GW-028

RO Reject Water Fields Site Investigation Work Plan

November 20, 2013

HOLLYFRONTIER
THE HOLLYFRONTIER COMPANIES

Mr. Carl Chavez
New Mexico Energy, Minerals and Natural Resources Department
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

November 20, 2012

RE: Submittal of the *Reverse Osmosis Reject Water Discharge Fields Site Investigation Work Plan*

Dear Mr. Chavez:

Enclosed is the *Reverse Osmosis Reject Water Discharge Fields Site Investigation Work Plan*. This document is being submitted in response to Section 6 of the Discharge Permit GW-028. As requested in the permit, this work plan outlines a soil and groundwater investigation of the fields where reverse osmosis water is discharged.

If you have any questions or comments regarding this report, please feel free to contact me at 575-746-5382.

Sincerely,

Robert Combs
Environmental Specialist
Navajo Refining Company, LLC

c: Pamela R. Krueger, ARCADIS

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Artesia Refinery

Reverse Osmosis Reject Water Discharge Fields Site Investigation Work Plan
OCD Discharge Permit GW-028

November 2012

ARCADIS

Pamela R. Krueger
Senior Project Manager, ARCADIS

Reverse Osmosis Reject Water Discharge Fields Site Investigation Work Plan

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November 20, 2012

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Acronyms and Abbreviations

ft bgs	feet below ground surface
CSM	Conceptual Site Model
CL	Lean Clay
CH	Fat Clay
CA	Caliche
COCs	Constituents of Concern
DRO	Diesel Range Organics
FWGMWP	Facility Wide Groundwater Monitoring Work Plan
ft/ft	feet per foot
GC	Clayey Gravel
GP	Poorly-graded Gravel
GW	Well-graded Gravel
GWQCC	Groundwater Quality Control Commission
HFC	Holly Frontier Corporation
HWB	Hazardous Waste Bureau
msl	mean sea level
mg/L	milligrams per liter
mm	millimeter

ML	Silt
Navajo	Navajo Refining Company
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
OCD	Oil Conservation Division
oz	ounce
PID	Photo-ionization Detector
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RCRA Permit	RCRA Post-Closure Care Permit
Refinery	Artesia Refinery located in Artesia, New Mexico
RO	Reverse Osmosis
SC	Clayey Sand
SM	Silty Sand and Silty Gravel
SP	Poorly-graded Sand
SW	Well-graded Sand
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
VOCs	Volatile Organic Compounds

1. Introduction

The Navajo Refining Company (Navajo) is a subsidiary of the Holly Frontier Corporation (HFC). Navajo owns and operates the Artesia Refinery, which is located in Artesia, New Mexico (Refinery). Figure 1 shows the location of the Refinery. The Refinery has been in operation since the 1920's and processes crude oil into asphalt, fuel oil, gasoline, diesel, jet fuel and liquefied petroleum gas.

Navajo operates a reverse osmosis (RO) unit that processes fresh water as a means to remove contaminants such as minerals and salts. The fresh water is a blend of fresh groundwater and publicly supplied water from the City of Artesia. This unit is a pretreatment step in the production of cooling tower makeup water and boiler grade feedwater. The RO unit produces two effluent streams: the RO permeate stream, which is the purified water, and the RO reject water stream, which contains the concentrated salts and minerals that cannot pass through the RO membranes. The RO reject water stream is discharged to the surface of one of two vacant fields located northeast of the refinery operations areas to water native grass in those fields. This discharge occurs in accordance with the April 1993 approved Discharge Permit GW-028 (GW-028), issued by the State of New Mexico Energy, Minerals and Natural Resource Department Oil Conservation Division (OCD).

On August 22, 2012, OCD issued a renewal and update to GW-028 for the Refinery. Section 6.D.2 of GW-028 requires the submittal of a site investigation work plan for the two RO reject water discharge fields. The work plan is required to be submitted within 90 days of the issuance of the renewal of GW-028. This document comprises the required work plan for the site investigation.

2. Site Description

2.1 Site History and Description

Navajo operates a 100,000 barrel-per-day petroleum Refinery located at 501 East Main Street in the city of Artesia, Eddy County, New Mexico. The Refinery has been in operation since the 1920's and processes crude oil into asphalt, fuel oil, gasoline, diesel, jet fuel, and liquefied petroleum gas. The Refinery is an active, growing industrial facility. There are no plans to close the Refinery or reduce the size of the operation. This section of the work plan provides a description of the site and site history.

Figure 1 shows the location of the Refinery in relation to the town of Artesia, New Mexico. As can be seen in Figure 1, the Refinery is located on the eastern side of Artesia, New Mexico. The area to the north, south and east of the Refinery is used primarily for agricultural and ranching purposes, while the area to the west, southwest and northwest of the Refinery consists of business and residential districts.

Figure 2 depicts the boundaries of the active Refinery, the boundary of property owned by Navajo, and nearby features. Figure 2 also depicts the boundary of property owned by Montana Refining Company, which is also a subsidiary of HFC.

As shown in Figure 2, the two RO reject fields are located to the northeast of the Refinery process areas, within the boundary of property owned by Navajo. The south RO reject field is located adjacent to and south of Eagle Creek, an arroyo that drains stormwater from the City of Artesia. The north RO reject field is located adjacent to and north of Eagle Creek.

2.2 Surface Conditions

2.2.1 Area Land Uses

The primary business and residential areas of the City of Artesia are located to the west, southwest and northwest of the Refinery. There are a few commercial businesses south of the Refinery along Highway 82, including an oil-field pipe company located at the southeast corner of the plant. Much of the property for one-half mile north to East Richey Avenue and east toward Bolton Road is owned by HFC, as shown in Figure 2.

The active Refinery and much of the surrounding property owned by HFC is fenced and guarded with controlled entry points.

2.2.2 Topography

The Refinery is located on the east side of the City of Artesia in the broad Pecos River Valley of Eastern New Mexico. The topography of the site and surrounding areas is shown in Figure 1. The average elevation of the city is 3,380 feet above mean sea level (msl). The plain on which Artesia is located slopes eastward at about 20 feet per mile.

2.2.3 Surface Water Drainage Features

Surface drainage in the area is dominated by small ephemeral creeks and arroyos that flow eastward to the Pecos River, located approximately three miles east of the city. The major drainage for the immediate area of the Refinery is Eagle Creek (or Eagle Creek), an ephemeral watercourse normally flowing only following rain events, that runs southwest to northeast through the northern process area of the Refinery and then eastward to the Pecos River. The RO reject fields are located on either side of Eagle Creek.

