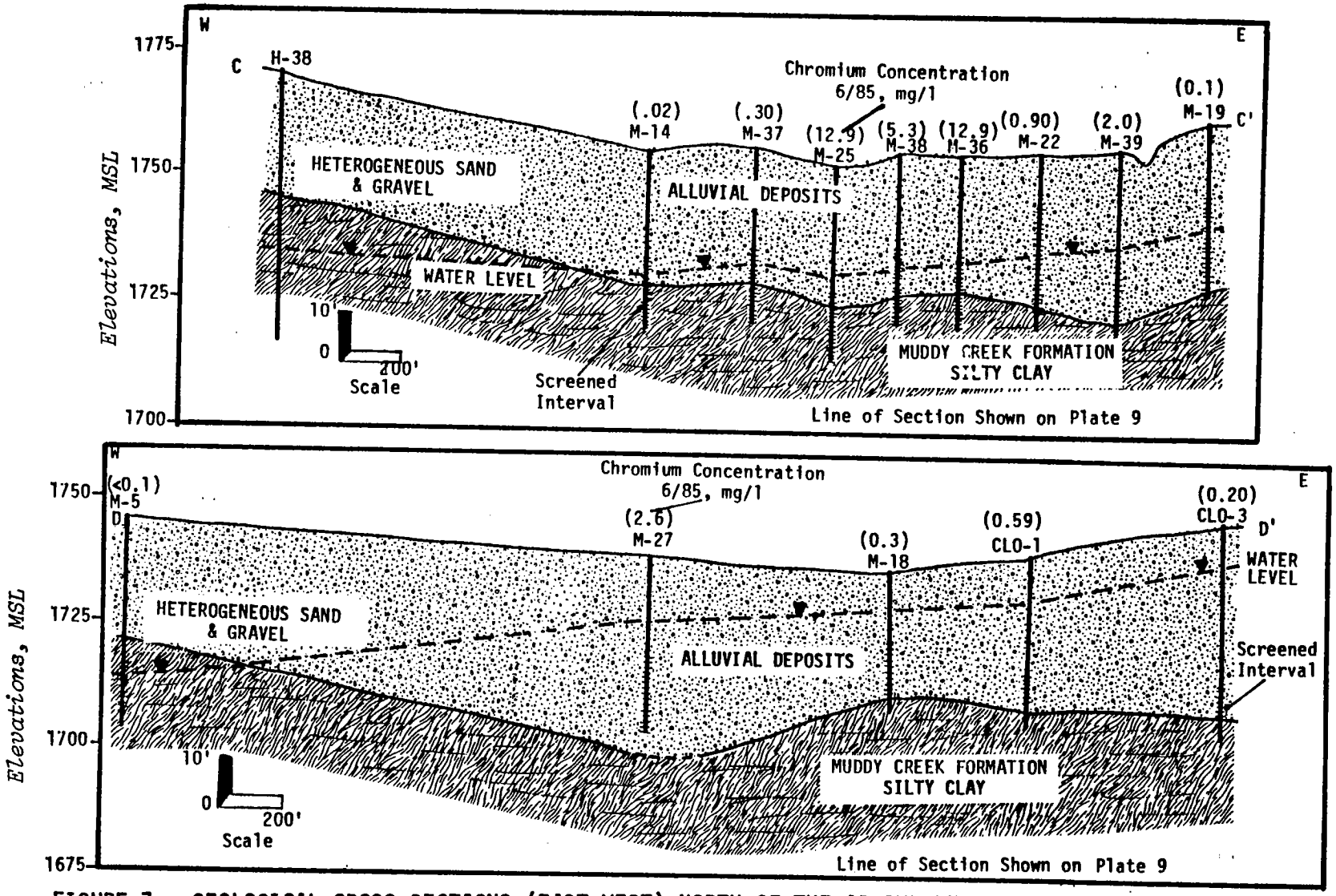

FIGURE 7. GEOLOGICAL CROSS SECTIONS (EAST-WEST) NORTH OF THE AP IMPOUNDMENT AREA, HENDERSON FACILITY.

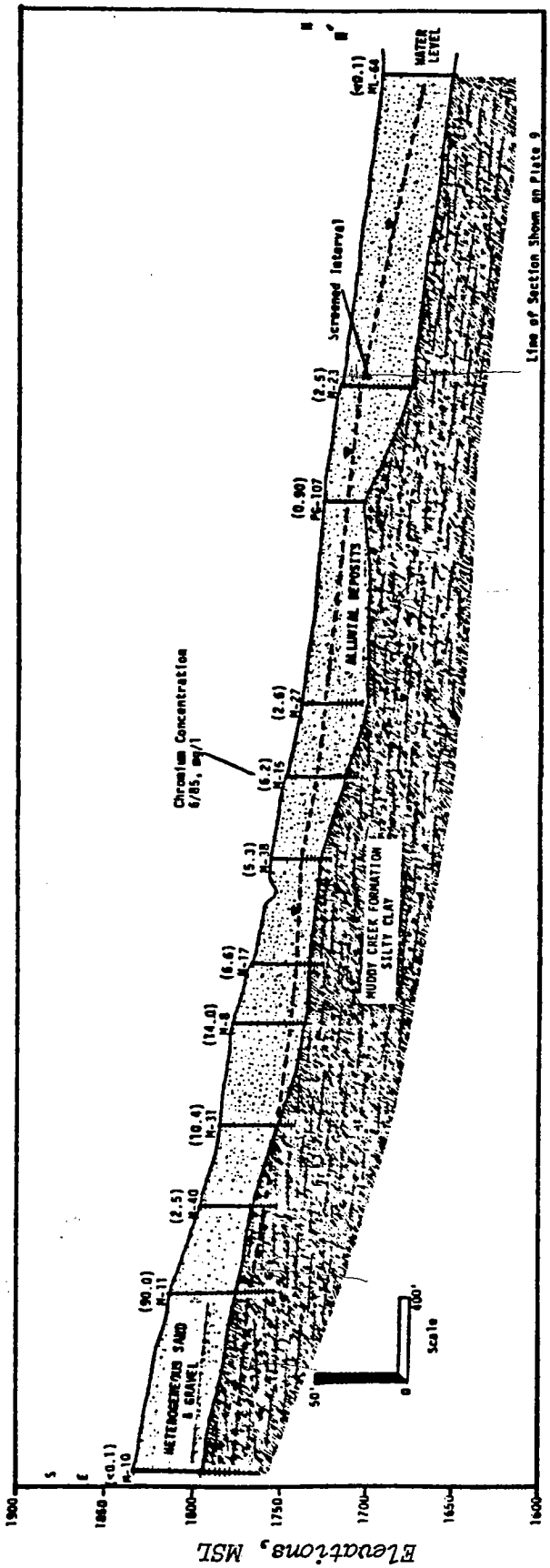

FIGURE 8. GEOLOGICAL CROSS SECTION (NORTH-SOUTH) THROUGH THE HENDERSON FACILITY.

steam plant. The geological cross sections presented in Figure 7, shows the presence of a small channel system along section C-C'. A major channel system is indicated along section D-D'. The cross section (E-E') in Figure 8 shows the general configuration of the Muddy Creek formation in a north-south direction. It is evident from examination of these sections that the buried channel systems in the area trend in a northerly direction, are narrow, and become more entrenched into the Muddy Creek formation in this direction.

Plio-Pleistocene Alluvial Fan Deposits

The Kerr-McGee Henderson Facility is situated over alluvial sediments derived from erosion of the McCullough Range (1 mile south of Kerr-McGee) that form northwest-sloping coalescing alluvial fans. These alluvial fans were deposited during the infrequent flood runoff periods and were deposited on the older erosional surface of the Muddy Creek formation. The thickness of these deposits varies locally depending upon the erosional configuration of the Muddy Creek surface. Generally, these alluvial deposits thicken from south to north beneath the Henderson Facility. Plate 3, shows the thickness of the alluvial fan deposits which is also the depth to the top of the Muddy Creek formation. These sediments are thickest over the erosional channels and thinnest over intervening interfluve areas. Thickness of these sediments range from 19.5 to 61.5 feet beneath the Henderson Facility.

The lithology of these deposits consists primarily of a reddish-brown, heterogeneous, poorly sorted mixture of sand and gravel (volcanics) with

lesser amounts of silt and clay. Boulders and cobbles are common. Due to their mode of deposition, no distinct beds or units are continuous over the Henderson Facility. Distinct layers are only present in the form of gravel beds cemented with caliche (calcium carbonate), present only in the northwest corner of the site. Since caliche is not found elsewhere on the site it will not be discussed further.

A major feature of these alluvial deposits is the stream deposited sands and gravels that were deposited within the old channels developed on the Muddy Creek formation. These deposits conform to the old channel boundaries which were characteristically linear and narrow in configuration. These "channel fill" deposits are typically more uniform sands and gravels (few fines) and show higher permeability than the adjacent poorly-sorted alluvial deposits. Once the old erosional channels were filled with the "channel fill" deposits they were encased by the poorly-sorted alluvial fan deposits. The importance of these "channel fill" deposits is that they greatly affect and control the occurrence and movement of the groundwater.

Often times a distinct formation change between the Muddy Creek formation and alluvial sediments does not exist. Normally, a 5-foot transitional zone occurs above the Muddy Creek formation where small white clayey silt lenses are interbedded with sand and gravel.

The geologic cross sections presented in Figure 6, 7, and 8 shows the thickness and distribution of the alluvial deposits. Typically deposits found in the erosional channels are "clean" sands and gravels (with few fines) as compared to other alluvial fan deposits.

Structural Geology

The structural features of those strata pertinent to this investigation (Muddy Creek Formation and overlying basin-fill alluvial fan deposits) are discussed below.

The Muddy Creek formation is generally flat lying to gently tilted in surface exposures. It has been cut by many small faults and has locally been severely disrupted. This formation is sheared and tilted in the Las Vegas Wash area, and it is in sharp fault contact with the Frenchman Mountain Block.

The structure within the Plio-Pleistocene basin fill is characterized by a series of generally north-south trending faults. These faults are thought to result from natural consolidation of basin-fill sediments and are referred to as "compaction faults" by Bell (1981). These faults are typically marked by escarpments exhibiting heights up to 100 feet or more. These escarpments have also been considerably modified by erosion in many areas and are shown on Figure 4.

There are no recognizable structural features present in the Muddy Creek formation or overlying alluvial fan Plio-Pleistocene basin-fill deposits that underlie the Kerr-McGee Henderson Facility.

Geological History

The geologic history of the Henderson region is characterized by repeated periods of deposition, uplift, igneous activity, and erosion. Thick sequences of marine sedimentary deposits accumulated throughout Paleozoic and Mesozoic time, with periodic interruption by orogenic (crustal deformation) activity. Continental-type sedimentary deposition and widespread volcanic and fault activity continued through Cenozoic time. Thick deposits of volcanics were extruded over broad areas and accompanied by strike-slip faulting during mid- to late-Tertiary time. The volcanic and tectonic activity peaked during the Miocene epoch. Following this volcanic and tectonic activity in Miocene time, and continuing through Pliocene time, a thick sequence of alluvial and lacustrine sediments were deposited in a deep structural basin. These deposits included the Horse Springs and Muddy Creek formations. Following deposition of the Muddy Creek formation, a period of erosion occurred. The erosional period was followed by periodic deposition of Pleistocene coarse-grained alluvial deposits consisting of coalescing sequences of alluvial fans flanking the mountain ranges.

HYDROGEOLOGY

Regional Hydrogeology

Nearly all of the groundwater supply in Las Vegas Valley comes from what Harill (1976) has termed the "Valley-Fill Groundwater Reservoir." This reservoir consists of the Muddy Creek formation and the overlying Plio-Pleistocene basin-fill sediments.

The aquifer system was originally subdivided into two major components by Maxey and Jameson (1948): 1) The Near Surface Water and 2) the Confined Water. The Confined Water was further divided into three zones - shallow, middle, and deep. The Confined Water aquifer, as defined by Maxey and Jameson, is recognizable only in the central part of the Basin and does not allow for correlation to other parts of the Basin. Harrill therefore, prefers to use the terms: 1)"Near Surface" Reservoir and 2) "Principal Aquifers", where the "Principal Aquifers" includes the original subdivisions by Maxey and Jameson as well as other recognized zones.

The shallow and middle zones of the Confined Water aquifer are the major sources of pumped water in Las Vegas Valley. These zones occur in the thickest sequences of Plio-Pleistocene valley fill deposits. These two zones are not present in subsurface in the Henderson area (including the Henderson Facility) due to the thin deposits of these sediments. The deep zone of the Confined Water system is believed to exist in the Muddy Creek formation. The shallow, middle, and deep Confined Water zones tapped by wells in the central part of the Las Vegas Valley occur at depths of about 200-450, 500, and 700 feet respectively.

Recharge to the "Principal Aquifers" is from runoff from precipitation occurring in the surrounding mountains which infiltrate the alluvium along the valley margins. Recharge also occurs through upward flow between

aquifer systems. Discharge is principally through evapotranspiration, pumping from wells, and recharge to the "Near-Surface" aquifer system.

The "Near-Surface" aquifer is found at the top of the Muddy Creek formation usually in the overlying alluvial sand and gravel deposits. The "Near-Surface" aquifer may also occur in the upper portions of the Muddy Creek formation. All aquifers in Las Vegas Valley are separated by thick sequences of low-permeability, fine-grained sediments. Interconnection between all aquifers in the Valley only occurs through upward leakage along fault zones and through semi-confining layers. This upward leakage recharges the "Near-Surface" aquifer which is augmented by artificial recharge from irrigation and other forms of artificial water application to the land surface. The upward leakage between aquifers prevents the downward movement of groundwater from the "Near-Surface" aquifer. Little recharge occurs in the Valley itself from precipitation which is largely consumed by evapotranspiration.

Site Hydrogeology

The geological units which are important to this investigation are the upper portions of the Muddy Creek formation and the overlying alluvial fan sediments. This aquifer is termed the "Near Surface" aquifer as described above. The deeper "Principal Aquifer" will not be discussed since it is several hundreds of feet deep and is separated from the "Near Surface" aquifer by low-permeability fine-grained sediments. Impact to the deep "Principal Aquifer" is therefore considered unlikely. Since groundwater at

the Henderson Facility is contained within both the alluvial fan sediments and the upper portions of the Muddy Creek formation, a discussion of each hydrogeologic environment will be presented.

Muddy Creek Formation

Groundwater occurs in the upper portions of the Muddy Creek formation beneath the Henderson Facility. Typically, groundwater is found within the Muddy Creek silts and clay over the southern and west-central portions of the Facility. Referring to Plate 4, the areas where the "Near-Surface" groundwater is contained within the Muddy Creek formation is indicated by zero or negative lines of saturated thickness. All groundwater in areas south of the zero boundary line lies within the Muddy Creek formation while groundwater found north and east of this line lies within the alluvial deposits. As shown in Plate 4, the groundwater may occur at depths as much as 17 feet below the top of the Muddy Creek formation.

Groundwater found within the Muddy Creek formation downgradient from past contaminant source areas show chromium levels above background. Results of laboratory vertical permeability tests on undisturbed samples from the Muddy Creek formation at neighboring Stauffer Chemical Company (<2000' west of Kerr-McGee) indicate that the upper 10 feet of the Muddy Creek formation has a vertical permeability of between 1.2×10^{-7} cm/sec (2.5×10^{-3} gpd/ft^2) to 2.0×10^{-6} cm/sec (4.2×10^{-2} gpd/ft^2) with an average of 5.85×10^{-7} cm/sec (1.2×10^{-2} gpd/ft^2), (Geraghty and Miller, 1980).

Kerr-McGee performed field permeability tests at four wells the Henderson Facility (M-9, M-11, M-12, and M-13) completed in the Muddy Creek formation. These tests indicate that the Muddy Creek formation has a horizontal permeability or hydraulic conductivity ranging from 6.5 gpd/ft^2 (3.1×10^{-4} cm/sec) to 54.5 gpd/ft^2 (2.6×10^{-3} cm/sec) with an average of 29.1 gpd/ft^2 (1.4×10^{-3} cm/sec). The average hydraulic gradient over areas where the groundwater occurs within the Muddy Creek formation at the Henderson Facility was measured to be an average of $\frac{\Delta h}{\ell} = .027$. Transmissivity values varied from 45.2 to 180 gpd/ft and averaged 89.1 gpd/ft. The storage coefficient was taken from aquifer test data developed from Stauffer Chemical (Hall, 1983). The average storage coefficient was .053.

Using Darcy's flow equation and an effective porosity of 0.20 for the thin sand and silt stringers, an average flow velocity of 0.53 feet/day was calculated for groundwater flowing through the Muddy Creek formation. Because this velocity seems somewhat high for flow through clays, small sand and silt stringers and lenses within the upper part of the Muddy Creek formation may account for most of its permeability, and groundwater flow is principally occurring through these small zones. These small lenses appear to be in communication with the overlying alluvial aquifer.

Groundwater moves in a northwesterly direction through the Muddy Creek formation and over most of the site as shown in Plate 5. The groundwater gradient is uniform over most of the site except near the pumping

depressions caused by Stauffer Chemical's interceptor well field in the northwest portion of the Henderson Facility. The gradient varies from 1.2% to 2.7% (excluding Stauffer's recovery area) and averages 1.5%.

Water-level data collected from June, 1983 to June, 1985, from Muddy Creek monitoring wells M-11, M-12, and M-13 show small groundwater fluctuations of 1.3, 1.68, and 1.2 feet respectively, over this period and appear to be a result of seasonal climatic changes. The groundwater is typically at its lowest levels during the spring months and at its highest levels during early to late fall.

Alluvial Fan Deposits

Alluvial fan deposits outcrop over the entire Henderson Facility and overlie the Muddy Creek formation. Over the southern and west-central half of the Facility the alluvial fan deposits are unsaturated. Referring to Plate 4 and Figure 8, the unconfined alluvial fan deposits become saturated (contain groundwater) north and east of the zero saturated thickness line. South and west of this line the unconfined groundwater lies within the Muddy Creek formation. The saturated thickness map (Plate 4) for the alluvial fan deposits indicate that these deposits range from 0 to greater than 27.7 feet in saturated thickness. Generally the larger zones of saturation occur over the buried "channel fill" deposited in stream channels developed on top of the Muddy Creek formation. The smallest zones of saturation occur over the interfluve areas that separate these old channel systems. An examination of

the saturated thickness map (Plate 4) indicates there is a buried stream channel trending north-northeast from pond AP-5 as evidenced by the large saturated thickness of the alluvial deposits in this area. A second channel system is indicated in the northwest corner of the map and in fact was previously defined by Stauffer Chemical (Hall, 1983).

The greatest depositional thicknesses of alluvial fan sediments occur within the old stream channel system developed on the Muddy Creek surface. Referring to Plate 3, the thickness of the alluvial fan deposits vary from 19.5 feet at well MC-59 to 61.5 feet at geological boring MC-17.

The depth-to-groundwater map presented in Plate 6 indicates that the depth-to-groundwater varies from over 55 feet at the southern portion of the Facility to 5 feet in the northeast corner near well PG-103. The depth-to-groundwater decreases in a northeasterly direction until it reaches the vicinity of the AP impoundments. From the AP impoundments to the north property boundary the depth-to-groundwater decreases rapidly east to northeast. The reason for the rapid decrease in the depth-to-groundwater toward the east-northeast (near well PG-103) is believed to be influenced by the erosional configuration of the Muddy Creek formation or related to structural features that may be present in the subsurface, such as a fault.

Because of the variability in alluvial fan deposition and saturated thickness of the alluvial deposits, no specific or average permeability or transmissivity value have been used to describe the groundwater flow

velocity in these deposits. Typically the "channel fill" deposits which are found in the old buried stream channels developed on top of the Muddy Creek formation are much more permeable than the deposits in the interfluve areas that separate the buried channel systems. The higher permeability and transmissivity noted for the "channel fill" deposits probably is a result of reworking of these sediments by stream action and lesser amounts of fine materials present.

The groundwater velocity was calculated for the alluvial deposits using Darcy's equation, assuming an effective porosity of 0.20 and using an average gradient of 0.015, varied from 0.5 to 16 feet/day. The greatest groundwater velocity of 16 feet/day occurred within the "channel fill" deposits near well M-27. The lowest groundwater velocity of 0.5 feet/day was from an interfluve area north of pond P-3 (well M-4) where poorly sorted alluvial fan deposits occur. Intermediate values of permeability, transmissivity, and flow velocity probably occur between the crests of the interfluve areas to the center of the "channel fill" deposits.

The transmissivity of the alluvial deposits ranged from 231 gpd/ft at well M-4 (interfluve area) to 23,786 gpd/ft at well M-27 ("channel fill" deposits.)

The hydraulic conductivity varied from 50.2 gpd/ft^2 (well M-4) to 1496 gpd/ft^2 at well M-27. The storage coefficient, as determined by Stauffer Chemical Corporation from numerous pumping tests, averages 0.053 (Hall, 1983). A summary of Kerr-McGee aquifer tests is presented in Table 1.

Water table fluctuations are noted in several wells completed within the alluvial deposits at the Facility. Figure 9 shows water-level fluctuations for wells north of the P- and S-series impoundments from June, 1983, to June, 1985. Maximum water-level fluctuations in any one well varied from 1.54 to 2.55 feet and averaged 2.07 feet. Water-level fluctuations (Figure 10) in the areas north of the AP impoundments show maximum fluctuations for the period of record (June, 1983 to June, 1985) between 1.72 to 3.08 feet and averaged 2.25 feet. These groundwater fluctuations are the result of seasonal climatic changes with groundwater at its lowest level during the spring months and at its highest level during the fall.

SITE HYDROGEOLOGICAL INVESTIGATIONS

Previous Hydrogeologic Investigations

Since November 1981, Kerr-McGee has conducted hydrogeological evaluations of the "Near-Surface" groundwater. As part of the RCRA groundwater monitoring program for hazardous waste storage, wells M-1 through M-9 were installed. Interim status groundwater samples were collected and water levels measured

TABLE 1. SUMMARY OF AQUIFER TEST RESULTS CONDUCTED BY KERR-McGEE ON SELECTED WELLS AT THE HENDERSON FACILITY.

WELL	TRANSMISSIVITY gpd/ft		HYDRAULIC CONDUCTIVITY gpd/ft	
	SLUG METHOD Bouwer and Rice, 1976	JACOB SEMI-LOG Drawdown	SLUG METHOD	JACOB SEMI-LOG Drawdown
M-2	1219	---	313	---
M-2	---	1764	---	453
M-3	2379	---	983	---
M-4	231	---	50.2	---
M-8	3628	---	834	---
M-9*	180	---	54.5	---
M-11*	---	79.2	---	8.5
M-11*	61.2	---	6.5	---
M-12*	45.2	---	19.2	---
M-13*	70.1	---	36.1	---
M-15	4717	---	306	---
M-17	1445	---	182	---
M-27[1]	23,786	---	1496	---

Note: *Aquifer test conducted on Muddy Creek clays
[1]Aquifer test in "Channel Fill" Alluvial Deposit
All other aquifer tests were conducted on Alluvial fan deposits

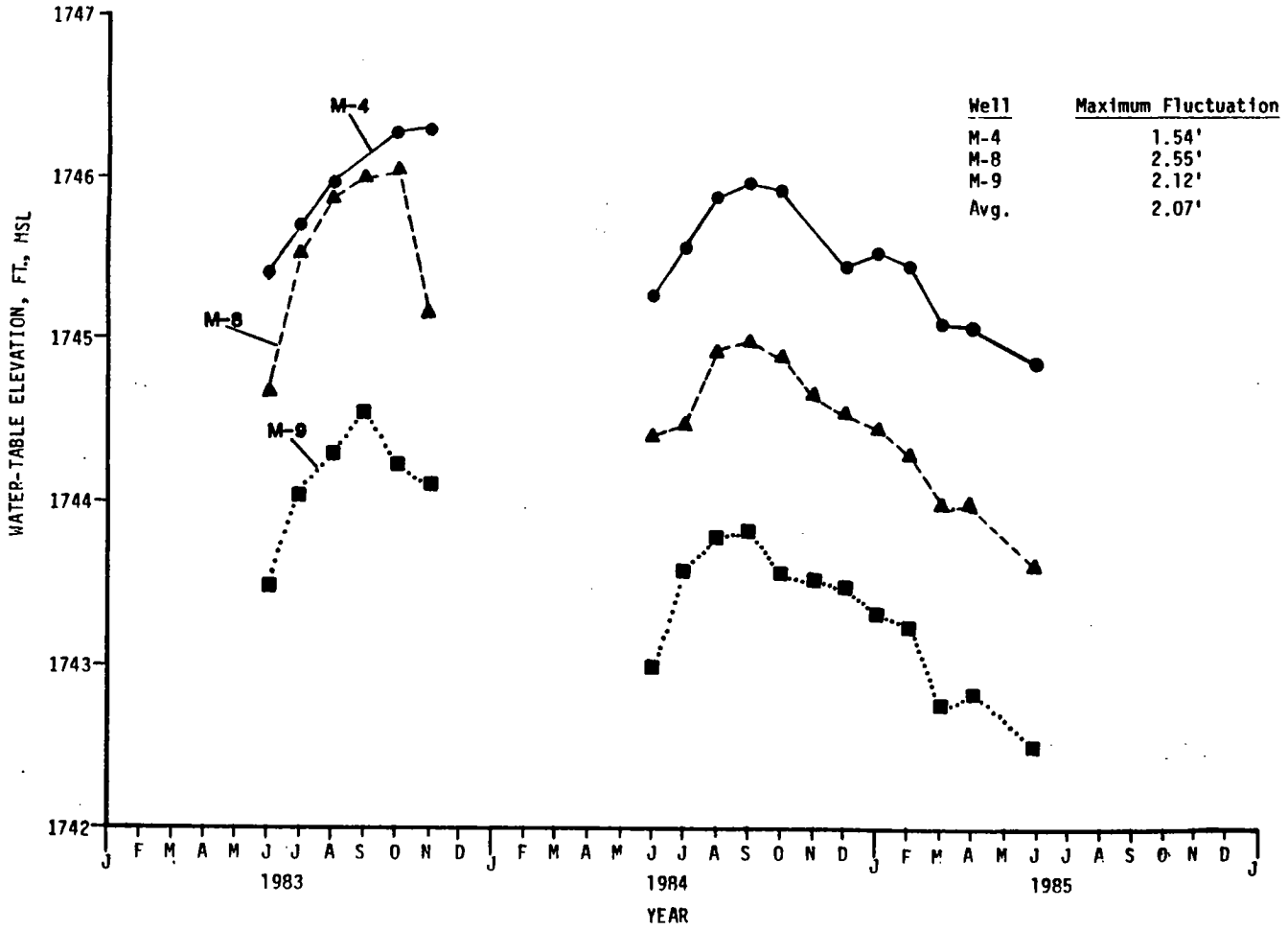

FIGURE 9. HYDROGRAPHS SHOWING WATER-LEVEL FLUCTUATIONS IN SELECTED WELLS DOWNGRADIENT FROM THE P- AND S-SERIES IMPOUNDMENTS AT THE HENDERSON FACILITY.

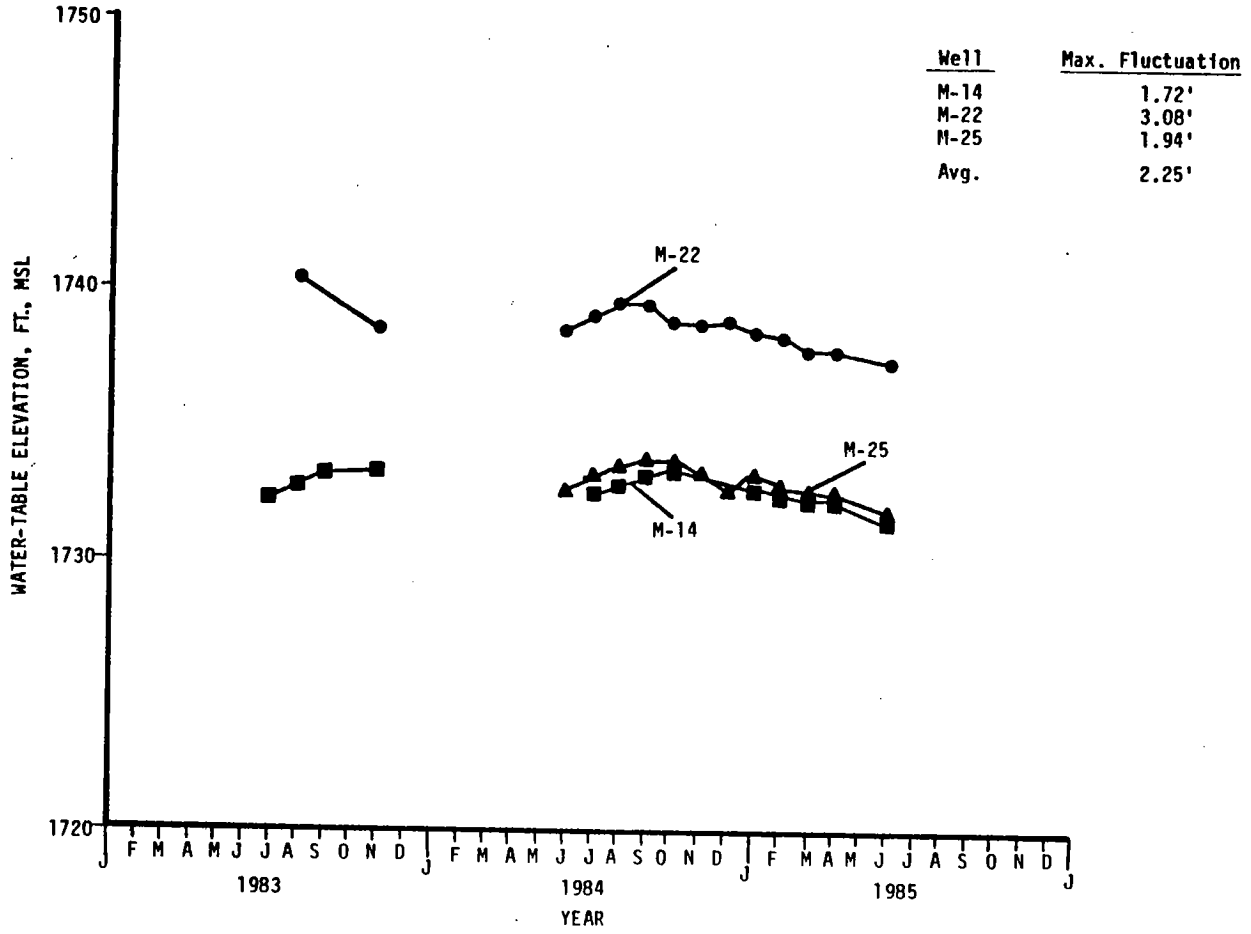

FIGURE 10. HYDROGRAPHS SHOWING WATER-LEVEL FLUCTUATIONS FROM SELECTED WELLS NORTH OF THE AP IMPOUNDMENT AREA, HENDERSON FACILITY.

at these 9 wells. Evaluation of these data indicated the presence of chromium in the groundwater over drinking water standards. As an internal Kerr-McGee program, a phased approach to define and delineate the chromium plume was implemented.

The program started in June, 1983, when 8 additional wells (M-10 through M-17) were installed to define the a real extent of the plume and investigate potential source areas. In August, 1983, an additional 6 monitoring wells were installed (M-18 through M-23).

