



Soil Feasibility Study

Petronila Creek Nueces County, Texas



Prepared for:

**Railroad Commission of Texas
Oil and Gas Division
Site Remediation and Special Response**

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September 2008

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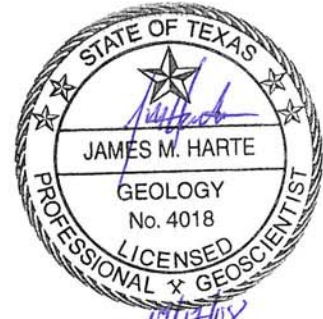


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September 2008

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1.0 INTRODUCTION

1.1 Scope of Soil Feasibility Study

Analytical and geophysical data collected around the Driscoll segment of Petronila Creek indicate broad extents of soils around the creek impacted with salinity. Historic discharge practices of brine water from oil and gas exploration in the area have likely been a primary contributor to elevated salinity levels in soils, groundwater, and Petronila Creek surface water. Chemical signatures of cations and anions (e.g., calcium, sodium, magnesium, chloride and sulfate) suggest that the source of salinity is from produced water associated with deep brine formations (Paine, Nance, and Collins, 2005). Saline water management and discharge during oil and gas exploration and production in the Driscoll area may have included discharge and infiltration into brine pits, and direct discharge into creeks and ditches. In addition, there may have been leaking injection of brine-disposal wells. Salinity levels in the area prior to oil and gas activity may have been elevated due to a combination of factors including: (1) presence of primary saline pore water incorporated during Pleistocene coastal facies of the Beaumont Formation; (2) salt particles blown inland and deposited by prevailing onshore winds; and (3) extensive inland flooding of saline water from the Gulf Mexico and estuarine water during periodic tropical storms (Paine, Nance, and Collins, 2005).

The culmination of historic information, analytical data, and geophysical data indicate that sources of elevated salinity are present within approximately seven square miles around Petronila Creek that may contribute, at variable rates, to salinity loading of the creek. This study focuses on evaluating Best Management Practices (BMPs) to address soils determined to have “elevated” concentrations, and is based on a “broad-brush” investigation performed between 2006 and 2008 in the areas around Petronila Creek in the general vicinity of United States Highway (US) 77 and County Road (CR) 18. Results of these iterative investigations indicate the ubiquitous nature of salinity in groundwater in the area due to historical oil and gas operations. Data also indicate that elevated levels of salinity in groundwater. Groundwater contamination will be addressed in a separate feasibility study.

BMPs considered in this study include containment, in-situ treatment, immobilization, and removal of contaminated soil. Each BMP was evaluated according to a series of factors, including effectiveness, level of effort required to implement, regulatory agency and stakeholder acceptance, and cost. Each area was then assigned a remedial priority based on chloride and conductivity concentrations, extent of impacted soils, and likelihood to impact the creek (e.g., distance to groundwater and surface water, preferential migration pathways).

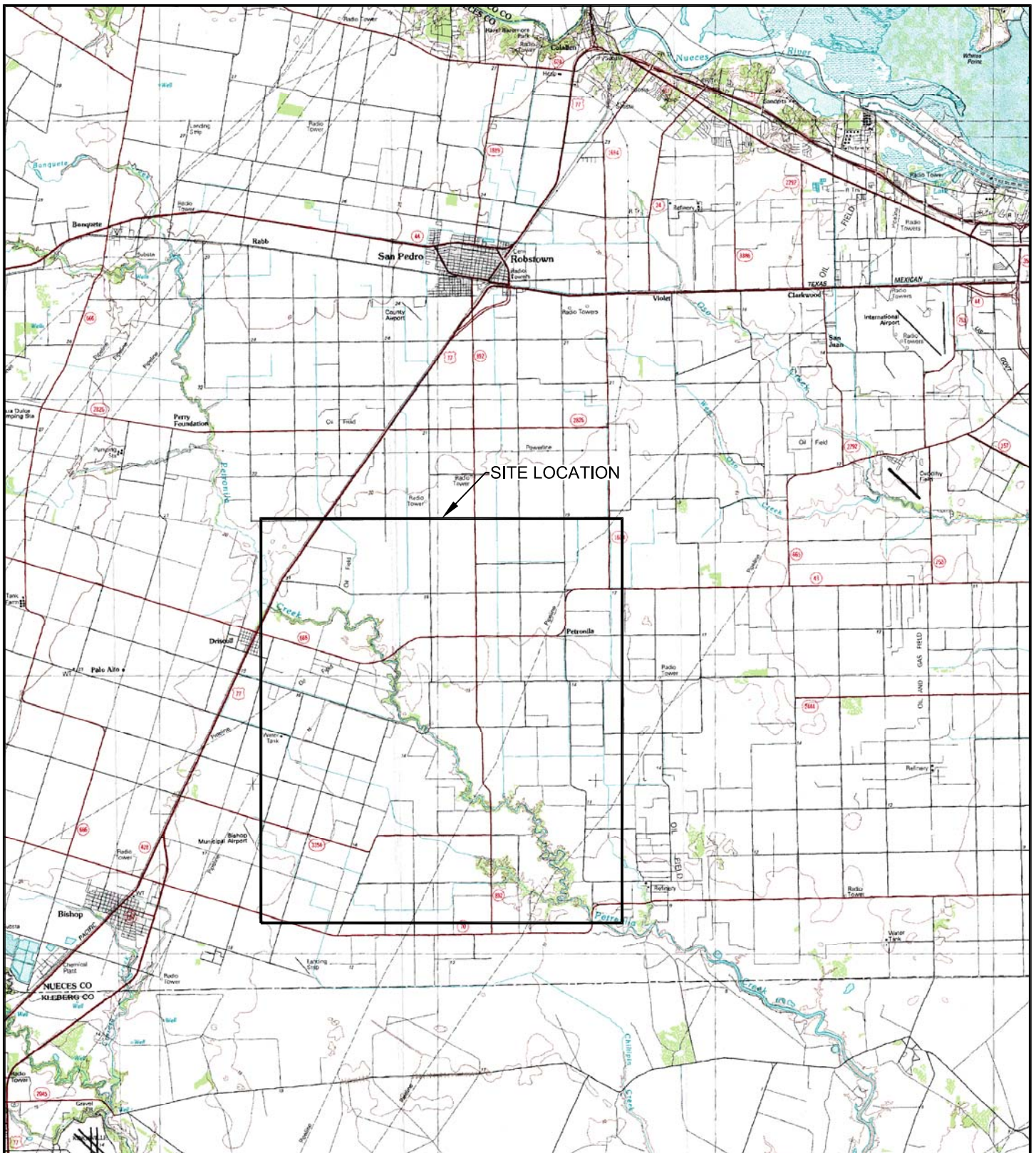
1.2 Site Background

The Total Maximum Daily Load (TMDL) Section of the Texas Commission on Environmental Quality (TCEQ) placed Segment 2204 (Petronila Creek) on the State's 303(d) list because it does not meet water quality standards due to high salinity. Segment 2204 includes the entire length of Petronila Creek, which begins at the confluence of Agua Dulce Creek and Banquete Creek in Nueces County and continues approximately 70 kilometers (km) to Laureles Ranch in Kleberg County. A site location map is presented as Figure 1-1.

Results from a TCEQ and Bureau of Economic Geology (BEG) investigation revealed that the chloride and total dissolved solids (TDS) content in Petronila Creek increased significantly between Gauging Station 13098 (located at US 77) and Gauging Station 13096 (located downstream of the Clara Driscoll oil field). The United States Environmental Protection Agency (USEPA) and TCEQ awarded the RRC a non-point source grant to determine if oil and gas operations along Petronila Creek are contributing to the high salinity of the surface water. The overall objective of this effort is to determine the source(s) leading to the elevated TDS and chloride in Petronila Creek, and to develop BMPs designed to reduce salinity loading in the creek.

As part of the TCEQ's TMDL project, BEG conducted an airborne geophysical survey, supporting ground-based measurements, and surface water analyses of Petronila Creek (Segment 2204) (Paine, Nance, and Collins, 2005). According to the BEG report, the results from the geophysical and chemical analyses suggest that the sources of salinity in Petronila Creek between US 77 and the estuarine-influenced zone include brine produced from local oil fields (North Clara Driscoll, Clara Driscoll, and Luby). Some of which was discharged into ditches (referred to as tidal disposal) before the RRC ended that practice in 1987 and/or discharged into pits before the RRC's no pit order was implemented in 1969. Airborne geophysical data suggest that there are extensive areas of salinization between the drainage ditches and Petronila Creek that may provide continuing sources of salinity along the Driscoll, Concordia, and Luby segments of Petronila Creek. The Luby Field area, which is at the downstream limit of the surveyed area, is not included in the present investigation because the area coincides with the zone of estuarine mixing (i.e., this portion of the study area also contains naturally-occurring salinity from tidal influence) (Paine, Nance, and Collins, 2005).

TRC conducted site reconnaissance along Petronila Creek and record review in May 2006. Findings from this effort indicated that historic oil and gas exploration and operations around Petronila Creek may be primary contributors to salinity loading to the



SCALE IN MILES
1" = 3 MILES



SITE LOCATION MAP

RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-1-1
DRAWN BY.	CL	DATE	4/17/08



505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE

1-1

SOURCE

U.S.G.S. 1:100,000-SCALE TOPOGRAPHIC MAP, CORPUS
CHRISTI (1980), TEXAS.

creek. TRC identified several potential sources in the Driscoll and Concordia oil fields that could contribute salinity to Petronila Creek. Findings and conclusions were provided in the report titled *Final Petronila Creek Records Review, Site Reconnaissance Results, and Recommendations* issued to the RRC by TRC in August 2006. This report recommended that further investigation in the form of soil and water sampling be performed to assess the extent of salinity in groundwater, surface water, and soil around Petronila Creek.

TRC conducted a second phase of field investigation (Phase II) during the spring of 2007, which included seasonal surface water monitoring and in-situ assessment of soils within the vicinity of Petronila Creek. The in-situ soil investigation was conducted using Cone Penetrometer Testing (CPT) technology to provide a “broad-brush” assessment of salinity concentrations around the creek. Findings from both events were submitted to the RRC in the *Draft – Interim Technical Memorandum for Petronila Creek*, prepared by TRC and dated August 10, 2007.

Surface water analytical data collected during the Phase II event indicated general increases of conductivity, anion, and cation concentrations in Petronila Creek water between Creek Segments 2 and 25, and decreasing concentrations downstream of Segment 25. Of the cations and anions, chloride was detected at the highest concentration. Elevated TDS, conductivity, anion, and cation concentrations were also observed from water samples collected from the North Clara Driscoll and Clara Driscoll oil field drainage ditches, which join Petronila Creek near Creek Segments 6 and 14, respectively.

The Phase II groundwater sampling event included the sampling of groundwater monitoring wells associated with two former oil field/pipeline releases, referred to as the Driscoll #2 Site and Driscoll #3 Site. The results of the groundwater sampling collected from these monitoring wells during the spring of 2007 indicated elevated TDS, conductivity, anion, and cation concentrations. Both areas are registered under Solid Waste Number 39988 and are currently under the jurisdiction of the TCEQ.

The results of the Phase II CPT investigation indicated discrete areas of shallow soils (less than 10 feet below ground surface [bgs]) with elevated conductivity concentrations. Conductivity concentrations in these areas increased with depth, and spread laterally with depth, suggesting vertical and lateral transport in the direction of groundwater flow.

A third phase of investigation (Phase III) was completed in December 2007 with a scope of work based on the results of the Phase II investigation. Phase III work focused on specific areas found to have elevated conductivity based on CPT data (and therefore

elevated chloride and TDS levels) that may contribute to salinity loading of Petronila Creek. During this phase, seasonal water monitoring was performed and included surface water sampling, stream flow measurements, and gauging stream stage. Groundwater investigation was also performed and involved monitoring well installation, synoptic well and creek gauging, and groundwater sampling of the monitoring wells.

Groundwater elevations collected from monitoring wells in October and December 2007 were compared to the approximate elevation of the bottom of the creek. Groundwater elevations were higher than the bottom of the creek suggesting that a hydraulic connection is present (i.e., gaining creek) between Petronila Creek and the groundwater bearing unit (GWB). Analysis of cross-sections showing lithology, potentiometric elevations, and the creek profile indicate that the GWB intersects Petronila Creek to a greater extent in the downstream direction where the creek is more deeply incised (downstream of Segment 9).