Upstream of the Refinery, Eagle Creek functions as a major stormwater conveyance for the community. It also drains outlying areas west of the city and is periodically scoured by intense rain events. The elevation of Eagle Creek is 3,360 feet at its entrance to the Refinery and decreases to approximately 3,305 feet at its confluence with the Pecos River. Eagle Creek was channelized from west of Artesia to the Pecos River to help control and minimize flood events. In the vicinity of the Refinery, the Eagle Creek channel was cemented to provide further protection during flood events. A check dam was also constructed west of Artesia along Eagle Creek. At this time, federal floodplain maps indicate that most of the city and the Refinery have been effectively removed from the 100 year floodplain.

Both of the RO reject fields are sloped toward the northeast. The south RO reject field is surrounded by earthen berms to prevent surface runoff. The north RO reject field is surrounded by an elevated dirt road that limits surface runoff from this field.

2.3 Subsurface Conditions Identified During Previous Investigations

Navajo has performed multiple soil and groundwater investigation activities as required by a Resource Conservation and Recovery Act (RCRA) Post-Closure Care Permit (RCRA Permit) administered by the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB). The following subsections describe the subsurface conditions identified at the Refinery as a result of previous investigations as well as a review of available literature.

2.3.1 Regional Soils

Soils at the Refinery are primarily of the Pima and Karro series. Soils were historically characterized during permitting and found to be about 60% Pima and 40% Karro soils. The Pima and Karro soils have similar properties. Pima soils are deep, well drained, dark colored, calcareous soils, which occur on floodplains of narrow drainageways (e.g. – Eagle Creek). These soils have moderate shrink-swell potential and were subject to periodic flooding. Runoff from Pima soils is slow, permeability is moderately low and the water-holding capacity is high. The effective rooting depth is greater than five feet and the water table is deeper than five feet.

The Karro soils are highly calcareous. Calcium carbonate typically accumulates as caliche at a depth of about 45 inches. These soils are found on level to gently sloping terrains and are susceptible to wind erosion. Runoff is slow and water-holding capacity is high. Permeability is moderate and the effective rooting depth and depth to groundwater are both over five feet.

2.3.2 Regional Geology

The Refinery is located on the northwest shelf of the Permian Basin, in the Roswell Basin. In this region, the deposits are comprised of approximately 250 to 300 feet of Quaternary alluvium unconformably overlying approximately 2,000 feet of Permian clastic and carbonate rocks. These Permian deposits unconformably overlie Precambrian syenite, gneiss and diabase crystalline rocks. The relationships between the sedimentary deposits are discussed below.

2.3.2.1 Quaternary Alluvium

The Quaternary alluvium in the Refinery area is dominantly comprised of clays, silts, sands and gravels deposited in the Pecos River Valley. These “valley fill” deposits extend in a north-south belt approximately 20 miles wide, generally west of the Pecos River. The thickness of the valley fill varies from a thin veneer on the western margins of the Pecos River valley to a maximum of 300 feet in depressions, one of which is located beneath the Refinery. These depressions have resulted from dissolution of the underlying Permian carbonates and evaporites. The sedimentology and mineralogy of the valley fill deposits can be divided into three units: the uppermost carbonate gravel unit, the interbedded clay unit, and the underlying quartzose unit.

The carbonate gravel unit blankets the other valley fill units and forms a fairly uniform slope from the Permian rock outcrop areas on the west side of the Permian Valley east to the Pecos River floodplain. The unit consists of coarse-grained carbonate gravel deposits along major drainage ways to the Pecos River, which grade into brown calcareous silts and thin masses of caliche in the interstream regions. The carbonate gravel unit includes the Orchard Park, Blackdom and Lakewood terrace deposits as well as Holocene and Pleistocene Pecos River alluvial deposits.

The agricultural land around Artesia is part of the Orchard Park terrace deposit, which forms a thin veneer overlying older valley fill alluvium. The Orchard Park terrace surface gently rises in elevation to between 5 and 25 feet above the Lakewood terrace. The Orchard Park is generally less than 20 feet in thickness in the Refinery area and is comprised of silt interbedded with poorly sorted lenses of mixed size pebbles in a silt and sand matrix. Chalky caliche commonly occurs in the upper layers.

The Blackdom terrace is about 40 to 50 feet in elevation above the Orchard Park terrace west of Artesia. However, the deposits associated with the Blackdom terrace are generally less than 20 feet in thickness. The Blackdom terrace deposits are coarser grained than the deposits associated with the Orchard Park and Lakewood terraces. In addition, the caliche soils have a higher density than those developed on the Orchard Park terrace.

The Lakewood deposits, the lowest of the three terrace units, are essentially the current alluvial sediments in the floodplain along the river. They consist of brown sandy silt interbedded with lenses of gravel and sand and some localized caliche in higher parts. The Lakewood terrace is confined to the area immediately adjacent to the river and is underlain by Pleistocene alluvium deposited by the Pecos River and its tributaries.

The clay unit is not laterally continuous throughout the valley fill deposits, but occurs in isolated lenses generally overlying the quartzose unit. The clay unit is comprised of light-to-medium-gray clays and silts deposited in localized ponds and lakes. These ponds and lakes may have formed in conjunction with dissolution and collapse of the underlying Permian rocks.

The quartzose unit consists primarily of fragments of quartz and igneous rocks cemented by calcium carbonate. This unit is laterally contiguous throughout the Pecos River Valley and is generally less than 250 feet thick. The quartzose unit unconformably overlies Permian Rocks and lower quartzose gravels are commonly used for groundwater production.

2.3.2.2 Permian Artesian Group

The Permian Artesian Group is comprised of five formations (from shallowest to deepest): the Tansill, Yates, Seven Rivers, Queen and Grayburg Formations. The Tansill and Yates Formations outcrop at the surface east of the Pecos River and are not present in the vicinity of the Refinery.

The uppermost Permian formation in the Artesia area is the Seven Rivers Formation, which outcrops east of the Pecos River. This eastward-dipping formation is eroded and buried by the valley fill alluvium at a depth of 300 feet in the area between the river and the Refinery. Nearer the Refinery, the formation thins and disappears farther west. Where the formation is present, it consists of a sequence of evaporites, carbonates, gypsum and shale with isolated sand and fractured anhydrite/gypsum lenses.

An examination of available borehole logs by IT Corporation, in the mid-1980s provided no indication that the Seven Rivers formation has been encountered beneath the Refinery. However, the lithologic logs of wells completed in the Refinery area describe unconsolidated alluvial deposits from depths of about 20 feet to over 250 feet.