In August, 1983, a test to recover chromium impacted groundwater was conducted. Monitor well M-3 was pumped for a period of about 11 months with the captured groundwater being recycled to surface impoundment P-2 (old). This program was discontinued in July, 1984, because heavy rainfall reduced excess storage capacity of the improvements. In May, 1984, monitor wells M-24 through M-27 were completed at the request of Nevada Division of Environmental Protection. These were installed to further define the extent of the chromium plume and provide additional monitoring wells which would be used to access cleanup of the impacted groundwater. In July, 1984, three additional monitoring wells (M-28 through M-30) and nine geotechnical test borings were installed as part of a geotechnical study for the Unit 6 building. These wells were not installed as part of the chromium investigation, but have been included in the list of wells sampled and evaluated as part of this detailed study.

As part of the program to define the subsurface configuration of the contaminant plume, geophysical methods were employed. In January, 1985, Kerr-McGee conducted an electromagnetic (EM) geophysical survey over the northern half of the property. As a follow-up to this survey, a program was

initiated in June, 1985, to further define the plume boundary. Monitor wells M-31 through M-40 were installed along with 4 geological test borings. Aquifer tests were conducted on several of the existing wells at this time. Additionally, a complete well inventory (Appendix B), well sampling (for chromium), and water level measurements made for wells on or immediately adjacent to Kerr-McGee property. These included wells installed by neighboring companies. The water-quality information, water-level data, geological data, and aquifer test data collected are reported in this report. The location of all monitoring wells and geological test borings is shown in Plate 1. The well completions and lithological logs are presented in Appendix C.

Ongoing Groundwater Monitoring Programs

Groundwater monitoring continues under RCRA interim status for both the landfill (undergoing closure) and surface impoundments P-1 and S-1. Wells monitored quarterly as part of this program for the landfill include M-5 (upgradient) and downgradient wells M-6, M-7, and H-28. Impoundments P-1 and S-1 are now undergoing closure and have been drained and not used since January, 1983. Wells monitored for the impoundments are upgradient well M-1 and downgradient wells M-8, M-9, and M-2. Water-levels are taken during each sampling period from each well.

In addition to the RCRA groundwater monitoring, there are 30 internal wells that are used to monitor the chromium plume present in the groundwater. Currently 18 of these wells with average chromium concentrations greater

than 1 mg/l are monitored on a monthly basis for chromium and water levels. Wells M-31 through M-40 were installed in June, 1985, and are new to the program. All forty wells are analyzed quarterly for chromium. Water level measurements are taken at each well prior to sampling.

CHROMIUM PLUME DESCRIPTION AND HYDRODYNAMICS

The source of any groundwater chromium in excess of background at the Facility would be from sodium dichromate which is used in the chlorate process cell houses and recycled through Facility ponds. As previously reported, the cell houses leaked over the years. A remedial program to stop these leaks has been instituted. Therefore, the source of chromium to the groundwater has been mitigated.

The extent of chromium in the groundwater over background levels has been determined through the geohydrologic investigation described in this report and is presented in Plate 7. This identifies a major plume starting at the cell houses Units #4 and #5 and continuing some distance to the north. A secondary plume, incorporated within the major plume, is apparent in the P- and S- pond area. This secondary plume is of little consequence because: (1) total chromium impact is essentially within one plume and (2) any remedial recovery program would be designed to cut off the entire plume. Furthermore, the geohydrologic conditions are considerably different as one moves from the cell house area northward along the plume. An effective containment program should be based on the most favorable geohydrologic conditions.

The plume moving through the Muddy Creek clays will show the highest concentrations since the groundwater in these areas is moving relatively slowly (0.53 feet/day) through the saturated clays and small sand and silt stringers in the upper part of the formation.

The slow migration of the chromium plume through these clays minimizes natural attenuation processes such as dilution and dispersion. Therefore, it is likely that those portions of the chromium plume which migrate through the clays (and fine sand and silt stringers) of the upper part of the Muddy Creek formation will show minimal attenuation with distance traveled.

When chromium in the groundwater reaches the area of the P- and S-series ponds different hydrogeologic conditions control the movement of the plume. Referring to Plate 4, the saturated zone in this area is shown extending above the surface of the Muddy Creek formation (as evidence by the zero thickness line) into the alluvial fan deposits north and downgradient from this area. These deposits are much more permeable than the Muddy Creek formation and the chromium plume moves through these deposits at much faster rates (0.5 to 16 feet/day) in relation to fluids in the groundwater beneath Units 4 and 5. The natural attenuation processes of dilution and dispersion play a greater role in reducing the concentration of the chromium in the plume with distance traveled. The chromium plume in the groundwater travels at different rates due to the erosional variability of the Muddy Creek surface and the location of the more permeable "channel fill" deposits.

The chromium plume will move: 1) slowest in areas where the saturated zone is contained within the clay of the Muddy Creek formation; 2) at an intermediate flow rate through the alluvial fan sediments that do not occupy the old drainage surfaces; and 3) at the greatest rates through the "channel

fill" alluvial fan sediments that have been reworked by stream action and now occupy Muddy Creek formation channel surfaces. Based upon the aquifer test results the groundwater movement varies over a range from about 0.1 feet/day (Muddy Creek formation) to 16 feet/day ("channel fill" deposits).

Downhole conductivity profiles were conducted in selected wells to determine vertical plume distribution. Referring to Figures 11, 12, and 13, an increase in conductivity with depth is evident. This stratification is a common occurrence in plume geometry.

Figures 14 and 15 show the concentrations of chromium in selected wells over time. Referring to Figure 14, chromium concentration in well M-9 shows an increasing trend. Figure 15 shows chromium concentrations for wells M-14, M-22, and M-25. However, the chromium levels have not changed significantly with time in this area . A majority of the wells have shown a decrease in chromium concentrations with time.

To more fully appreciate the relationship between the chromium concentrations in the groundwater and the site hydrogeology, refer to Figures 6, 7, and 8. These cross-sections show the chromium concentration in relation to subsurface geology. Often the highest chromium concentrations are associated with the deeper portions of the erosional features in areas where the alluvial fan sediments are saturated. However, no correlation could be found for the chromium levels contained within the saturated portions of the Muddy Creek formation.

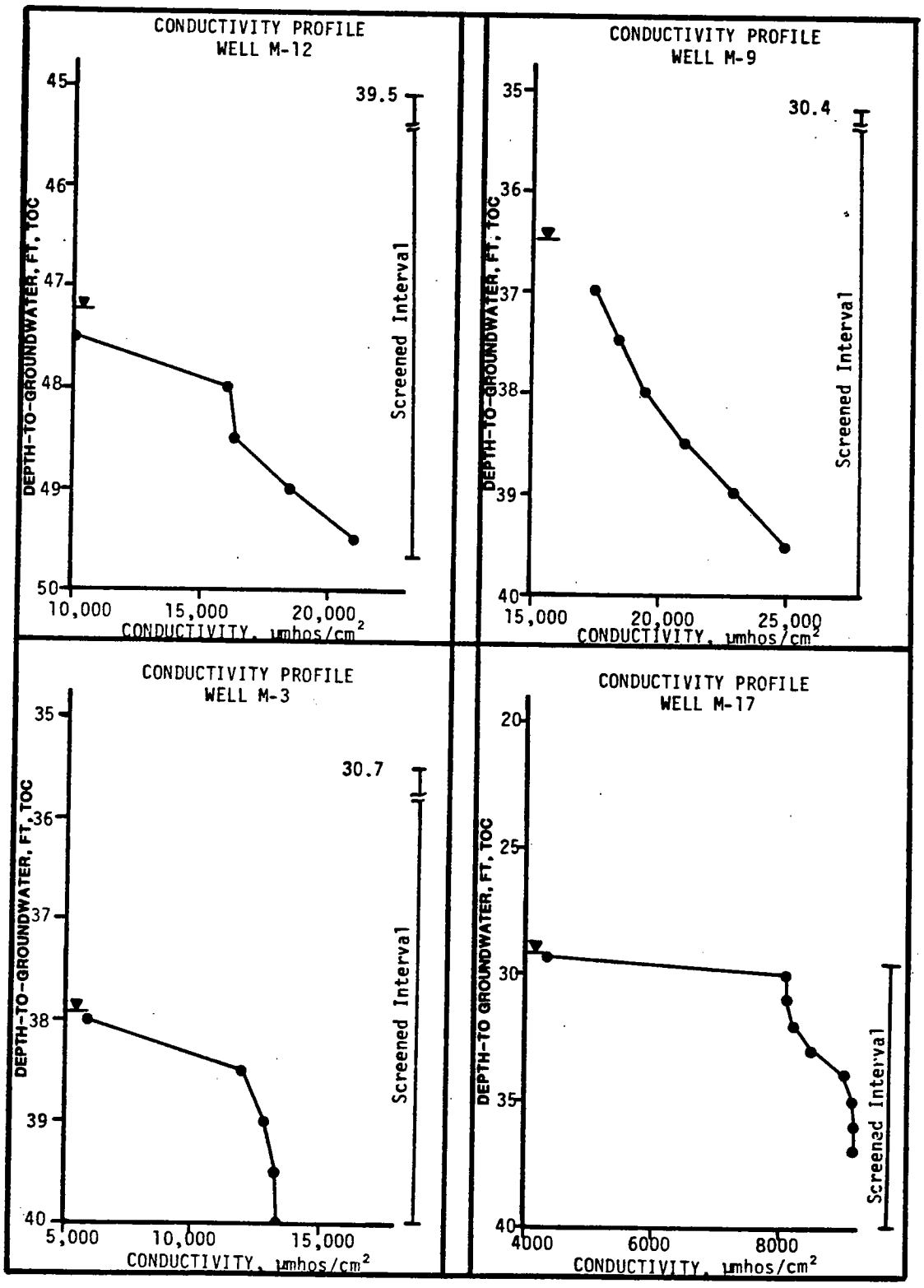

FIGURE 11. DOWNHOLE CONDUCTIVITY PROFILES THROUGH THE SATURATED ZONE FOR SELECTED WELLS AT THE HENDERSON FACILITY.

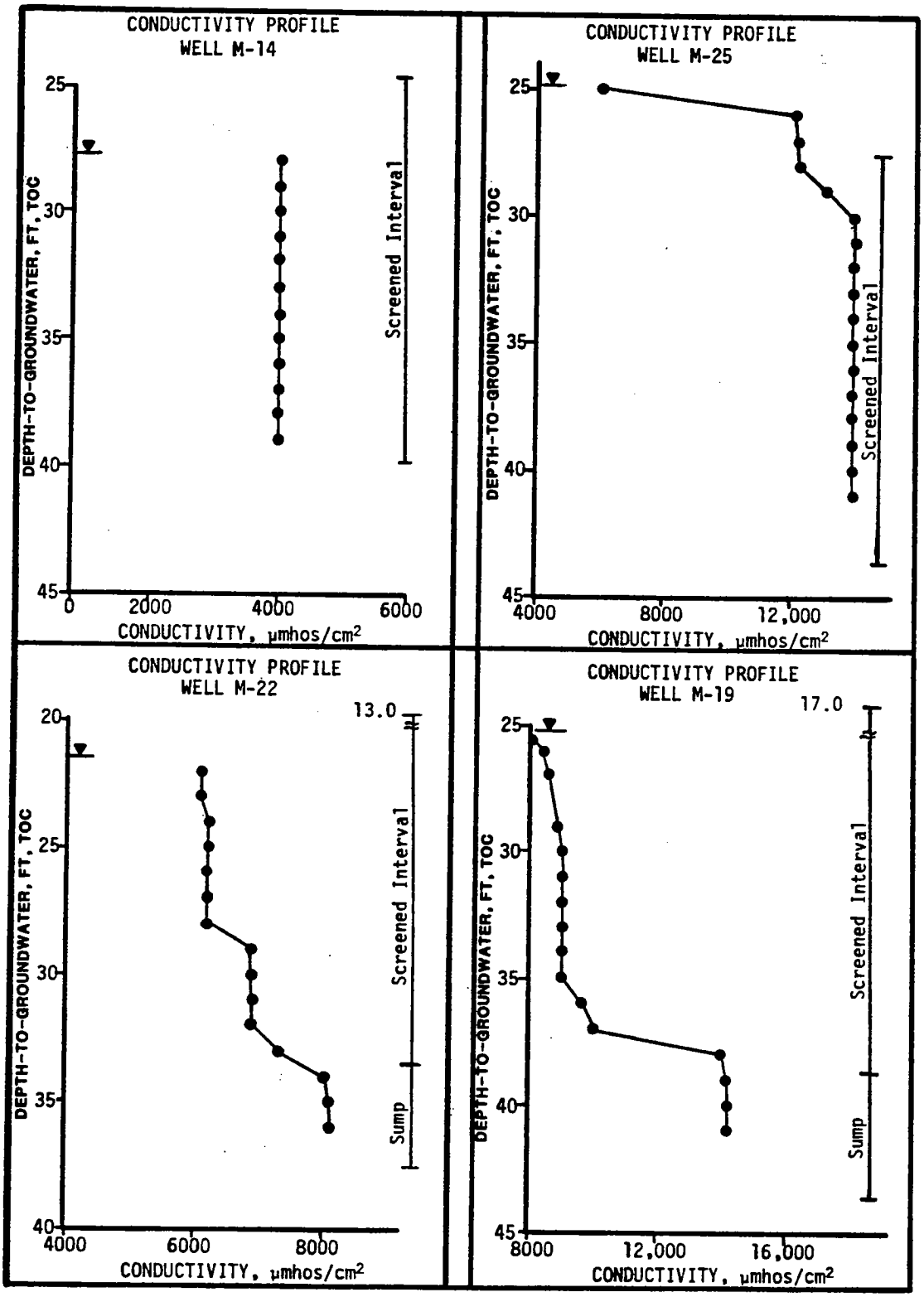

FIGURE 12. DOWNHOLE CONDUCTIVITY PROFILES THROUGH THE SATURATED ZONE FOR SELECTED WELLS AT THE HENDERSON FACILITY.

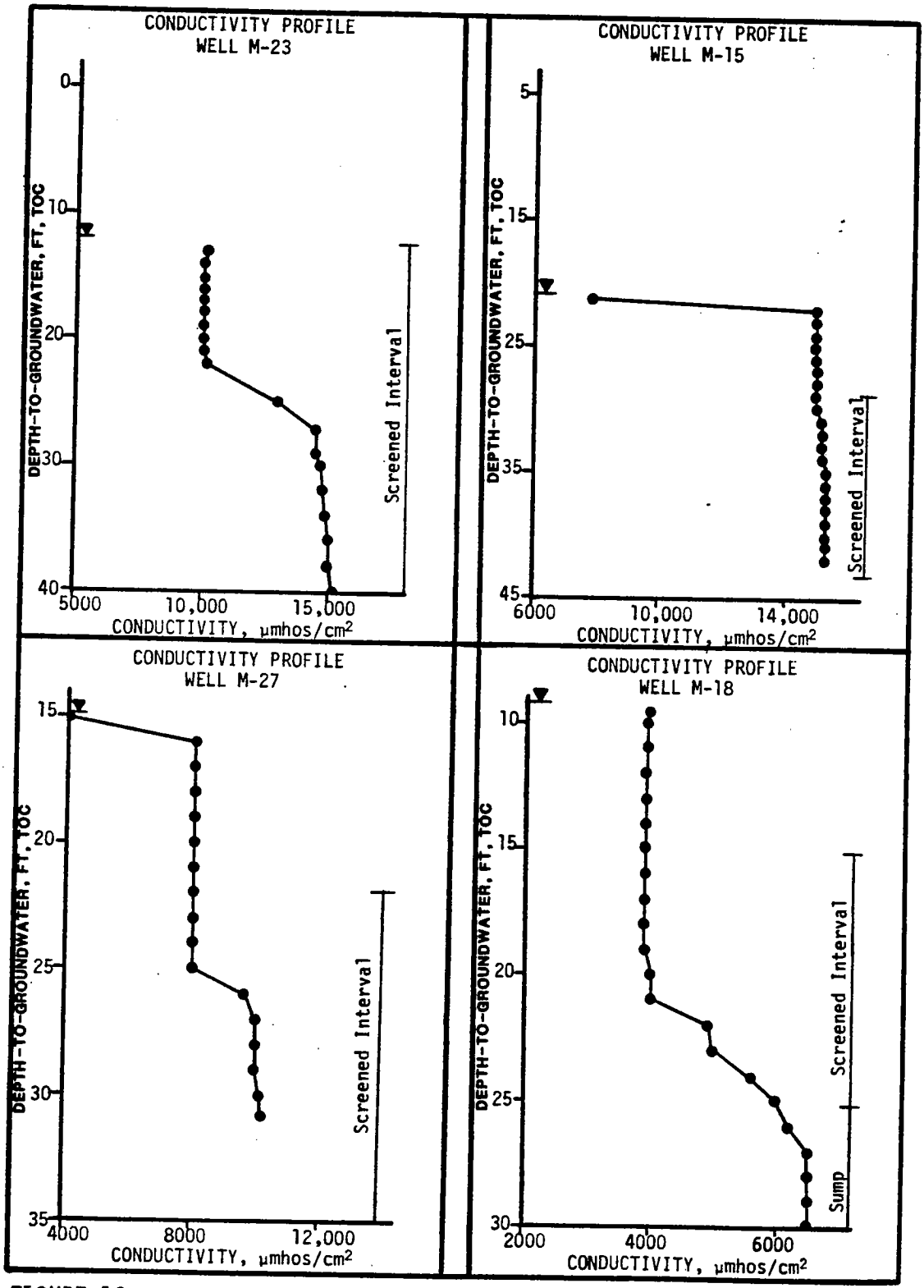

FIGURE 13. DOWNHOLE CONDUCTIVITY PROFILES THROUGH THE SATURATED ZONE FOR SELECTED WELLS AT THE HENDERSON FACILITY.

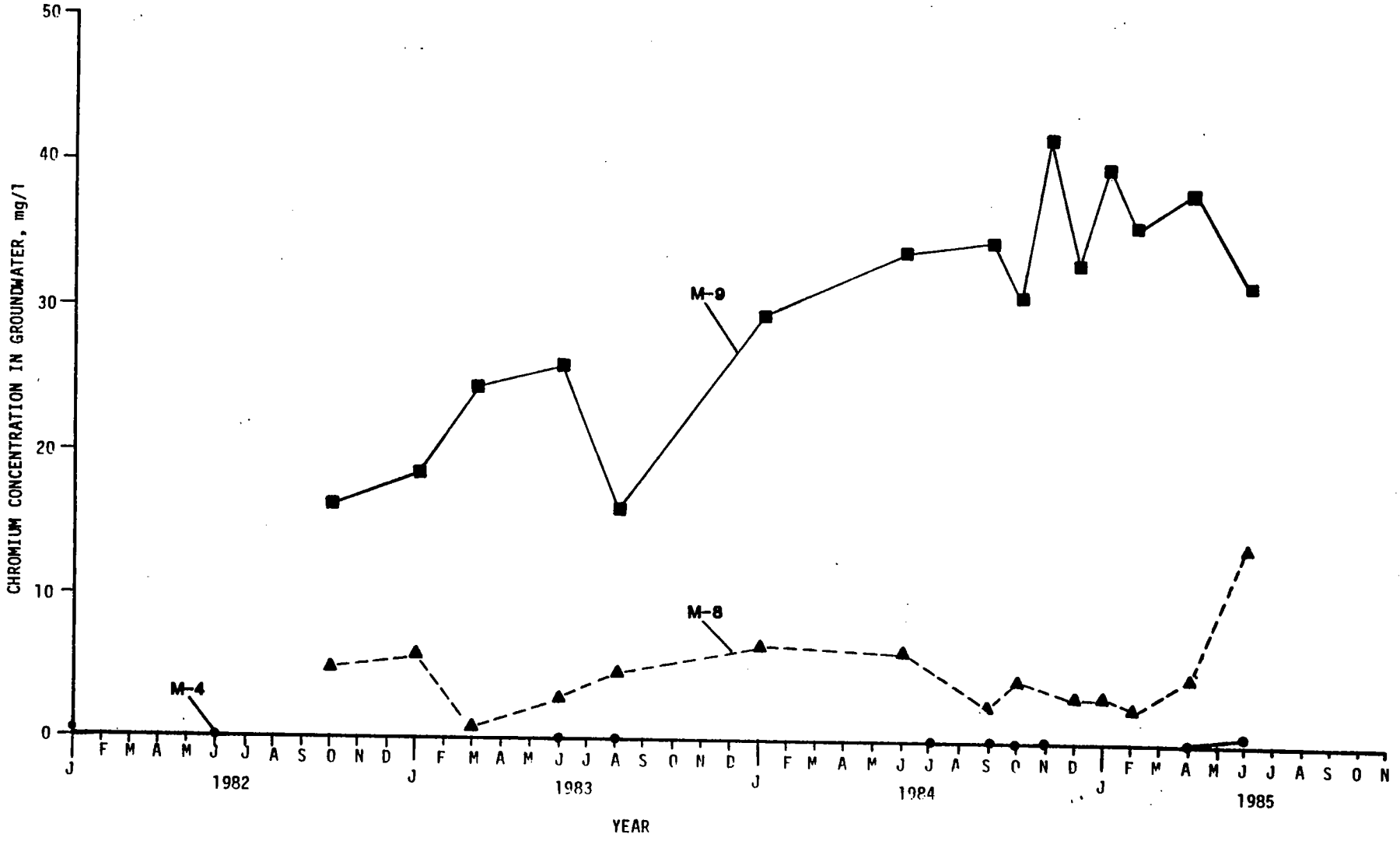

FIGURE 14. CHROMIUM CONCENTRATIONS IN SELECTED WELLS DOWNGRADIENT FROM THE P- AND S-SERIES IMPOUNDMENTS, HENDERSON FACILITY.

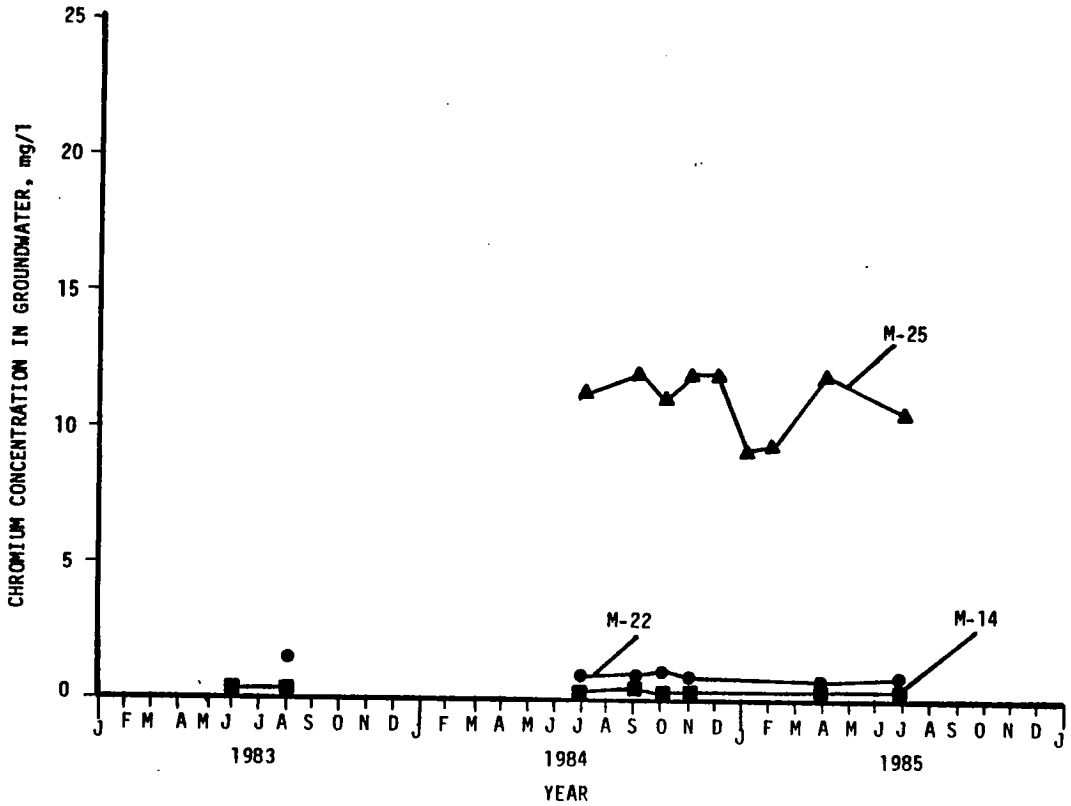

FIGURE 15. CHROMIUM CONCENTRATIONS IN SELECTED WELLS NORTH OF THE AP IMPOUNDMENT AREA, HENDERSON FACILITY.

The conductivity map presented in Plate 8 shows the areal distribution of the groundwater conductivity. The conductivity map and the chromium-plume map (Plate 7) are nearly identical suggesting that there is a good correlation between groundwater conductivity and chromium concentrations. This was expected since the source of the chromium was contained in high conductivity solutions.

GEOPHYSICAL SURVEY

In January, 1985, an electromagnetic (EM) terrain conductivity survey[1] (profiling) was conducted over the northern half of the Facility. The survey could not be conducted over the southern half of the property because the groundwater occurred at too great of a depth. The EM unit has an effective depth of exploration of 20 feet.

The EM method measures the ground/soil conductivity and is primarily dependent upon the pore water or groundwater contained within the pores of the soils. This technique measures minor changes in ground conductivity over background values. The use of the EM method is especially suited to map high conductivity groundwater plumes originating from point source areas.

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[1] The equipment issued was a Geonics EM-31 electromanetic terrain conductivity meter.

EM Survey Results

Eight profile were completed in the EM Survey along east-west traverses at 20-foot spacings (Plate 9). Profiles numbered 1 to 3, and 5 through 8 are presented in graphical form in Appendix D. Profile 4 was too short to be of any use and was not plotted in graphical form.

The EM survey was not as successful as hoped mainly due to the large variation in the depth-to-groundwater over the surveyed areas and the fact that the depth-to-groundwater was greater than the effective depth of exploration of the EM Unit. Referring to Plate 6, it is evident that the depth-to-groundwater decreases rapidly moving from west to east over the northern half of the Facility.

Review of profiles 1, 2, 3, 5, and 6 show no discernible features that would indicate the subsurface configuration of the contaminant plume. Slight variations and trends in these profiles are evident, but it is not possible to conclusively know what factors cause these slight trends and variations. These variations may be due to changes in groundwater conductivity, changes in depth to groundwater or changes in the depth to the Muddy Creek formation.

Profiles 7 and 8, however, showed a very significant conductivity change (decrease) occurring to the west near Stauffer wells MC-65, MC-66, and MC-64 (Plate 1). This change corresponds to a high developed on the Muddy Creek formation. Also, the groundwater exhibits lower conductivities in this area as compared to areas located eastward along these profiles.

REFERENCES

Bell, J. W., 1981; Subsidence in Las Vegas Valley, MacKay School of Mines, University of Nevada, Reno and Nevada Bureau of Mines and Geology, Bulletin 95, 84 p.

Fenneman, N. M., 1931, Physiography of the Western United States; New York, McGraw Hill Book Company, Inc., 534 p.

Geraghty and Miller, Inc., October, 1980; Groundwater Investigation Stauffer Chemical Company, Henderson, Nevada; Consulting Report

Hall, L. E., March, 1983; 1982 Hydrogeologic Investigation in Support of the Groundwater Intercept System at Stauffer Chemical Company, Henderson, Nevada; Inhouse Report.

Harill, J. R., 1976; Pumping and Groundwater Storage Depletion in Las Vegas Valley, Nevada, 1955-1974: Nevada Department of Conservation and Natural Resources, Water Resource Bulletin 44, 70 p.

Maxey, G. B., and Jameson, C. H., 1948; Geology and Water Resources of the Las Vegas, Pahrump, and Indian Springs Valley, Clark and Nye Counties, Nevada: Nevada Department of Conservation and Water Resources, Water Resource Bulletin 5, 128 p.

APPENDIX A

Summary of Impoundment Usage, Design, and Capacity

KERR-McGEE CHEMICAL CORPORATION
HENDERSON, NEVADA

POND DESIGN & USAGE
NEVADA NPDES PERMIT
NV 0000078

SINGLE LINER SYSTEMS

POND C-1

Liner	:	PVC bottom reinforced butyl side
Surface Area	:	69,000 ft^2
Volume	:	3,125,000 gallons
Process Waste Received	:	Boiler Plant Blow Down Boiler Plant Wash Down 2.8 MnO_2 Cathode Wash Solution - 1.2 gpm Boron Neutralization Waste - .9 gpm (Evaporation)

POND AP-2

Liner	:	PVC bottom reinforced butyl side
Surface Area	:	14,000 ft^2
Volume	:	400,000 gallons
Process Waste	:	Sodium Perchlorate purification and Ammonium Perchlorate process purification filter wash liquor; total recycle.

POND P-3

Liner	:	Reinforced butyl rubber
Surface Area	:	12,000 ft^2
Volume	:	390,000 gallons
Process Waste	:	Sodium Chlorate solution due to wash down, storm water collection and excess above that the process vessels can handle. Total recycle.

DOUBLE LINER SYSTEMS

POND AP-1

Liner	:	Bottom liner - 40 mil HDPE (high-density polyethylene). Side underliner - geo-textile polypropylene 400 gm/m^2. Top liner - 60 mil HDPE.
Surface Area	:	14,000 ft^2
Volume	:	370,000 gallons
Process Waste	:	Sodium Perchlorate purification and Ammonium Perchlorate process purification filter wash liquor. Total recycle.

POND AP-3

Liner	:	Botton liner - 40 mil HDPE Side underliner - geotextile polypropylene - 400gm/m^2 Top liner - 60 mil HDPE
Surface Area	:	2000 ft^2
Volume	:	65,000 gallons
Process Waste	:	Sodium Perchlorate purification and Ammonium Perchlorate process purification filter wash liquor. Total recycle. This pond is used as a pump basin for AP-1.

POND AP-4

Liner	:	Bottom liner - 40 mil HDPE Side underliner - geotextile polypropylene - 400gm/m^2 Top liner - 60 mil HDPE
Surface Area	:	20,000 ft^2
Volume	:	720,000 gallon
Process Waste	:	Ammonium Perchlorate cooling tower waste; salt crystalizer washout.