Between June and September 2007, the Petronila Creek area received precipitation in excess of the average rainfall for the area and caused flooding in the area. Analytical data of the water in Petronila Creek was collected in October 2007 and indicated a significant increase in salinity between Segments 2 and 6, a slight increase in salinity between Segments 6 and 19, and a moderate decrease in salinity between Segments 19 and 33, as compared to salinity concentrations observed in February 2007 (TRC, 2007b).

Similar increases in salinity were observed in analytical results of samples collected from the North Clara Driscoll and Clara Driscoll drainage ditches. Salinity increases (including chloride, TDS, and sulfate) were observed in the North Clara Driscoll drainage ditch between sample locations P-D-02 and P-D-01, and in the Clara Driscoll drainage ditch between sample locations P-D-06 and P-D-07 (TRC, 2007b).

The soil analytical data collected during the Phase III investigation identified elevated salinity concentrations at shallow soil depths in the following areas: Driscoll #2 Site, Driscoll #3 Site, oil field wasteland areas near P-MW-3, P-MW-6 and P-MW-16, and the drainage ditches along CR18 and North Clara Driscoll field. The Phase III groundwater analytical data for the shallow wells indicated that the highest salinity concentrations occurred at the Driscoll #3 Site, oil field wasteland areas near P-MW-3, P-MW-6, P-MW-16, and wells P-MW-20 and P-MW-21, located along drainage ditch CR18. A cumulative analysis of the soil and groundwater information gathered from the Phase II and Phase III investigations suggested seven likely source areas: (1) oil wasteland south of Petronila Creek near well P-MW-16; (2) oil wasteland area south of Petronila Creek near well P-MW-6; (3) oil wasteland area north of Petronila creek near

well P-MW-03; (4) unknown source near the Driscoll #2 Site (P-D2-MW-12); (5) former disposal pit near the Driscoll #3 Site (P-D3-MW-27; (6) North Clara Driscoll drainage ditch; and (7) CR18 drainage ditch (TRC, 2007b).

These elevated salinity areas were investigated as part of this feasibility study based on their likelihood to impact Petronila Creek by leaching/migration via groundwater and/or surface runoff. These seven locations with elevated salinity levels are presented in Section 2.0.

Field sampling conducted in June 2008 focused on the collection of soil samples from each of the seven areas identified in the Phase III report with the objective of determining the feasibility of addressing each area with one or more BMPs. Each of the elevated salinity areas (i.e., potential source areas) was investigated in closer detail with the collection of multiple soil or ditch sediment samples. The June 2008 sampling results are integrated into this feasibility study. Tabulated analytical results are provided in Appendix A, and the laboratory analytical reports are provided in Appendix B.

1.3 Report Contents

The remainder of this report provides a conceptual site model (Section 2.0), alternatives for salinity/TDS abatement (Section 3.0), BMP design alternatives (Section 4.0), and the recommended BMP (Section 5.0).

2.0 CONCEPTUAL SITE MODEL

This feasibility study evaluates BMPs at the seven source areas identified during the project field investigations. To simplify investigation and discussion, each of the source areas identified in the Phase II and Phase III investigations was designated a numeric identification as described below and shown on Figure 2-1:

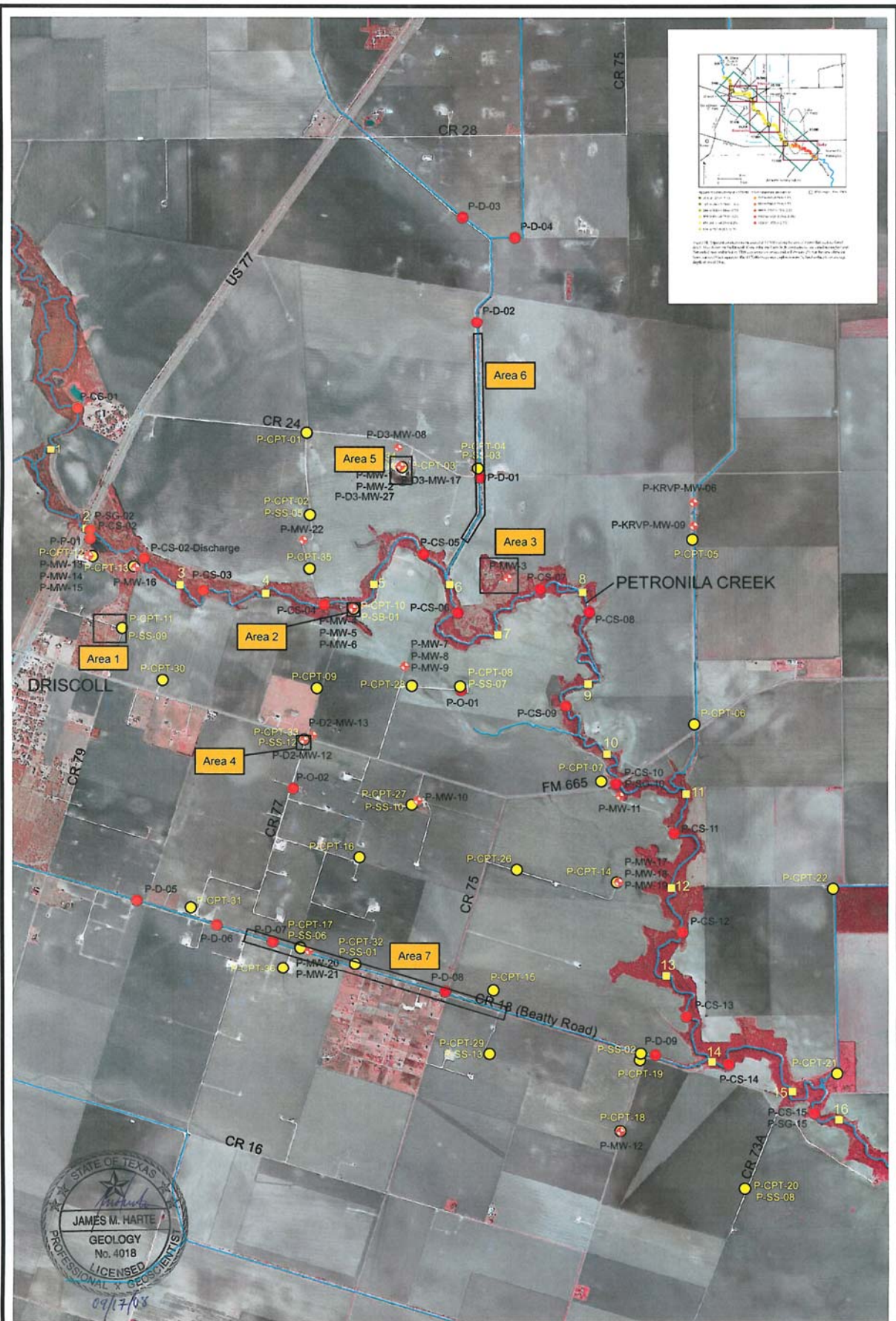
- Area 1 – Oil wasteland area south of Petronila Creek near CPT boring P-CPT-11
- Area 2 – Oil wasteland area south of Petronila Creek near Well P-MW-6
- Area 3 – Oil wasteland area north of Petronila Creek near Well P-MW-03
- Area 4 – Unknown source near the El Paso Driscoll #2 release site
- Area 5 – Former disposal pit near El Paso Driscoll #3 release site
- Area 6 – North Clara Driscoll drainage ditch
- Area 7 – CR18 drainage ditch

A conceptual site model was developed to define the physical setting of these areas relative to Petronila Creek. The conceptual site model includes a description of the geology/hydrogeology, chemicals of concern, distribution of salinity and other target constituents in each of the focus areas, and migration pathways of saline-impacted water.

2.1 Geology and Hydrogeology

Based on the BEG Geologic Atlas of Texas, Corpus Christi Sheet, the Quaternary alluvium deposits and the Beaumont Formation are the only geologic units in direct contact with Petronila Creek in the Driscoll and Concordia areas. The Beaumont Formation consists of clay, silt, sand, and gravel, includes mainly stream channel, point bar, natural levee, and backswamp deposits, and has a thickness of approximately 100 feet (BEG, 1975).

The subsurface lithology interpreted to a maximum depth of approximately 61 feet bgs, based on monitoring wells, and CPT and soil borings, indicated predominantly clays and silts from ground surface to between 10 and 15 feet bgs. Below 10 to 15 feet bgs (approximately 40 feet above mean sea level [amsl]), laterally continuous and discontinuous silty sand lenses reside within a matrix of sandy clay and/or finer grained materials (i.e., silts and clays). These sandy lenses are generally five to 15 feet thick and appear to be more continuous and thicker to the southeast towards Baffin Bay and the



LEGEND

- A-A' Cross-Section Line
- Seasonal Water Sample Location
- CPT (P-CPT-XX) and Shallow Soil Sample (P-SG-XX) Locations
- Monitoring Well Location
- Surface Drainage (Petronila Creek and drainage ditches)
- Creek Segments for Petronila Creek (Kilometer Markers)

SOURCE:

1. U.S.G.S. Digital Ortho Quarter Quads (DOQQs) for Concho NE (2004), Concho NW (2004), Driscoll East NE (2004), Driscoll East NW (2004), Driscoll East SE (2004), and Driscoll East SW (2004). Texas DOQQs.
2. BEG Airborne Geophysical Survey Report ("Figure 18 inset")

SITE MAP

RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.: 160551

DATE: 5/28/2008



555 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
512-323-6000

FIGURE
2-1

Gulf of Mexico. The lithologic data collected from the subsurface investigations are consistent with a fluvial depositional environment and are representative of the Beaumont Formation.

The principal GWBUs in Nueces County are the Goliad Sand, Lissie Formation, and Beaumont Formation. In general, these three units are located within the Gulf Coast Aquifer. Groundwater in these GWBUs flows southeastward toward the Gulf of Mexico and occurs under unconfined and confined conditions (TWDB, 1968). The Gulf Coast Aquifer is separated into two subunits, known as the Chicot Aquifer and Evangeline Aquifer. In Nueces County, the Chicot Aquifer is located within the Beaumont Formation and overlying alluvium. The Evangeline Aquifer is older than the Chicot Aquifer and generally located at deeper levels within the Goliad Formation in Nueces County (TWDB, 1968). Based on observed lithologic information from subsurface drilling, Petronila Creek and the seven focus areas are within the Chicot Aquifer.

The lithology of the Beaumont Formation varies with depth, and the project monitoring wells were screened within the following lithologic layers: clays/silts (generally shallower wells), sand lenses (generally deeper wells), or both (intermediate wells). The presence of a static water level in monitoring wells screened in the shallower clays and silty clays suggests that these clays are saturated, even though field observations did not indicate obvious saturated conditions. The potentiometric groundwater levels reveal vertical groundwater gradients (both upward and downward), and saturated shallow clay units around the creek suggest that the GWBU exists under unconfined conditions with recharge from surface infiltration.

2.2 Potential Sources of Creek Impacts and Migration Pathways

Oil and gas exploration and management practices, as discussed in Sections 1.1 and 1.2, have impacted soil and groundwater around the creek. Several source areas were identified during the Phase II and Phase III investigations. This soil feasibility study addresses the seven most likely source areas identified to date; these seven potential source areas are listed in Section 2.0. Because these investigations covered such a large area and there is incomplete historical data on land use, it is feasible that there may be other contributing areas that were not discovered during the Phase II and Phase III investigations.

Analytical data collected in February and October 2007 detected elevated concentrations of salinity between Segments 2 and 34 of Petronila Creek. The salinity levels increased between Segments 2 and 20 suggesting saline loading into Petronila Creek occurs between Segments 2 and 20. Chloride, TDS, and conductivity concentrations detected along Petronila Creek for both sampling events are plotted in

Figures 2-2 and 2-3. Salinity concentrations observed in October 2007 were greater than February 2007. The increase in TDS and chloride concentrations is most likely related to significant amounts of precipitation in the area during the summer of 2007. Precipitation would cause more leaching of salinity constituents that percolate vertically to the GWBU and increase surface erosion/runoff to the creek. The greatest increase in concentrations from February to October 2007 occurred between Segments 2 and 6 where several of the high salinity areas are relatively close to the creek resulting in the following: (1) shorter distance for groundwater to migrate from the source to the creek, and/or (2) direct salinity loading to the creek from surface runoff. Analytical data of water samples collected from Petronila Creek are presented in Table 1 of Appendix A.