In the area of the Refinery, the Queen and Grayburg Formations have been mapped as a single unit by geologists as consisting of about 700 feet of interbedded dolomite and calcareous dolomite, gypsum, fine-grained sandstone, carbonates, siltstone and mudstone. In locations where the Seven Rivers Formation is absent, the upper portion of the Queen Formation acts as a confining bed between the deep artesian aquifer and the valley fill zone.

2.3.2.3 San Andres Formation

The San Andres Formation lies beneath the Grayburg and Queen Formations and immediately above the Precambrian crystalline basement rocks. The San Andres Formation is composed mainly of limestone and dolomite containing irregularly and erratic solution cavities, which range up to several feet in diameter. Its thickness is greater than 700 feet. The upper portion of the formation is composed of oolitic dolomite with some anhydrite cement.

2.3.3 Regional Groundwater

The principal aquifers in the Artesia area are within the San Andres Formation and the valley fill alluvium. Figure 3 presents a conceptualization of the Roswell Basin aquifer and the aquifers within the basin.

In the vicinity of the Refinery process area, a near-surface water-bearing zone has been encountered which is apparently limited in vertical extent and is shallow with respect to the surface yet exhibits artesian properties at some monitoring wells. The deeper carbonate aquifer is referred to as the deep artesian aquifer, whereas the water-bearing zones of the shallower alluvial fill aquifer are referred to as the valley fill zone. Adjacent to the Refinery, the first water-bearing zone in the valley fill zone is referred to as the near-surface saturated zone.

On-going groundwater monitoring is conducted according to a Facility Wide Groundwater Monitoring Work Plan (FWGMWP) which includes requirements of GW-028 as well as the RCRA Permit. The FWGMWP is updated annually and submitted to both OCD and HWB for review and approval. Figure 4 shows the locations of groundwater monitoring wells, groundwater recovery trenches, and irrigation wells that are installed within the Refinery and in the vicinity of the RO reject water discharge fields. Figure 4 also shows the frequency of sample collection from the monitoring wells, according to the June 2012 update to the FWGMWP (ARCADIS, 2012).

2.3.3.1 Shallow Saturated Zone

Lithologic logs from monitor wells installed in and near the Refinery process area document a shallow saturated zone overlying the main valley fill alluvium and containing water of variable quality in fractured caliche and sand and gravel lenses at depths of 15 to 30 feet below ground surface (ft bgs). This water is under artesian pressure for at least some or most of the year with static water levels 3 to 5 feet above the saturated zones. The most probable sources of the water are thought to be recharge from Eagle Creek and lawn watering runoff from the grass-covered urban park that occupies the Eagle Creek Channel immediately upstream of the Refinery.

The water in the shallow saturated zone is highly variable in quality, volume, areal extent and saturated thickness. Concentrations of total dissolved solids (TDS) exceeding 2,000 milligrams per liter (mg/L) and sulfate exceeding 500 mg/L have been recorded on the northwest side of the Refinery.

2.3.3.2 Valley Fill Zone

Quaternary alluvial deposits of sand, silt, clay and gravel are the main components of the valley fill zone. These sediments are about 300 feet thick in the area between the City of Artesia near the Refinery and the Pecos River. The three principal units in the valley fill are the carbonate gravel, clay and quartzose.

The carbonate gravel unit, described in an earlier section, is the uppermost alluvial unit in the valley fill. Coarse-grained gravels deposited in the major tributaries to the Pecos River grade to calcareous silts and thin zones of caliche in the interstream areas. Near the surface, groundwater is localized in thin discontinuous gravel beds typical of braided channel material deposited during flood events originating in the foothills and Sacramento Mountains to the west.

Wells completed in the valley fill zone typically are screened across from one to five water-producing zones. Thicknesses of up to 170 feet have been reported for water-production zones, but most are less than 20 feet. Producing zones are principally sand and gravel separated by less permeable lenses of silt and clay. Wells in the valley fill range from 40 to 60 ft bgs and the formation yields water containing 500 to 1,500 mg/L TDS. The average transmissivity of the alluvium has been estimated at 100,000 to 150,000 gallons per day per square foot.

Recharge of the valley fill zone is generally attributed to irrigation return flow from pumpage of the aquifers and from infiltration from the Pecos River. In areas of the valley where the San Andres and valley fill zones are hydraulically connected in the subsurface, water tends to flow up from the deep to the shallow saturated zone except in areas of heavy San Andres pumpage. The general direction of groundwater flow in the valley fill zone follows the regional stratigraphic dip eastward toward the Pecos River, then southward subparallel to the river.

North of Artesia, the river has been a gaining stream for most of the period of record. The potentiometric surface of the shallow saturated zone slopes gently east and southeast, following regional stratigraphic dips. However, south of Artesia in the vicinity and immediately east of Highway 285, heavy pumping between 1938 and 1975 reversed the hydraulic gradient. In this area the surface forms a shallow trough due to extensive water use for irrigation.

Adjacent to the Pecos River, the valley fill zone contains groundwater beginning at a depth of 6 to 12 feet. The alluvium is predominately silty sand, which possibly contains lenses of higher permeability material. Groundwater flow is subparallel to the Pecos River Valley and is generally toward the river, although during periods of high river flow, the hydraulic gradient may be away from the river into the alluvium.

Silt and clay deposits in the valley fill zone are not continuous, but occur as isolated lenses, generally overlying the quartzose unit. Most logs of wells located immediately to the north and east of the Refinery show considerable thicknesses of clays or clay mixtures. However, these clays may be more closely related to the fine-grained materials of the carbonate gravel unit found in the interstream areas between the major drainage ways.

The thickness of these clay/clay mixtures ranges from 20 to 160 feet. The intervals of occurrence differ from well to well, and thin zones or gravels are interspersed in the upper 100 feet. Drillers seeking deep artesian water drill through the valley fill zone and usually log large intervening zones as “clay and cap”. This lack of detail makes it difficult to correlate specific zones of coarse-grained sediments within the silt and clay deposits.

The quartzose unit is considered the primary production unit in the valley fill zone. Away from the Pecos River, the unit consists of fragments of sandstone, quartzite, quartz chert, igneous and carbonate rocks. The fragments range from medium grained (1/4 millimeter [mm]) to pebble size (16 mm) and are commonly cemented with calcium carbonate. By contrast, in the vicinity of the river, the unit contains principally medium to coarse uncemented quartz grains.

Seventeen monitoring wells have been installed in the valley fill zone in the vicinity of the Refinery and the evaporation ponds. The information available on the nearby irrigation wells indicate that at least two of those wells (RA-3156 and RA-3353) are screened in the valley fill zone. Historic analytical data from these wells does not indicate the presence of hydrocarbon impacts from refinery operations.