POND AP-5

Liner	:	Bottom liner - 40 mil HDPE Side underliner - geotextile polypropylene - 400gm/m^2 Top liner - 60 mil HDPE
Surface Area	:	35,000 ft^2
Volume	:	1,817,000 gallons
Process Waste	:	Ammonium Perchlorate cooling tower waste

APPENDIX B

Monitor Well Inventory

MONITOR WELL INVENTORY
KERR-McGEE HENDERSON FACILITY

MONITOR WELL NUMBER	REFERENCE CASING ELEV., MSL	GROUND ELEV., MSL	*CASING STICKUP FT.	*DRILLED WELL DEPTH FT.	**MEASURED WELL DEPTH FT. TOC 6/85	*SCREENED INTERVAL, FT	CASING TYPE AND SIZE IN.	DATE WELL DRILLED	*DEPTH TO TOP OF MUDDY CREEK FT	ELEV. OF MUDDY CREEK MSL	*DEPTH TO GW FT. 6/85	WATER-TABLE ELEVATION MSL, 6/85	SATURATED AQUIFER THICKNESS FT, 6/85	CHROMIUM CONCENT. mg/l 6/85	GW COND., $\mu mhos/cm^2$ 6/85	**DEPTH TO WATER, FT TOC, 6/85
KM Wells	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
M-1	1792.68	1791.38	1.30	50.0	45.38	33.5-43.5	5" Steel	11/81	40.0	1751.4	43.4	1748.0	-3.4	1.2	16,200	44.70
M-2	1780.02	1778.60	1.42	44.0	40.69	30-40	5" Steel	11/81	39.0	1739.6	35.2	1743.4	3.8	3.1	8,800	36.64
M-3	1780.46	1779.76	0.70	44.5	40.44	30-40	5" Steel	11/81	41.0	1738.8	37.2	1742.5	3.8	8.0	13,300	37.92
M-4	1781.45	1780.05	1.40	45.0	41.34	30-40	5" Steel	11/81	36.0	1744.1	35.3	1744.8	0.7	0.6	5,200	36.69
M-5	1747.86	1747.01	0.85	43.0	40.25	29-39	5" Steel	6/1/82	25.5	1721.5	32.6	1714.4	-7.1	<0.1	10,100	33.46
M-6	1729.15	1728.04	1.11	43.0	35.90	25-35	5" Steel	6/2/82	32.0	1696.0	33.2	1694.9	-1.1	<0.1	9,500	34.26
M-7	1729.81	1728.81	1.00	37.0	35.23	25-35	5" Steel	6/3/82	29.5	1699.3	28.7	1700.2	0.9	<0.1	8,300	29.66
M-8	1780.00	1778.80	1.20	45.0	40.96	30-40	5" Steel	6/14/82	43.0	1735.8	35.3	1743.5	7.7	14.0	7,100	36.49
M-9	1778.92	1778.57	0.35	45.0	39.83	30-40	5" Steel	6/15/82	35.0	1743.6	36.1	1742.4	-1.1	32.0	25,000	36.48
M-10	1834.76	1832.70	2.06	75.0	69.45	43-63	5" Steel	5/83	38.0	1794.7	55.2	1777.6	-17.1	<0.1	3,200	57.21
M-11	1814.45	1812.28	2.17	60.0	~58.0	33-53	5" Steel	5/83	36.5	1775.8	43.7	1768.6	-7.2	90.0	25,100	45.82
M-12	1814.90	1812.37	2.53	65.0	49.90	37-47	5" Steel	5/83	34.5	1777.9	44.7	1767.7	-10.2	11.0	21,000	47.22
M-13	1814.23	1812.33	1.90	55.0	54.76	28-48	5" Steel	5/83	37.5	1774.8	46.0	1766.3	-8.5	1.1	6,900	47.90
M-14	1759.43	1757.03	2.40	37.0	39.24	22-37	2" PVC	5/83	28.0	1729.0	25.4	1731.6	2.6	0.2	4,000	27.80
M-15	1750.31	1747.93	2.38	41.0	42.55	26-41	2" PVC	5/83	34.0	1713.9	18.7	1729.3	15.4	6.2	15,100	21.05
M-16	---	1759.42	---	37.0	---	22-37	2" PVC	5/83	30.0	1729.4	---	---	---	---	---	---
M-17	~1769.90	1767.15	2.75	42.0	37.00	27-42	2" PVC	5/83	35.0	1732.2	26.3	~1740.8	~8.6	6.6	9,100	29.07
M-18	1738.93	1737.78	1.14	28.0	29.80	14-24	2" PVC	8/10/83	25.0	1712.8	8.1	1729.7	16.9	0.3	6,500	9.25
M-19	1766.93	1763.63	3.30	40.0	41.20	14.5-34.5	2" PVC	8/10/83	33.0	1730.6	21.8	1741.8	11.2	0.1	14,200	25.11
M-20	1798.21	1795.79	2.42	45.0	46.55	20.4-40.4	2" PVC	8/11/83	39.5	1756.3	33.7	1762.1	5.8	<0.1	6,000	36.07
M-21	1790.50	1788.37	2.13	43.0	44.74	18-38	2" PVC	8/11/83	37.0	1751.4	38.8	1749.6	-1.8	0.20	3,800	40.94
M-22	1758.91	1756.72	2.19	35.0	36.70	11-31	2" PVC	8/11/83	30.0	1726.7	19.4	1737.3	10.6	0.90	8,100	21.60
M-23	1717.61	1715.04	2.57	43.0	44.47	9.4-37.4	2" PVC	8/11/83	37.5	1677.5	9.8	1705.2	27.7	2.5	15,100	12.37

MONITOR WELL INVENTORY
KERR-McGEE HENDERSON FACILITY

MONITOR WELL NUMBER	REFERENCE CASING ELEV., MSL	GROUND ELEV., MSL	*CASING STICKUP FT.	*DRILLED WELL DEPTH FT.	**MEASURED WELL DEPTH FT, 6/85 TOC	*SCREENED INTERVAL, FT	CASING TYPE AND SIZE IN.	DATE WELL DRILLED	*DEPTH TO TOP OF MUDDY CREEK FT	ELEV. OF MUDDY CREEK MSL	*DEPTH TO GW FT. 6/85	WATER-TABLE ELEVATION MSL, 6/85	SATURATED AQUIFER THICKNESS FT, 6/85	CHROMIUM CONCENT. mg/l 6/85	GW COND., $\mu mhos/cm^2$ 6/85	**DEPTH TO WATER, FT TOC, 6/85
M-24	1788.54	1786.34	2.20	40.0	42.69	25-40	2" PVC	5/14/84	36.0	1750.3	37.9	1748.4	-1.9	1.1	4,200	40.13
M-25	1756.81	1753.79	3.02	40.0	41.47	25-40	2" PVC	5/14/84	28.0	1725.8	21.9	1731.9	6.1	12.9	14,000	24.94
M-26	---	1748.94	----	40.0	-----	25-40	2" PVC	5/14/84	35.0	1713.94	----	-----	---	---	-------	-----
M-27	1741.28	1739.46	1.82	35.0	30.92	20-35	2" PVC	5/14/84	>40.0	<1699.5	13.2	1726.4	>26.9	2.6	10,100	14.88
M-28	1811.27	1811.1	-.24	50.5	47.61	30-50	2" PVC	7/23/85	31.0	1780.5	43.0	1768.5	-12.0	<0.1	6,700	42.78
M-29	1806.60	1806.24	0.36	42.0	41.74	42-27	2" PVC	7/12/85	21.0	1785.2	36.1	1770.1	-15.1	0.1	34,600	36.48
M-30	1810.68	1810.88	-.20	46.50	43.32	45-30	2" PVC	7/17/84	25.0	1785.9	39.0	1771.9	-14.0	0.6	5,500	38.80
M-31	1787.92	1785.54	2.38	45.0	47.60	30-45	2" PVC	6/85	35.0	1750.5	35.0	1750.5	0.0	10.4	11,000	37.36
M-32	1787.48	1785.63	1.85	45.0	46.76	30-45	2" PVC	"	34.0	1751.6	33.4	1752.3	0.6	1.3	8,900	35.22
M-33	1786.98	1785.03	1.95	45.0	46.78	30-45	2" PVC	"	35.0	1750.0	32.2	1752.8	2.8	0.1	7,200	34.15
M-34	1776.10	1774.25	1.85	40.0	41.83	25-40	2" PVC	"	35.0	1739.3	29.3	1745.0	5.7	2.2	7,800	31.10
M-35	1775.01	1773.11	1.90	40.0	42.33	25-40	2" PVC	"	33.5	1739.6	27.1	1746.1	6.4	0.6	6,500	28.95
M-36	1758.88	1756.03	2.85	35.0	37.85	20-35	2" PVC	"	27.5	1728.5	21.2	1734.8	6.3	2.0	13,100	24.08
M-37	1759.58	1757.43	2.15	35.0	37.18	20-35	2" PVC	"	27.0	1730.4	23.1	1734.3	3.9	0.3	20,000	25.27
M-38	1759.08	1756.48	2.60	35.0	37.44	20-35	2" PVC	"	28.0	1728.5	21.9	1734.6	6.1	5.3	9,100	24.52
M-39	1760.22	1757.62	2.60	40.0	42.60	20-35	2" PVC	"	34.0	1723.6	19.4	1738.3	14.6	2.0	8,500	21.97
M-40	1797.89	1795.49	2.40	45.0	47.40	30-45	2" PVC	"	32.0	1763.5	37.5	1758.0	-5.5	2.5	11,200	39.93

MONITOR WELL INVENTORY
KERR-McGEE HENDERSON FACILITY

MONITOR WELL NUMBER	REFERENCE CASING ELEV., MSL	GROUND ELEV., MSL	*CASING STICKUP FT.	*DRILLED WELL DEPTH FT.	**MEASURED WELL DEPTH FT, 6/85 TOC	*SCREENED INTERVAL, FT	CASING TYPE AND SIZE IN.	DATE WELL DRILLED	*DEPTH TO TOP OF MUDDY CREEK FT.	ELEV. OF MUDDY CREEK MSL	*DEPTH TO GW FT. 6/85	WATER-TABLE ELEVATION MSL, 6/85	SATURATED AQUIFER THICKNESS FT, 6/85	CHROMIUM CONCENT. mg/l 6/85	GW COND. $\mu mhos/cm^2$ 6/85	**DEPTH TO WATER, FT TOC, 6/85
KM Test Borings																
84-2	---	1811.27	---	32.0	---	---	---	7/16/84	28.50	1782.8	---	---	---	---	---	---
84-3	---	1804.33	---	32.0	---	---	---	7/11/84	22.50	1781.8	---	---	---	---	---	---
84-5	---	1805.39	---	29.75	---	---	---	7/13/84	22.50	1782.89	---	---	---	---	---	---
84-7	---	1811.31	---	32.5	---	---	---	7/16/84	31.0	1780.3	---	---	---	---	---	---
84-8	---	~1795.8	---	42.0	---	---	---	7/25/84	29.5	1766.3	---	---	---	---	---	---
84-9	---	~1795.8	---	40.0	---	---	---	7/10/84	30.0	1765.8	---	---	---	---	---	---
84-10	---	~1795.8	---	36.8	---	---	---	7/25/84	36.0	1759.8	---	---	---	---	---	---
84-11	---	~1795.8	---	37.0	---	---	---	7/27/84	28.0	1767.8	---	---	---	---	---	---
84-12	---	~1795.8	---	47.0	---	---	---	7/26/84	35.0	1760.8	---	---	---	---	---	---
85-13	---	1778.57	---	37.0	---	---	---	6/85	35.0	1743.6	---	---	---	---	---	---
85-14	---	1778.80	---	45.0	---	---	---	6/85	43.0	1735.8	---	---	---	---	---	---
85-15	---	1780.05	---	40.0	---	---	---	6/85	36.0	1744.1	---	---	---	---	---	---
85-16	---	1779.76	---	45.0	---	---	---	6/85	41.0	1738.8	---	---	---	---	---	---
TIMET WELLS																
CLU-1	1787.65	1785.42	2.23	43.0	---	28-33	2" PVC	4/11/83	33.0	1752.4	29.8	1755.65	3.30	0.38	11,730	32.00
CLD-1	1743.05	1740.85	2.20	35.0	---	24-29	2" PVC	4/06/83	31.0	1709.9	9.1	1731.72	21.8	0.59	>20,000	11.33
CLD-2	1751.44	1748.84	2.60	42.0	---	32-37	2" PVC	4/29/82	37.0	1711.84	14.7	1734.19	22.4	0.11	18,060	17.25
CLD-2R	--------	---	----	----	---	----	---	---	---	---	---	---	----	----	---	---
CLD-3	1750.19	1747.89	2.30	44.0	---	33-38	2" PVC	4/05/83	39.0	1708.9	8.45	1739.44	30.5	0.20	10,160	10.75
CLD-4	1779.87	1777.71	2.16	45.0	---	34-39	2" PVC	4/06/83	40.0	1737.7	28.3	1749.45	11.8	0.06	>20,000	30.42
J2D-1	1770.03	1767.45	2.58	----	---	-----	---	---	----	---	---	1750.78	----	----	9,100	19.25
J2D-2	--------	---	----	----	---	-----	---	---	----	---	---	---	----	----	---	---

MONITOR WELL INVENTORY
KERR-McGEE HENDERSON FACILITY

MONITOR WELL NUMBER	REFERENCE CASING ELEV., MSL	GROUND ELEV., MSL	*CASING STICKUP FT.	*DRILLED WELL DEPTH FT.	**MEASURED WELL DEPTH FT, 6/85 TOC	*SCREENED INTERVAL, FT	CASING TYPE AND SIZE IN.	DATE WELL DRILLED	*DEPTH TO TOP OF MUDDY CREEK FT	ELEV. OF MUDDY CREEK MSL	*DEPTH TO GW FT. 6/85	WATER-TABLE ELEVATION MSL, 6/85	SATURATED AQUIFER THICKNESS FT, 6/85	CHROMIUM CONCENT. mg/l 6/85	GW COND., $\mu mhos/cm^2$ 6/85	**DEPTH TO WATER, FT TOC, 6/85
TIMET WELLS														---	---	---
J2D-3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
J2U-1	---	---	---	---	---	---	---	---	---	---	---	---	---			
DRI WELLS																
PG-102	1695.80	1696.30	-0.50	36.0	27.65	---	2" PVC	---	>36	<1660.3	25.06	1671.24	>10.9	---	---	24.56
PG-103	1694.45	~1694.50	~-0.05	16.0	-----	---	2" PVC	---	>16	<1678.5	~5.0	~1689.5	>11.0	---	---	~5.0'
PG-107	1727.11	1727.16	-0.05	25.0	17.30	---	2" PVC	---	25.0	1702.2	15.27	1711.9	9.7	0.90	14,000	15.22
PG-108	1725.38	1725.68	-0.30	21.0	11.30	---	2" PVC	---	>21	<1704.7	8.95	1716.7	>12.0	0.10	21,600	8.65
Stauffer Wells																
H-10	1703.93	1703.10	0.83	---	49.25	---	5" Steel	---	40.0	1663.1	----	---	---	<0.1	---	---
H-23	1730.60	1729.70	0.90	---	48.36	---	5" Steel	---	42.5	1687.2	34.1	1695.6	8.4	---	---	35.02
H-28	1730.33	1729.33	1.00	---	48.96	---	5" Steel	---	44.5	1684.8	33.7	1695.6	10.8	<0.1	12,000	34.74
H-36	1716.20	1715.40	0.80	---	-----	---	5" Steel	---	38.0	1677.4	28.7	1686.7	9.3	---	---	29.50
H-38	1772.69	1771.05	1.64	---	54.00	---	5" Steel	---	25.0	1746.1	36.0	1735.1	-11.0	---	---	37.60
H-48	1682.79	1680.30	2.49	---	-----	---	5" Steel	---	59.0	1621.3	-----	---	---	---	---	---
H-49	1685.38	1684.22	1.16	---	39.58	---	5" Steel	---	48.0	1636.2	28.2	1656.0	19.8	<0.1	---	29.39
H-50	1700.48	1699.06	1.42	---	44.45	---	5" Steel	---	40.0	1659.1	34.2	1664.8	5.7	0.1	---	35.66
H-51	1699.00	1697.09	1.91	---	44.15	---	5" Steel	---	57.5	1639.6	30.9	1666.2	26.6	<0.1	---	32.82
H-52	1727.71	1726.36	1.35	---	30.04	---	5" Steel	---	28.0	1698.4	17.3	1709.1	10.7	<0.1	8,500	18.64
H-54	1722.30	1719.80	2.50	---	-----	---	5" Steel	---	51.0	1668.8	---	---	---	---	---	---
H-56	1681.60	1680.28	1.32	---	63.00	---	5" Steel	---	-----	---	26.9	1653.4	---	<0.1	---	28.21

MONITOR WELL INVENTORY
KERR-McGEE HENDERSON FACILITY

MONITOR WELL NUMBER	REFERENCE CASING ELEV., MSL	GROUND ELEV., MSL	*CASING STICKUP FT.	*DRILLED WELL DEPTH FT.	**MEASURED WELL DEPTH FT, 6/85 TOC	*SCREENED INTERVAL, FT	CASING TYPE AND SIZE IN.	DATE WELL DRILLED	*DEPTH TO TOP OF MUDDY CREEK FT	ELEV. OF MUDDY CREEK MSL	*DEPTH TO GW FT. 6/85	WATER-TABLE ELEVATION MSL, 6/85	SATURATED AQUIFER THICKNESS FT, 6/85	CHROMIUM CONCENT. mg/l 6/85	GW COND. $\mu mhos/cm^2$ 6/85	**DEPTH TO WATER, FT TOC, 6/85
H-57	1721.67	~1720.17	~1.50	---	---	---	5" steel	---	---	---	---	1688.8	---	---	---	---
H-58	1691.86	1689.56	2.30	---	59.34	---	"	---	56.0	1633.6	32.6	1657.0	23.4	<0.1	---	34.87
MC-1	1730.12	1728.92	1.20	---	43.87	---	2" PVC	---	35.0	1693.9	32.1	1696.9	3.0	---	---	33.25
MC-2	---	1727.0	---	---	---	---	"	---	33.0	1694.0	---	---	---	---	---	---
MC-3	1724.41	1723.81	0.60	---	---	---	"	---	40.0	1683.8	32.6	1691.2	7.4	---	---	33.19
MC-4	---	1718.0	---	---	---	---	"	---	40.0	1678.0	---	---	---	---	---	---
MC-5	1714.45	1713.4	1.05	---	---	---	"	---	36.0	1677.4	26.8	1686.6	9.2	---	---	27.85
MC-6	1710.68	1710.0	0.68	---	---	---	"	---	38.0	1672.0	25.3	1684.7	12.7	---	---	25.98
MC-9	1714.46	1713.6	0.86	---	---	---	"	---	50.0	1663.6	26.4	1687.2	23.6	---	---	27.26
MC-11	1667.2	1662.9	4.30	---	---	---	"	---	10.5	1652.4	4.7	1658.2	5.8	---	---	9.0
MC-15	---	1680.3	---	---	---	---	"	---	59.0	1621.3	---	---	---	---	---	---
MC-16	---	1684.1	---	---	---	---	"	---	48.0	1636.1	---	---	---	---	---	---
MC-17	---	1711.3	---	---	---	---	"	---	61.5	1649.8	---	---	---	---	---	---
MC-18	---	1698.1	---	---	---	---	"	---	57.5	1640.6	---	---	---	---	---	---
MC-19	---	1695.1	---	---	---	---	"	---	42.0	1653.1	---	---	---	---	---	---
MC-20	---	1689.7	---	---	---	---	"	---	29.0	1658.7	---	---	---	---	---	---
MC-26	1716.81	1715.2	1.81	---	---	---	"	---	31.0	1684.2	28.2	1686.8	2.6	---	---	30.01
MC-27	1719.90	1718.4	1.50	---	---	---	"	---	45.0	1673.4	31.0	1687.4	14.0	---	---	32.5
MC-28	1720.50	1719.0	1.50	---	---	---	"	---	49.0	1670.0	31.5	1687.5	17.5	---	---	33.0
MC-29	1722.02	1720.53	1.49	---	49.64	---	"	---	49.0	1671.5	30.5	1690.0	18.5	---	---	32.00
MC-30	1724.13	1722.18	1.95	---	44.46	---	"	---	45.0	1677.2	32.0	1690.2	13.0	---	49,000	33.92
MC-31	1724.53	1723.00	1.53	---	38.66	---	"	---	41.0	1682.0	32.7	1690.4	8.4	---	---	34.18
MC-32	1725.87	1724.77	1.10	---	33.28	---	"	---	33.5	1691.2	31.4	1693.4	2.2	---	10,000	32.47
MC-40	1720.28	1718.86	1.42	---	51.49	---	"	---	51.0	1667.8	30.0	1688.9	21.1	---	---	31.39

MONITOR WELL INVENTORY
KERR-McGEE HENDERSON FACILITY

MONITOR WELL NUMBER	REFERENCE CASING ELEV., MSL	GROUND ELEV., MSL	*CASING STICKUP FT.	*DRILLED WELL DEPTH FT.	**MEASURED WELL DEPTH FT, 6/85 TOC	*SCREENED INTERVAL, FT	CASING TYPE AND SIZE IN.	DATE WELL DRILLED	*DEPTH TO TOP OF MUDDY CREEK FT	ELEV. OF MUDDY CREEK MSL	*DEPTH TO GW FT. 6/85	WATER-TABLE ELEVATION MSL, 6/85	SATURATED AQUIFER THICKNESS FT, 6/85	CHROMIUM CONCENT. mg/l 6/85	GW COND. $\mu mhos/cm^2$ 6/85	**DEPTH TO WATER, FT TOC, 6/85
MC-41	1720.77	1719.8	0.97	---	---	---	2" PVC	---	51.0	1668.8	31.3	1688.5	19.7	---	---	32.27
MC-42	1721.25	1718.8	2.45	---	---	---	"	---	53.0	1665.8	30.7	1688.1	22.3	---	---	33.15
MC-43	1709.77	~1708.27	~1.50	---	---	---	"	---	>17.0	<1691.3	---	---	---	---	---	---
MC-44	1708.24	~1706.74	~1.50	---	---	---	"	---	>25.0	<1681.7	---	---	---	---	---	---
MC-45	1709.60	~1708.10	~1.50	---	---	---	"	---	>34.0	<1674.1	~24.7	1683.4	>9.3	---	---	26.20
MC-46	1709.54	~1708.04	~1.50	---	---	---	"	---	>32.0	<1676.0	---	---	---	---	---	---
MC-49	1708.69	~1707.19	~1.50	---	---	---	"	---	38.0	~1669.2	~26.2	1681.0	11.8	---	---	27.69
MC-50	1711.77	~1710.27	~1.50	---	---	---	"	---	49.0	~1661.3	~25.2	1685.1	23.8	---	---	26.67
MC-51	1714.44	1713.39	1.05	---	47.20	---	"	---	47.0	1666.4	25.0	1688.4	22.0	---	---	26.05
MC-52	1714.43	1712.93	1.50	---	49.37	---	"	---	46.0	1666.9	25.2	1687.7	20.8	---	---	26.72
MC-53	1713.84	1712.24	1.60	---	41.88	---	"	---	37.0	1675.2	25.6	1686.7	11.5	<0.1	11,900	27.17
MC-54	1719.01	~1717.51	~1.50	---	---	---	"	---	37.5	~1680.0	---	---	---	---	---	---
MC-55	1720.07	1718.82	1.25	---	23.30	---	"	---	21.0	1697.8	>22.1	<1696.8	>-1	---	---	Dry @ 23.30
MC-56	1716.99	~1715.49	~1.50	---	---	---	"	---	49.5	~1666.0	~27.1	1688.4	~22.4	---	---	28.59
MC-59	1723.34	1721.98	1.36	---	23.36	---	"	---	19.5	1702.5	19.4	1702.6	0.1	<0.1	9,000	20.77
MC-60	1701.86	1700.18	1.68	---	32.94	---	"	---	30.5	1669.7	>31.3	<1668.9	>0.8	---	---	>32.94 Dry
MC-61	1704.99	1703.61	1.38	---	48.80	---	"	---	46.0	1657.6	30.0	1673.6	16.0	<0.1	40,000	31.40
MC-62	1699.13	1697.68	1.45	---	51.80	---	"	---	48.5	1649.2	32.0	1665.6	16.4	<0.1	44,000	33.49
MC-63	1697.89	1696.56	1.33	---	52.92	---	"	---	50.5	1646.1	29.4	1667.2	21.1	<0.1	10,800	30.74
MC-64	1696.63	1695.45	1.18	---	43.73	---	"	---	41.0	1654.5	26.3	1669.2	14.7	<0.1	11,500	27.46
MC-65	1704.07	1702.41	1.66	---	42.47	---	"	---	40.0	1662.4	31.3	1671.1	8.7	<0.1	14,500	32.95
MC-66	1701.00	1699.55	1.45	---	48.20	---	"	---	45.5	1654.1	30.6	1669.0	14.9	<0.1	10,200	32.00
MC-67	1691.08	~1689.58	~1.50	---	---	---	"	---	57.0	~1632.6	---	---	---	---	---	---
MC-68	1718.90	~1717.40	~1.50	---	---	---	"	---	42.0	~1675.4	~30.9	1686.5	~11.1	---	---	32.40

MONITOR WELL INVENTORY
KERR-McGEE HENDERSON FACILITY

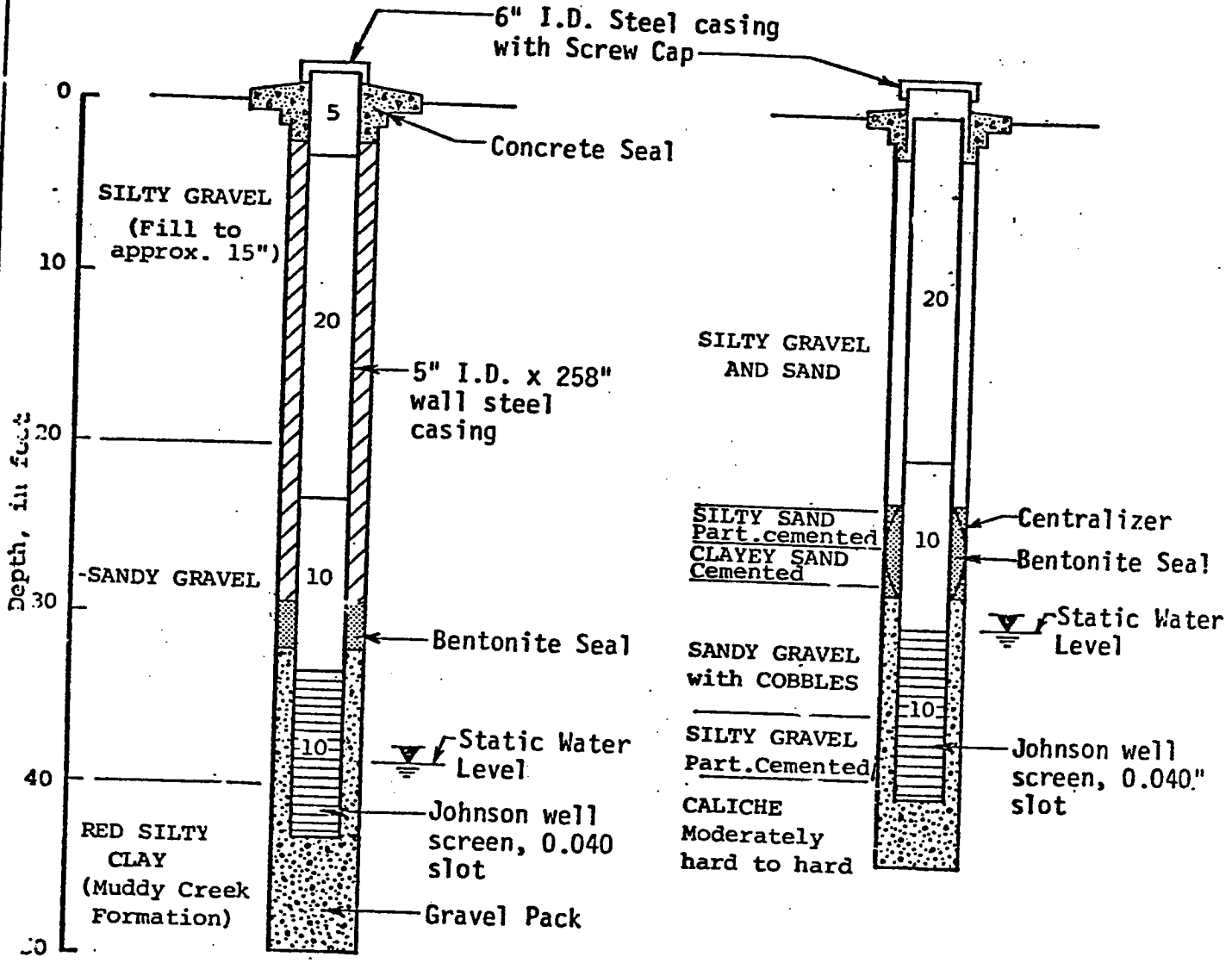
MONITOR WELL NUMBER	REFERENCE CASING ELEV., MSL	GROUND ELEV., MSL	*CASING STICKUP FT.	*DRILLED WELL DEPTH FT.	**MEASURED WELL DEPTH FT, 6/85 TOC	*SCREENED INTERVAL, FT	CASING TYPE AND SIZE IN.	DATE WELL DRILLED	*DEPTH TO TOP OF MUDDY CREEK FT	ELEV. OF MUDDY CREEK MSL	*DEPTH TO GW FT. 6/85	WATER-TABLE ELEVATION MSL, 6/85	SATURATED AQUIFER THICKNESS FT, 6/85	CHROMIUM CONCENT. mg/l 6/85	GW COND. $\mu mhos/cm^2$ 6/85	**DEPTH TO WATER, FT TOC, 6/85
MC-69	1717.33	~1715.83	~1.50	---	---	---	2" PVC	---	43.0	~1672.8	~29.0	1686.8	~14.0	---	---	30.53
MC-70	1721.29	1720.66	0.63	---	34.91	---	"	---	34.5	1686.2	29.9	1690.8	4.6	<0.1	---	30.50
MC-74	---	---	---	---	---	---	"	---	33.0	---	---	---	---	---	---	---
MC-79	1720.80	~1719.30	~1.50	---	---	---	"	---	51.0	~1668.3	~29.8	1689.5	~21.2	---	---	31.30
MC-80	1727.81	1726.38	1.43	---	46.90	---	"	---	46.0	1680.4	33.7	1692.7	12.3	---	>50,000	35.09
MC-92	1712.73	~1711.23	~1.50	---	---	---	"	---	48.0	~1663.2	---	---	---	---	---	---
MC-93	1717.89	1716.62	1.27	---	42.82	---	"	---	39.0	1677.6	26.7	1690.0	12.4	<0.1	---	27.93
MC-94	1719.89	1718.43	1.46	---	40.42	---	"	---	38.0	1680.4	27.6	1690.8	10.4	---	---	29.09
MC-95	1717.96	1715.24	2.72	---	49.86	---	"	---	45.0	1670.2	25.6	1689.7	19.5	---	---	28.29
MC-96	1714.43	1712.25	2.18	---	39.58	---	"	---	45.0	1667.3	24.5	1687.7	20.4	---	---	26.71
MC-97	1722.54	1721.04	1.50	---	42.49	---	"	---	40.0	1681.0	30.6	1690.4	9.4	---	11,200	32.12
MC-98	1720.99	~1719.49	~1.50	---	---	---	"	---	44.0	~1675.5	~29.9	1689.6	~14.1	---	---	31.39
MC-99	1718.21	1716.57	1.64	---	49.42	---	"	---	47.5	1669.1	28.9	1687.7	18.6	---	---	30.55
D	1718.77	~1716.77	~2.0	---	---	---	"	---	36.0	~1680.8	~34.8	1682.0	~***1.4	---	---	36.77
E	1719.64	~1717.64	~2.0	---	---	---	"	---	41.0	~1676.6	~39.9	1677.7	~***1.1	---	---	41.94
F	1721.75	~1719.75	~2.0	---	---	---	"	---	42.0	~1677.8	~39.1	1680.7	~***2.9	---	---	41.05
G	1723.01	~1721.01	~2.0	---	---	---	5" steel	---	52.0	~1669.0	~44.5	1676.5	~***7.5	---	---	46.51
H	1722.82	~1720.82	~2.0	---	---	---	"	---	48.0	~1672.8	~30.9	1689.9	~***17.1	---	---	32.92
I	1725.37	~1725.37	~2.0	---	---	---	"	---	42.0	~1683.4	~34.2	1689.2	~***5.8	<0.1	---	36.17

* Measured from ground level
** Measured from top of casing
*** Pumping level

Note: Chromium concentrations in TIMET wells were analyzed in September, 1984.
Saturated Aquifer Thickness is saturated interval above the Muddy Creek Formation.
Negative (-) number indicates saturated interval within Muddy Creek Formation.