The fate and transport of saline-impacted media from the potential source areas to the creek is not completely understood; therefore, the relative contribution of salinity loading to the creek by each area has not been determined. In addition, data indicate elevated salinity concentrations in the GWBU over a broad portion of the study area and this ubiquitous source area presents another mechanism of salinity loading. These issues are being addressed in a separate feasibility study that includes development of a conceptual site model of groundwater to provide more perspective and information regarding salinity flux to the creek.

Potential migration pathways from areas closest to the creek may be two-fold: (1) leaching from soil followed by percolation to the GWBU and then migration via the GWBU to the creek, and (2) direct salinity loading to the creek by erosion and surface runoff. Visual evidence of erosion and surface water runoff (i.e., drainage channels that trend toward the creek) was observed in Area 2.

Potential source areas farther from Petronila Creek may also contribute to salinity loading of Petronila Creek; however, the predominant transport to the creek will be leaching from soil followed by percolation to the GWBU and then migration via the GWBU to the creek. Evidence of vertical migration is indicated by CPT conductivity data collected from Areas 4 and 5 showing increasing conductivity with depth. Analytical data collected at Areas 1 and 3 suggest that vertical migration of salinity to the GWBU with eventual advection towards the creek may also be the primary form transport away from these areas. These pathways will be discussed in more detail in the groundwater conceptual site model.

The greatest quantity of salinity loading to the creek may be from Areas 6 and 7, which are ditches that drain water from large agricultural areas in the vicinity. Analytical results of sediment samples collected from these areas detected elevated concentrations of chlorides and conductivity over long distances (up to 8,000 feet) across each ditch.

Figure 2-2
Chloride Concentrations Along Petronila Creek

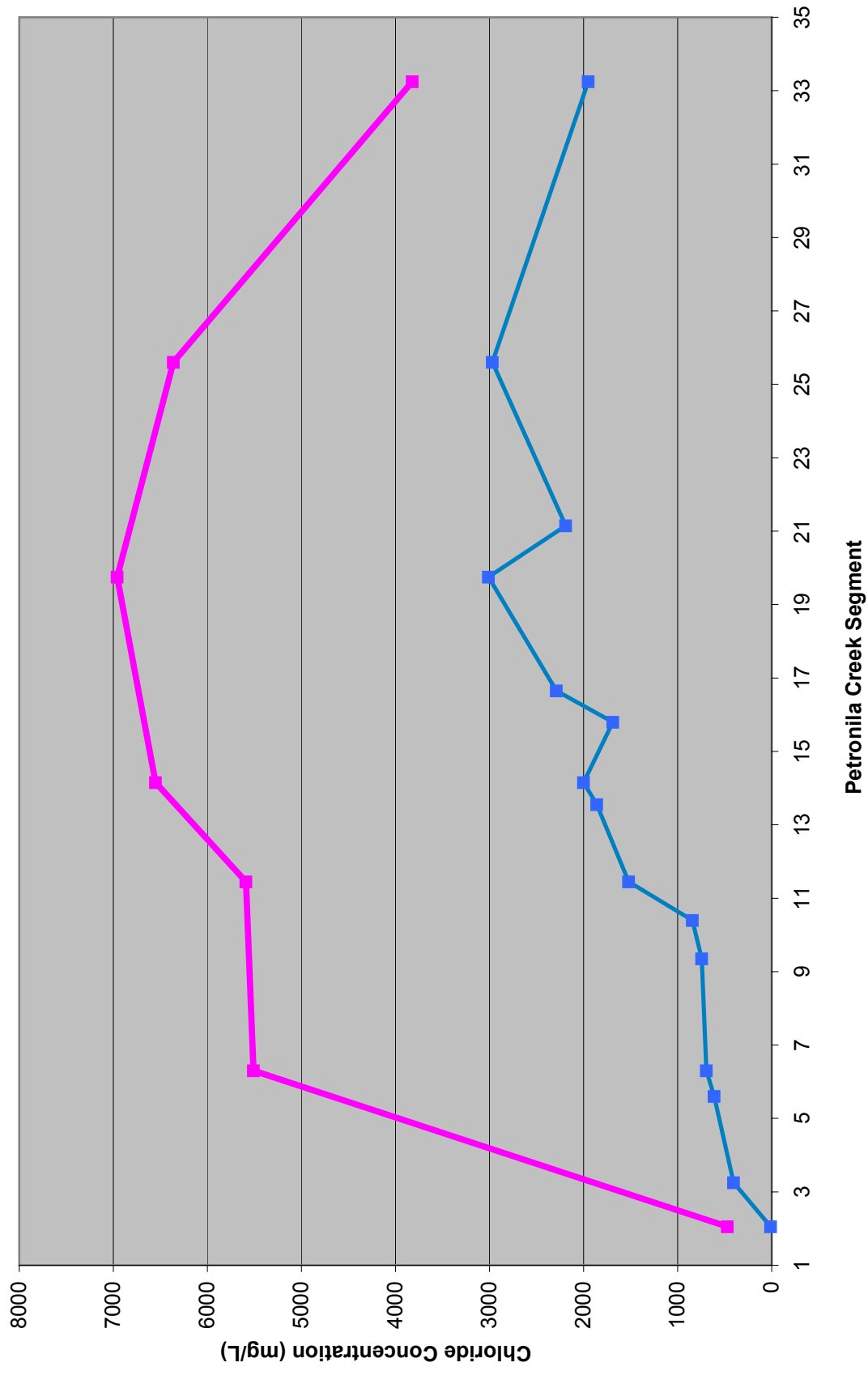
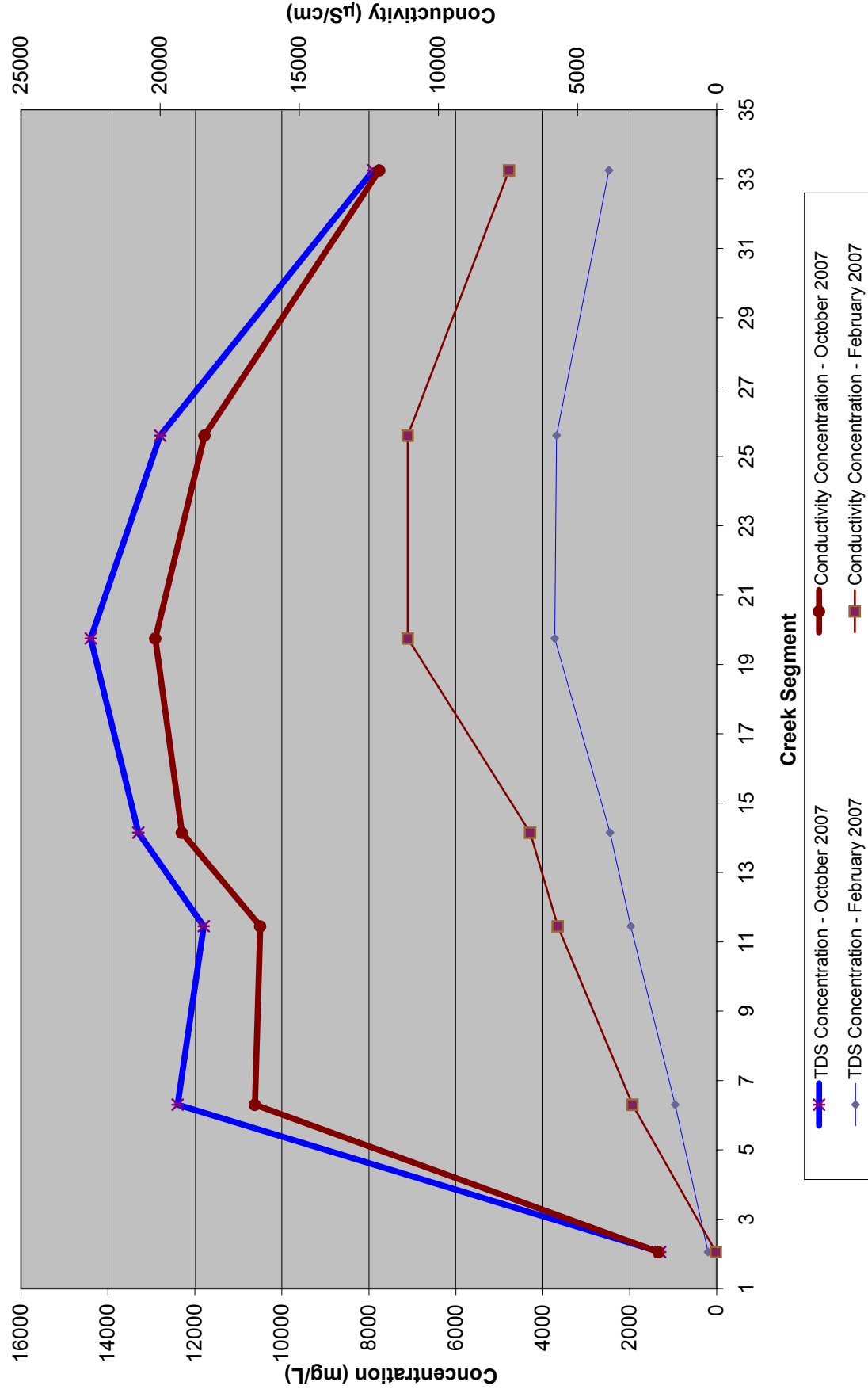


Figure 2-3
TDS and Conductivity Concentrations Along Petronila Creek



Predominant transport from these areas would be leaching during storm events with direct flow to Petronila Creek. Infiltration and vertical leaching through the bottom of the ditch to the GWBU may be a secondary transport mechanism. Evidence of this secondary transport mechanism is observed along the CR18 ditch where a plume of elevated CPT conductivity data starts at the ditch near the intersection of CR77 and CR18 and then moves downgradient (i.e., southeast).

2.3 Elevated Salinity Areas

The June 2008 field investigation, which involved soil sampling in the seven focus areas identified at the beginning of Section 2.0, was conducted to understand the concentration and distribution of salinity components in the soil. The field investigation tasks were completed in general accordance with the following documents:

- *Work Order for Soil Delineation and Feasibility Study, Petronila Creek, Driscoll, Nueces County, Texas* (TRC, 2008), submitted to the RRC May 9, 2008, and approved May 13, 2008.
- *Investigation of Increased Salinity Along Petronila Creek (Segment 2204) Quality Assurance Project Plan – Revision 1* (RRC, 2007) submitted by the RRC to the TCEQ and USEPA in February 2007, and approved April 24, 2007.

The following variances from the Work Order are noted:

- Nine soil borings were planned for Area 1; however, a tenth boring was completed.
- The Work Order stated that one soil sample per boring would be submitted for laboratory analysis at Areas 1 to 5. However, two or three soil samples were submitted from several borings to obtain better vertical definition.
- Photo-ionization detector (PID) was not used to field screen the soil samples because the main constituents of concern were chloride and conductivity. A PID was used for health and safety purposes to monitoring the breathing zone during drilling operations.