2.3.3.3 Deep Artesian Aquifer

The deep artesian aquifer is closely related to the Permian San Andres Limestone and generally consists of one or more water producing zones of variable permeability located in the upper portion of the carbonate rocks. However, in the Artesia area, the producing interval rises stratigraphically and includes the lower sections of the overlying Grayburg and Queen formations. Near the Refinery, the depth to the top of the producing interval is estimated to be about 440 feet. The Seven Rivers formation and the other members of the Artesia Group are generally considered confining beds although some pumpage occurs locally from fractures and secondary porosity in the lower Grayburg and Queen members.

The deep artesian aquifer has been extensively developed for industrial, municipal and agricultural use. The quality of water from this aquifer ranges from 500 mg/L to more than 5,000 mg/L TDS depending on location. In the Artesia area, water is generally derived from depths ranging from 850 to 1,250 ft bgs. The aquifer recharge is in the Sacramento Mountains to the west of Artesia. Extensive use of this aquifer in recent decades has lowered the potentiometric head in the aquifer in some locations from 50 to 80 ft bgs, although extensive rainfall in some years may bring the water levels in some wells close to the surface.

Information available for irrigation well RA-4798 indicates that it is screened at 840 to 850 ft bgs, in the deep artesian aquifer. Historic analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations.

2.4 Previous Investigations and Analyses

2.4.1 RO Reject Water Analyses

Because the RO reject water stream contains concentrated minerals and salts, the discharge is sampled and analyzed for chloride, fluoride, and sulfate on a routine basis. Currently, samples are collected from the RO reject water discharge and analyzed at least quarterly. Table 1 provides a summary of the RO reject water analytical results from 1992 through 2011. The RO reject water analyses are reported in the annual groundwater monitoring reports submitted to both OCD and HWB.

The concentrations of chloride, fluoride, and sulfate have been compared to the standards for groundwater containing 10,000 mg/L or less of TDS, as defined in section 20.6.2.3103 of the New Mexico Administrative Code (NMAC). Reported concentrations above the standard are highlighted in the table. As shown in Table 1, the concentrations of fluoride and sulfate have typically exceeded the groundwater standard throughout the reporting period. Chloride concentrations fluctuate, but periodically exceed the groundwater standard throughout the reporting period.

Figure 5 depicts the concentrations of chloride, fluoride and sulfate reported in the RO discharge samples from 1992 through 2012. A trend line is shown for each compound in the graphs. Chloride concentrations fluctuate, with a slight overall increase in concentration through time. Fluoride and sulfate concentrations show less fluctuation and in general have remained consistent through time.

2.4.2 Groundwater Analyses

Groundwater monitoring wells are located in the vicinity of the south RO reject field in all directions, as shown in Figure 4. One groundwater monitoring well (NP-9) is located within north RO reject field and one well (NP-5) is located to the northeast of the north RO reject field. Although there are no groundwater monitoring wells located within the south RO reject field, there are several wells located immediately upgradient or west of the field. Several wells are located downgradient or east of the south RO reject field that are sampled on a semiannual basis. Specifically, MW-45 and MW-56 are located at the northwestern corner of the south RO reject field while MW-29 is located immediately to the west or upgradient of the south RO reject field. KWB-1A is the closest monitoring well downgradient or east of the south RO reject field.

Table 2 provides a summary of the groundwater analytical results for samples collected from the monitoring wells in the immediate vicinity of the RO reject fields between 2003 and 2012. The monitoring program for these wells has changed throughout recent years and thus not all analytes were included in the monitoring program for all events. The data from the monitoring wells was compared to the groundwater standards and reported concentrations above the standards are highlighted in the table.

It should be noted that samples collected from the wells included in Table 2 are typically analyzed for volatile organic compounds (VOCs) in addition to the compounds included in Table 2. However, none of the samples collected from the monitoring wells have contained VOC concentrations above the laboratory detection limits or above the screening levels with the exception of benzene. Therefore, only benzene results are included in Table 2. Benzene concentrations above the laboratory detection limits have not been measured in these six wells since 2006.

In 2010, the FWGMWP was updated to include field filtering of metals samples at least once per year in order to measure the dissolved metals concentrations in addition to the total metals concentrations. The data presented in Table 2 includes only the total metals concentrations since there is more data available and this allows for a more thorough evaluation of the data trends.

Total petroleum hydrocarbons (TPH) diesel range organics (DRO) is present in the samples collected from monitoring wells MW-29, MW-45 and MW-56, all of which are upgradient of the south RO reject field. TPH DRO has not been reported above the screening level in NP-9, within the north RO reject field, or in NP-5 and KWB-1A (downgradient of the RO reject fields) with one exception. TPH DRO has been reported above the screening level only one time, in the sample collected from NP-5 in April 2008. All of the subsequent samples have been below the laboratory detection limits. The source of the TPH DRO in the wells upgradient of the south RO reject field is believed to be the known hydrocarbon impacts to groundwater within the Refinery.

Benzene was sporadically detected at concentrations above the screening level in five of these six wells prior to December 2006. However, none of the samples collected in December 2006 or during subsequent monitoring events have contained detectable concentrations of benzene. Therefore, benzene is not considered to be of concern in this area.

The reported concentrations for total metals in the samples collected from these six wells have all been below the screening levels, except for barium in the two samples collected in 2008 from MW-29. The barium concentrations reported for those two samples were significantly different from the barium concentrations reported for samples collected from MW-29 in 2007 and in the samples collected from MW-29 between 2009 and 2012. Therefore, these two results are believed to be anomalous and not representative of the barium concentration at this location. All of the remaining reported concentrations of metals from these six wells were either below laboratory detection limits or below the screening levels. Therefore, these metals are not considered to be of concern in this area.

Chloride, fluoride and sulfate concentrations in the monitoring well samples were consistently above the screening standards, with the exception of fluoride in samples collected from MW-56 and KWB-1A. Figures 6 through 11 depict the concentrations of chloride, fluoride and sulfate reported for each of the wells listed above from 2003 through 2012. A trend line is shown for each compound in the graphs, which indicate the following:

- Chloride concentrations show increasing trends in wells NP-5, NP-9, MW-45, MW-56, and KWB-1A. Chloride concentrations show a decreasing trend in MW-29.

- Fluoride concentrations show decreasing or stable trends in wells NP-5, NP-9, MW-29, MW-45 and MW-56. Fluoride concentrations show a slightly increasing trend in KWB-1A.

- Sulfate concentrations show decreasing or stable trends in wells NP-5, NP-9, MW-29, and KWB-1A. Fluoride concentrations show slightly increasing trends in MW-45 and MW-56.