APPENDIX C

Monitoring Well Logs



YIELD = APPROXIMATELY 1/2 gpm
WATER YELLOW COLORED

M-1

YIELD = PUMP CAPACITY = 15 gpm
WATER YELLOW COLORED

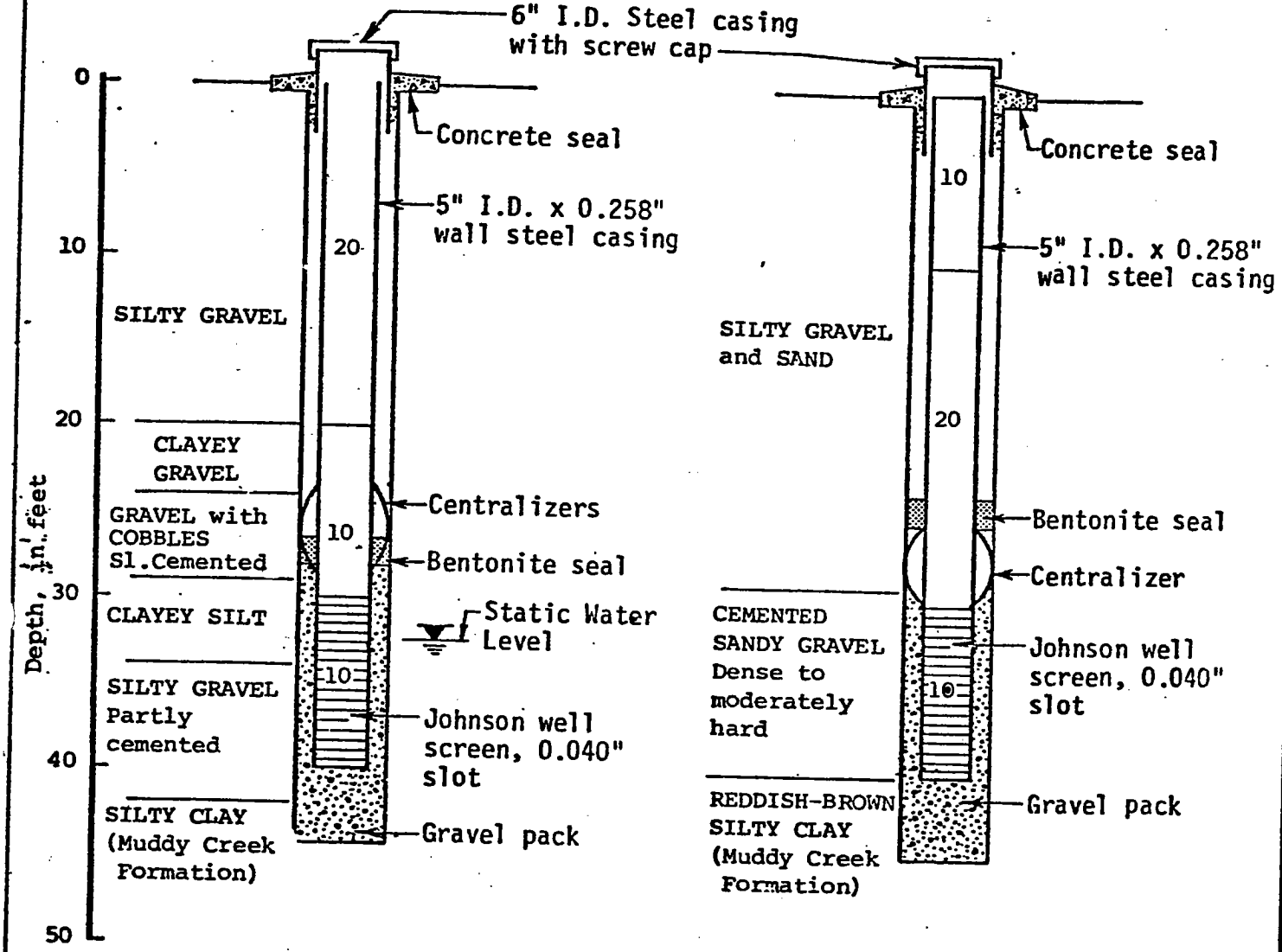
M-2

Project No.

MONITOR WELLS M-1 AND M-2

Drawing No.

ConverseWardDavisDixon Geotechnical Consultants

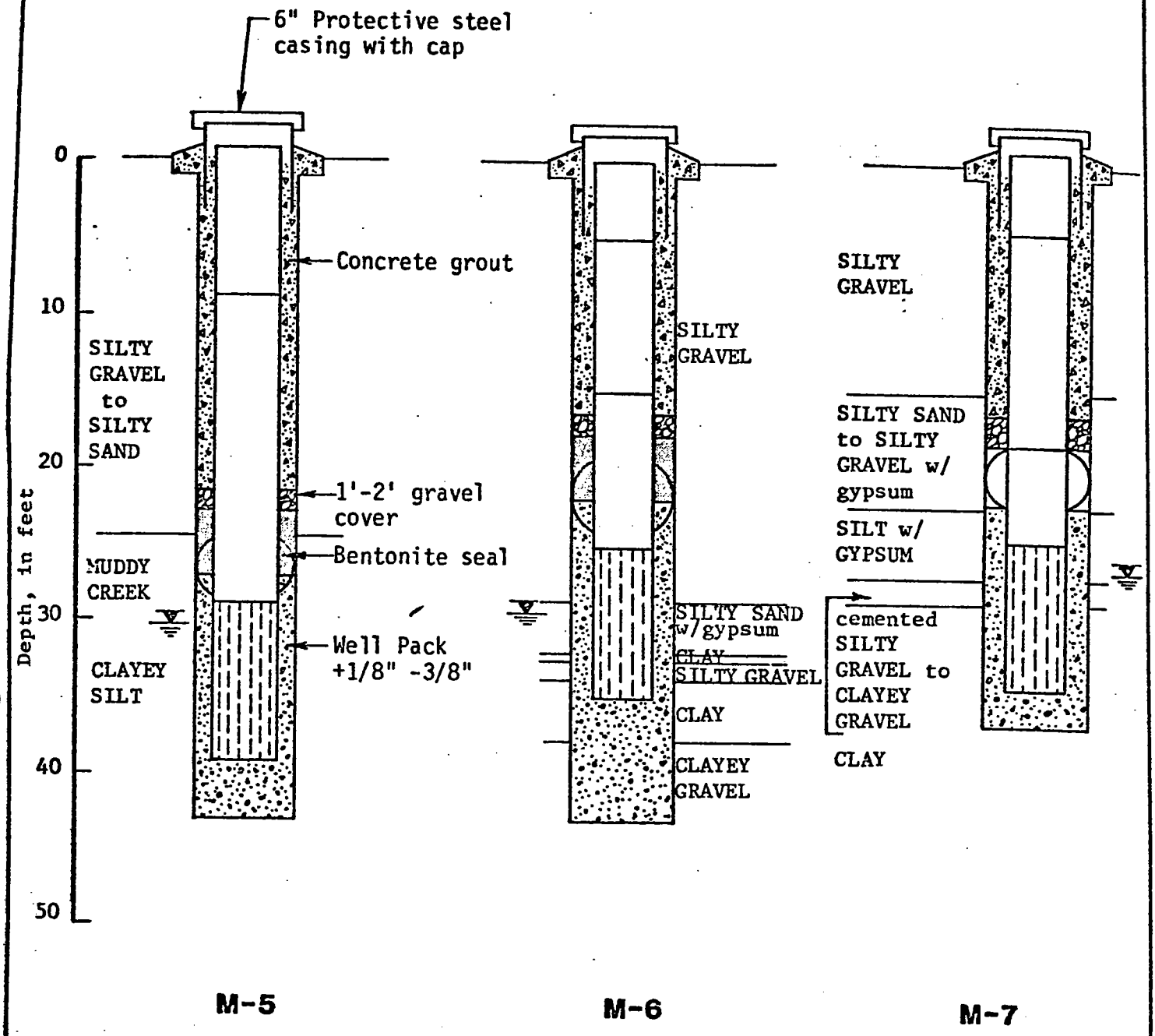


Project No.

MONITOR WELLS M-3 AND M-4

Figure No.

ConverseWardDavisDixon Geotechnical Consultants



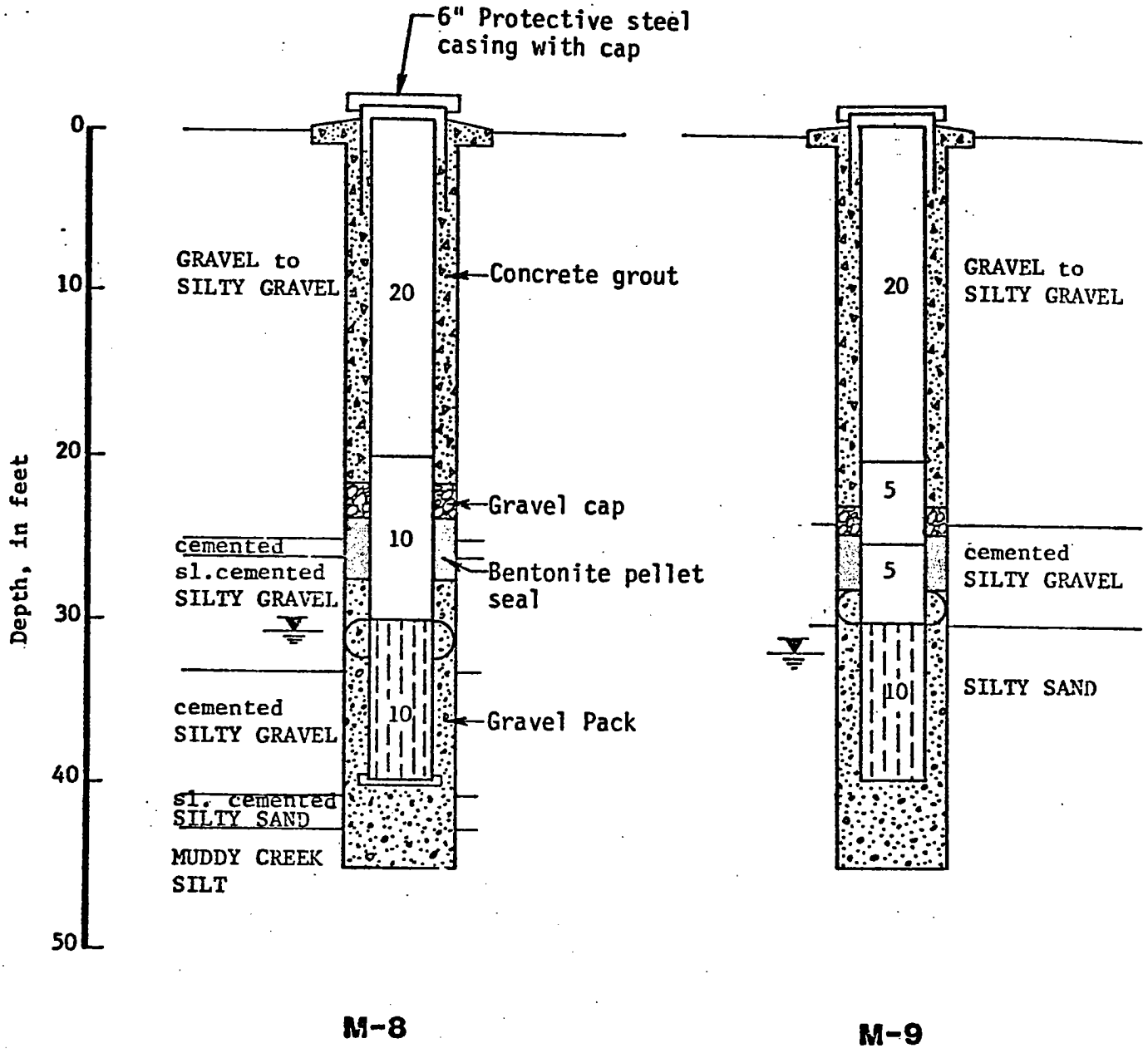
Remarks: Water from wells M-5, M-6 and M-7 has strong organic chemical odor.

MONITOR WELLS, M-5, M-6 AND M-7

Project No.
82-3160

Figure No.

Converse Consultants Geotechnical Engineering and Applied Sciences



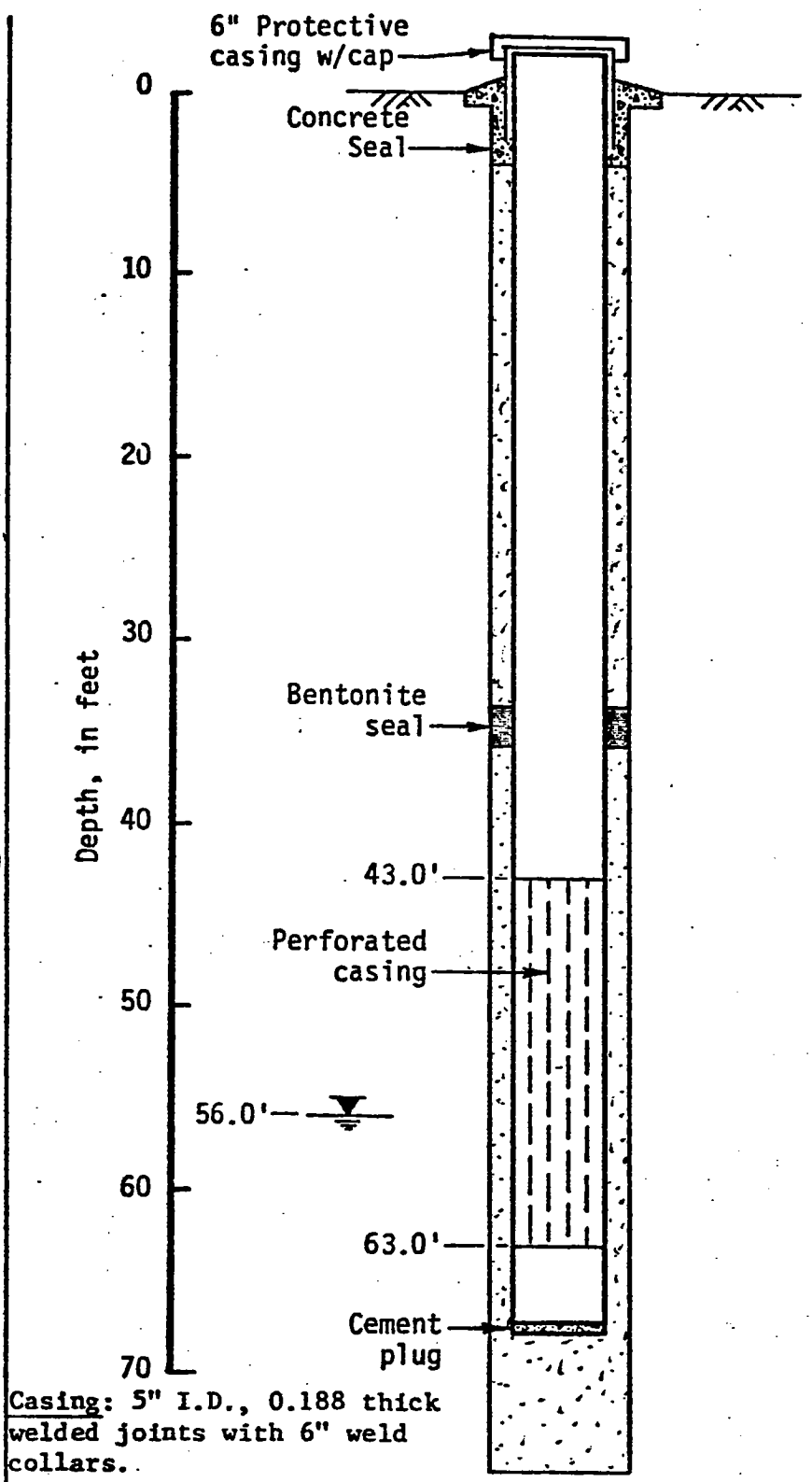
Remarks: Water from well M-8 and M-9 has yellow color.

MONITOR WELLS, M-8 AND M-9

Project No.

82-3160

Figure No.

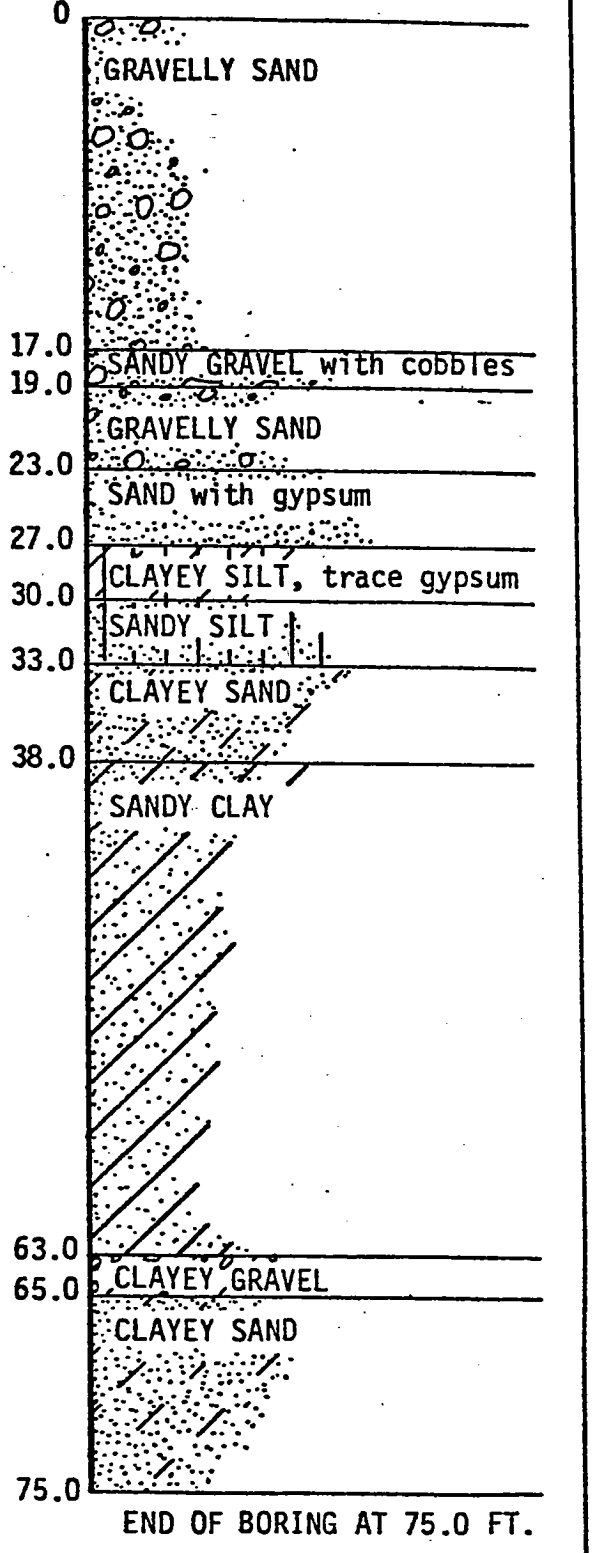


Casing: 5" I.D., 0.188 thick welded joints with 6" weld collars.

Perforations: .090 slot, 8 rows on 6" centers.

Centralizers: One above perforated section.

LOG OF PILOT HOLE AND WELL BORING

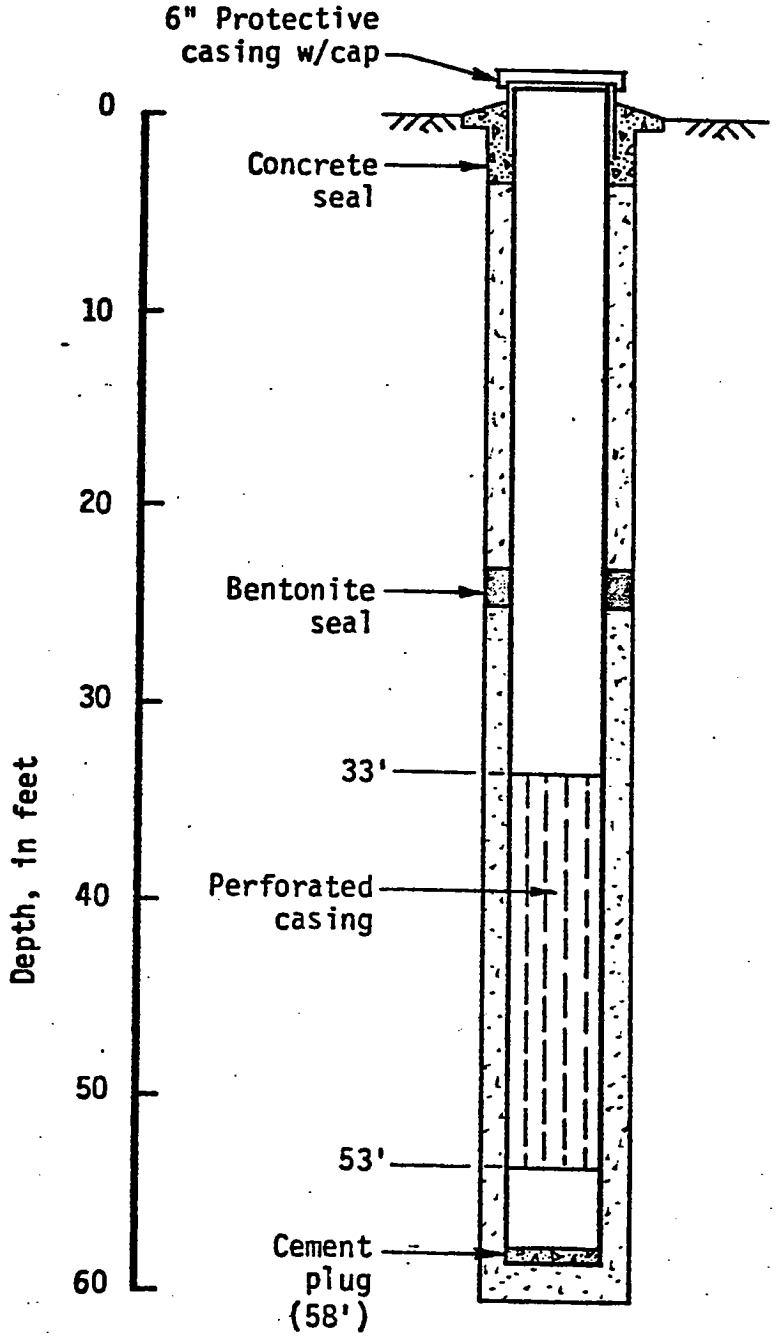


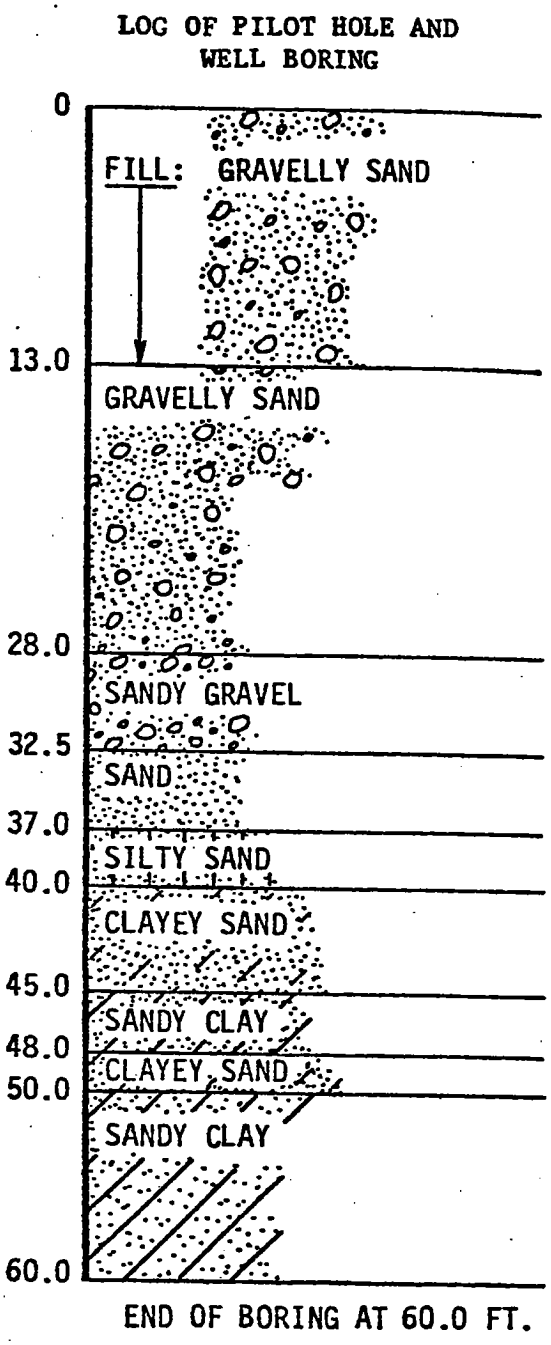
END OF BORING AT 75.0 FT.

WELL M-10

Project No.
83-3168

Figure No.
2





Casing: 5" I.D., 0.188 thick welded joints with 6" weld collars.
Perforations: .090 slot, 8 rows on 6" centers.
Centralizers: One above perforated section.

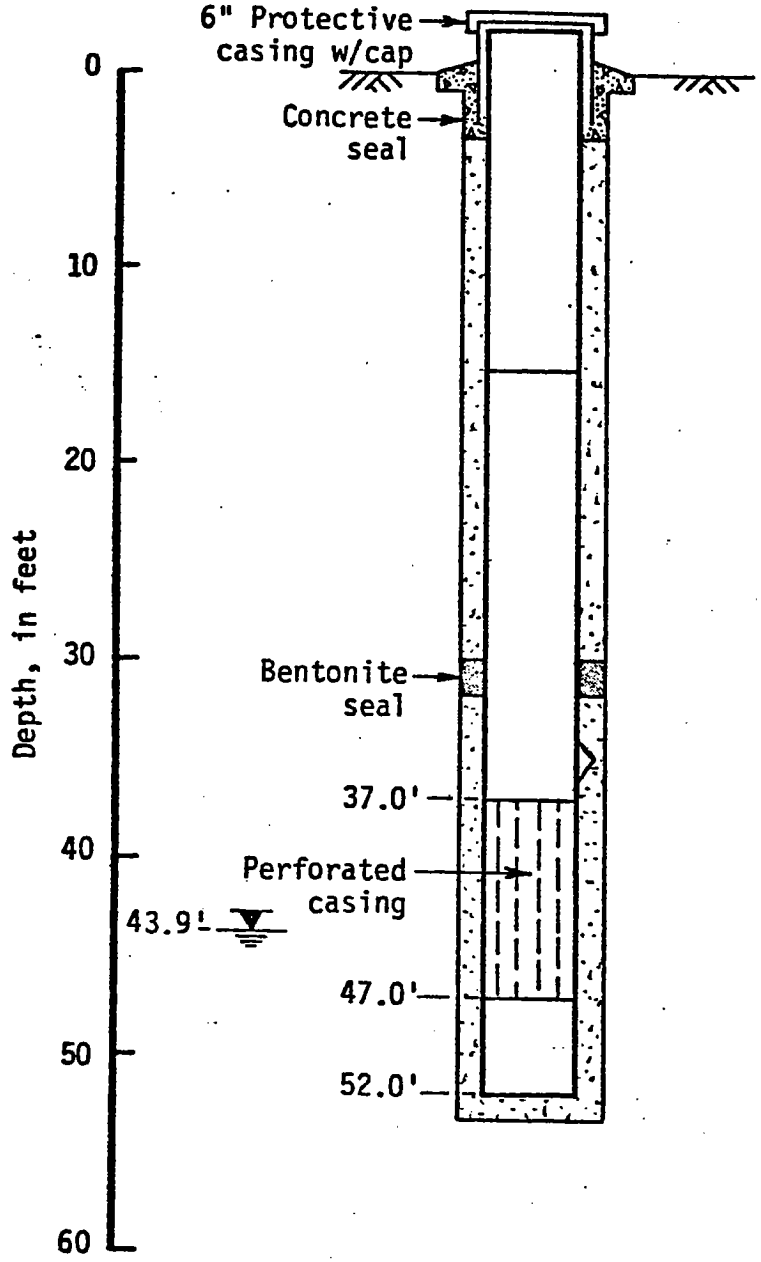
Note: Water level not measured.

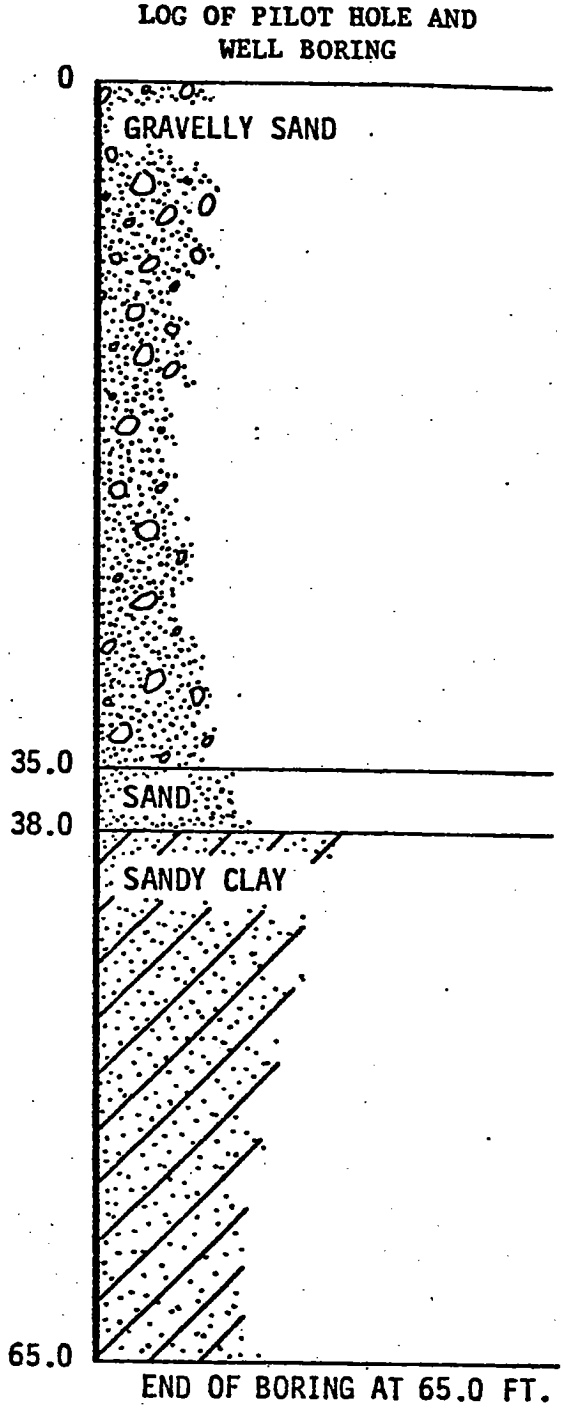
WELL M-11

Project No.
83-3168

Figure No.