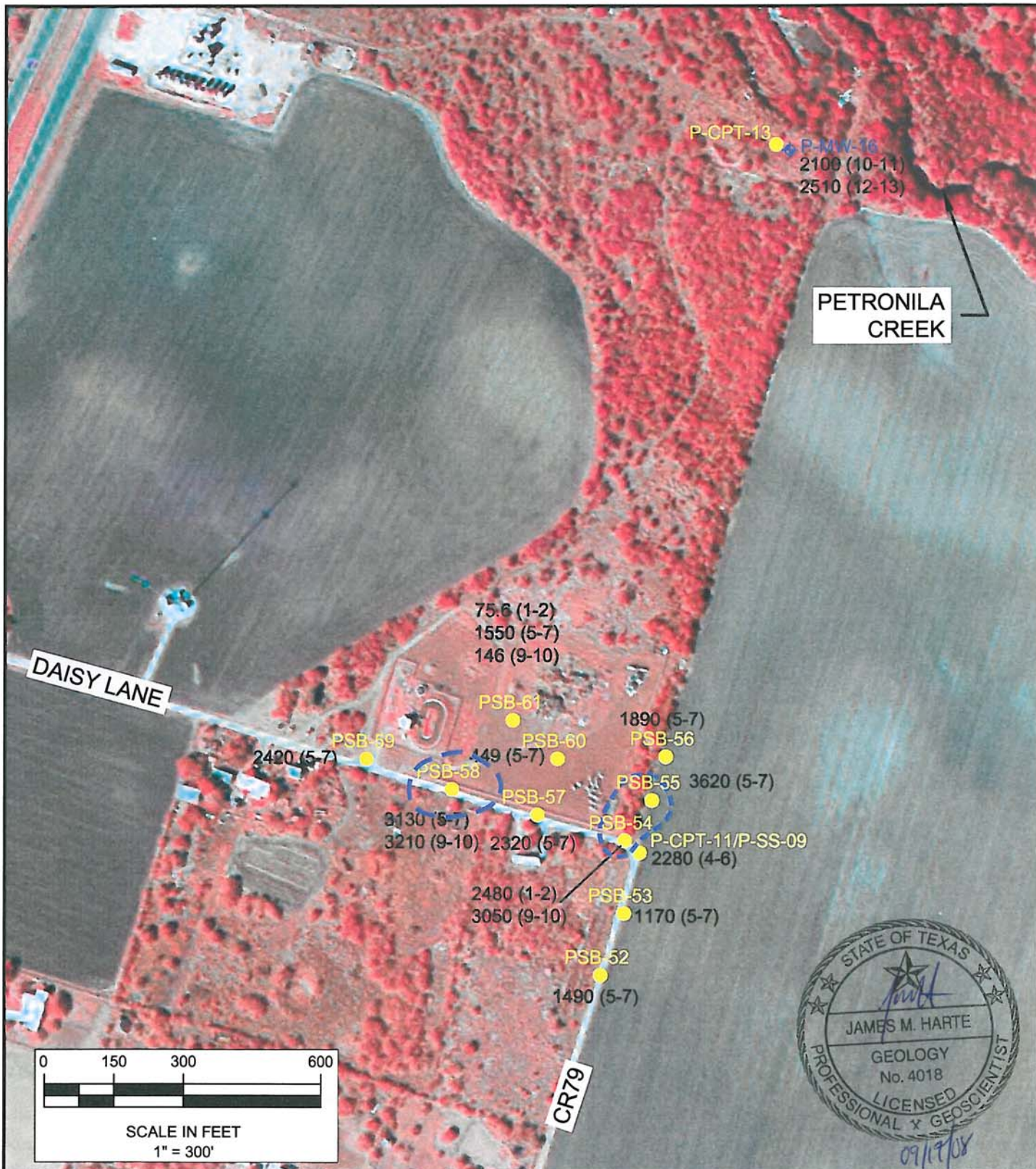
Soil samples were collected and submitted to DHL Analytical (Austin, Texas) for analysis of chloride (SW846 Method 6020), electrical conductivity (Agron 10-2.3), and moisture content (ASTM D2216). No deviations from the QAPP were noted.

Soil borings were completed in Areas 1 through 5 using a direct push technology (DPT) rig. Continuous soil samples to a maximum depth of 20 feet bgs were collected

from each borehole using a split-barrel sampler. The soil analytical data is provided in Table 2 of Appendix A, and the laboratory reports are provided in Appendix B.

For the purpose of this assessment, elevated levels are defined as chloride concentrations in excess of 3,000 milligrams per kilogram (mg/kg) and conductivity concentrations in excess of 8,000 micromhos per centimeter ($\mu\text{mhos/cm}$). These threshold levels were based on the RRC's "Field Guide for the Assessment and Cleanup of Produced Water Releases-Draft" dated June 28, 2006, and were used to make relative definition of elevated salinity levels in soil. The lateral and vertical distribution of chloride and conductivity concentrations detected in Areas 1 through 5 is depicted in Figures 2-4 through 2-27. Soils with chloride and conductivity concentrations in excess of their respective threshold levels are identified with a blue dashed line (chloride) or red dashed line (conductivity) in each of the figures. The extent of elevated concentrations (i.e., defined by the dashed lines) at Areas 1 through 5 was determined using a combination of analytical data and observation of vegetation that is indicative of shallow soils with salinity concentrations that do not pose an adverse ecological impact. Additional delineation may be needed during the design phase, if a BMP is applied to any of these areas.

The soils with the highest concentrations relative to each area are identified with a gray box in the figures and represent the areas that were initially considered for remediation. The high concentration area defined by the gray box is not based on formal clean-up levels since these have not been developed at this point in the project. Area 1 was not defined with a gray box because the concentrations were low relative to the remaining areas. The concentration range and average concentration for chloride and conductivity, and the estimated area of saline-impacted soil is summarized in Table 2-1.



EXPLANATION:

- EXTENT OF ELEVATED CHLORIDE CONCENTRATIONS
- 490 (5-7) CHLORIDE CONCENTRATION IN mg/kg (SAMPLE DEPTH IN FEET)
- MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



SITE MAP - AREA 1 CHLORIDE CONCENTRATIONS RAILROAD COMMISSION OF TEXAS PETRONILA CREEK

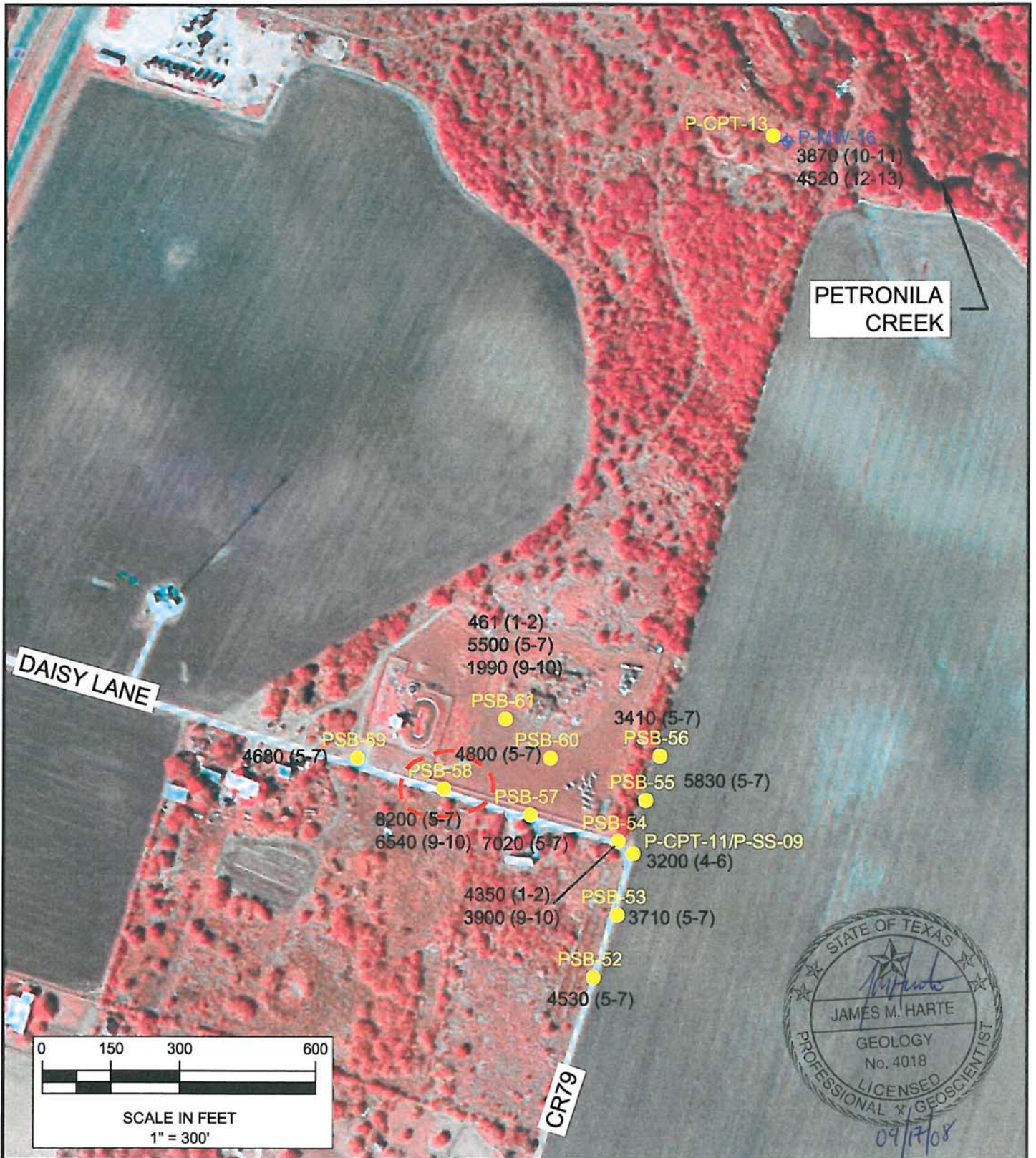
PROJECT NO.	160551	DWG FILE	160551-2-4
DRAWN BY.	CL	DATE	7/23/08



505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE

2-4



EXPLANATION:

- EXTENT OF ELEVATED CONDUCTIVITY CONCENTRATIONS
- 461 (1-2) CONDUCTIVITY IN umhos/cm (SAMPLE DEPTH IN FEET)
- MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



**SITE MAP - AREA 1
CONDUCTIVITY CONCENTRATIONS**

RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

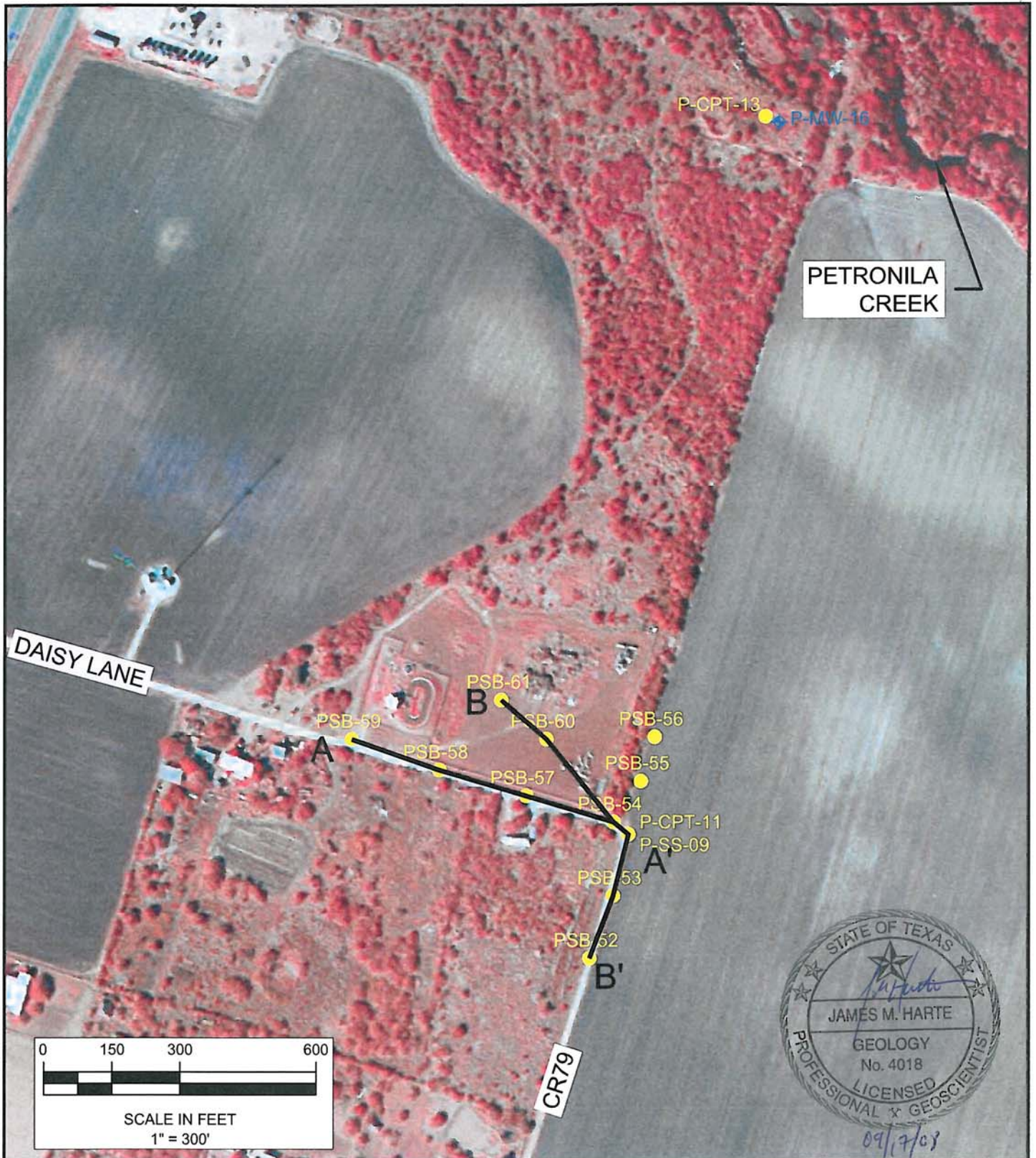
PROJECT NO.	160551	DWG FILE	160551-2-5
DRAWN BY.	CL	DATE	6/12/08