Figures 12 through 14 illustrate the reported concentrations of chloride, fluoride, and sulfate from the RO reject discharge samples as well as the samples from wells NP-5, NP-9, MW-29, MW-45, MW-56 and KWB-1A from the last 10 years, respectively. As seen in Figure 12, the reported concentrations of chloride in the RO reject discharge is similar to the reported concentrations in the wells. Fluoride concentrations in the RO reject discharge are typically higher than the reported concentrations in the wells, while sulfate concentrations in the RO reject discharge are typically lower than the reported concentrations in the wells.

3. Site Conditions

3.1 Site Specific Lithology

Information obtained during various investigations of soil and groundwater required by the RCRA Permit has been compiled into a Conceptual Site Model (CSM) for the Refinery. Appendix A of this work plan contains excerpted figures from a document that presented the CSM. Figure A-1 depicts the plan view of locations of lithologic cross-sections used to develop the CSM. Only those lithologic cross-sections located within the area of the RO reject fields are included in Appendix A.

In developing the cross-sections, individual soil units that were described in the soil boring logs were grouped into more general hydrostratigraphic alluvial units for the CSM. Seven general hydrostratigraphic alluvial units are depicted in the cross-sections as:

Hydrostratigraphic Unit	USCS Symbols
CLAY/CALICHE	CL (lean clay), CH (fat clay), and CA (caliche)
CLAYEY/SILTY SAND	SC (clayey sand) and SM (silty sand)
SAND	SP (poorly-graded sand) and SW (well-graded sand)
SILT	ML (silt)
GRAVEL	GP (poorly-graded gravel) and GW (well-graded gravel)
CLAYEY/SILTY SAND	GC (clayey gravel) and SM (silty gravel)
FILL/ASPHALT	None

Cross-section A-A' (Figure A-2) was constructed along a line that is generally oriented from north to south, east of the north RO reject field, through the center of the south RO reject field, and along the eastern portion of the Refinery. This cross-section indicates the presence of clay and silt to a depth of approximately 25 ft bgs throughout the south RO reject field. A thin gravelly clay lens is present at about 24 to 25 ft bgs, as indicated by a soil boring located within the south RO reject field. A thin clayey sand lens was also present at a depth of approximately 10 ft bgs at MW-46R, which is located north of the south RO reject field near Eagle Creek. The overlying silt and clay undulates, creating intermittent confined groundwater conditions. None of the wells along this cross-section were completed in the underlying valley fill zone.

Cross-section E-E’ (Figure A-3) was constructed along a line that is generally oriented from west to east in the northwestern portion of the Refinery and passes through the center of the south RO reject field. Interbedded sand and gravel lenses are present at depths corresponding to the shallow saturated zone throughout most of this cross-section. The same thin gravelly clay lens is indicated within the south RO reject field. This cross-section indicates that this gravelly clay lens extends to the east and becomes shallower as the ground surface dips. At NP-2, which is located near Bolton Road, the gravelly clay lens is present at about 9 ft bgs.

Cross-section H-H’ (Figure A-4) was constructed along a line that is generally oriented from north to south approximately 800 feet west of cross-section A-A’, through the north RO reject field and extending southward along the western boundary of the south RO reject field and through the Refinery. The borings installed within the north RO reject field extended to depths between 23 and 30 ft bgs. No sand or gravel lenses were encountered in these borings. The cross-section indicates the presence of silt to a depth of approximately 7 to 8 ft bgs, underlain by clay. None of the wells along this cross-section were completed in the underlying valley fill zone.

3.2 Groundwater Flow

As shown in the stratigraphic cross-sections, the subsurface geology is complex, with numerous interbedded zones of sands and gravels overlain by lower conductive silts, clays, and caliche zones. Groundwater flows through these sand and gravel channels in braided channel flow. The overlying clays and clayey silts undulate, creating intermittent confined and unconfined groundwater conditions. As observed on the cross-sections, most of the well screens straddle the sand or gravel channel and extend into the overlying confining units. In some cases, such as MW-46R located on cross-section A-A’, the well screens are located primarily in less transmissive materials with only a small portion of the screen located in a sand lens.

Figure 15 depicts the potentiometric surface for the shallow saturated zone based on measurements made in March 2012. In the area of the north RO reject field, groundwater appears to be flowing to the northeast with a gradient of approximately 0.01 feet per foot (ft/ft). It should be noted that there are few wells in the area of the north RO reject field and thus, the flow direction may be somewhat skewed by the lack of data. In the area of the south RO reject field, groundwater appears to be flowing due east with an average gradient of approximately 0.003 ft/ft.

3.3 RO Reject Discharge Water Balance

A water balance evaluation was conducted to assess the potential influence the RO reject water discharge has on groundwater hydraulics and the apparent distribution of constituents of concern (COCs) in the area. Inputs for the water balance included precipitation records, calculated evapotranspiration, RO reject water discharge rates and volumes, and an approximate discharge area.

Using a conservative approach, it was assumed that the RO reject water is discharged to the southern RO reject water area only and is concentrated within the vegetated portions of the field. The area of discharge was calculated to be approximately 32 acres. The mean annual Class A pan evaporation of 100 inches was estimated for the site (Kohler et al, 1959). This annual evaporation rate was adjusted using the crop coefficient for pasture grasses (Jenson et al, 1990). The resulting annual evapotranspiration was calculated to be 80 inches. Calculated evapotranspiration was combined with long term average monthly precipitation totals to yield an annual water balance deficit of 68 inches.

An average RO reject water production rate of 246 gallons per minute was calculated using production records from October 2007 to June 2012. It was conservatively assumed that RO reject water was continuously produced, and all reject water was sent to the irrigation trench and floodplain described above. This volume of water applied to the approximately 32 acres resulted in 147 inches of water application. Combined with the natural deficit of 68 inches, the annual water surplus after RO reject water input is 79 inches.

An evaluation of shallow saturated zone water levels measured in wells surrounding the area of RO reject water application indicate that water levels generally decrease through the summer. This is likely a result of increased evapotranspiration. During the winter months, water levels generally increase by an average of one to two feet. This pattern is not unlike water levels of wells near other irrigated areas, where similar water level fluctuations are observed (KWB-1A). The potentiometric surface interpreted using measured water levels in wells surrounding the RO reject water application area does not indicate any significant groundwater mounding in the area (Figure 15). Since no apparent water mounding is observed, RO reject water application is not expected to significantly influence hydraulic gradients and subsequent groundwater or site COC movement and distribution.

4. Scope of Services

Section 6.D.2 of GW-028 requires the submittal of a site investigation work plan for the two RO reject water discharge fields. This section of the permit states that the objective of the site investigation is to further define the geology and hydrogeology, the vertical and horizontal extent and magnitude of vadose zone and groundwater contamination, and the rate and direction of contaminant migration.