Converse Consultants Geotechnical Engineering and Applied Sciences





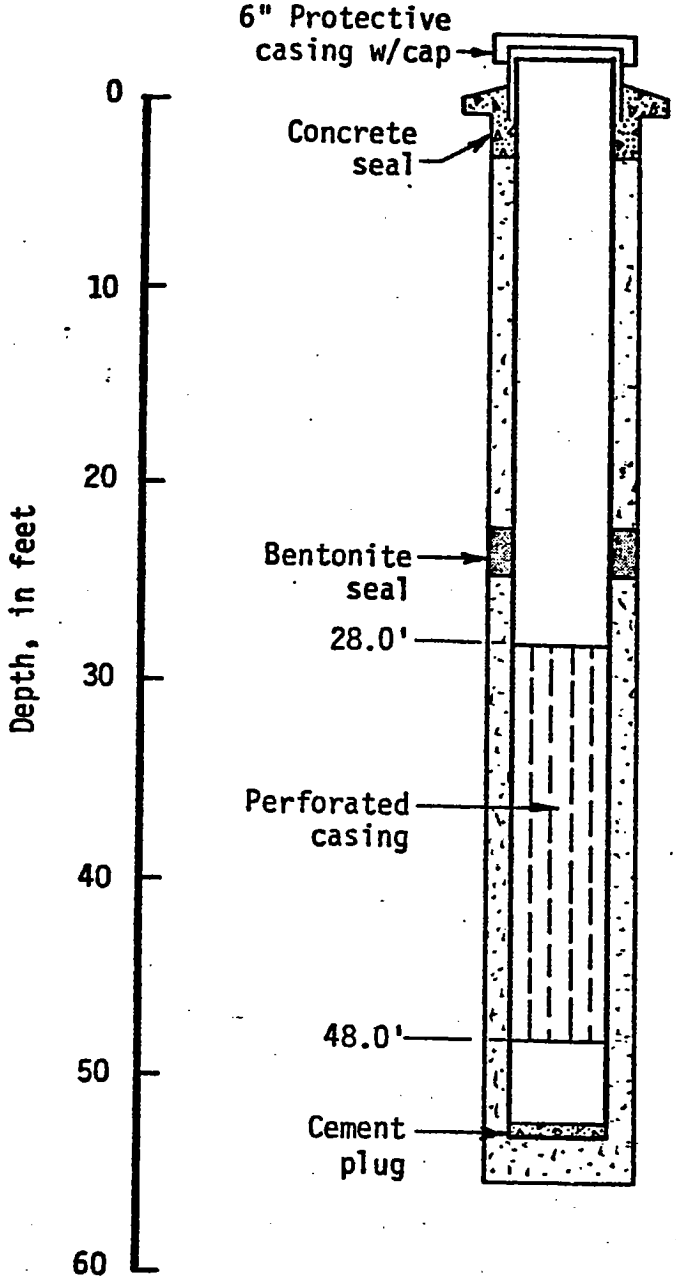
Casing: 5" I.D., 0.188 thick welded joints with 6" weld collars.
Perforations: .090 slot, 8 rows on 6" centers.
Centralizers: One above perforated section.

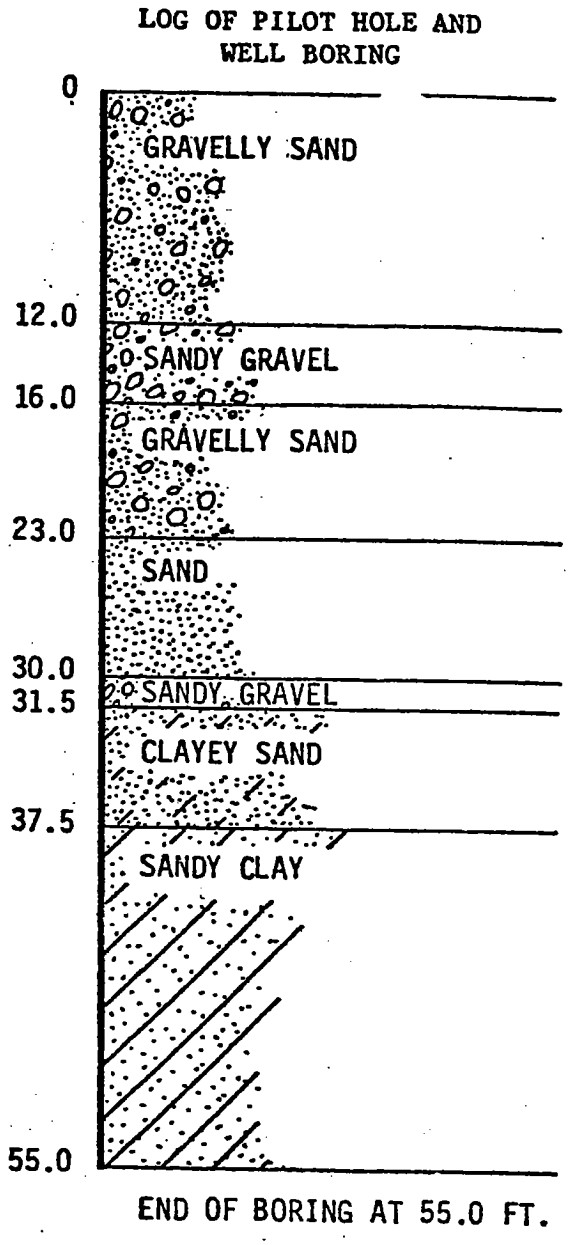
WELL M-12

Project No.
83-3168

Figure No.
4

Converse Consultants Geotechnical Engineering and Applied Sciences





Casing: 5" I.D., 0.188 thick welded joints with 6" weld collars.
Perforations: .090 slot, 8 rows on 6" centers.
Centralizers: One above perforated section.

Note: Water level not measured.

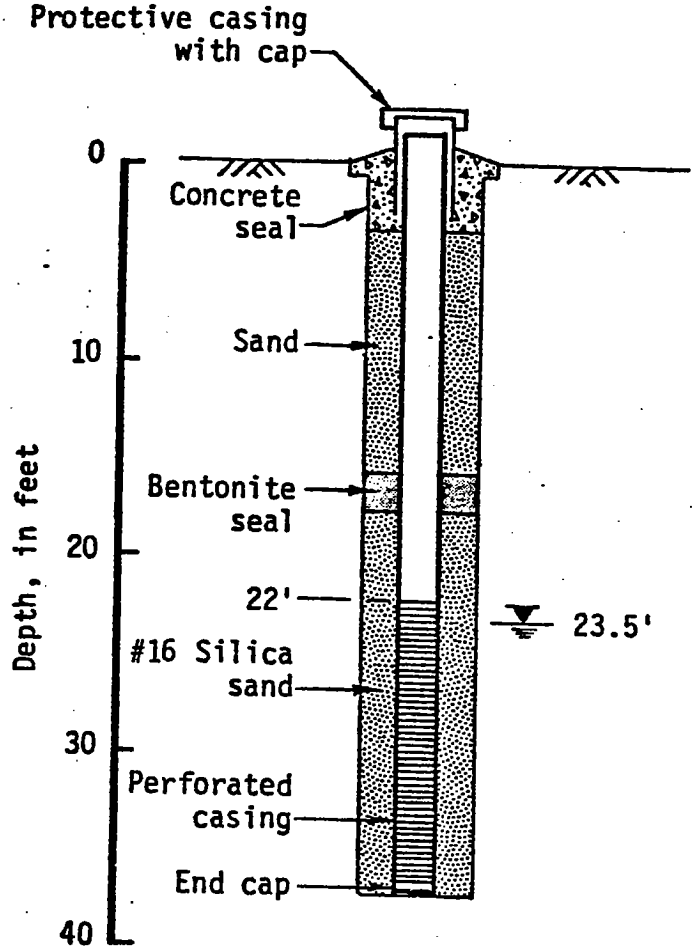
WELL M-13

Project No.

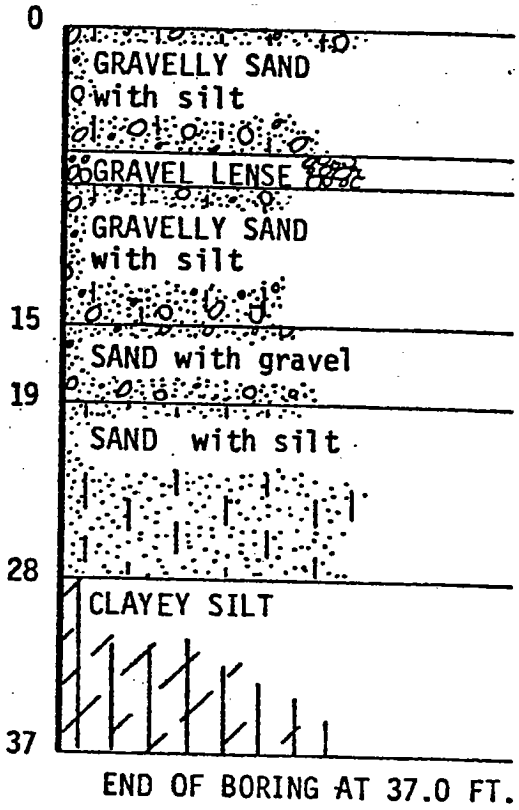
83-3168

Figure No.

Converse Consultants Geotechnical Engineering and Applied Sciences



LOG OF PILOT HOLE AND WELL BORING



END OF BORING AT 37.0 FT.

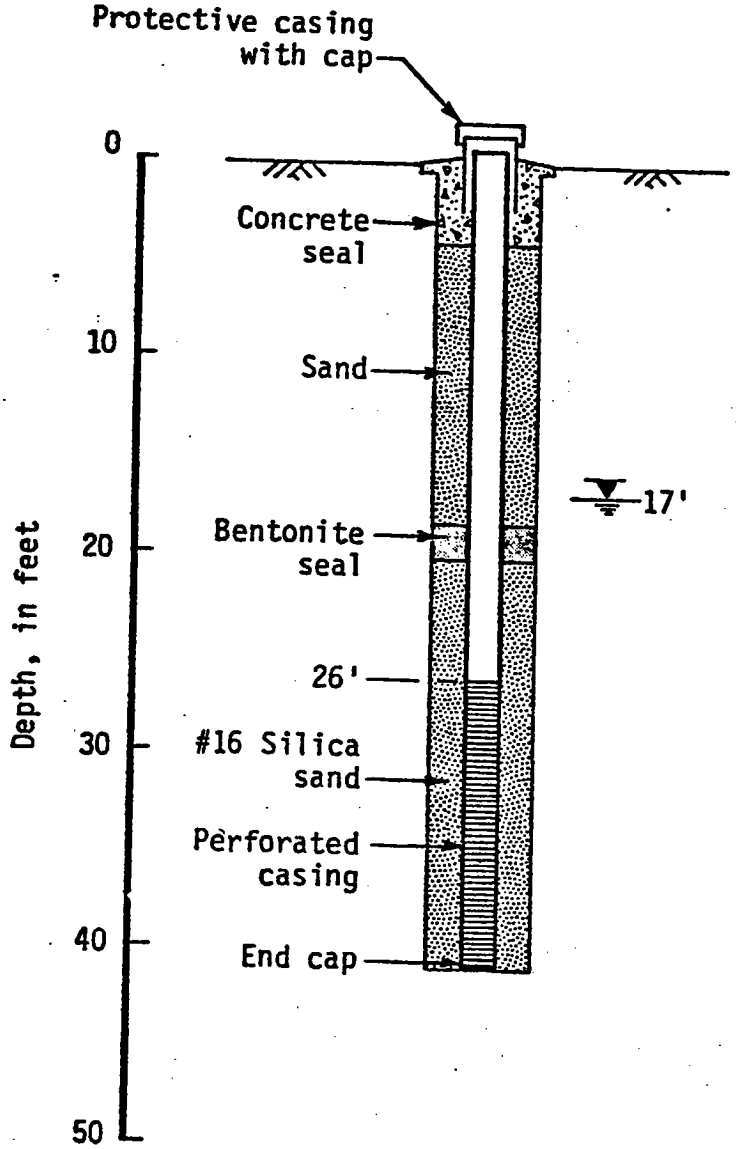
Casing: 2" I.D. PVC, No. 200 with cemented joints
Perforations: .020 slots, factory cut
Centralizers: Two, one each near top and bottom of perforated section.

WELL M-14

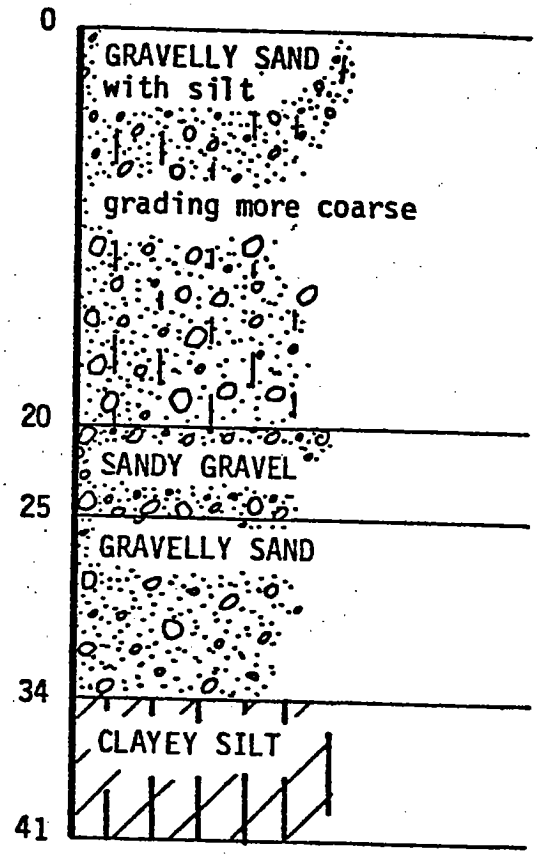
Project No.
83-3168

Converse Consultants Geotechnical Engineering and Applied Sciences

Figure No.



LOG OF PILOT HOLE AND WELL BORING



END OF BORING AT 41.0 FT.

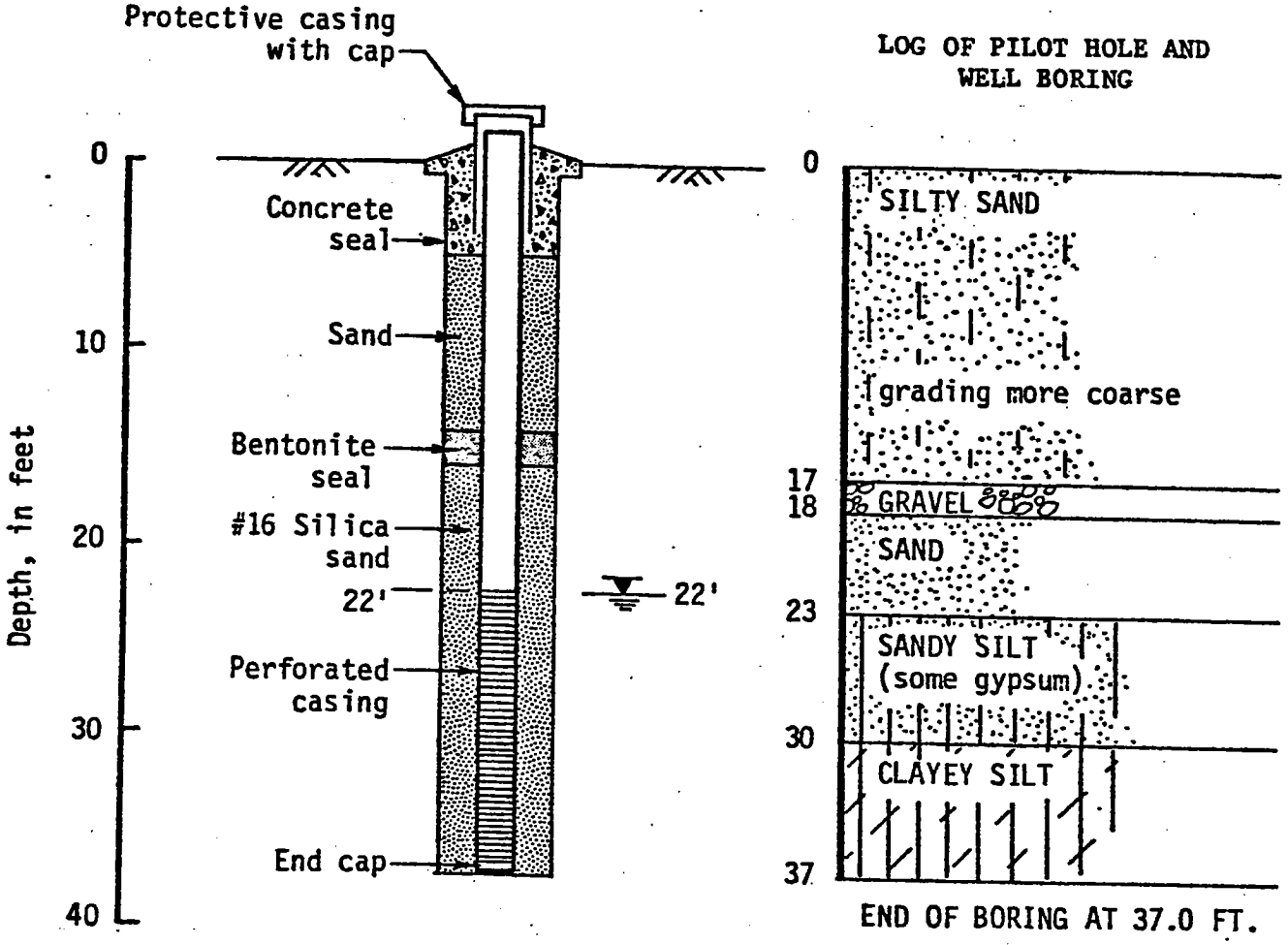
Casing: 2" I.D. PVC, No. 200 with cemented joints
Perforations: .020 slots, factory cut
Centralizers: Two, one each near top and bottom of perforated section.

WELL M-15

Project No.
83-3168

Figure No.

Converse Consultants Geotechnical Engineering and Applied Sciences

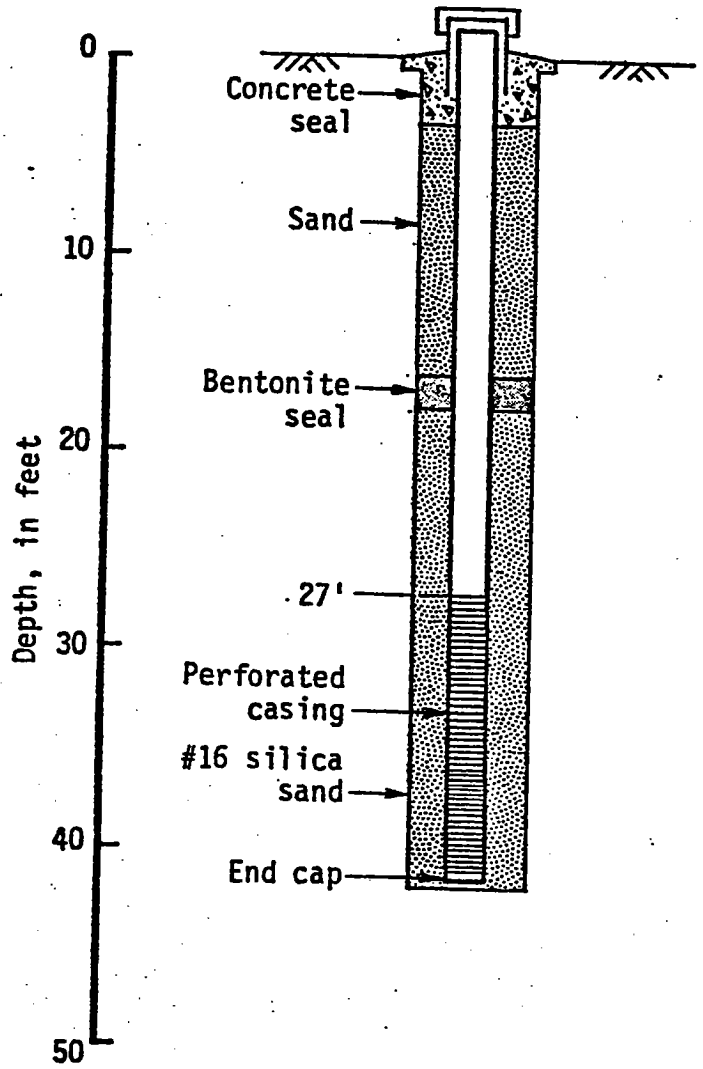


Casing: 2" I.D. PVC, No. 200 with cemented joints
Perforations: .020 slots, factory cut
Centralizers: One, near center of perforated section.

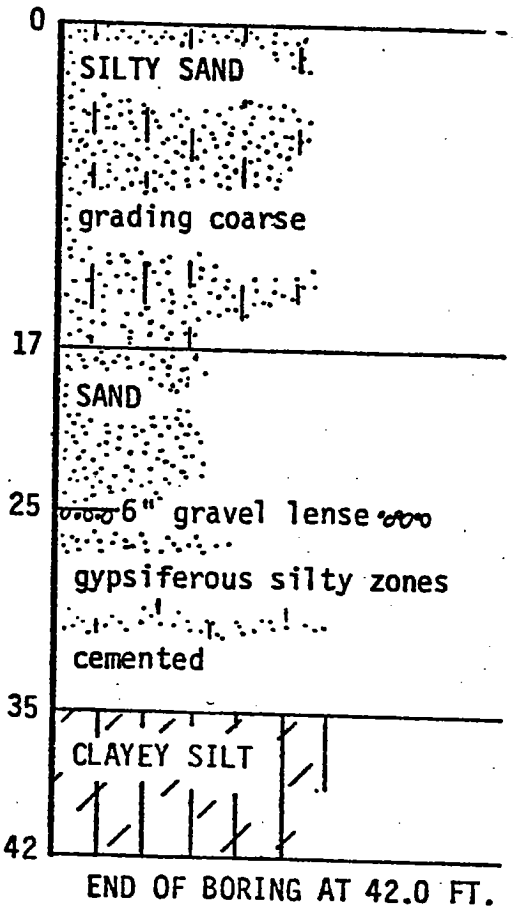
WELL M-16

Project No.
83-3168

Figure No.



LOG OF PILOT HOLE AND WELL BORING



END OF BORING AT 42.0 FT.

Note: Water level not measured.

Casing: 2" I.D. PVC, No. 200 with cemented joints
Perforations: .020 slots, factory cut
Centralizers: Two, one each near top and bottom of perforated section.

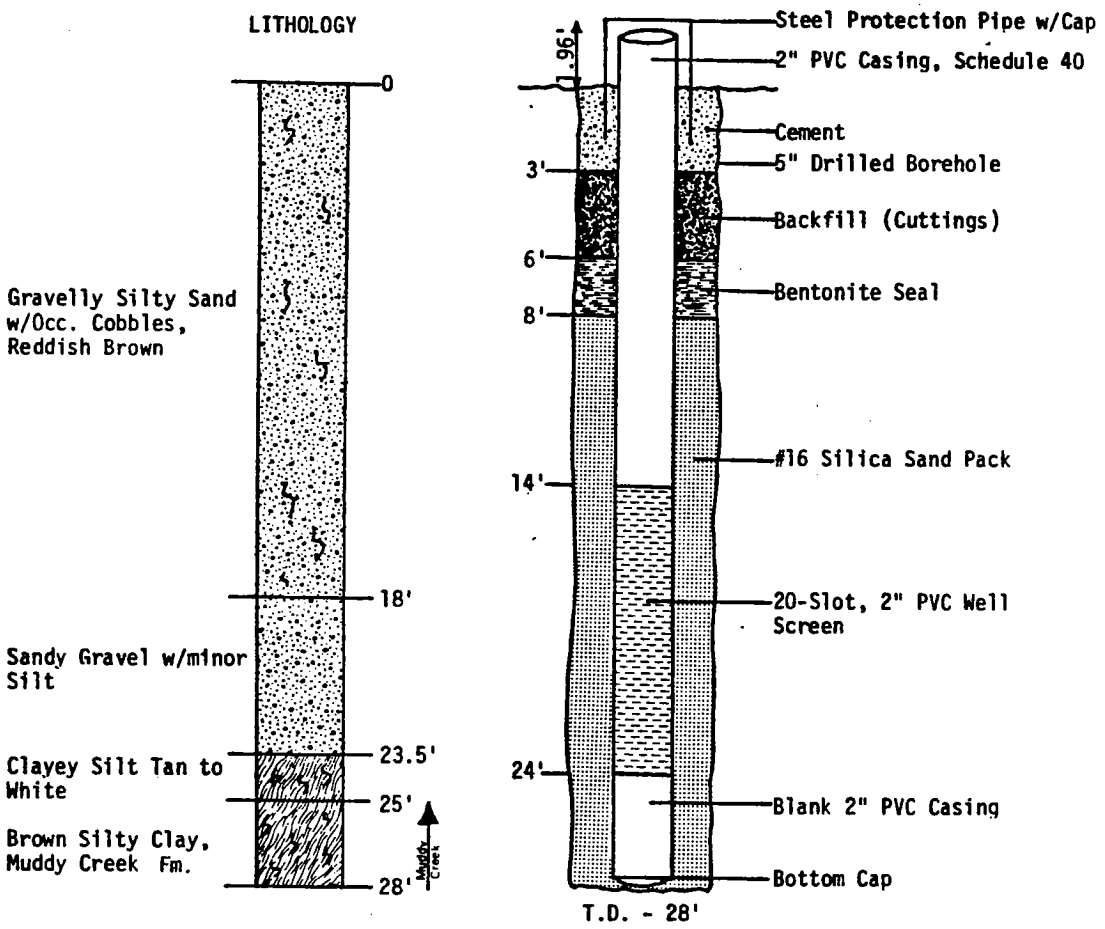
WELL M-17

Project No.
83-3168

Figure No.

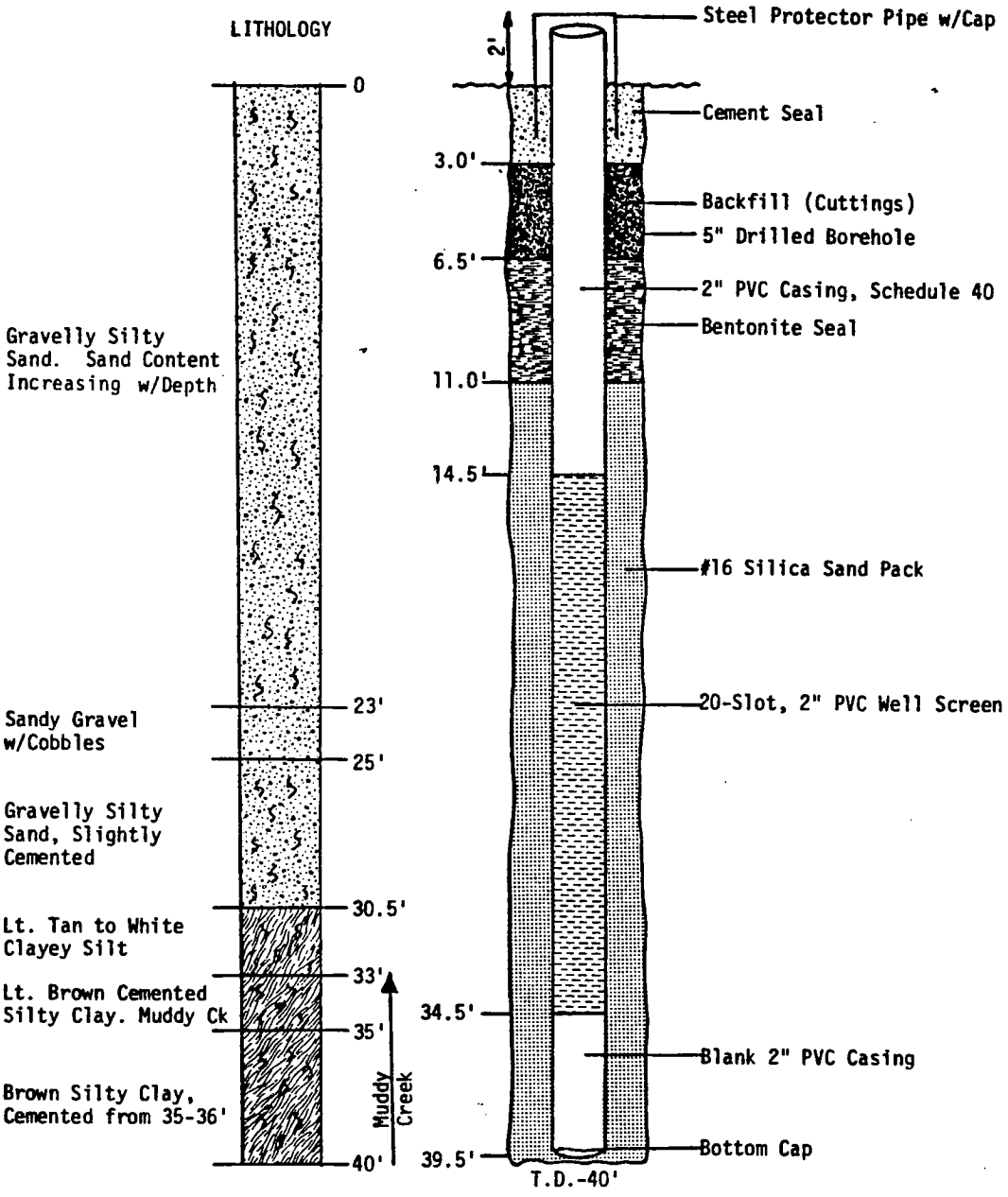
Converse Consultants Geotechnical Engineering and Applied Sciences