505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE

2-5



EXPLANATION:

- MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



**AREA 1
CROSS SECTIONS A-A' AND B-B'**
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-6
DRAWN BY.	CL	DATE	7/23/08

TRC 505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE

2-6

WEST A

P-SB-59

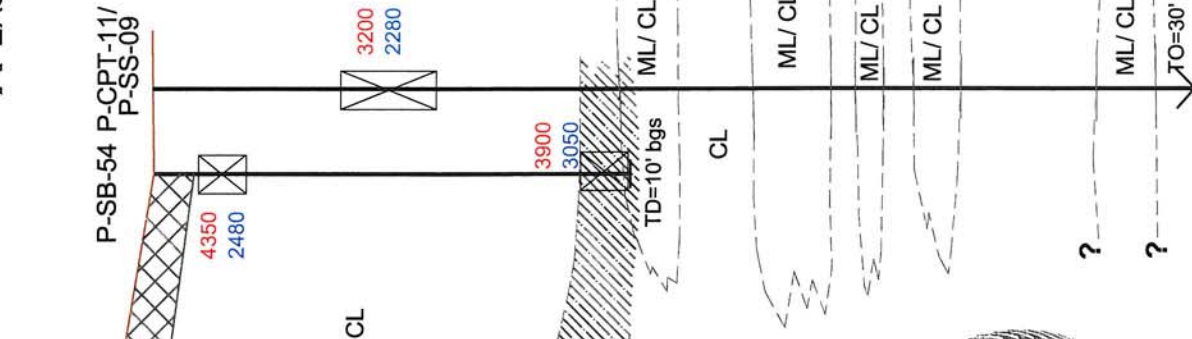
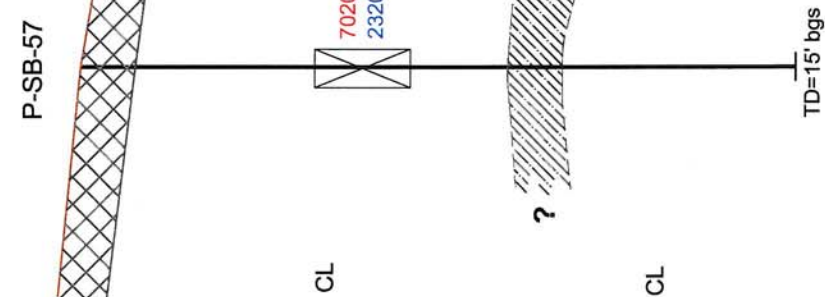
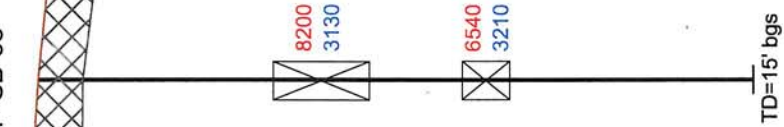
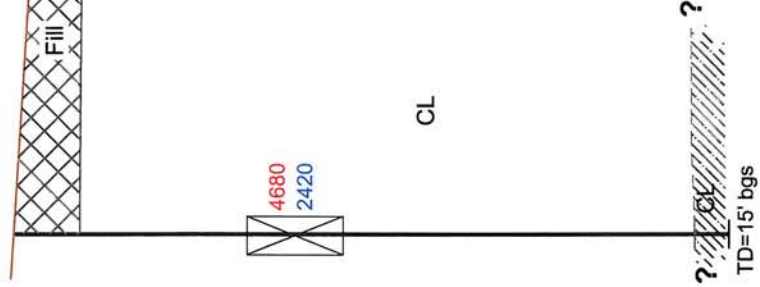
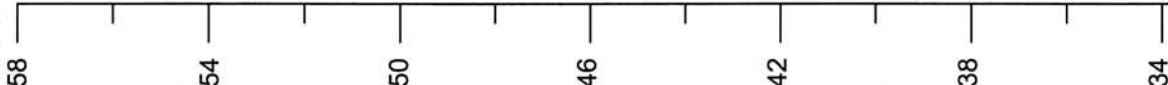
P-SB-58

P-SB-57

A' EAST

P-SB-54 P-CPT-11/
P-SS-09

ELEVATION (FEET) (NAVD88)



EXPLANATION:

☒ SAMPLE INTERVAL

▨ SATURATED ZONES IDENTIFIED FROM FIELD OBSERVATION

CONDUCTIVITY (reported in umhos/cm)

CHLORIDE (reported in mg/kg)

TD = TERMINAL SOIL BORING DEPTH
bgs = BELOW GROUND SURFACE

SCALE:
VERTICAL : 1" = 4'
HORIZONTAL : 1" = 90'
VERTICAL EXAGGERATION = 22.5X

LITHOLOGY:
CL - LEAN CLAY
CH - FAT CLAY
ML - SILT

AREA 1

CROSS-SECTION A-A'
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-7 A1XS-BB
DRAWN BY.	KS	DATE	7/23/08

505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE
2-7

B' SOUTH



SCALE:

HORIZONTAL : 1" = 90'

AREA 1

RAILROAD COMMISSION OF TEXAS

CHLORIDE (reported in mg/kg)

TD = TERMINAL SOIL BORING DEPTH
bgs = BELOW GROUND SURFACE

ML - SILT

SC - CLAYEY SAND

CROSS-SECTION E
RAILROAD COMMISSION OF
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-8 A1XS-BB
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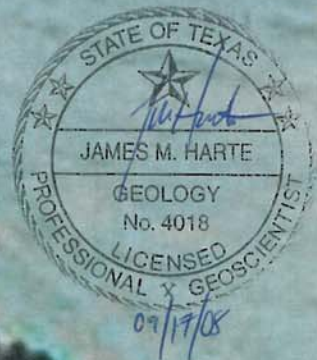
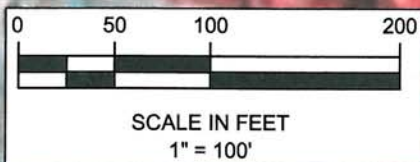
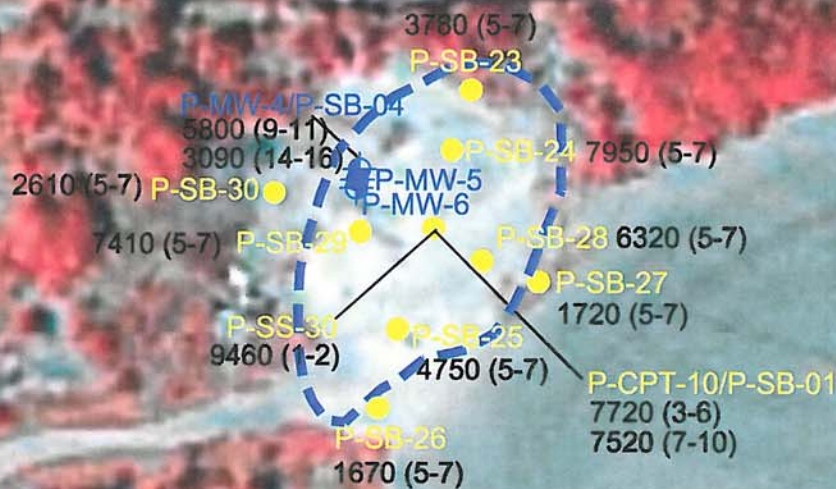
DRAWN BY:	KS	DATE	7/23/08
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505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080



FIGURE
2-8

PETRONILA CREEK



EXPLANATION:

- EXTENT OF ELEVATED CHLORIDE CONCENTRATIONS
- 4460 (1-2) CHLORIDE CONCENTRATION IN mg/kg (SAMPLE DEPTH IN FEET)
- MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



**SITE MAP - AREA 2
CHLORIDE CONCENTRATIONS
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK**

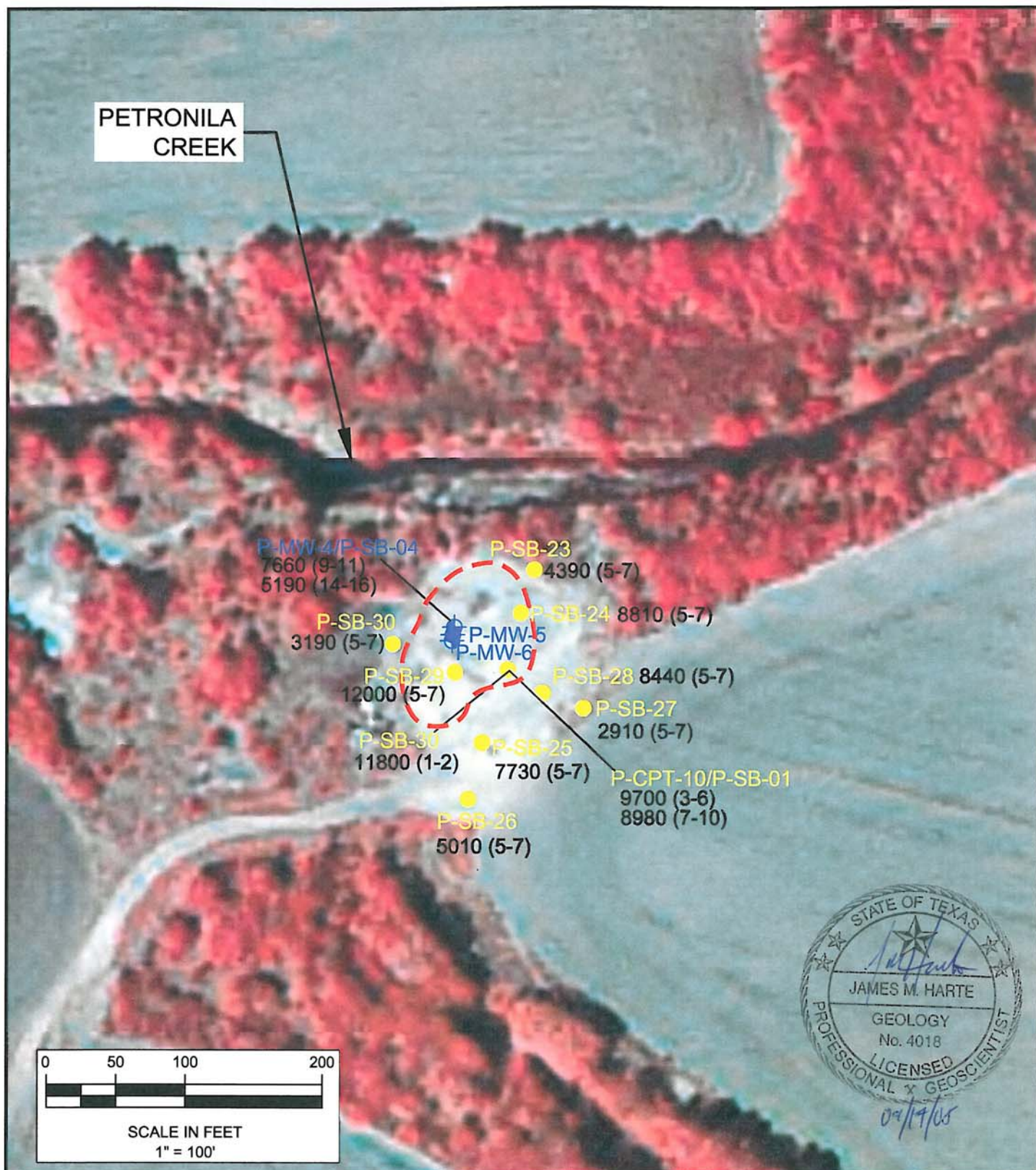
PROJECT NO.	160551	DWG FILE	160551-2-9
DRAWN BY.	CL	DATE	6/13/08



505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 328-6080

FIGURE

2-9



EXPLANATION:

- EXTENT OF ELEVATED CONDUCTIVITY CONCENTRATIONS
- 3190 (1-2) CONDUCTIVITY IN umhos/cm (SAMPLE DEPTH IN FEET)
- MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