4.1 Investigation Activities

4.1.1 Well Installation

Section 6.D.2 requires the installation of three monitoring wells within each of the RO reject fields. Figure 16 provides the recommended well locations. Actual locations for the borings and wells will be determined in the field based on subsurface clearance and accessibility.

Section 5 provides a detailed description of the well installation procedures.

4.1.2 Soil Sampling

Soil samples will be collected during installation of monitoring wells and submitted to a qualified laboratory for chemical analyses. Section 5 provides a detailed description of the sample collection frequency and analytical requirements.

4.1.3 Groundwater Sampling

Dissolved phase groundwater samples will be collected from each well, following development, and submitted to a qualified laboratory for chemical analyses. Section 5 provides a detailed description of the sample collection procedures and analytical requirements.

4.2 Health and Safety Considerations

Investigation activities described in this Work Plan will be performed within the RO reject fields and will not be performed in active Refinery areas. The primary health and safety considerations include the presence of harmful vapors and environmental hazards. A detailed health and safety plan will be developed with specific safety procedures for each activity to be performed. The field crews will adhere to the health and safety plan and all procedures. Any deviations from the planned work due to health and safety considerations will be documented and included in the investigation report.

5. Investigation Methods

This section of the Work Plan provides specific procedures that will be followed to implement the planned scope of services.

5.1 Monitoring Well Installation

Six monitoring wells will be installed, as discussed in Section 4.1.2. Figure 16 depicts the anticipated locations of the monitoring wells.

5.1.1 Drilling and Soil Sample Collection Methods

All monitoring wells will be constructed, developed and sampled according to standard operating procedures. Prior to drilling, each site will be inspected and cleared as necessary to allow access by the drill rig and crew. Public utilities and the Refinery safety coordinator will be advised of the proposed drilling locations to obtain clearance prior to actual commencement of drilling. A qualified geologist will be present during the drilling of each well to continuously log samples, monitor drilling operations, record depth to groundwater and other groundwater data, prepare borehole logs and well construction diagrams and record well installation procedures. Boring logs will be prepared and will include soil lithology, field screening results, and depth to water. Monitoring well construction diagrams will include construction details and the observed depth to water.

The wells will be installed using a truck-mounted hollow-stem auger rig. Subsurface samples will be collected continuously ahead of the auger flight using either a Shelby tube or split spoon sampler, depending on the type of soil encountered. Soil samples will be field screened using a photo-ionization detector (PID) and through visual observation. The PID will be calibrated to measure volatile organics typically associated with gasoline and diesel range hydrocarbons. PID readings, visual observations and odor will be noted in the field boring log and will be included on the boring log/well completion diagram.

Discrete soil samples will be selected from each boring for laboratory analysis based on the following guidelines:

- Surface soil: A shallow soil sample will be collected from the near surface soils, defined as the interval from the surface to 1 ft bgs.

- 1 ft bgs to groundwater: Samples will be collected from each 5 foot interval, providing adequate soil recovery occurs. If field screening methods (visual, olfactory and PID screening) indicate the presence of hydrocarbon impacts, at least one sample will be collected from the interval with highest indication of impacts.

- Capillary zone: A sample will be collected from immediately above the top of the saturated zone if the saturated zone can be clearly identified.

- Bottom of boring: A sample will be collected from the final 1 foot interval in each boring.

Soil samples chosen to be submitted for laboratory analyses from the boring will be placed into appropriate containers (2 ounce [oz] or 4 oz glass jars), labeled and then placed in a cooler with ice.

5.1.2 Well Construction

Well casing, screen filter pack, bentonite seal and grout will be placed in the borehole following completion of drilling. A minimum of 15 feet of 2-inch PVC well screen with 0.020-inch slots will be installed in each boring such that screened interval extends from 5 feet above the top of the groundwater bearing unit to 10 feet below the top of the groundwater bearing unit. Solid 2-inch PVC piping will be attached to the screen interval and extended to the surface.

Clean sand (either 16/40 or 20/40) will be placed in the annular space to above the screen, and a 2 foot bentonite seal will be placed on top of the sand pack. The bentonite will be either granular or a slurry that is thick enough to prevent penetration of the sand pack. The bentonite seal will be allowed to hydrate a minimum of 30 minutes prior to grouting. Grout will be placed in the annular space above the bentonite seal to within 2 to 3 feet of the ground surface, using a tremie pipe.

Each well will be completed with a protective stickup riser. The PVC casing will be extended between 2 and 3 feet above the ground surface and a steel or aluminum outer protective casing will be placed over the PVC well riser and will be extended two feet below grade. The protective casing will be surrounded by a 4-foot by 4-foot by 4-inch thick concrete pad, sloped away from the protective casing. A locking well cap will be installed to prevent unauthorized access to the well.

All well materials, including end caps, casings and screens will be pre-cleaned and will have threaded connections. Well construction materials shall be kept wrapped in original packaging or plastic sheeting until used.

The field geologist will record measurements of various well dimensions, including distance from the top of the well casing to the:

- Bottom of the well,
- Top of the filter material,
- Top of the bentonite seal, and
- Top of the screen.

Elevations and locations of the wells will be measured by a registered surveyor at the completion of the installation. The elevation of the ground surface and top of well casing will be measured to within 0.01 feet msl in relation to a previously established benchmark. The location of each well will be measured by a registered surveyor in relation to the known benchmark, with an accuracy of +/- 0.1 feet.

5.1.3 Well Development

All wells installed as part of this investigation will be developed through bailing to remove fine grained-materials accumulated in the well casing until the bottom of the well casing can be reached. Conductivity, pH and temperature will be monitored throughout the development process. The development process will be considered complete after the parameters stabilize (i.e. less than 10% variability between readings) and at least three well casing volumes are removed.

All fluids produced during development will be collected in drums and disposed of in the Refinery wastewater treatment system, upstream of the separator.

5.1.4 Groundwater Sampling

Groundwater samples from each well installed as part of this investigation will be collected no sooner than 24 hours after development. Groundwater measurement and sample collection procedures described in Section 5 of the FWGMWP (ARCADIS,

2012) will be followed, including well gauging, purging, sample collection and handling procedures.

5.1.5 Analytical Methods

All soil and groundwater samples collected during well installation as part of this investigation will be analyzed for the constituents listed in the Groundwater Quality Control Commission (GWQCC) standards. Table 3 lists the methods and specific compounds that will be analyzed in all soil and groundwater samples.