WELL CONSTRUCTION DIAGRAM
MONITOR WELL M-18
HENDERSON FACILITY



Note: Drilled 8-10-83

WELL CONSTRUCTION DIAGRAM
MONITOR WELL M-19
HENDERSON FACILITY

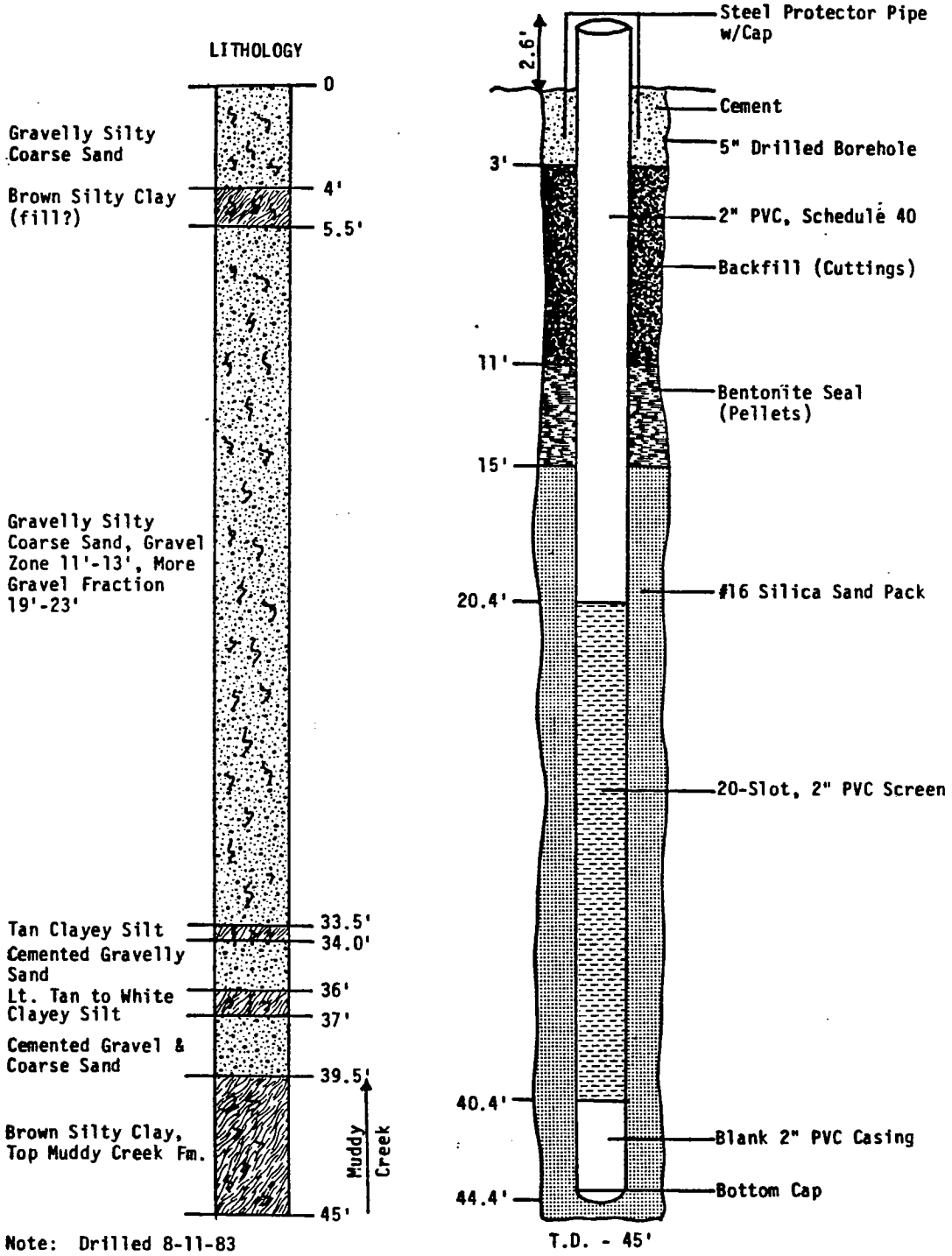


Note: Drilled 8-10-83

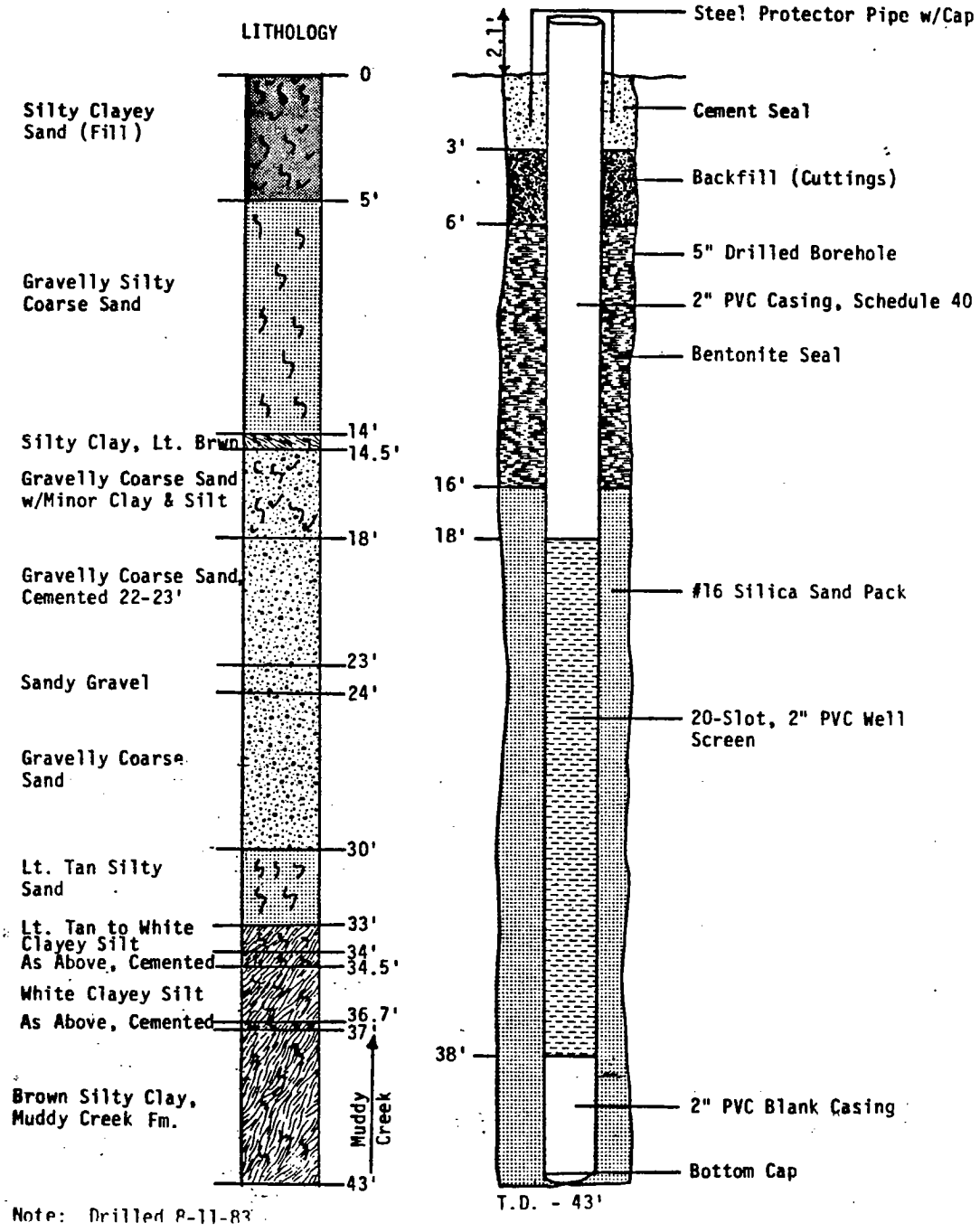
WELL CONSTRUCTION DIAGRAM

MONITOR WELL M-20

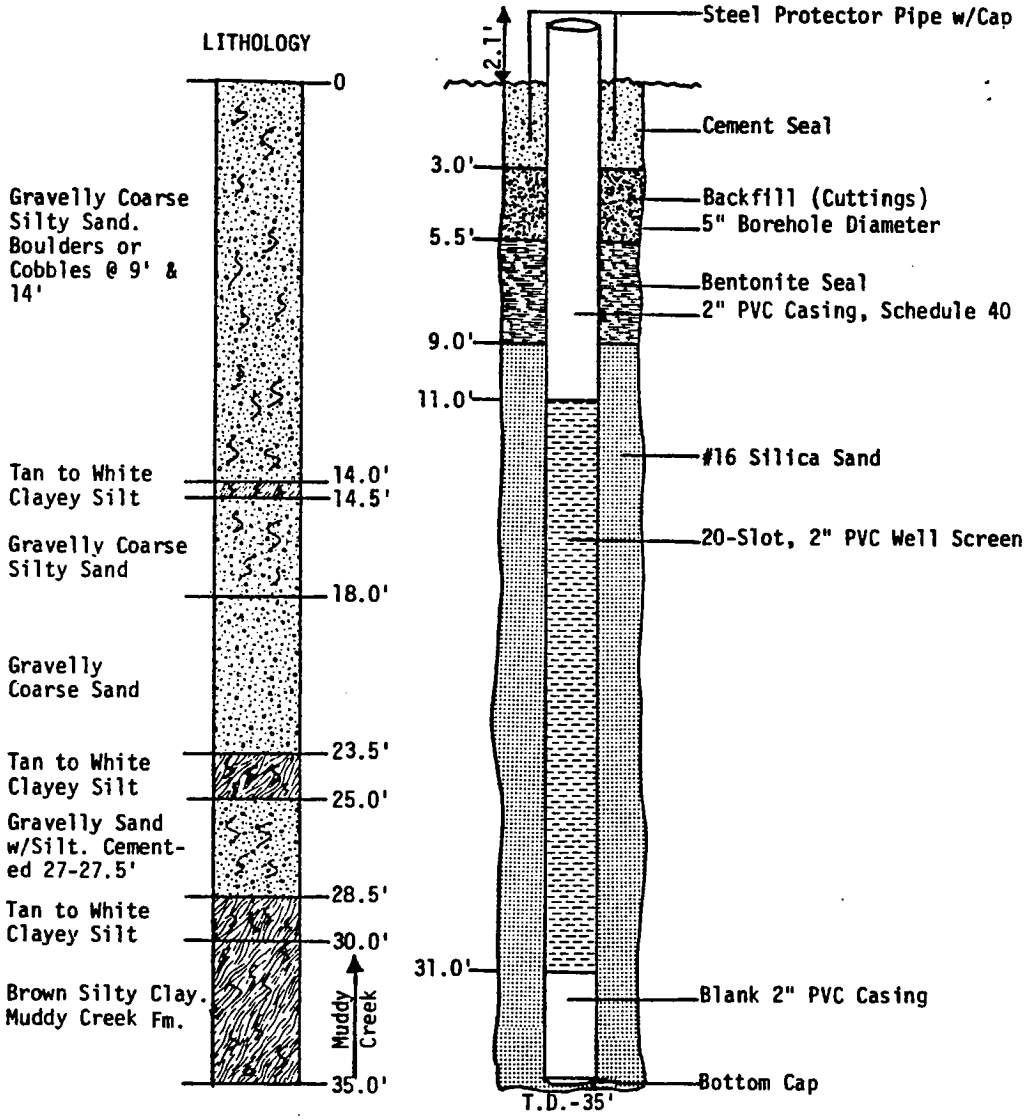
HENDERSON FACILITY



WELL CONSTRUCTION DIAGRAM
MONITOR WELL M-21
HENDERSON FACILITY

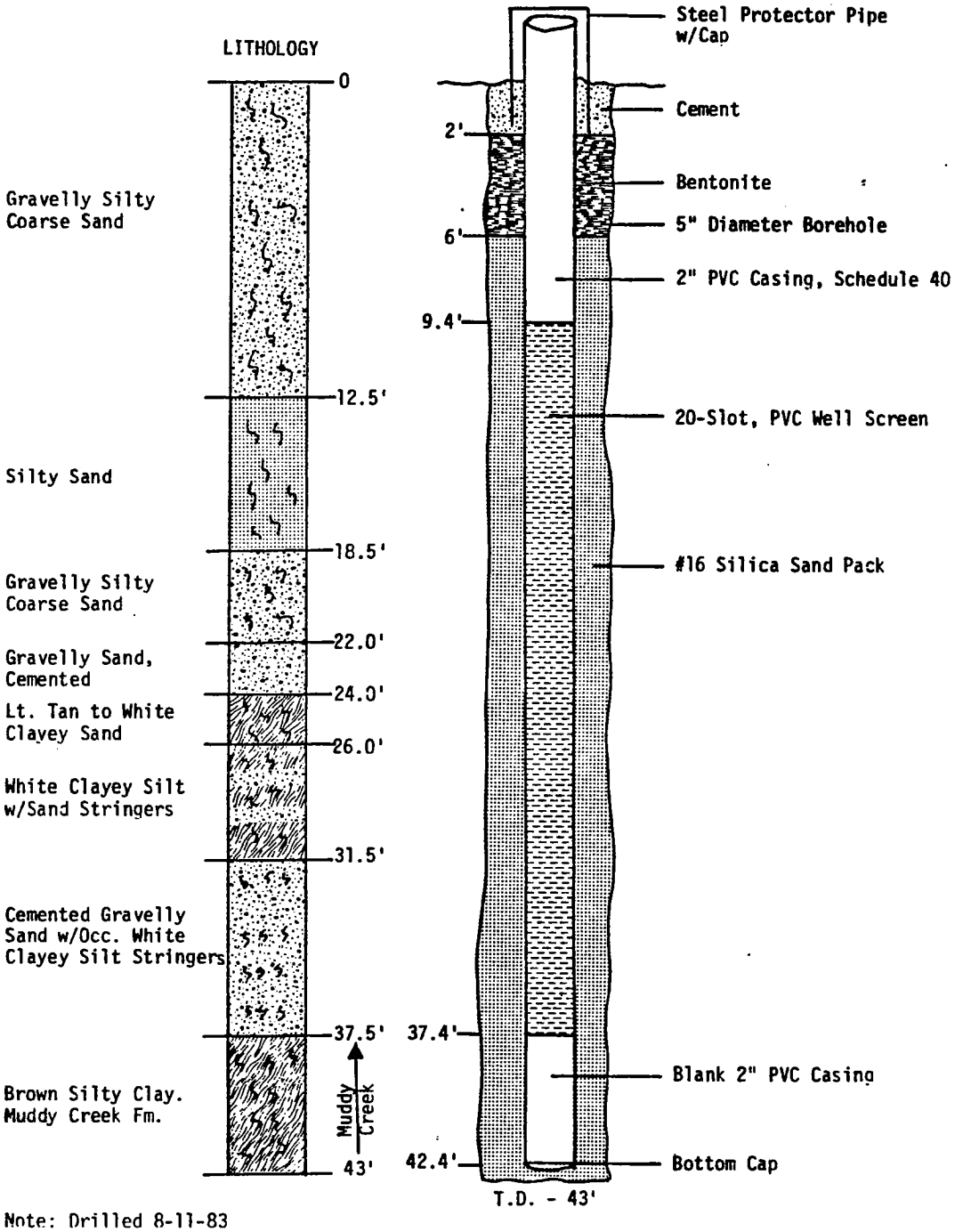


WELL CONSTRUCTION DIAGRAM
MONITOR WELL M-22
HENDERSON FACILITY



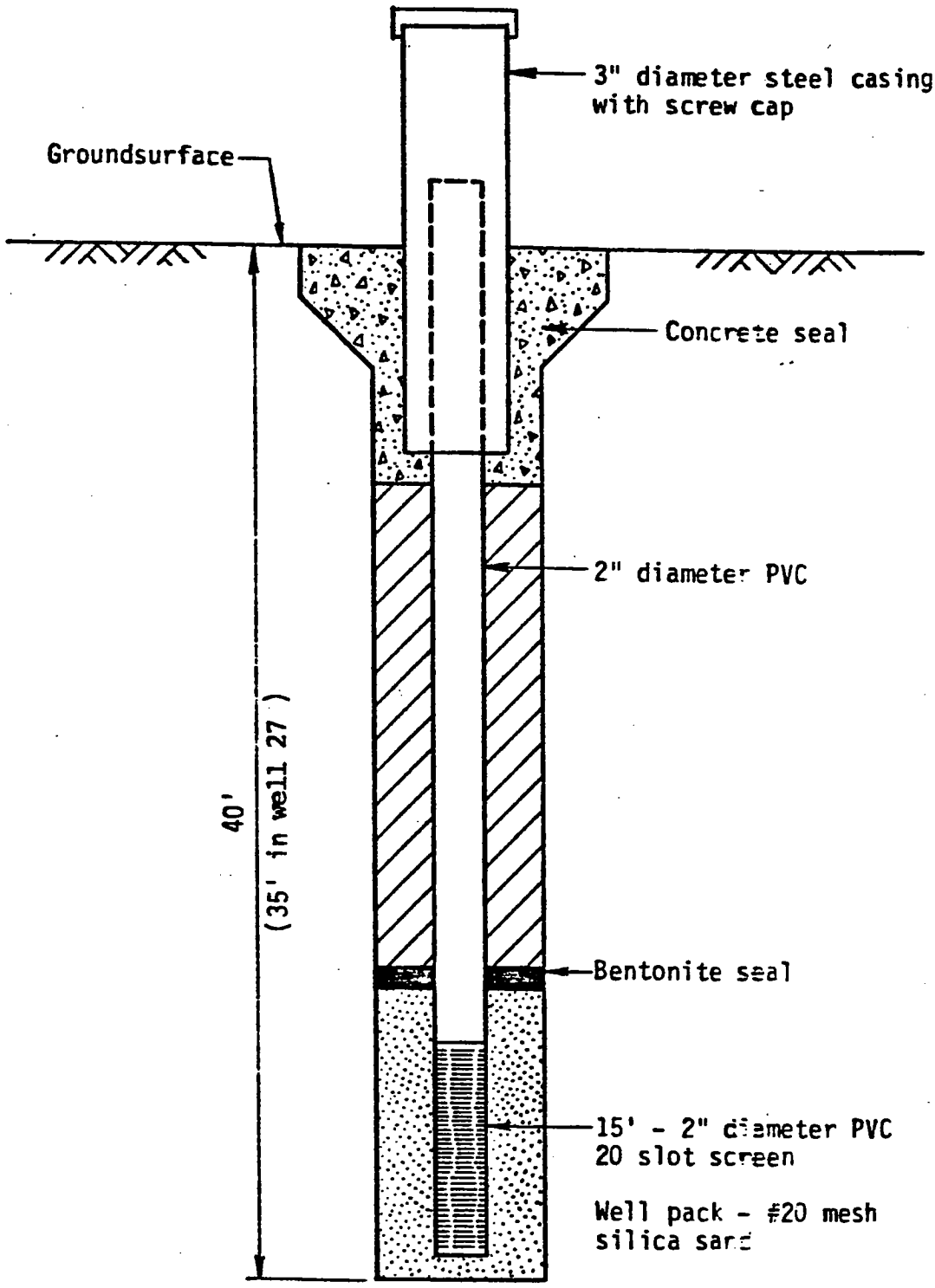
Note: Drilled 8-11-83

WELL CONSTRUCTION DIAGRAM
MONITOR WELL M-23
HENDERSON FACILITY



Note: Drilled 8-11-83

COMPLETION DIAGRAMS WELLS M-24 to M-27, KERR-McGEE HENDERSON FACILITY.



WATER SAMPLE WELL CONSTRUCTION

Project No

84-3223

Figure No

1

Converse Consultants Geotechnical Engineering and Applied Sciences

Approved for publication: ____ by ____

LOG OF WATER SAMPLE WELL 24

DATE 5/14/84

LOCATION KMCC, Henderson, NV

ELEVATION

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		SW	GRAVELLY SAND with silt	light brown	dry / slightly moist		
18		GW	SANDY GRAVEL				
20		SW/GW	SAND & GRAVEL				
26		SW	GRAVELLY SAND				
34		SM	SILTY SAND				
36		ML	SILT				
40							

End of well at 40.0 ft.

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DRAWING NO

LOG OF WATER SAMPLE WELL 25

LOCATION KMCC, Henderson, NV

DATE 5/14/82

ELEVATION

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		SW	GRAVELLY SAND	light brown			
20		SW/ GW	SAND & GRAVEL	light brown & dark brown			
28		CL	SILT & CLAY				
40							

End of well at 40.0 ft.

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DRAWING NO

Converse Consultants *Consulting Engineers and Geologists* PROJ NO 82-3223-01

APPROVED FOR PUBLICATION ____ BY ____

FORM 40

LOG OF WATER SAMPLE WELL 26

DATE 5/15/84

LOCATION KMCC, Henderson, NV

ELEVATION.

DEPTH IN FEET	SAMPLES	SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0		SW	GRAVELLY SAND with silt	light brown	dry		
2					slightly moist to moist		
4							
6							
8		GW	SANDY GRAVEL				
10		SW	GRAVELLY SAND				
12							
14							
16							
18							
20			---with trace silt, gravel varies, 15%-30% below 20'		moist		
22							
24							
26							
28					▼ wet		
30							
32							
34							
36		CL	SILTY CLAY		very moist		
38							
40							

End of well at 40.0 ft.

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DRAWING NO.

Converse Consultants *Consulting Engineers and Geologists* PROJ NO 84-3223-01

APPROVED FOR PUBLICATION

FORM 05 REV D

LOG OF WATER SAMPLE WELL 27

DATE 5/14/84

LOCATION KMCC, Henderson, NV

ELEVATION.

DEPTH IN FEET	SAMPLES SYMBOL	SOIL DESCRIPTION	COLOR	MOISTURE	CONSISTENCY	REMARKS
0	SW	GRAVELLY SAND with trace silt	light brown	dry	loose	
2				slightly moist to moist	loose to medium dense	
4						
6						
8						
10	SW/ GW	SAND & GRAVEL 40%-60% gravel				
12						
14						
16						
18						
20	SW	GRAVELLY SAND				
22						
24						
26						
28		CALICHE	light tan			
30						
32	SW	GRAVELLY SAND	light brown			*See Note.
34						
36						
38						
40						

End of well at 40.0 ft.

Note: Hole caved to 35' when PVC was installed. Okay per Kay Brothers.

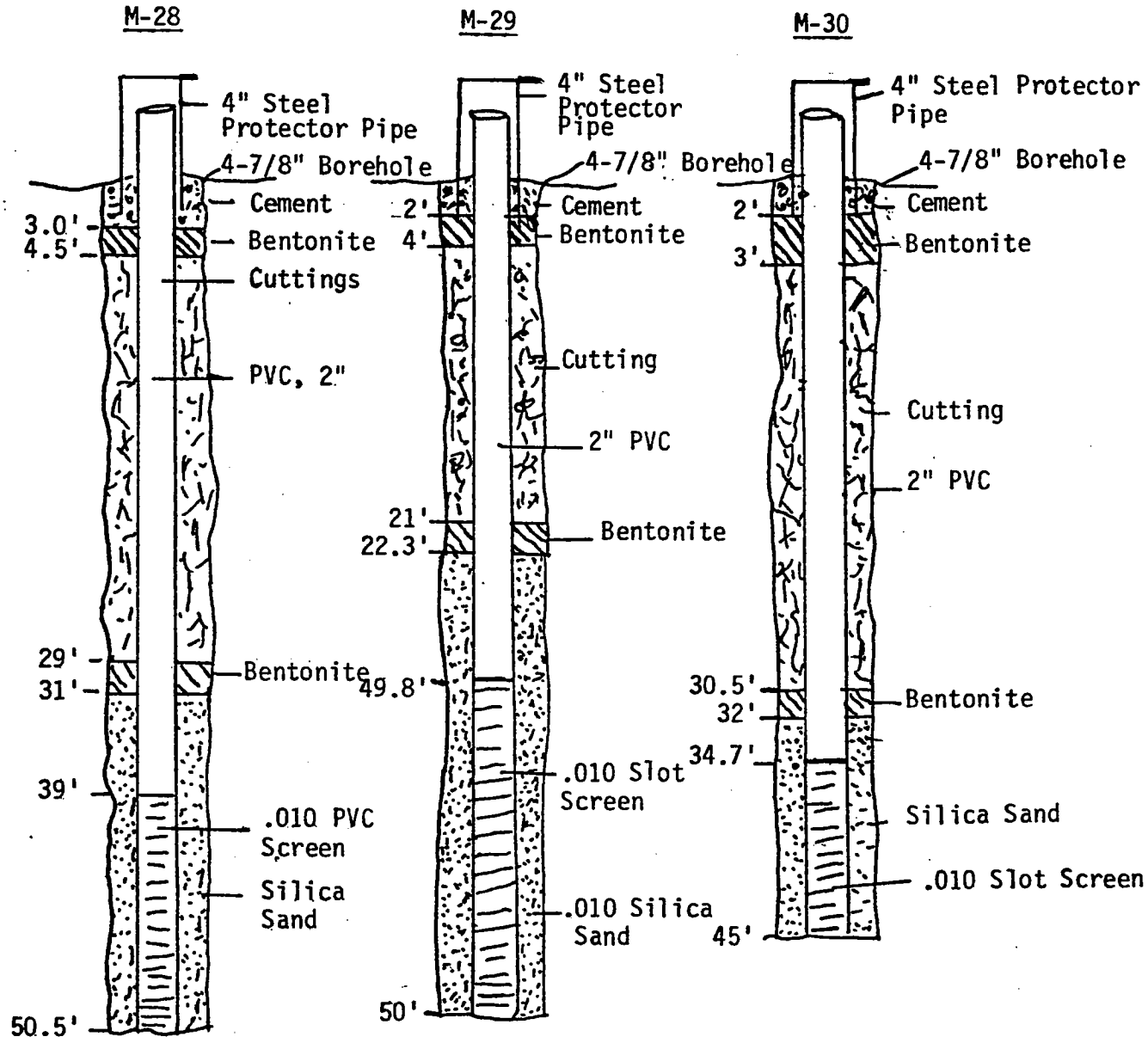
THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DRAWING NO

Converse Consultants *Consulting Engineers and Geologists*

PROJ NO 84-3223-01

WELL COMPLETION DIAGRAMS



MONITOR WELL M-28

LOG OF BORING NO. 84-6

Project Kerr McGee Job No. 4184J009

Elevation N/A Datum N/A

Type/Size Boring 7" Hollow Stem Rig Type B40L Date 7/23/84

Groundwater Conditions 42' at end of drilling

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							1.0' FILL, trash, sand, asphaltic concrete,
	Mod. Dense	8 8 7	R			SM	FILL, SAND, silty, dark brown, carbonate, moist, gravelly, some trash (glass)
5		8 10 12	R				
	Very Dense	17 35	R				
10		20 26	R				
							11.0'
			A				12.0' TILE CONCRETE
15		40 35/3	R				
							16.0'
	Dense	18 20				SM	SAND, gravelly, slightly silty, medium brown, slightly moist, calcium, chemical odor
	Very Dense	25					
20		41 34/4	R				
		26 42	R				
25		30 36	R				
		65	R				26.0' SLIGHTLY more fines, very hard drilling
30		40 35/4	R				

MONITOR WELL M-28
LOG OF BORING NO. 84-6 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Dense	24	R			SM	MUDDY creek formation, sand, very silty, white crystals (gypsum), light brown, calcareous
							32.0'
						SC	SAND, clayey
35		24 51/5	R				
40		9 25 27	R				SMALL crystals, water in sample
45		4 11 21	R				
							48.5'
							SHELBY tube 48.5 to 50.5'
50			ST				50.5'
							Bottom of Boring 50.5'
55							Piezometer installed at 50.5'
60							

MONITOR WELL M-29
LOG OF BORING NO. 84-4

Project Kerr McGee Job No. 4184J009

Elevation N/A Datum N/A

Type/Size Boring 7" Hollow Stem Rig Type B40L Date 7/12/84

Groundwater Conditions 42' 8:00 a.m. 7/13/84

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							1.0' CONCRETE
5							TUNNEL AIR VOID
							7.5'
							8.5' CONCRETE
10	Very Dense	3 16 25/4	R			SP	FILL, sand, slightly silty, gravelly, slightly moist, white precipitates
							11.0'
15	Very Dense	50/8 50/8 50/4	R R R			SP	SAND, slightly silty, gravelly, slightly moist, white precipitates YELLOW
							17.5'
20	Very Dense	75/6 50/8	S S			SM	SAND, silty to very silty, occasional gravel, reddish-brown to variable color, slightly moist
25		50/4 75/5	S R				
							27.5'
30	Very Dense	75/5	R			SC	MUDDY creek formation, sand, clayey, reddish-brown, moist

MONITOR WELL M-29

LOG OF BORING NO. 84-4 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
		50/8	R				33.5'
35	Very Stiff	11 26	R			CL/ML	SILT and clay, sandy, reddish-brown, slightly moist
		10 20 25/5	R				
40		8 16 22	R				
		6 18 30	R				
		25					44.0'
45		35	R			CL	CLAY, sandy, crystals, slightly moist, medium brown
		14 27	R				49.5'
50							Bottom of Boring 49.5'
							Piezometer set at 49.7
55							
60							

MONITOR WELL M-30

LOG OF BORING NO. 84-1 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
		9 15 23	R			ML	MUDDY creek formation .
35							35.0'
	Very Stiff	7 14 21	R			CL	CLAY, very sandy, silty
40		13 16 17	R				40.0' CLAY, silty
	Stiff	6 8 9					
45							45.0'
							Bottom of Boring 45.0'
50							Piezometer set at 44.7. 10' screen 32' sand fill Bentonite Plug at 30.5' and from 4 to 5'
55							
60							

MONITOR WELL M-30

LOG OF BORING NO. 84-1

Project Kerr McGee Job No. 4184J009

Elevation N/A Datum N/A

Type/Size Boring 7" Hollow Stem Rig Type B40L Date 7/16/84

Groundwater Conditions 40' at end of well installation

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Dense	18 32	R			SM	FILL, sand, silty, black, slightly moist 1.2'
5	Dense	11 11 14	R			SM	SAND, silty to very silty, brown, slightly moist, calcareous
		60	R				5.5'
	Very Dense						LENSE of gravel and cobbles 7.0'
10	Mod. Dense	7 9 13	R A			SP	SAND, slightly silty, gravelly, brown, slightly moist, calcareous No recovery
		9 19	R				
15	Very Dense	25/5					
		58	R				16.0'
	Very Dense					GP	GRAVEL CARBONATE coatings, variable color (grey, red, etc.), probably from chemicals 17.3'
	Dense	25 21 22	R			SP	SAND, slightly silty, gravelly, slightly moist, brown, calcareous 19.5'
20	Dense	30 35	R			SM	SAND, very silty, occasional gravel, slightly moist, brown, slightly calcareous
		15 33	R				Muddy Creek Formation
25		21	R				25.0'
	Stiff	30				ML	SILT, very sandy, moist, medium brown, non-calcareous, muddy creek formation
		11 25	R				
30							

LOG OF BORING NO. 84-2

Project Kerr McGee — Job No. 4184J009

Elevation N/A — Datum N/A

Type/Size Boring 7" Hollow Stem — Rig Type B40L — Date 7/16/84

Groundwater Conditions None Encountered

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							1.0' CONCRETE
	Very Dense	18 33	R			SP	FILL, SAND, slightly gravelly, light brown, slightly moist, calcareous
		35 40/8½	R				
5		21 24 30	R				
							8.5'
	Dense	19 20 24	R			SP	SAND, slightly gravelly, medium brown, slightly moist, calcareous, occasional cobble
10	Very Dense	22	R				12.0'
	Dense	31				GP	13.0' GRAVEL, cobbles, sandy, slightly moist
	Dense	15 15 32	R			SP	SAND, slightly silty, gravelly, medium brown, slightly moist, calcareous
15	Very Dense	25 35	R				
		22 23 25/5	R				
20		50 25/2½					
		28 32					
25		17 17 25/3					
							28.0'
	Very Dense	17 60	R			SM	MUDDY creek formation, caliche, sand, silty, brown, slightly moist, caliche lense at top
30							

LOG OF BORING NO. 84-2 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							31.0'
	Very Stiff	23 42	R			ML	SILT, sandy, slightly clayey, brown, slightly moist
							32.0'
35							Bottom of Boring 32.0'
40							
45							
50							
55							
60							

LOG OF BORING NO. 84-3

Project Kerr McGee — Job No. 4184J009

Elevation N/A — Datum N/A

Type/Size Boring 6" — Rig Type B40L — Date 7/11/84

Groundwater Conditions Perched at 11.2'

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							1.0' CONCRETE
5							TUNNEL AIR VOID
							8.0'
10	Very Dense	1 6/16	R			SC	FILL, chemically altered cement, very little lime remaining
		30	R				11.0'
15	Very Dense	100/5 100/7	R			SM	SAND, silty, gravelly, moist, yellow (sulfur) WAX from 11.3 to 11.4'
		100/8	S				
		100/4	S				18.0' BROWN, partially cemented
20		100/5	S				
							23.0'
25	Dense	16 20 14	S				DARK BROWN speckled white precipitators
		21	R				26.0'
	Very Dense	50/4					GYPSIFEROUS, very silty
		24 50/4	R				29.0'
30						SM/ML	MUDDY creek formation, sands and silts

LOG OF BORING NO. 84-3 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
		43	R			SM/ML	MUDDY creek formation
		60/3					
		10					
		21	R				
35		27					
	Dense						
	Very Dense						
							39.0'
40							CLAYS, sandy, brown, moist
							40.0'
							Bottom of Boring 40.0'
45							
50							
55							
60							

LOG OF BORING NO. 84-5 Sheet 1 of 2

Project Kerr McGee Job No. 4184J009

Elevation N/A Datum N/A

Type/Size Boring 6" Rig Type B40L Date 7/13/84

Groundwater Conditions None Encountered

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							1.0' CONCRETE
5							TUNNEL AIR VOID
							7.5'
							8.5' CONCRETE
10	Loose	1	R			SM	FILL, sand, silty, occasional gravel, light brown, slightly moist
	Mod. Dense	3 5					
		5					
		15	R				
	Dense	23					
	Very Dense	50/8	R				14.0'
15						SM	SAND, silty, occasional gravel, light brown, slightly moist, calcareous
		50/5	S				
		25/3	S				No Recovery
20			A				
		60	R				
25		75/3	R				No Recovery
							28.0'
30		74/5	R			SM	MUDDY creek formation, dark brown coarse sand, silty

LOG OF BORING NO. 84-5 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Dense	40 40 75/9	R R				Medium brown, crystals, calcareous 34.0'
35	Hard					CL	CLAYEY, sandy, crystals
40			S				39.9'
			ST				Bottom of Boring 39.9'
45							
50							
55							
60							