SITE MAP - AREA 2
CONDUCTIVITY CONCENTRATIONS
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

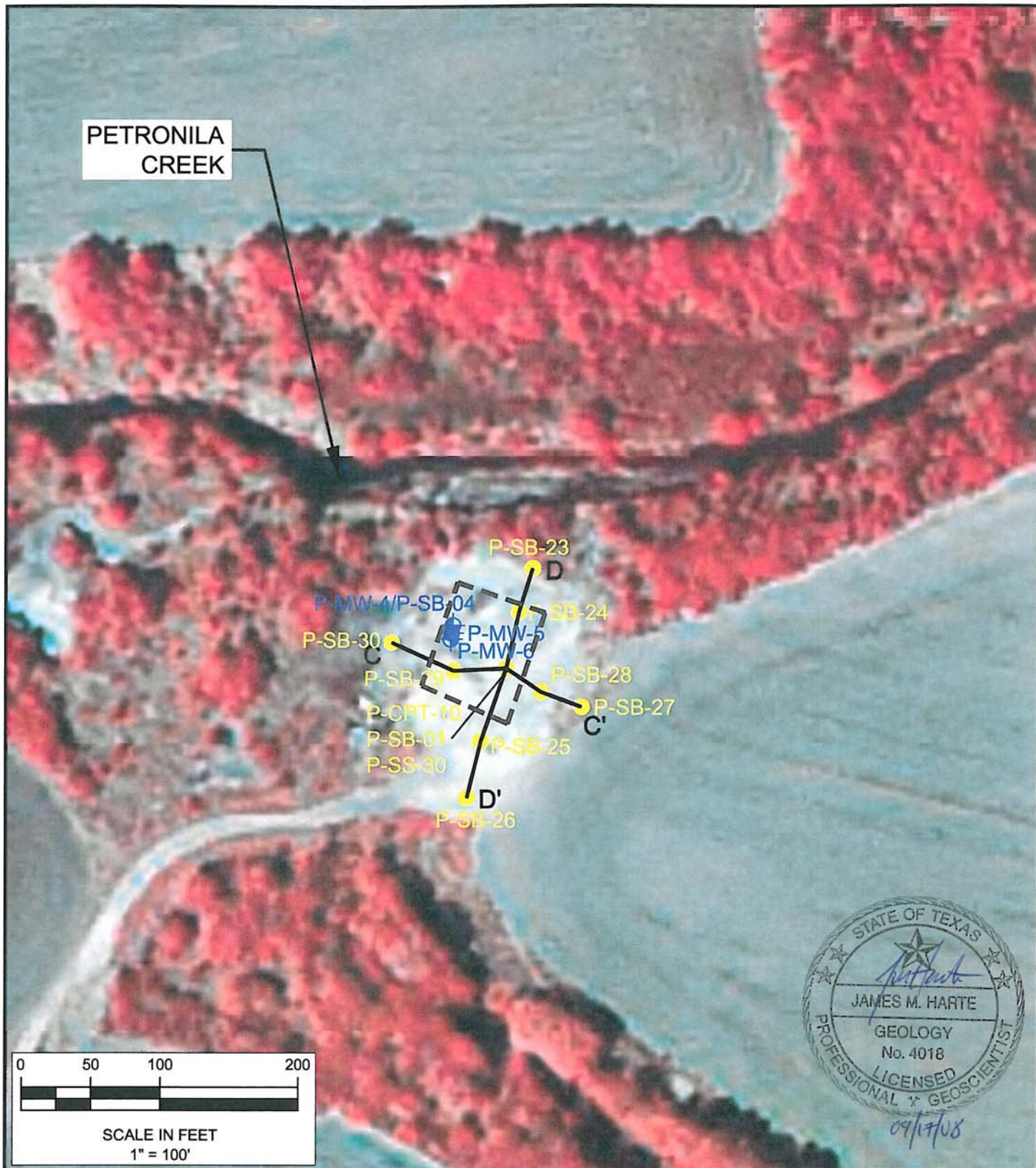
PROJECT NO.	160551	DWG FILE	160551-2-10
DRAWN BY.	CL	DATE	6/13/08



505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE

2-10



EXPLANATION:

- MONITORING WELL
- SOIL BORING
- AREA OF HIGHEST CONCENTRATION

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



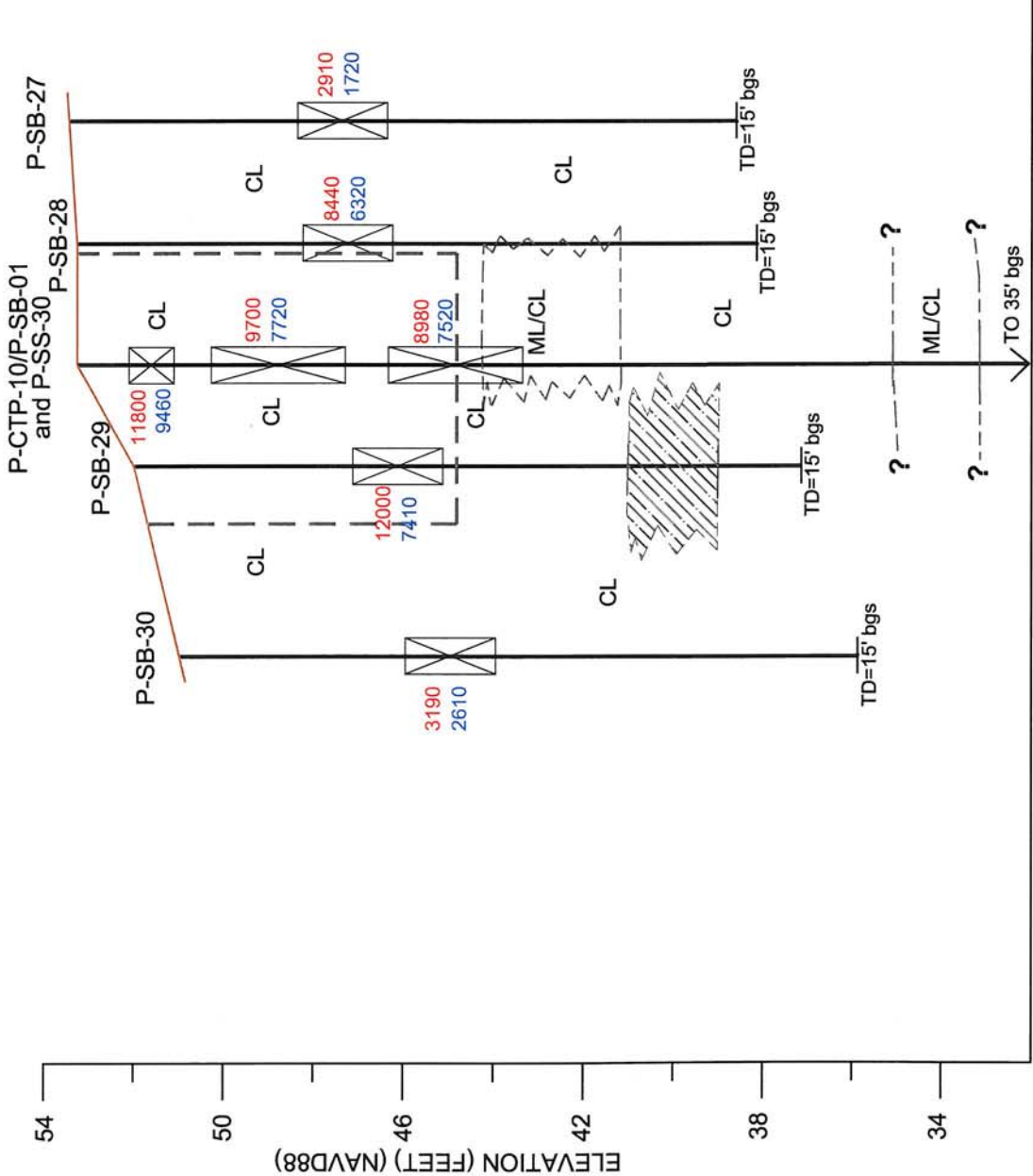
AREA 2
CROSS SECTIONS C-C' AND D-D'
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-11
DRAWN BY.	CL	DATE	7/23/08

505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE
2-11

C WEST **C'** EAST



AREA 2 CROSS-SECTION C-C' RAILROAD COMMISSION OF TEXAS PETRONILA CREEK			
PROJECT NO.	160551	DWG FILE	160551-2-12-XS-CC
DRAWN BY.	KS	DATE	7/22/08
		505 EAST HUNTLAND DRIVE SUITE 250 AUSTIN, TEXAS 78752 (512) 329-6080	
FIGURE			2-12

EXPLANATION:

- SAMPLE INTERVAL
- SATURATED ZONES IDENTIFIED FROM FIELD OBSERVATION
- CONDUCTIVITY (reported in umhos/cm)
- CHLORIDE (reported in mg/kg)
- AREA OF HIGHEST CONCENTRATION

SCALE:
 VERTICAL: 1" = 4'
 HORIZONTAL: 1" = 45'
 VERTICAL EXAGGERATION = 22.5X

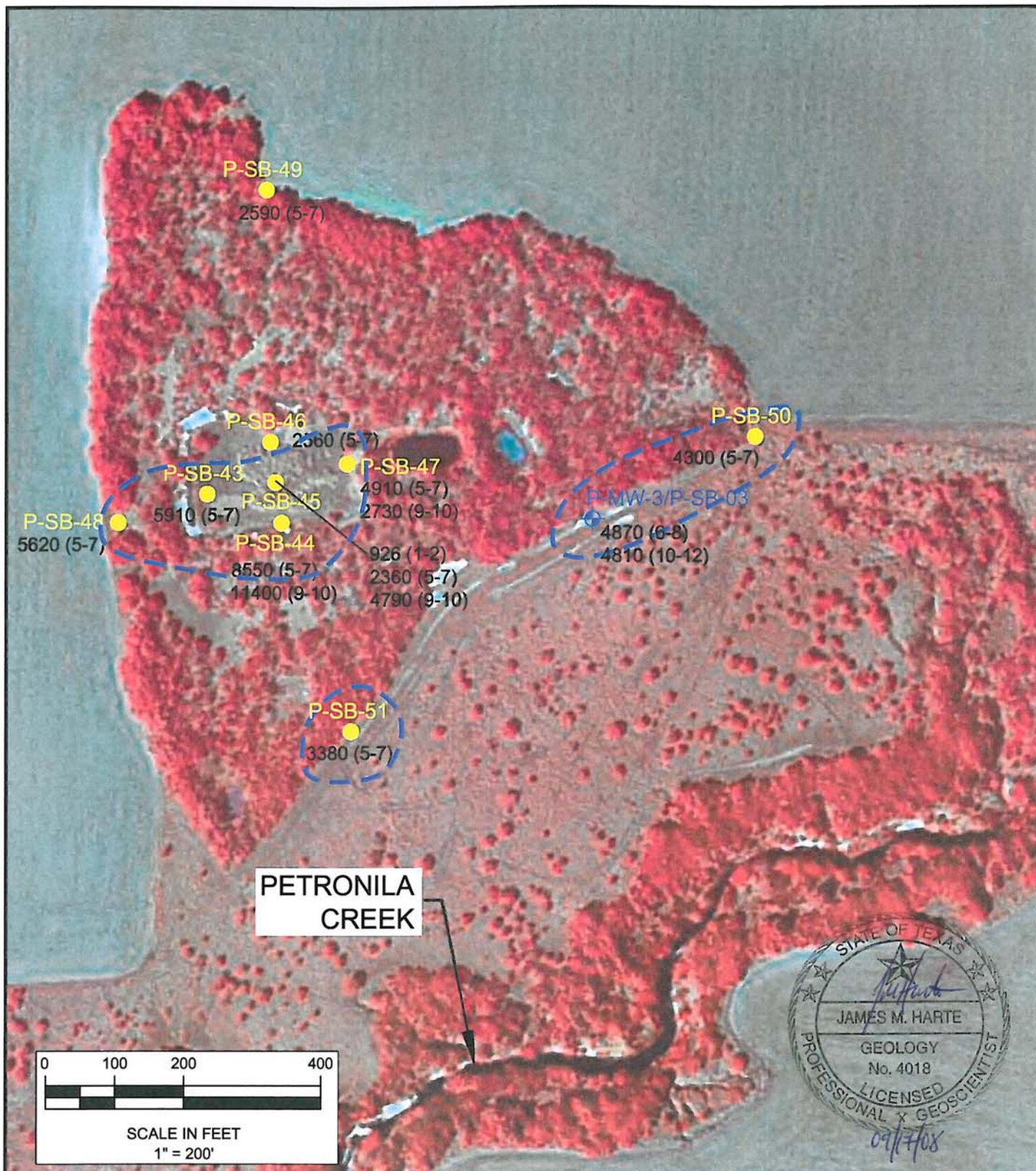
LITHOLOGY:
 CL - LEAN CLAY
 ML - SILT

TD = TERMINAL SOIL BORING DEPTH
bgs = BELOW GROUND SURFACE

D NORTH



FIGURE
2-13



EXPLANATION:

- EXTENT OF ELEVATED CHLORIDE CONCENTRATIONS
- 926 (1-2) CHLORIDE CONCENTRATION IN mg/kg (SAMPLE DEPTH IN FEET)
- MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.