5.1.6 Quality Assurance/Quality Control Samples

Quality assurance/quality control (QA/QC) samples will be collected to monitor the validity of the soil and groundwater sample collection procedures. The following samples will be collected for QA/QC purposes:

- Field duplicates will be collected at a rate of 10%, or 1 field duplicate for every 10 samples. Field duplicates will be analyzed for the same COCs as the parent sample. Separate soil and groundwater field duplicate samples will be collected.

- Trip blanks will accompany each shipping container (cooler) that contains samples to be analyzed for VOCs.

5.1.7 Decontamination Procedures and Investigation Derived Wastes

The drilling and sampling equipment will be decontaminated between each use. This equipment includes all downhole drilling equipment and well gauging devices. The equipment will be washed in a bath of non-phosphate soap (such as Alconox™) and water then rinsed with distilled water. Decontamination fluids will be contained and placed in a 55 gallon drum for later disposal in the Refinery wastewater treatment system, upstream of the separator.

Soil cuttings will be placed into 55-gallon drums for temporary staging and labeled appropriately. Sampling personnel will wear disposable gloves while collecting and handling samples. Gloves will be replaced prior to collection of each sample to prevent cross-contamination. Used gloves and dedicated disposal sampling equipment, including tubing and bailers, will be placed in a separate 55-gallon drum. The volume of containerized solid wastes will be observed and recorded.

Waste characterization samples will be collected from the 55-gallon drums of soil cuttings and will be analyzed to determine whether the waste is hazardous by characteristic or non-hazardous. Based on the results of those samples, the material will be disposed of appropriately.

Groundwater removed from each well during development and purging will be containerized in a labeled drum or similar container then disposed of within the Refinery wastewater treatment system, upstream of the separator.

Waste disposal records are maintained at the Refinery.

6. Schedule

The scope of services described in this Work Plan will be implemented within 90 days of receipt of approval of the Work Plan. The time required to complete the well installation is anticipated to be approximately one to two weeks, following completion of utility clearance activities.

The monitoring wells installed as part of this investigation will be sampled quarterly for one year, as required by 6.D.2.c of GW-028. The first quarterly monitoring event will occur following installation of the wells. The remaining three events will be scheduled following completion of the first event. The sampling procedures described in Section 5 of this Work Plan will be followed during subsequent sampling events.

Interim monitoring reports will be submitted following the completion of each quarterly monitoring event. The interim reports will include a copy of the laboratory reports for that monitoring event and a summary table presenting the data for that event as well as previous quarterly monitoring events, and a summary of the site conditions during sample collection. The interim reports will be submitted within 30 days of completion of each monitoring event, as required by 6.D.3 of GW-028.

Following completion of the fourth quarterly monitoring event, a Final Site Investigation Report will be submitted, according to 6.D.3 of GW-028. This report will include a summary of the well installation procedures, sample collection procedures, soil analytical results, and groundwater analytical results. Recommendations for additional monitoring, if warranted, will be made in this report. The Final Site Investigation Report will be submitted within 90 days of completion of the fourth quarterly monitoring event, according to 6.D.3 of GW-028.

7. References

ARCADIS, 2012, 2012 Facility Wide Groundwater Monitoring Workplan, June 2012.

Jenson, M., Wright, J., Pratt, B., 1990, Evapotranspiration and Irrigation Water Requirements. American Society of Civil Engineers, New York, 332.

Kohler, M., Nordenson, T., Baker, D. 1959, Evaporation Maps for the United States, U.S. Weather Bureau Technical Paper 37.

Tables

Table 1 - Summary of Analytical Results for RO Reject Discharge

Navajo Refining Company, Artesia Refinery

	Analytical Results		
	Chloride (mg/L)	**Fluoride (mg/L)**	**Sulfate (mg/L)**
GWQCC Standard:	250	1.6	600
Sample Date			
Nov-92	**671**	**2.5**	**1780**
Nov-92	**671**	**2.5**	**1780**
Nov-92	**636**	**2.9**	**2580**
May-93	**254**	**2.2**	**1640**
May-93	**254**	**2.2**	**1640**
Jun-93	237	**1.8**	**1520**
Jun-93	227	**1.6**	**1650**
Jul-93	212	**1.7**	**1660**
Aug-93	192	**2.3**	**1570**
Sep-93	214		**1610**
Oct-93	218		**1500**
Nov-93	**261**		**1517**
Nov-93	**261**		**1517**
Nov-93	**257**		**1218**
Dec-93	**266**		**2080**
Dec-93	**266**		**2235**
Jan-94	**269**	**2.8**	**1559**
Jan-94	**278**	**2.7**	**1803**
Feb-94	**267**	**2.24**	102
Feb-94	**259**	**2.2**	38
Mar-94	227	**2.2**	**1473**
Mar-94	**304**	**2.4**	**1458**
Apr-94	234	**2.3**	**899**
Apr-94	**257**	0.1	**1622**
May-94	248	**2.32**	**1328**
May-94	**262**	**2.5**	**1314**
Jun-94	221	**2.05**	**1747**
Jun-94	**253**	**2.4**	**2916**
Jul-94	218.3	**2.59**	**1772**
Jul-94	237	**2.4**	**2078**
Aug-94	222.9	**2.5**	**1577**
Aug-94	218	**2.5**	**2830**
Sep-94	227.6	**2.5**	**2080**
Sep-94	209	**2.4**	**1953**
Oct-94	195	**2.3**	**2202**
Oct-94	223	**2.2**	**1944**
Nov-94	204	**2.49**	**1682**
Dec-94	197	**2.3**	**2096**
Dec-94	214	**2.4**	**1578**
Jan-95	211	**2.3**	**1641**
Jan-95	225	**2.7**	**1495**
Feb-95	205	**2.4**	**1562**
Feb-95	161	**2.3**	**1626**
Mar-95	210	**2.4**	**729**
Apr-95	7.3	**2.3**	**1791**
Apr-95	106	**2.3**	**1901**
May-95	158	**2.5**	**1211**
May-95	147	**2.5**	**2460**
Jun-95	127	**2.5**	**2890**