LOG OF BORING NO. 84-7 Sheet 1 of 2

Project Kerr McGee Job No. 4184J009

Elevation N/A Datum N/A

Type/Size Boring 7" Hollow Stem Rig Type B40L Date 7/16/84

Groundwater Conditions None Encountered

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							1.0' CONCRETE
	Very Dense	16 30/4	R			SP	FILL, sand, gravelly, cobbles, occasional boulder, slightly silty, medium brown, slightly moist, calcareous
		20 25/5	R				
5		17 25	R				
							8.0'
	Mod. Dense	14 13 13	R			SP	SAND, occasional gravel, slightly silty, medium brown, slightly moist, calcareous
10		9 11 13	R				
	Dense	13 18 21	R				
15	Very Dense	18 30	R				
		22 43/5	R				
20		18 30	R				
		25	R				24.0'
25	Very Dense	42				SM	MUDDY creek formation, sand, very silty, gravelly, cobbles, calcareous, white streaks
		50/7	R				
		12 17					
							29.0'
30	V.Stiff	27	R			ML	SILT, sandy

LOG OF BORING NO. 84-7 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Stiff	8 14 17	R			ML	SILT, sandy
							32.5'
35							Bottom of Boring 32.5'
40							
45							
50							
55							
60							

LOG OF BORING NO. 84-8

Project Kerr McGee — Job No. 4184J009

Elevation N/A — Datum N/A

Type/Size Boring 7" Hollow Stem — Rig Type B40L — Date 7/25/84

Groundwater Conditions 35' at end of drilling

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Dense	18 46	R			SM	FILL, sand, silty, gravelly, black to brown, slightly moist, calcareous, chemicals
	Mod. Dense						
5		7 9 12	R				6.5'
	Very Dense					SM	SAND, silty, gravelly, medium brown, slightly moist, chemicals
10		36 39/5	R				11.0'
	Very Dense					SC	SAND, gravelly, slightly clayey, medium brown, slightly moist, chemicals
15		35 39	R				
20		45 35/3½	R				
25							25.0'
	Dense	23 25	R			SM	SAND, silty, gravelly, brown, slightly moist, chemicals, muddy creek formation
30							

LOG OF BORING NO. 84-8 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very	8 15 25/3	R				CALICHE gravels
							33.0'
35	Dense		ST			SM	MUDDY creek formation, silty sand and sandy silt. Shelby Tube 0.8'
							38.0'
40	Very Stiff		S			CL	CLAY, sandy, silty, very moist, brown, hard 3" lense
							42.0'
45							Bottom of Boring 42.0'
50							
							Piezometer installed at 42.0'
55							
60							

LOG OF BORING NO. 84-9

Project Kerr McGee — Job No. 4184J009

Elevation N/A — Datum N/A

Type/Size Boring 7" Hollow Stem — Rig Type B40L — Date 7/18/84

Groundwater Conditions 32' at end of drilling

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Dense	25 19	R			SP	FILL, sand, gravelly, slightly silty, some precipitate, dark brown, mottled white, slightly moist
	Very Dense	10	R				2.8' MEDIUM reddish-brown
5		12 15 18	R				
		38 26	R				9.0'
10	Very Dense	Refusal	R			SP	SAND, gravelly, silty, light to medium brown, slightly moist
15		16 25	R				
							18.0' MEDIUM brown, very silty
20		50/3	R				20.5' GRAVEL cobble lense to 21.0'
							23.5' GRAVEL cobble lense to 24.0'
25		100/6					
							28.0'
30	Very Dense					SC	MUDDY creek formation, sand, clayey, occasional gravel, medium brown

LOG OF BORING NO. 84-9 CONTINUED

Project Kerr McGee

Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Dense	28 30	R			SC	
35		13 15 30	R				
							38.5'
40	Very Stiff					CL	CLAY, sandy
							40.0'
							Bottom of Boring 40.0'
45							
50							
55							
60							

LOG OF BORING NO. 84-10

Project Kerr McGee — Job No. 4184J009

Elevation N/A — Datum N/A

Type/Size Boring 7" Hollow Stem — Rig Type B40L — Date 7/25/84

Groundwater Conditions 34' at end of drilling

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							2.5" ASPHALT
	Mod. Dense	20 18 15	R			SM	FILL, sand, silty, gravelly, brown, slightly moist, calcareous
5	Dense	14 21 32	R				
10							11.0'
	Very Dense	32 43/4	R			SM	SAND, silty, gravelly, variable color to brown, slightly moist BLACK & white precipitates, calcareous
15		38 37/4	R				
20		40 25/2	R				
25		67	R				VERY silty, dark brown
							28.0'
							COBBLES to 6", partially cemented caliche gravels to 38.5'
							29.0'
30	VeryDense					SC	MUDDY creek formation, sand , clayey, occ.;

LOG OF BORING NO. 84-11

Project Kerr McGee Job No. 4184J009

Elevation N/A Datum N/A

Type/Size Boring 7" Hollow Stem Rig Type B40L Date 7/27/84

Groundwater Conditions None Encountered

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
							0.5' CONCRETE
	Very Dense	21 25/3	R			SM	FILL, sand, silty, gravelly, brown, slightly moist
							4.0'
5	Very Dense					SM	SAND, silty, gravelly, brown, slightly moist
							Skipped drive at 6.0'
10		18 25/5	R				
15		27 25/3	R				
							19.0'
20							GRAVEL and cobble lenses to 20.0'
		37	R				
25		37 13/2	R				
							28.0'
30	Very Dense					SM/ML	MUDDY creek formation, sand, silt layers, slightly calcareous

LOG OF BORING NO. 84-11 CONTINUED

Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Dense	30 20/4	R				
							33.0'
35	Very Dense					SC	CLAYEY sands and partially cemented silts, non-calcareous, brown
			S_T				37.0' SHELBY from 36 to 37'
40							Bottom of Boring 37.0'
45							
50							
55							
60							

LOG OF BORING NO. 84-12 Sheet 1 of 2

Project Kerr McGee Job No. 4184J009

Elevation N/A Datum N/A

Type/Size Boring 7" Hollow Stem Rig Type B40L Date 7/27/84

Groundwater Conditions 27'

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
	Very Dense	18 30	R			SM	FILL, sand, very silty, gravelly, black, slightly moist 1.5'
	Dense					SM	SAND, silty, gravelly, brown, slightly moist, calcareous, lenses, slightly clayey, some gravelly lenses, slightly clayey lenses
5		18 25	R				
10		9 10 11	R				
15		13 18 23	R				
	Very Dense						
20		53	R A				No Recovery on drive 22.0' GRAVEL and cobble lenses, cemented coating
25		48 25/3	R				
							27.0'
	Very Dense					SM	MUDDY creek formation, wet, partially calcareous, medium brown, sandy, partially cemented silts and sands, wet at top
30							

LOG OF BORING NO. 84-12 CONTINUED

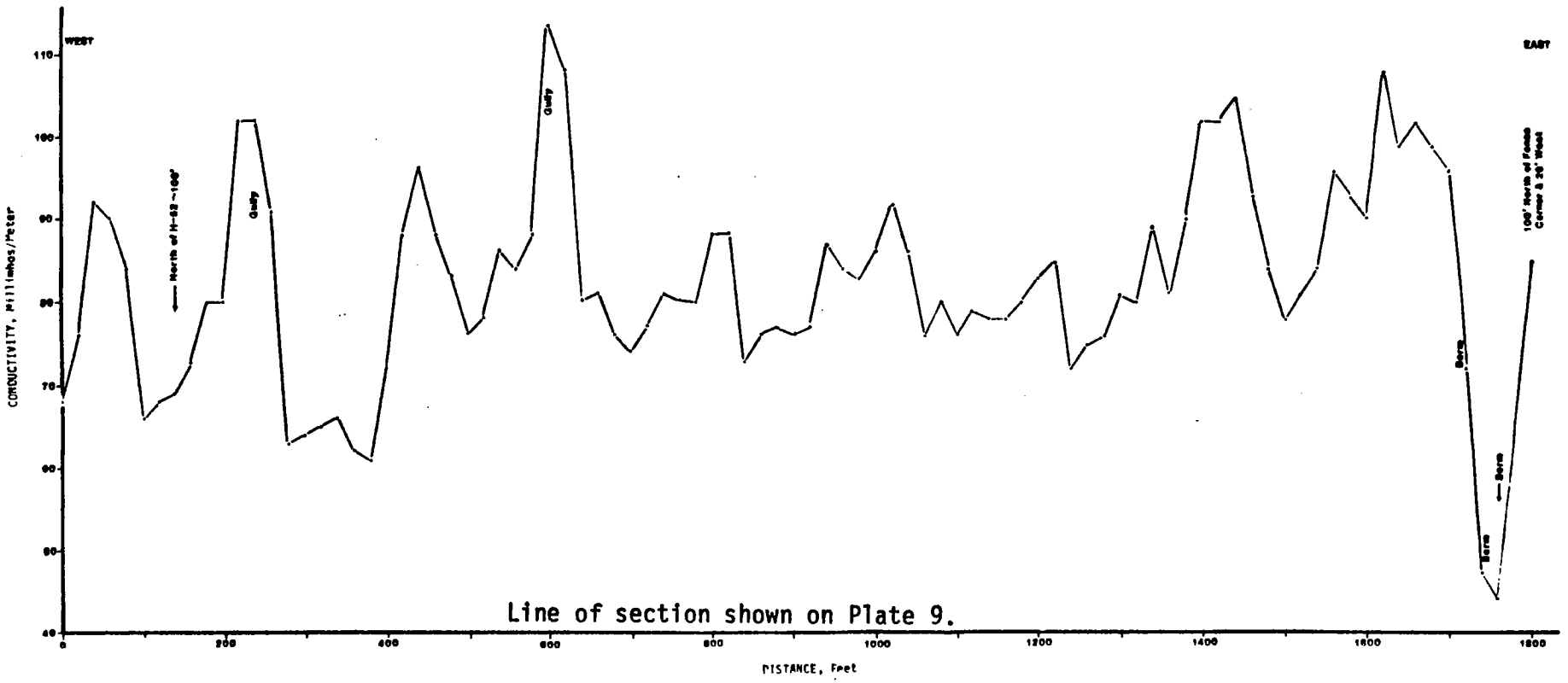
Project Kerr McGee Job No. 4184J009

Depth, feet	Blows/6" C	Blows/6" N/R	Sample Type	Dry Density pcf	Moisture Content, %	Unified Classification	Description
		10 43	R				33.5'
35	Very Stiff		S T			ML	SILT, non-cemented, sandy, reddish-brown, wet SHELBY tube - 500 PSI - 35 to 37'
40			S T				SHELBY tube - 40 to 42' - No recovery
45			S T				SHELBY tube - 45 to 47.0'
							47.0'
50							Bottom of Boring 47.0'
55							
60							

APPENDIX D

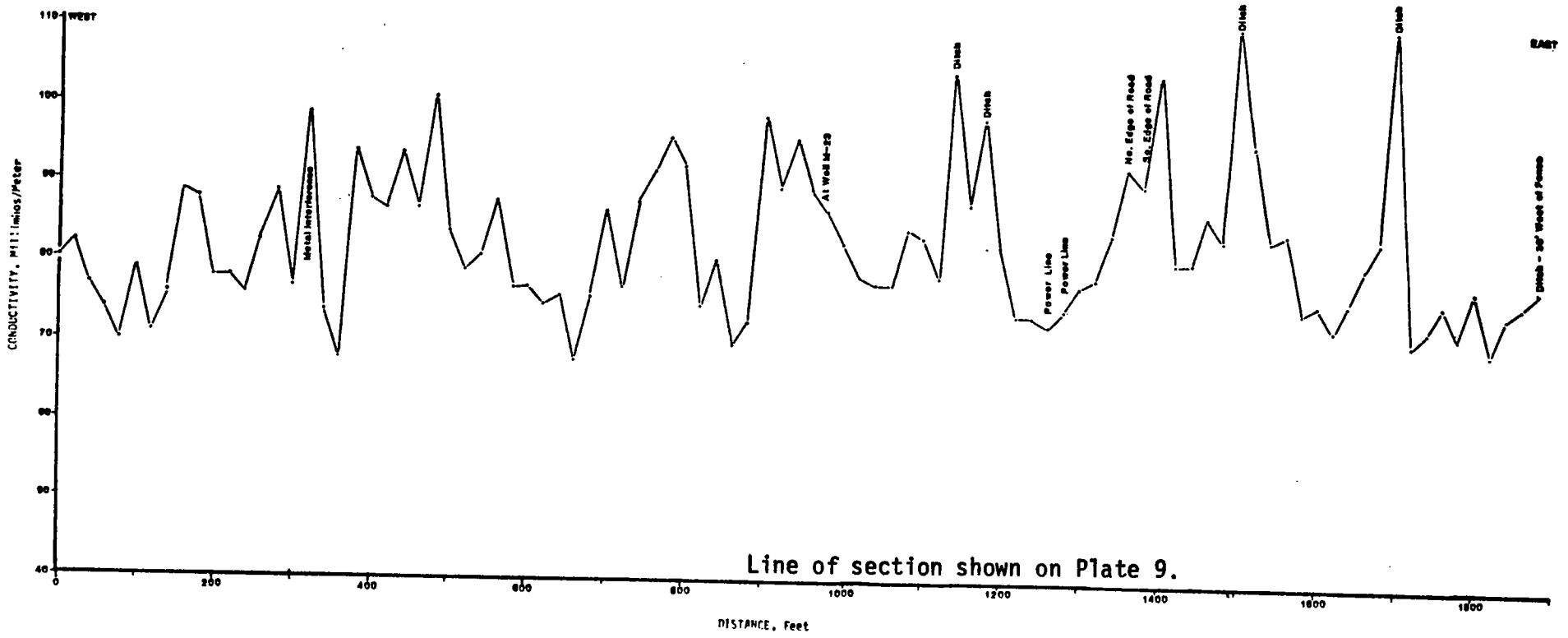
EM Survey Results

ELECTROMAGNETIC SURVEY RESULTS, PROFILE 1, KERR-McGEE HENDERSON FACILITY.



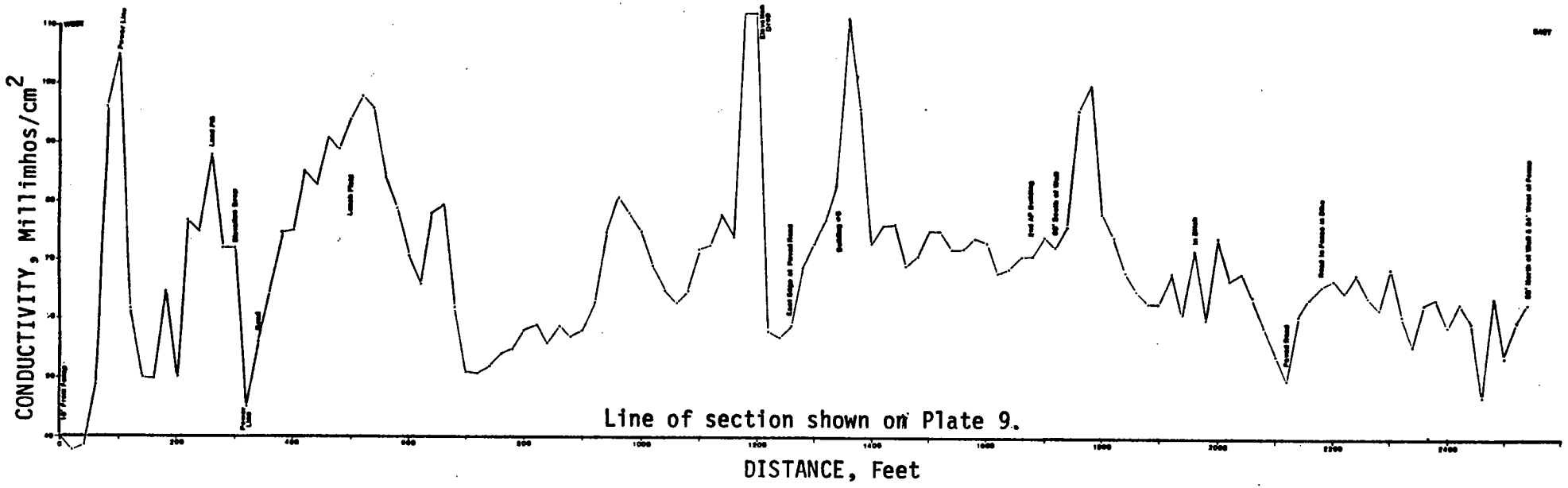
Line of section shown on Plate 9.

ELECTROMAGNETIC SURVEY RESULTS, PROFILE 2, KERR-McGEE HENDERSON FACILITY.

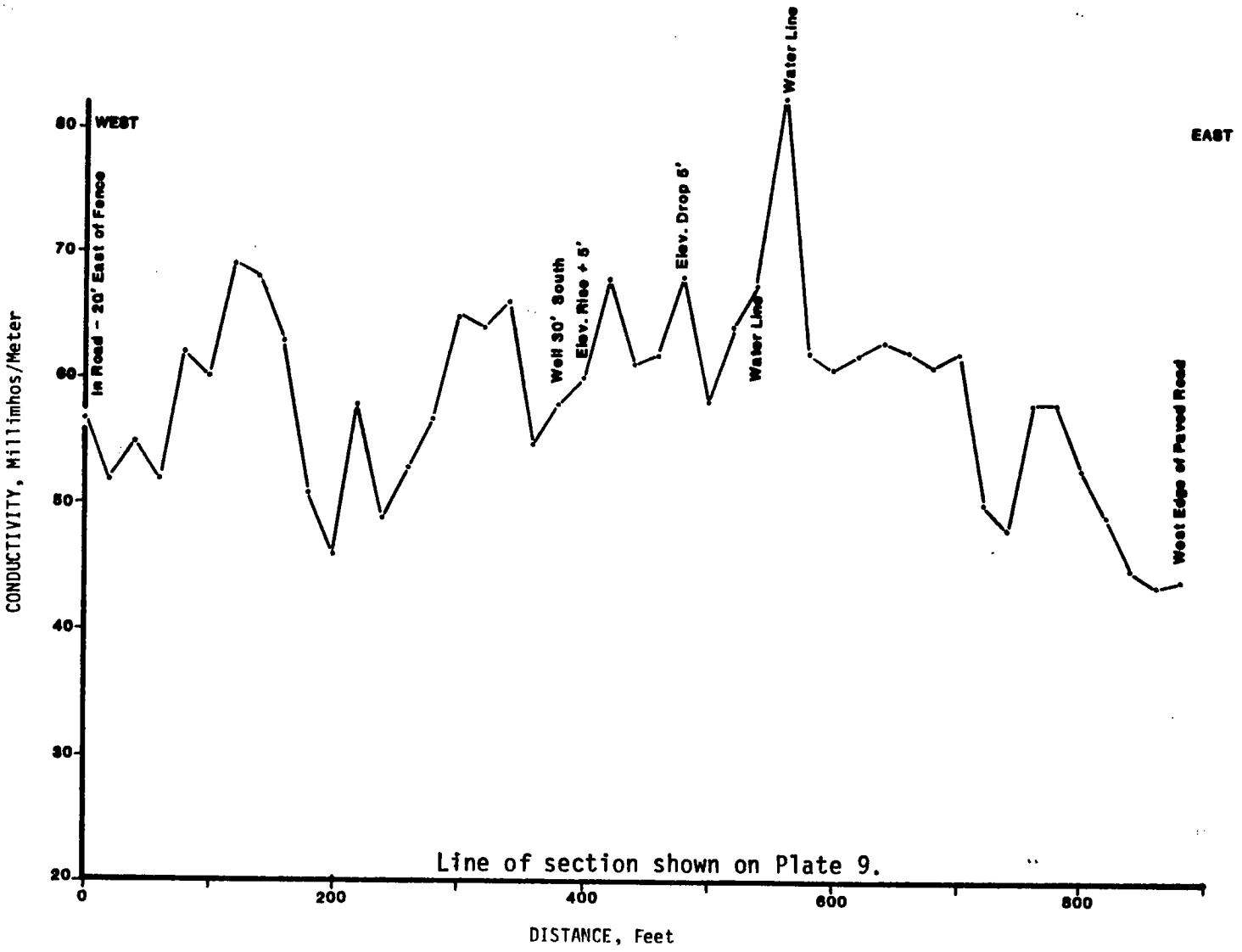


Line of section shown on Plate 9.

ELECTROMAGNETIC SURVEY RESULTS, PROFILE 3, KERR-McGEE HENDERSON FACILITY.

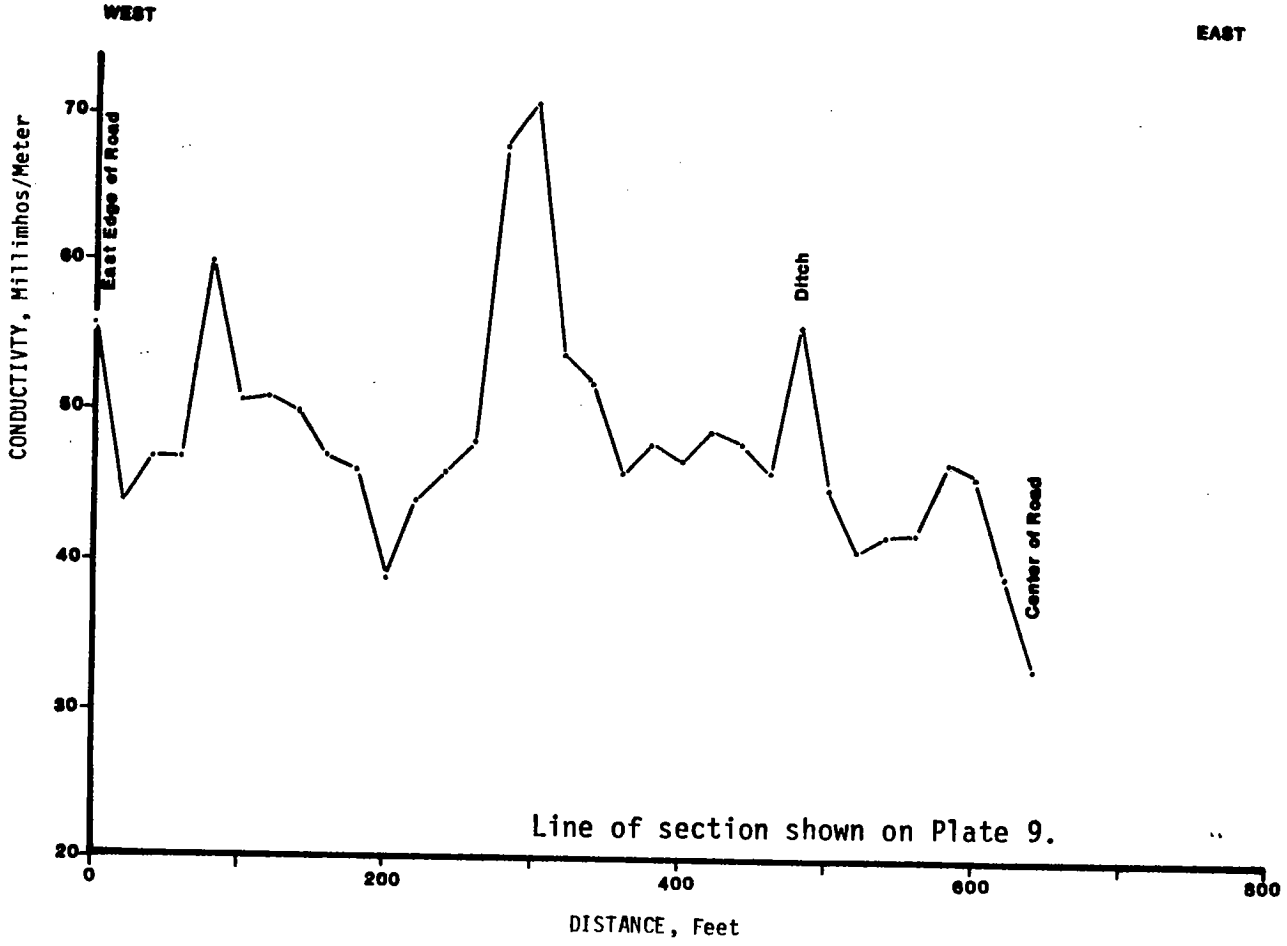


ELECTROMAGNETIC SURVEY RESULTS, PROFILE 5, KERR-McGEE HENDERSON FACILITY.



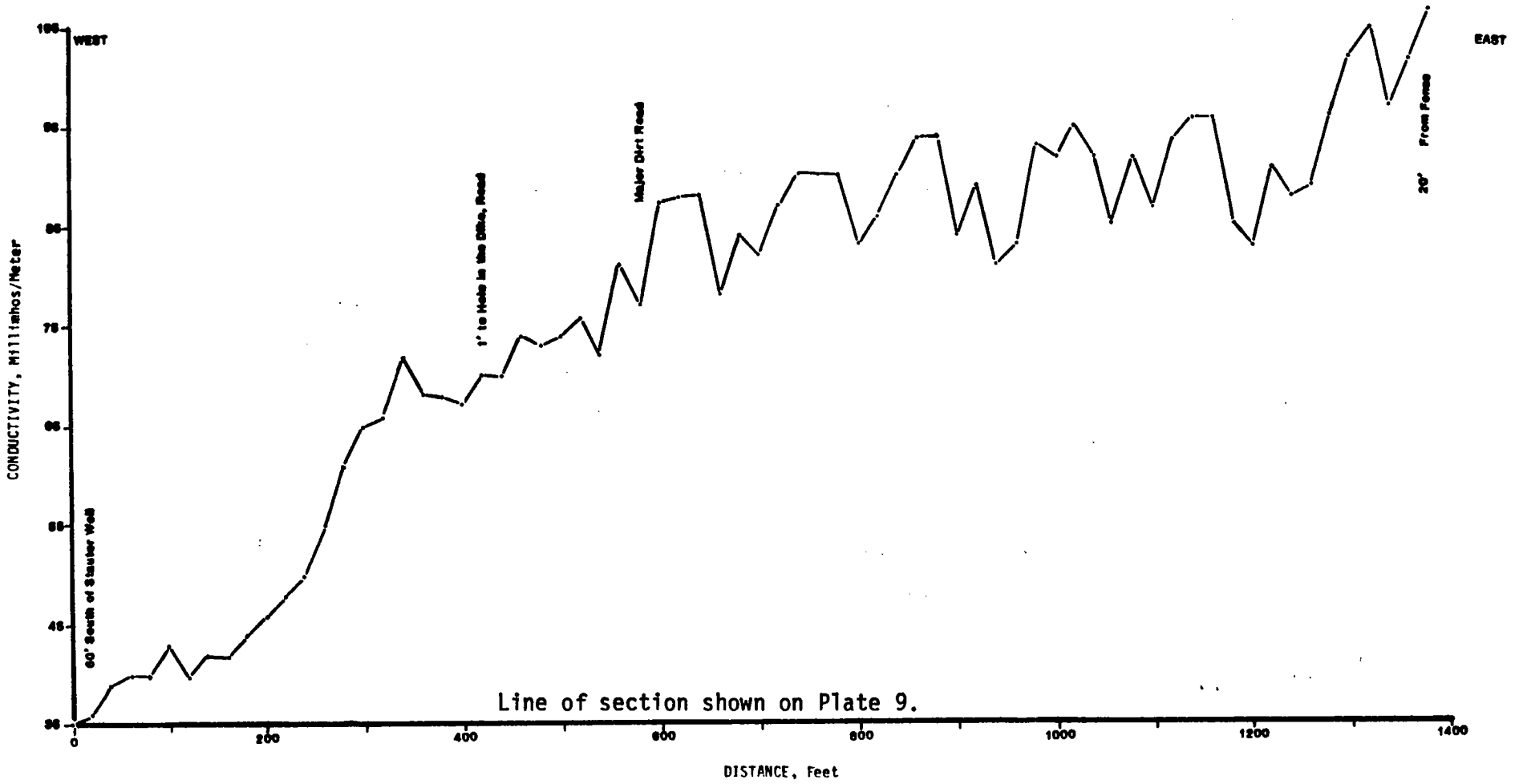
Line of section shown on Plate 9.

ELECTROMAGNETIC SURVEY RESULTS, PROFILE 6, KERR-McGEE HENDERSON FACILITY.



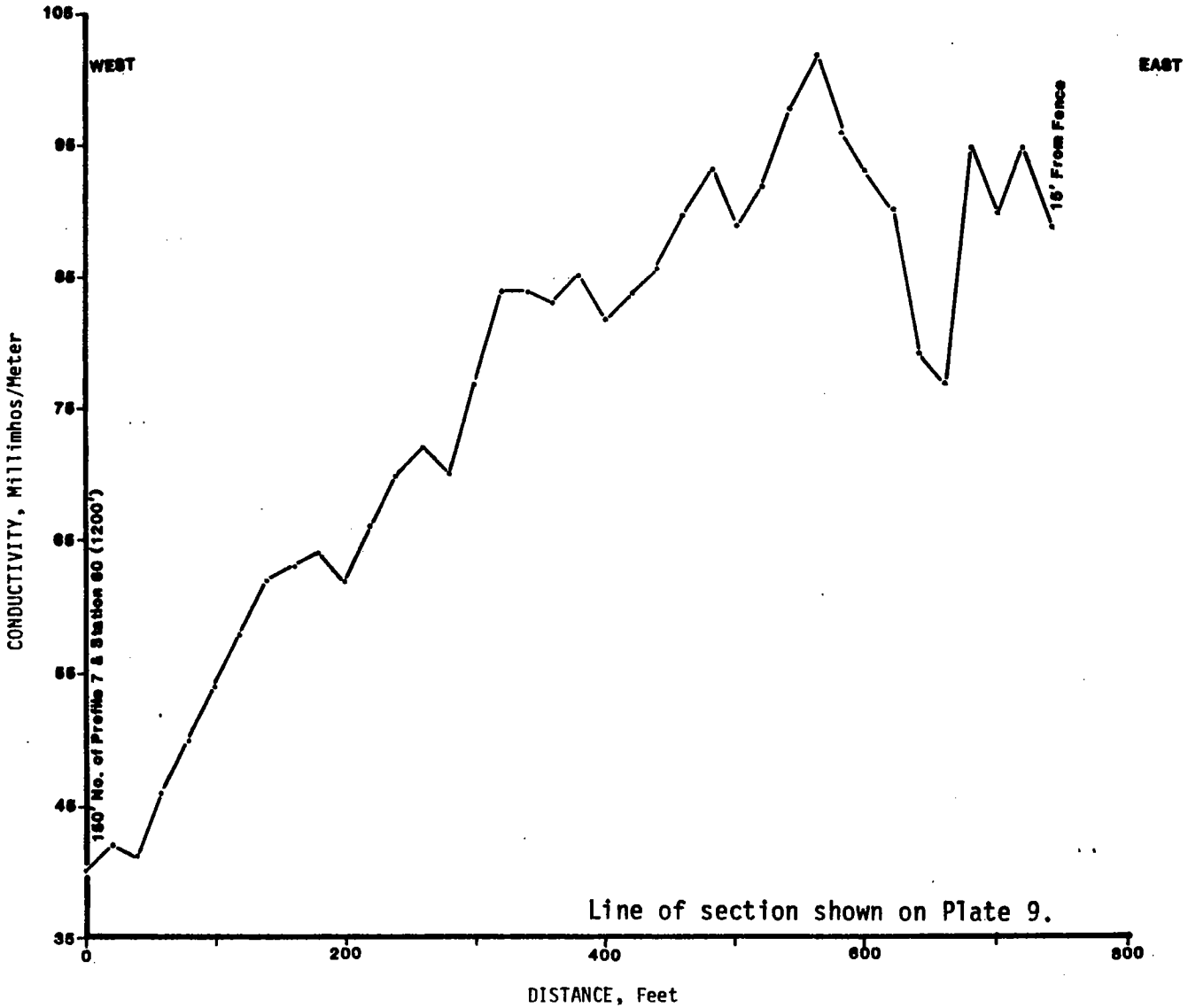
Line of section shown on Plate 9.

ELECTROMAGNETIC SURVEY RESULTS, PROFILE 7, KERR-McGEE HENDERSON FACILITY.