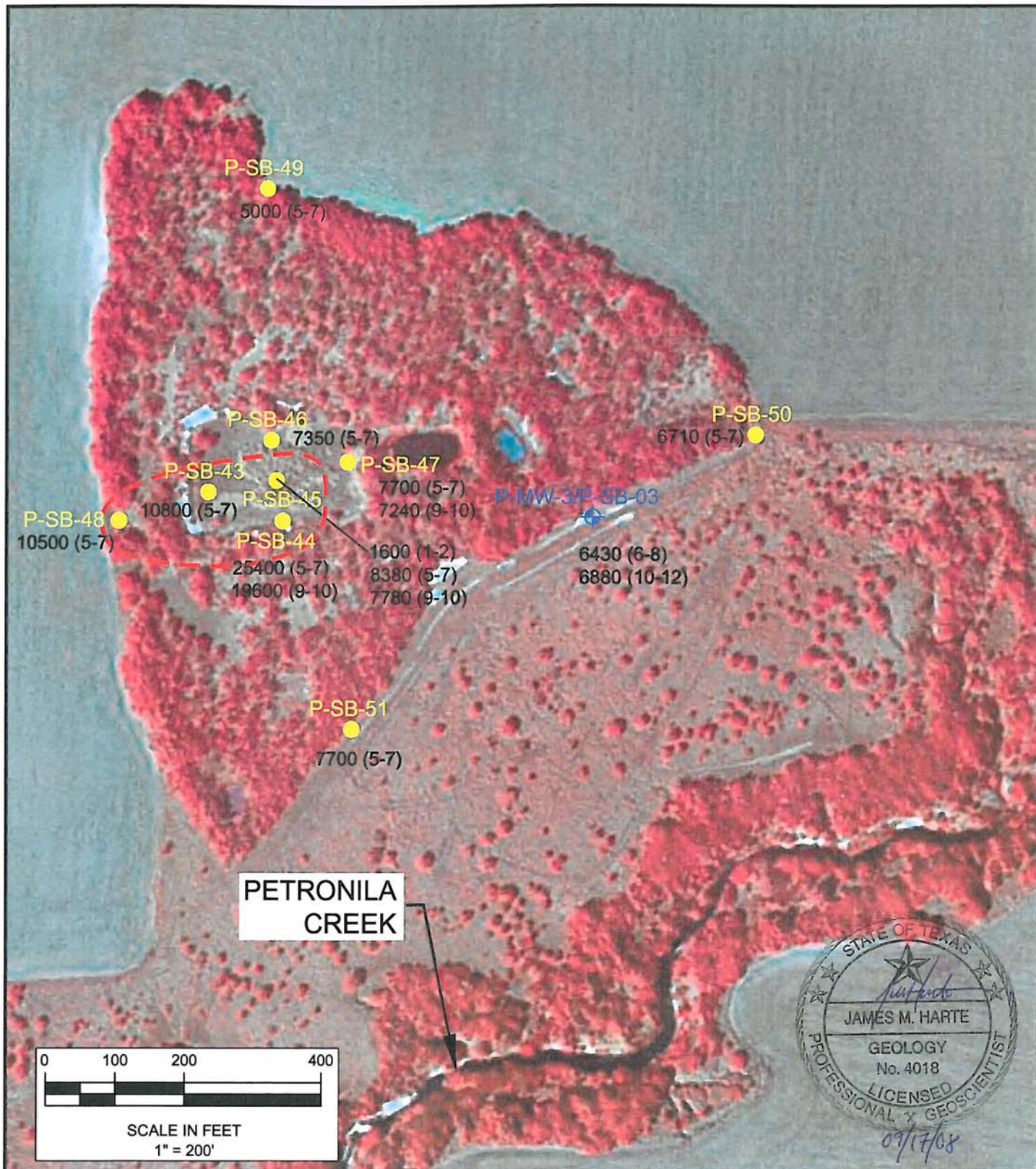


SITE MAP - AREA 3
CHLORIDE CONCENTRATIONS
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-14
DRAWN BY.	CL	DATE	6/13/08

TRC 505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 328-6080

FIGURE
2-14



EXPLANATION:

- EXTENT OF ELEVATED CONDUCTIVITY CONCENTRATIONS
- 1600 (1-2) CONDUCTIVITY IN umhos/cm (SAMPLE DEPTH IN FEET)
- + MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.

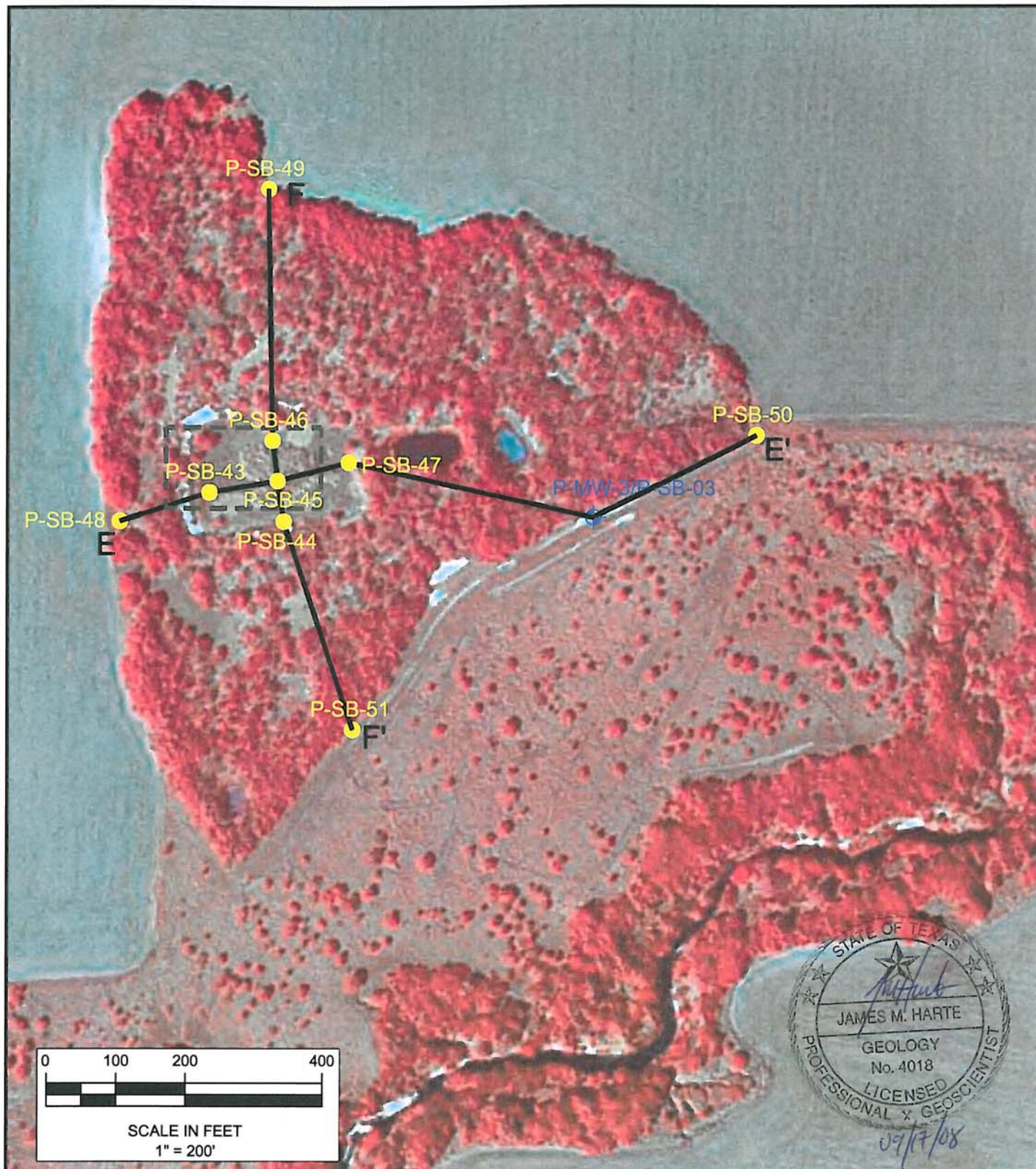


SITE MAP - AREA 3
CONDUCTIVITY CONCENTRATIONS
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-15
DRAWN BY.	CL	DATE	6/13/08

TRC 505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE
2-15



EXPLANATION:

- MONITORING WELL
- SOIL BORING
- AREA OF HIGHEST CONCENTRATION

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



AREA 3
CROSS SECTIONS E-E' AND F-F'
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-16
DRAWN BY.	CL	DATE	7/24/08

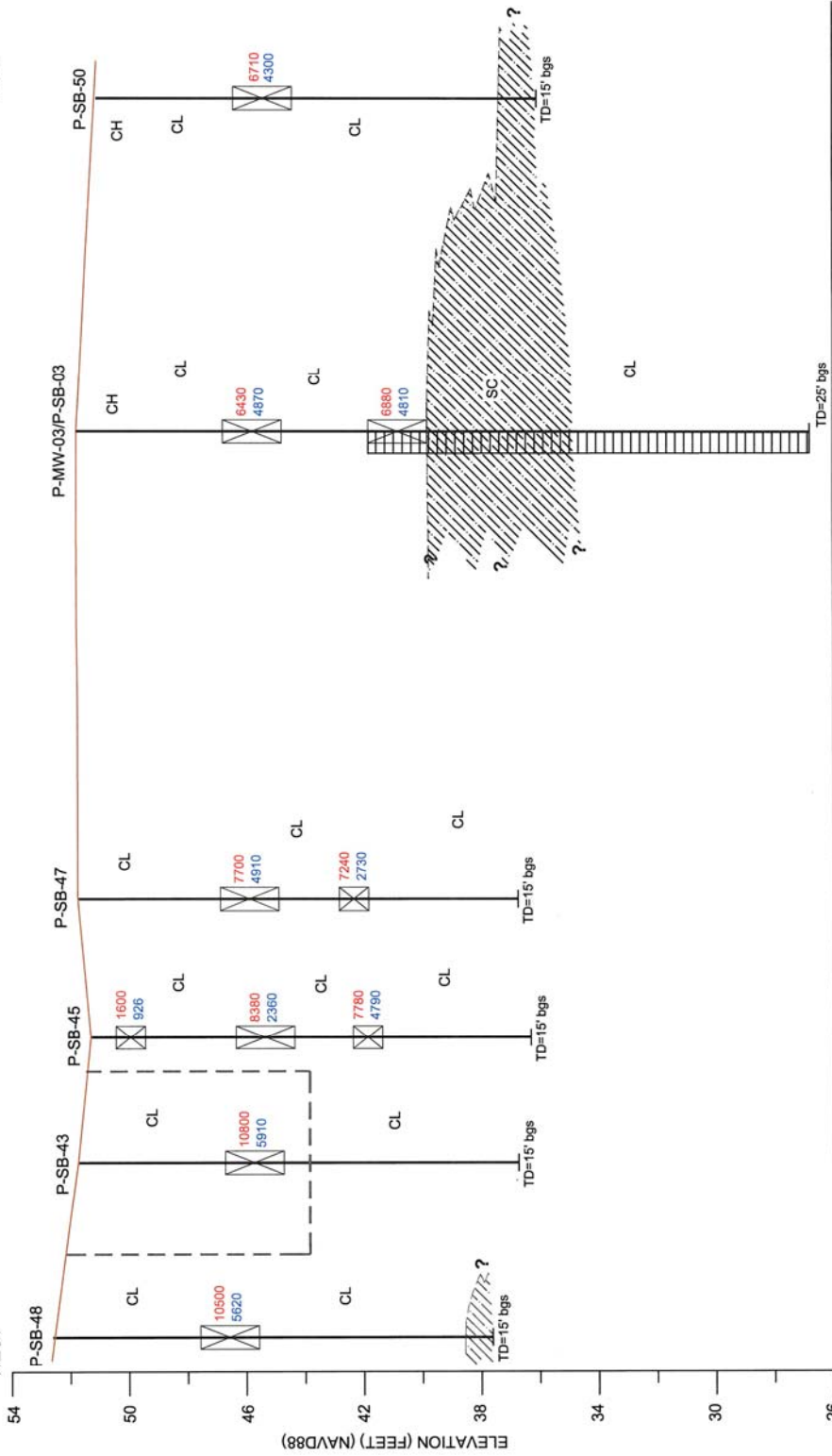
505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE

2-16

E' EAST

E WEST



EXPLANATION:

- SAMPLE INTERVAL
- MONITORING WELL SCREEN INTERVAL
- SATURATED ZONES IDENTIFIED FROM FIELD OBSERVATION
- CONDUCTIVITY (reported in umhos/cm)
- CHLORIDE (reported in mg/kg)
- AREA OF HIGHEST CONCENTRATION

LITHOLOGY:

- CL - LEAN CLAY
- CH - FAT CLAY
- SC - CLAYEY SAND

SCALE:

- VERTICAL : 1" = 4'
- HORIZONTAL : 1" = 90'
- VERTICAL EXAGGERATION = 22.5X

AREA 3

CROSS-SECTION E-E'

RAILROAD COMMISSION OF TEXAS

PETRONILA CREEK

PROJECT NO. 160551 DWG FILE 160551-2-17(A3XS-EE)

DRAWN BY: KS DATE 7/24/08

505 EAST HUNTLAND DRIVE

AUSTIN, TEXAS 78752

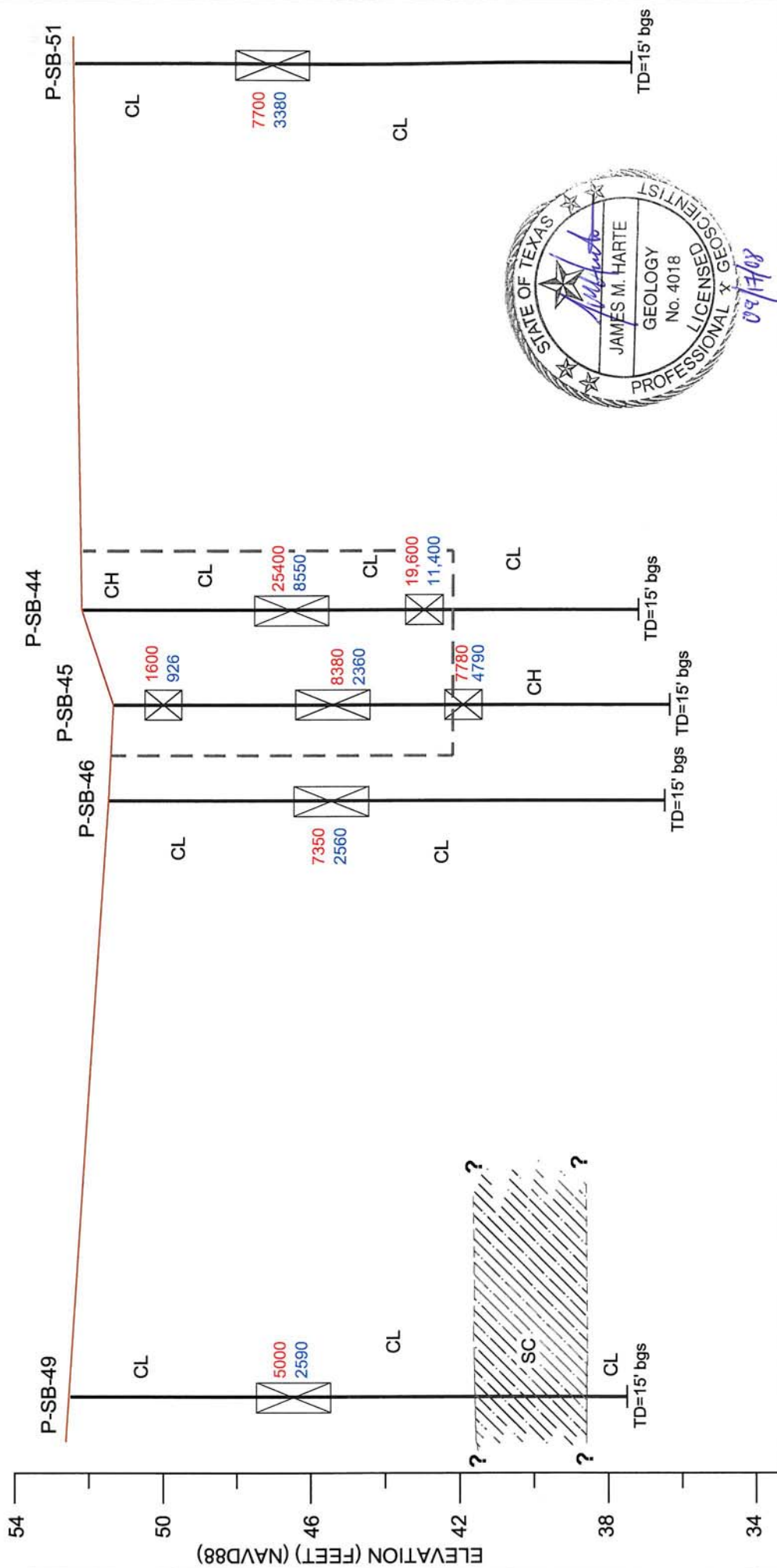
(512) 339-6080

FIGURE 2-17



F NORTH

F' SOUTH



EXPLANATION:

☒ SAMPLE INTERVAL

▨ SATURATED ZONES IDENTIFIED FROM FIELD OBSERVATION

CONDUCTIVITY (reported in umhos/cm)

CHLORIDE (reported in mg/kg)

AREA OF HIGHEST CONCENTRATION

TD = TERMINAL SOIL BORING DEPTH
bgs = BELOW GROUND SURFACE

SCALE:

VERTICAL : 1" = 4'

HORIZONTAL : 1" = 90'

VERTICAL EXAGGERATION = 22.5X

LITHOLOGY:

CL - LEAN CLAY

CH - FAT CLAY

SC - CLAYEY SAND

AREA 3

CROSS-SECTION F-F'

RAILROAD COMMISSION OF TEXAS

PETRONILA CREEK

PROJECT NO. 160551 DWG FILE 160551-2-18 (A3--XSFF)

DRAWN BY. KS DATE 7/23/08

505 EAST HUNTLAND DRIVE

SUITE 250

AUSTIN, TEXAS 78752

(512) 329-6080

FIGURE

2-18



EXPLANATION:

- EXTENT OF ELEVATED CHLORIDE CONTAMINATION
- 148 (5-7) CHLORIDE CONCENTRATION IN mg/kg (SAMPLE DEPTH IN FEET)
- + MONITORING WELL
- SOIL BORING


SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



SITE MAP - AREA 4 CHLORIDE CONCENTRATIONS RAILROAD COMMISSION OF TEXAS PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-19
DRAWN BY.	CL	DATE	6/13/08

	505 EAST HUNTLAND DRIVE	FIGURE
	SUITE 250	
AUSTIN, TEXAS 78752		
(512) 329-6080		



EXPLANATION:

2720 (5-7) CONDUCTIVITY IN umhos/cm (SAMPLE DEPTH IN FEET)

- ⊕ MONITORING WELL
- SOIL BORING

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



SITE MAP - AREA 4
CONDUCTIVITY CONCENTRATIONS
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-20
DRAWN BY.	CL	DATE	6/13/08



505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE
2-20



EXPLANATION:

- MONITORING WELL
- SOIL BORING
- AREA OF HIGHEST CONCENTRATION

SOURCE

USDA-FSA-APFO DIGITAL ORTHOPHOTO QUARTER QUAD (DOQQ) DRISCOLL EAST SW (2004), TEXAS DOQQ.



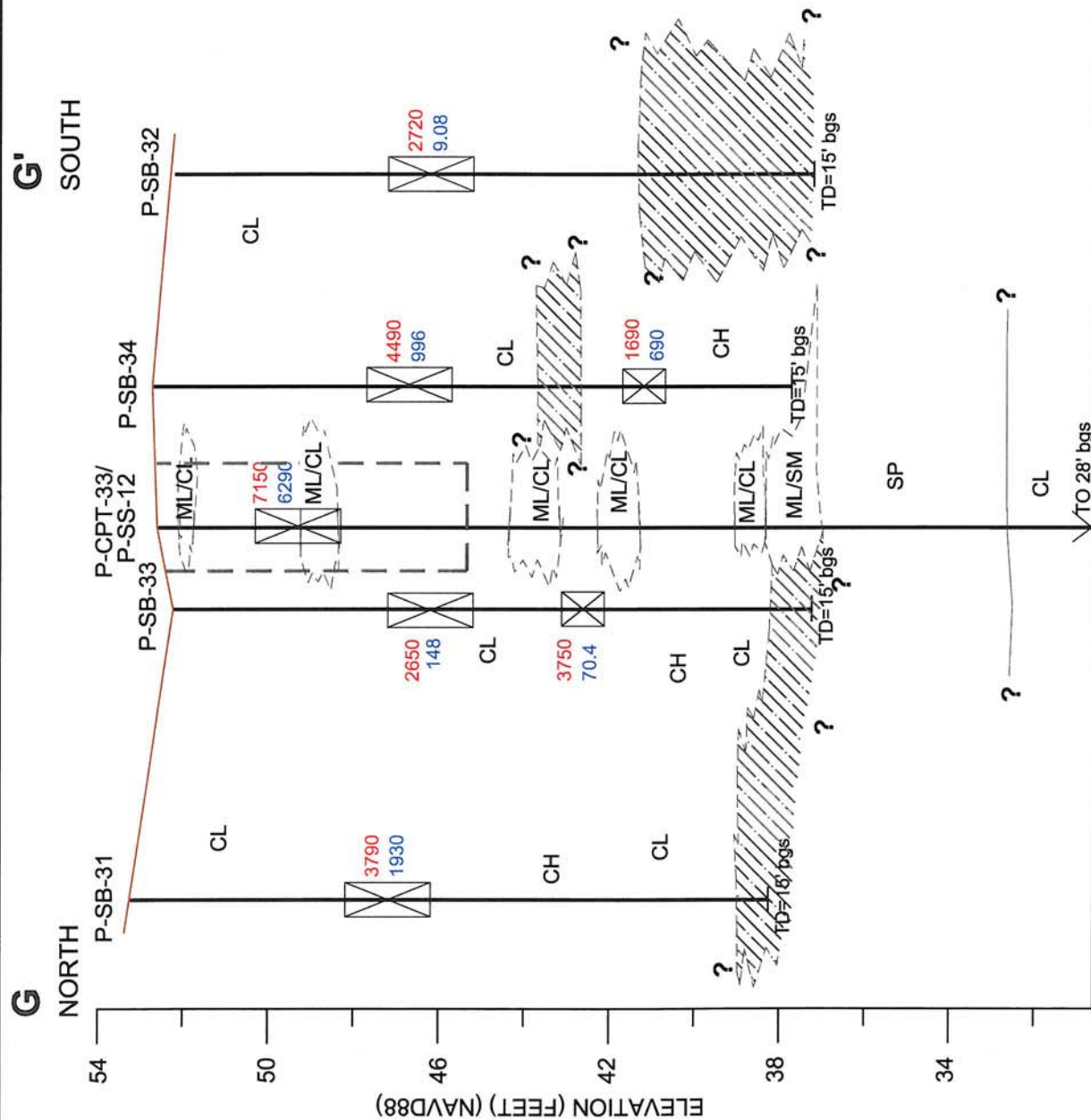
AREA 4
CROSS SECTION G-G'
RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE	160551-2-21
DRAWN BY.	CL	DATE	7/23/08

505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080

FIGURE

2-21



AREA 4

CROSS-SECTION G-G'

RAILROAD COMMISSION OF TEXAS
PETRONILA CREEK

PROJECT NO.	160551	DWG FILE 160551-2-22(A4XS-GG)
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DRAWN BY:	KS	DATE	7/23/08
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505 EAST HUNTLAND DRIVE
SUITE 250
AUSTIN, TEXAS 78752
(512) 329-6080



EXPLANATION:

SAMPLE INTERVAL

SATURATED ZONES IDENTIFIED FROM FIELD OBSERVATION

CONDUCTIVITY (reported in umhos/cm)
CHLORIDE (reported in mg/kg)

AREA OF HIGHEST CONCENTRATION

TD = TERMINAL SOIL BORING DEPTH
bgs = BELOW GROUND SURFACE

LITHOLOGY:

CL - LEAN CLAY

CH - FAT CLAY

ML - SILT

SM - SILTY SAND

SCALE:
VERTICAL
HORIZONTAL
VERTICAL

SP - POORLY GRADED SAND