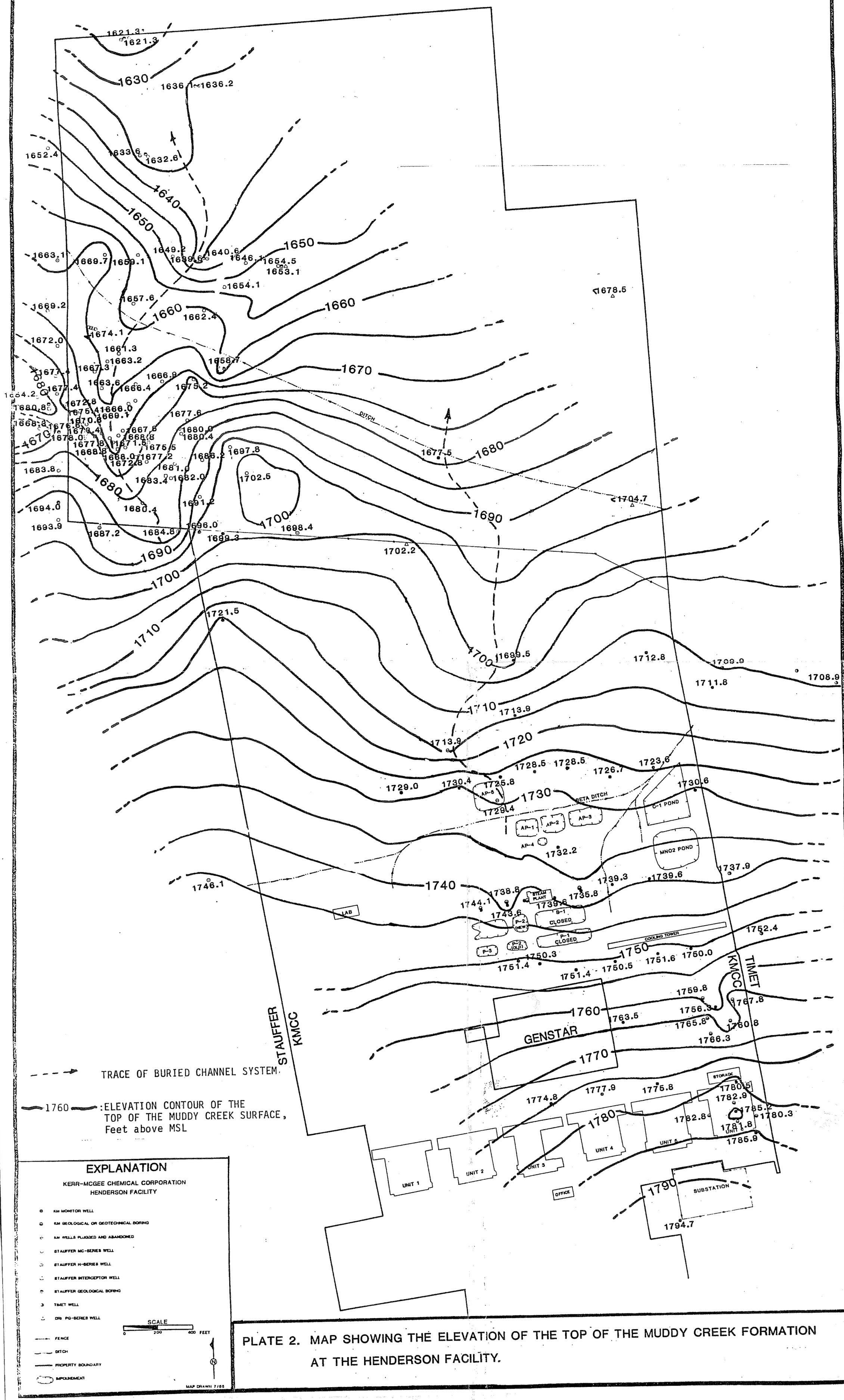


Line of section shown on Plate 9.

ELECTROMAGNETIC SURVEY RESULTS, PROFILE 8, KERR-McGEE HENDERSON FACILITY.



Line of section shown on Plate 9.



TRACE OF BURIED CHANNEL SYSTEM.

1760 :ELEVATION CONTOUR OF THE TOP OF THE MUDDY CREEK SURFACE, Feet above MSL

EXPLANATION

KERR-MCGEE CHEMICAL CORPORATION
HENDERSON FACILITY

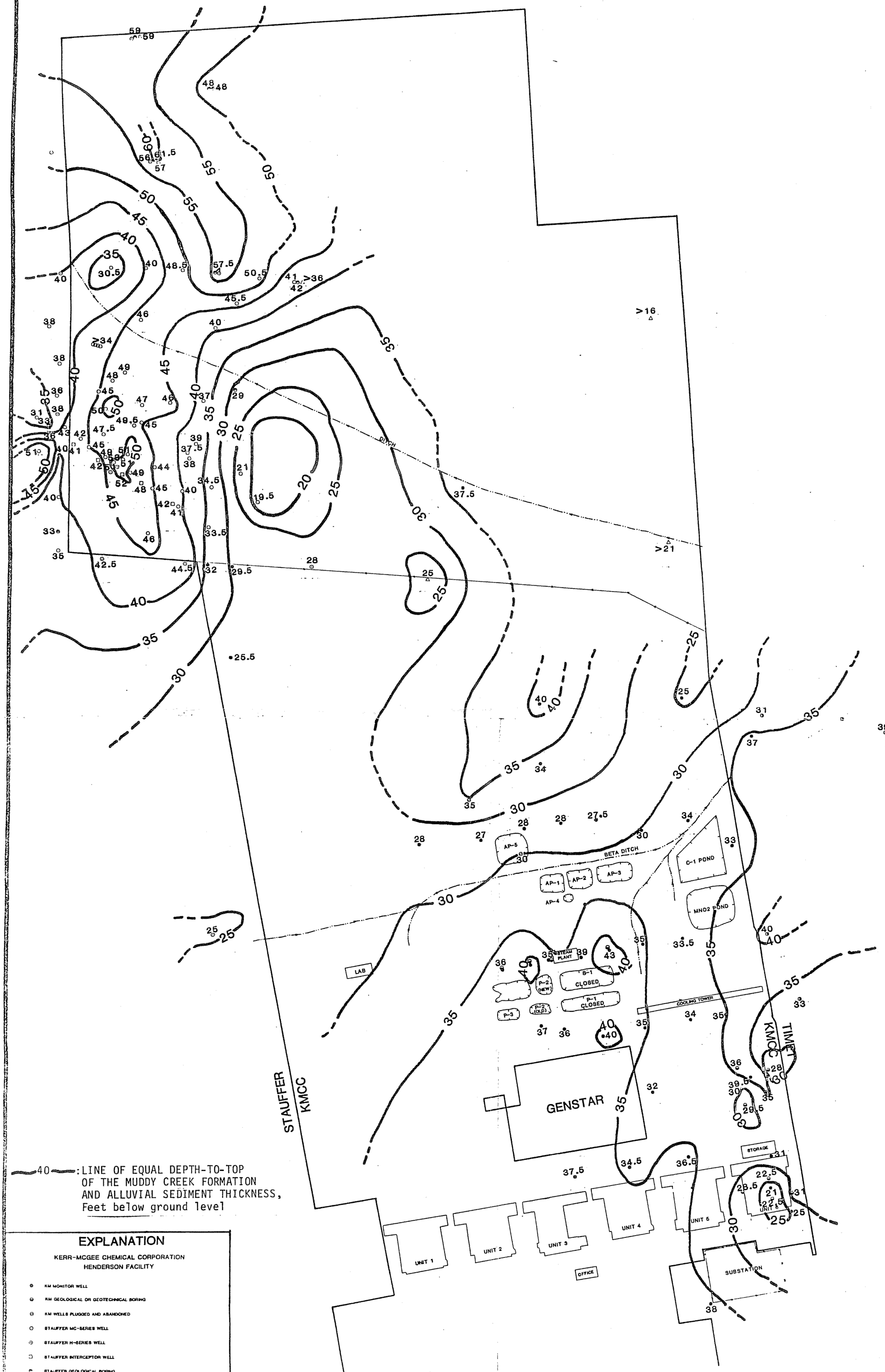
- KM MONITOR WELL
- KM GEOLOGICAL OR GEOTECHNICAL BORING
- KM WELLS PLUGGED AND ABANDONED
- STAUFFER MC-SERIES WELL
- STAUFFER H-SERIES WELL
- STAUFFER INTERCEPTOR WELL
- STAUFFER GEOLOGICAL BORING
- TIMET WELL
- DRS PG-SERIES WELL

SCALE 0 200 400 FEET

FENCE
DITCH
PROPERTY BOUNDARY
IMPOUNDMENT

MAP DRAWN 7/88

PLATE 2. MAP SHOWING THE ELEVATION OF THE TOP OF THE MUDDY CREEK FORMATION AT THE HENDERSON FACILITY.



—40—: LINE OF EQUAL DEPTH-TO-TOP OF THE MUDDY CREEK FORMATION AND ALLUVIAL SEDIMENT THICKNESS, Feet below ground level

EXPLANATION

KERR-MCGEE CHEMICAL CORPORATION
HENDERSON FACILITY

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- KM WELLS PLUGGED AND ABANDONED
- STAUFFER MC-SERIES WELL
- STAUFFER H-SERIES WELL
- STAUFFER INTERCEPTOR WELL
- STAUFFER GEOLOGICAL BORING
- TIMET WELL
- DRB PQ-SERIES WELL
- FENCE
- DITCH
- PROPERTY BOUNDARY
- IMPOUNDMENT

SCALE 0 200 400 FEET

MAP DRAWN 7/85

PLATE 3. MAP SHOWING DEPTH-TO-TOP OF THE MUDDY CREEK AND THE THICKNESS OF THE ALLUVIAL FAN SEDIMENTS AT THE HENDERSON FACILITY.

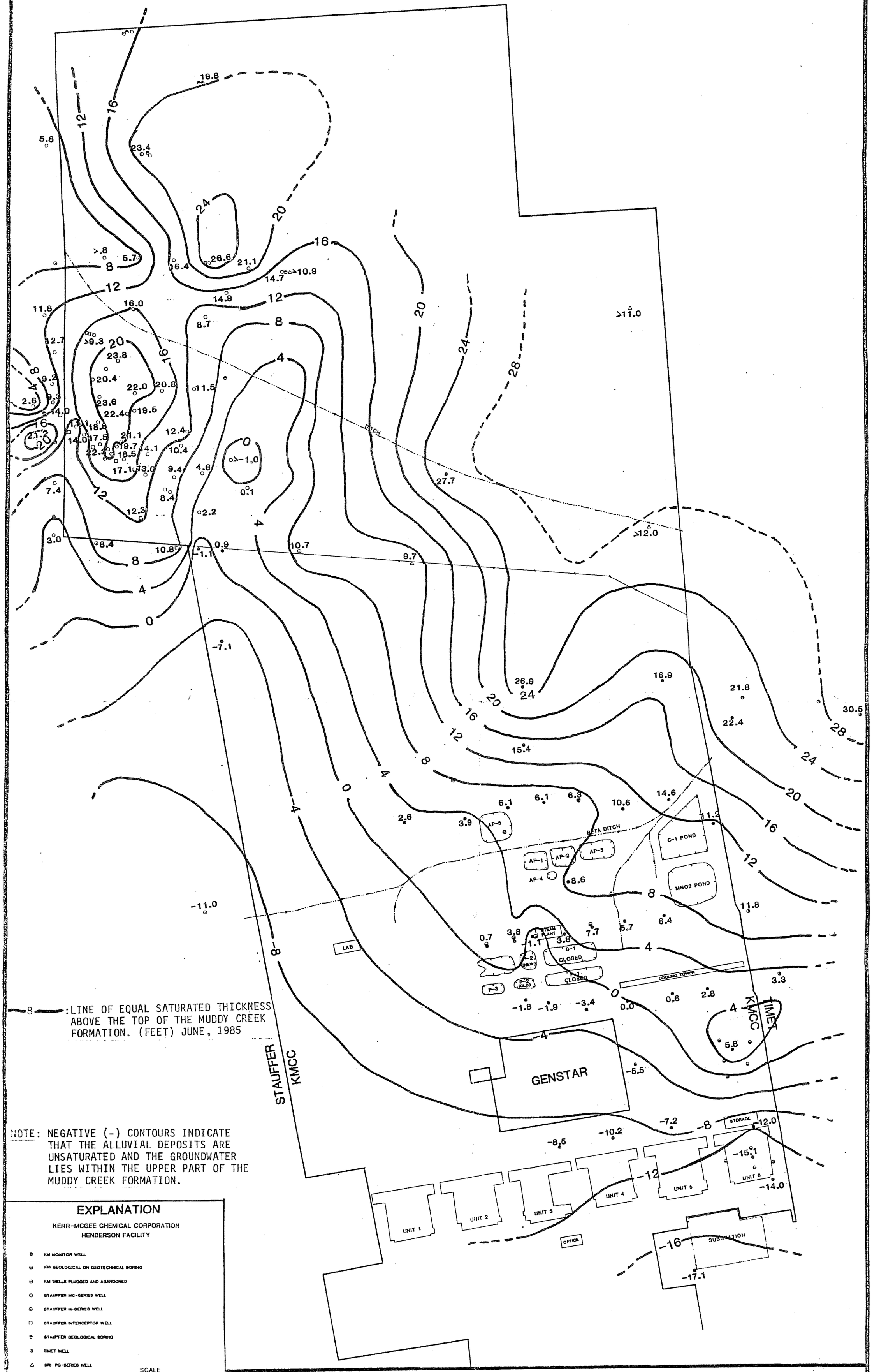
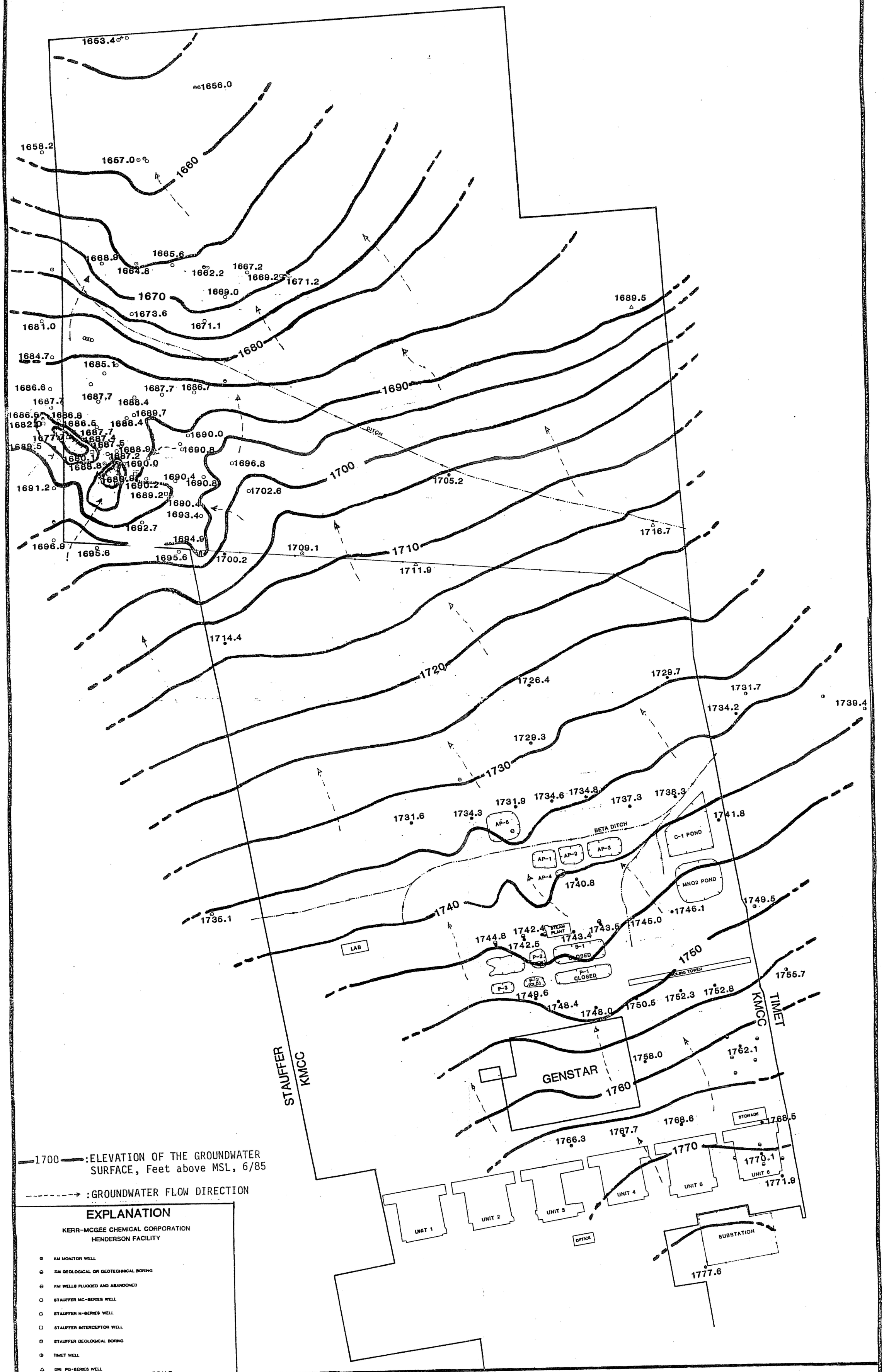


PLATE 4. MAP SHOWING SATURATED AQUIFER THICKNESS FOR THE ALLUVIAL DEPOSITS IN JUNE, 1985 AT THE HENDERSON FACILITY.



—1700—:ELEVATION OF THE GROUNDWATER SURFACE, Feet above MSL, 6/85

--------→ :GROUNDWATER FLOW DIRECTION

EXPLANATION

KERR-MCGEE CHEMICAL CORPORATION
HENDERSON FACILITY

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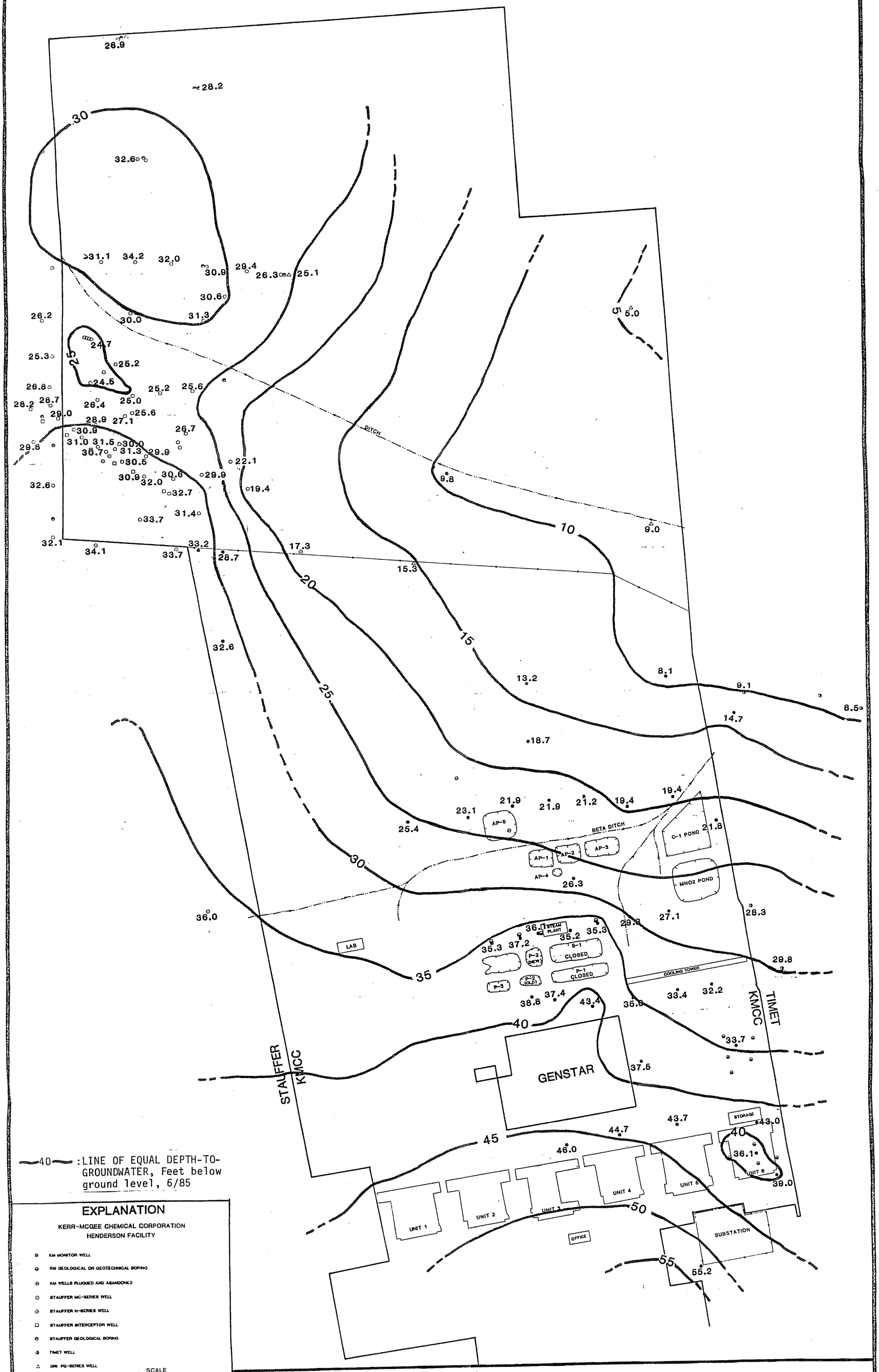
- STAUFFER H-SERIES WELL
- STAUFFER INTERCEPTOR WELL
- STAUFFER GEOLOGICAL BORING
- TIMET WELL
- DRI PG-SERIES WELL

SCALE 0 200 400 FEET

FENCE
DITCH
PROPERTY BOUNDARY
IMPOUNDMENT

MAP DRAWN 7/85

PLATE 5. POTENTIOMETRIC MAP FOR THE NEAR SURFACE AQUIFER IN JUNE, 1985 AT THE HENDERSON FACILITY.



—40— :LINE OF EQUAL DEPTH-TO-GROUNDWATER, Feet below ground level, 6/85

EXPLANATION

KERR-MCGEE CHEMICAL CORPORATION
HENDERSON FACILITY

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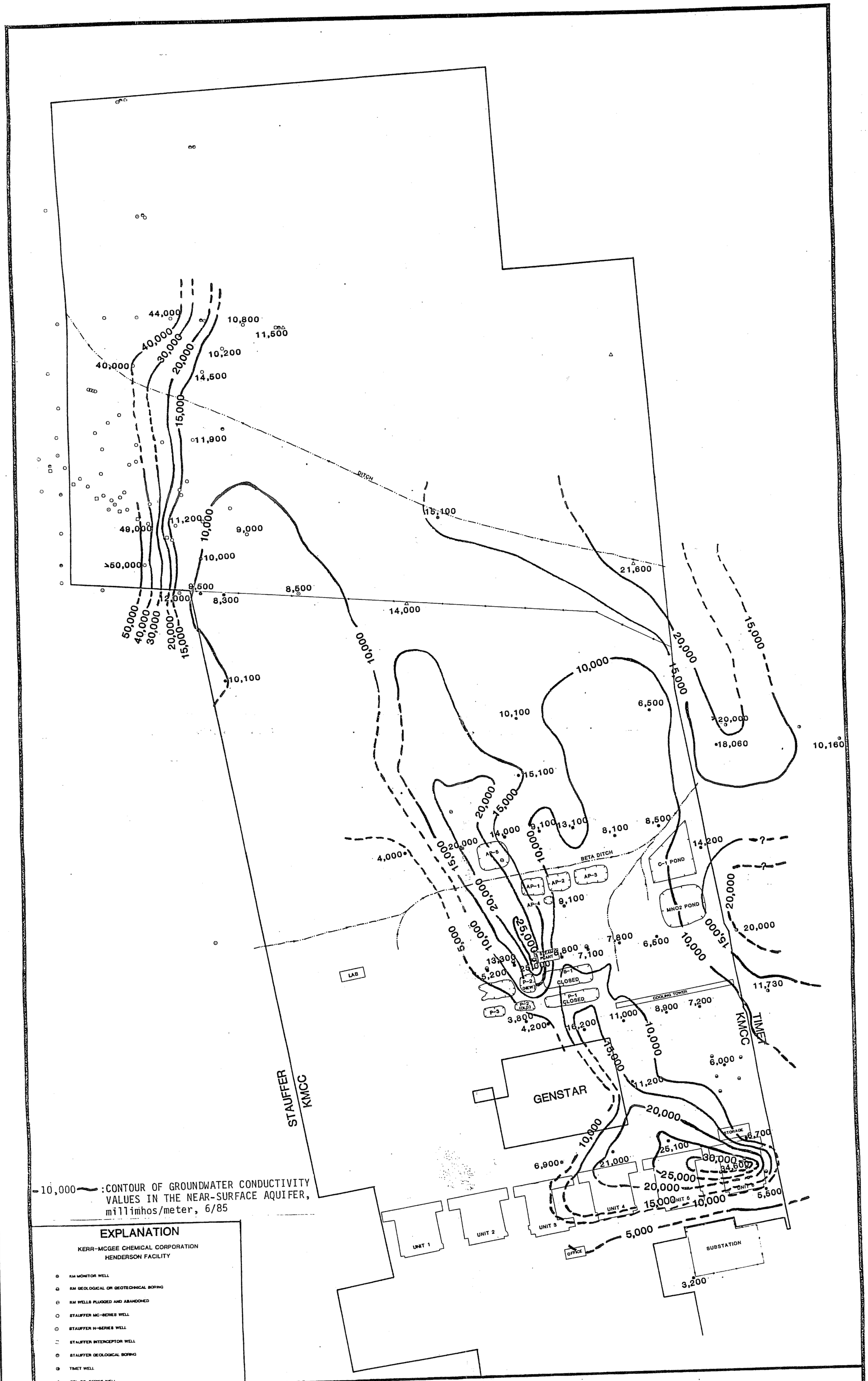
- STAUFFER H-SERIES WELL
- STAUFFER INTERCEPTOR WELL
- STAUFFER GEOLOGICAL BORING
- TIMET WELL
- DRI PO-SERIES WELL

SCALE 0 200 400 FEET

- FENCE
- DITCH
- PROPERTY BOUNDARY
- IMPOUNDMENT

MAP DRAWN 7/85

PLATE 6. MAP SHOWING DEPTH-TO-GROUNDWATER IN JUNE, 1985 AT THE HENDERSON FACILITY.



-10,000~ :CONTOUR OF GROUNDWATER CONDUCTIVITY VALUES IN THE NEAR-SURFACE AQUIFER, millimhos/meter, 6/85

EXPLANATION

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HENDERSON FACILITY

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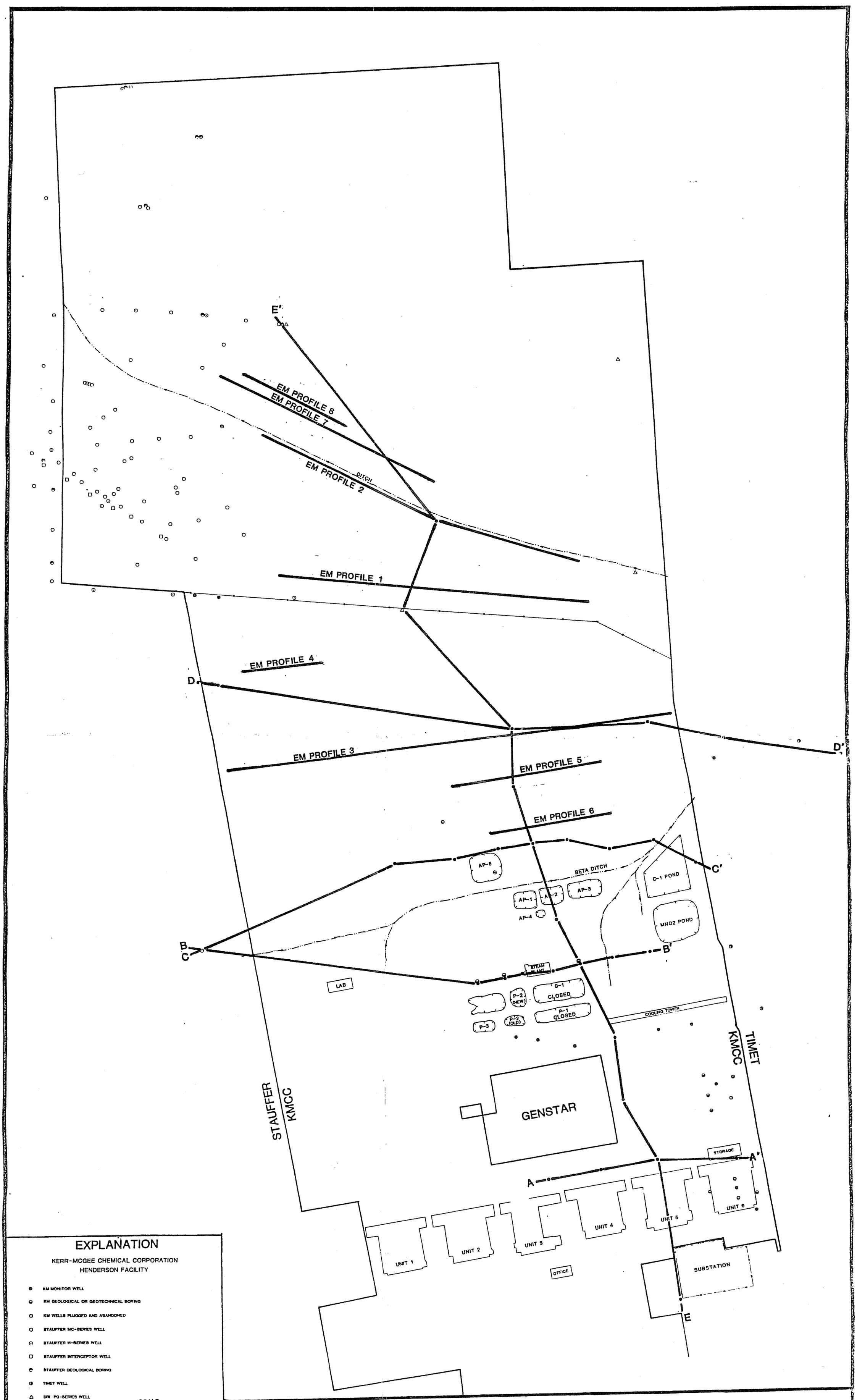
- STAUFFER H-SERIES WELL
- STAUFFER INTERCEPTOR WELL
- STAUFFER GEOLOGICAL BORING
- TIMET WELL
- △ DRI PG-SERIES WELL

SCALE 0 200 400 FEET

FENCE
DITCH
PROPERTY BOUNDARY
IMPOUNDMENT

MAP DRAWN 7/85

PLATE 8. MAP SHOWING CONDUCTIVITY DISTRIBUTION IN THE NEAR-SURFACE AQUIFER IN JUNE, 1985 AT THE HENDERSON FACILITY.



EXPLANATION

KERR-MCGEE CHEMICAL CORPORATION
HENDERSON FACILITY

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- STAUFFER H-SERIES WELL
- STAUFFER INTERCEPTOR WELL
- STAUFFER GEOLOGICAL BORING
- TIMET WELL
- DRI PO-SERIES WELL

SCALE 0 200 400 FEET

- FENCE
- DITCH
- PROPERTY BOUNDARY
- IMPOUNDMENT

MAP DRAWN 7/85

PLATE 9. MAP SHOWING LOCATIONS OF THE GEOLOGICAL CROSS SECTIONS AND EM PROFILE LINES AT THE HENDERSON FACILITY.