Table 1 - Summary of Analytical Results for RO Reject Discharge

Navajo Refining Company, Artesia Refinery

	Analytical Results		
	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)
GWQCC Standard:	250	1.6	600
Sample Date			
Jul-95	108	**2.2**	**1257**
Jul-95	103	**2.3**	**1260**
Aug-95	106	**2.2**	**1268**
Aug-95	113	**2.4**	**1551**
Sep-95	88	**2.4**	**1679**
Sep-95	111	**2.4**	**1417**
Oct-95	180	**2.27**	**1560**
Nov-95	155	**2.45**	**1440**
Nov-95	120	**9.9**	**1995**
Dec-95	180	**2.42**	**5897**
Jan-96	152	**2.3**	**1216**
Jan-96	107	**2.3**	**1824**
Jan-96	107	**2.5**	**1235**
Feb-96	129	**2.7**	**1938**
Feb-96	73	**2.4**	**1492**
Mar-96	105	**2.7**	**2821**
Apr-96	109	**2.3**	**703**
Apr-96	115	**2.8**	**1913**
May-96	133	**3.1**	**1657**
May-96	165	**2.4**	**1378**
Jun-96	203	**2.4**	**2390**
Jun-96	190	**2.5**	**1980**
Jul-96	114	**2.4**	**2550**
Jul-96	85.5	**1.8**	**1600**
Jul-96	125	**2.6**	**1480**
Aug-96	76	**3**	**2150**
Aug-96	105	**2.6**	**1430**
Sep-96	37.4	**3**	**1350**
Sep-96	155	**3.1**	**1520**
Mar-97	210	**3.1**	**1600**
Jun-97	140	0.57	**2200**
Sep-97	83	**8.5**	**1900**
Dec-97	**350**	**11**	**1800**
Mar-98	**660**	**31**	**1900**
May-98	190	**3.5**	**1700**
Sep-98	190	**4.9**	**2000**
Dec-98	**430**	**4**	**2100**
Sep-99	200	**4.7**	**2300**
Jan-00	84	**3.8**	**1900**
May-00	98	**4.2**	**1700**
Aug-00	**280**	**3.6**	**1400**
Nov-00	**280**	**3.7**	**1700**
Mar-01	**410**	**3.8**	**1900**
Jun-01	201	**4.03**	**1630**
Oct-01	61.2	**4.1**	**1670**
Jan-02	**337**	**3.78**	**1820**
Mar-02	72.7	**3.55**	**1410**
Jun-03	45	**3.29**	**1480**
Sep-03	**423**	**2.29**	66.7

Table 1 - Summary of Analytical Results for RO Reject Discharge

Navajo Refining Company, Artesia Refinery

	Analytical Results		
	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)
GWQCC Standard:	250	1.6	600
Sample Date			
Mar-04	**301**	**2.92**	**1530**
Jun-04	69.5	**3.82**	**1710**
Sep-04	44.1	**3.16**	**1410**
Dec-04	233	**3.16**	**1660**
Jan-07	**515**	**3.98**	**2160**
Feb-07	**583**	**3.38**	**1920**
May-07	**293**	**2.82**	**1530**
Jul-07	**328**	**2.91**	**1560**
Dec-07	**464**	**3.46**	**1910**
Feb-08	**417**	**2.55**	**1540**
May-08	**293**	**2.82**	**1530**
Aug-08	241	**3.98**	**1980**
Dec-08	**307**	**3.76**	**1810**
Feb-09	**325**	**3.17**	**1740**
May-09	**392**	**2.83**	**1740**
Aug-09	**461**	**3.62**	**1870**
Nov-09	**525**	**3.92**	**2040**
Feb-10	**355**	**3.1**	**1650**
May-10	180	**2.66**	**1290**
Aug-10	**357**	**3.95**	**2220**
Nov-10	**344**	**3.46**	**1750**
Feb-11	**378**	**2.76**	**1480**
May-11	167	**3.59**	**1930**
Aug-11	55.3	**3.32**	**1630**
Nov-11	54.4	**2.62**	**1150**
Feb-12	68.3	**3.08**	**1180**
May-12	246	**3.17**	**1520**
Aug-12	182	**3.04**	**1480**
Oct-12	47.7	**3.41**	**1620**

Notes:

Blank cells indicate that the sample was not analyzed for this compound during this event.

Values shown in bold font with yellow highlight exceed the screening standard.

Abbreviations:

GWQCC = Groundwater Quality Control Commission

mg/L = milligrams per liter

RO = Reverse Osmosis

Table 2 - Summary of Analytical Results from Groundwater Monitoring Wells Near the RO Reject Fields

Navajo Refining Company, Artesia Refinery

Well	Location	Date	TPH DRO (mg/L)	Benzene (ug/L)	Total As (mg/L)	Total Ba (mg/L)	Total Cd (mg/L)	Total Cr (mg/L)	Total Pb (mg/L)	Total Mg (mg/L)	Total Mn (mg/L)	Total Hg (mg/L)	Total Ni (mg/L)	Total Se (mg/L)	Total Ag (mg/L)	Total V (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)
		Screening Standard:	0.2	5	0.01	1	0.005	0.05	0.015	--	0.2	0.002	0.2	0.05	0.05	0.183	250	1.6	600
		Screening Standard Source:	NMED	EPAMCL	EPA MCL	GWQCC	EPA MCL	GWQCC	EPA MCL	--	GWQCC	EPA MCL	GWQCC	EPA MCL	GWQCC	NMED TW	GWQCC	GWQCC	GWQCC
NP-5	NE of North RO Reject Field	11/6/2003		11													203		3900
NP-5	NE of North RO Reject Field	6/29/2004																	
NP-5	NE of North RO Reject Field	4/27/2005		6.3															
NP-5	NE of North RO Reject Field	9/27/2005		<5.0															
NP-5	NE of North RO Reject Field	10/3/2006	<0.050	9.7													204	2.46	4340
NP-5	NE of North RO Reject Field	12/15/2006	<0.050	<5.0													181	2.58	4270
NP-5	NE of North RO Reject Field	4/19/2007	<0.010	<0.60	<0.0018	0.0410	<0.00075	<0.0025	<0.0010	561	<0.0050	<0.000042	<0.0015	0.205	<0.0010	0.0814	162	2.76	4220
NP-5	NE of North RO Reject Field	10/2/2007	<0.020	<0.60	<0.0018	0.00962	<0.00015	<0.00050	<0.00020	585	<0.0010	<0.000042	<0.00030	0.118	<0.00020	0.0205	230	2.27	3910
NP-5	NE of North RO Reject Field	4/7/2008	1.5	<0.50	< 0.0018	0.0223	< 0.00015	< 0.0005	< 0.0002	509	0.00506	< 0.000042	< 0.0003	0.0711	< 0.0002	0.0218	153	2.63	4160
NP-5	NE of North RO Reject Field	9/23/2008	< 0.020	<0.50	< 0.0012	0.00887	< 0.001	< 0.0007	< 0.0012	595	< 0.0009	< 0.000042	< 0.0011	0.0408	< 0.0007	0.0183	161	2.33	4040
NP-5	NE of North RO Reject Field	4/8/2009	<0.020	<0.50													171	2.62	4470
NP-5	NE of North RO Reject Field	10/5/2009	<0.050	<5.0													164	2.70	3980
NP-5	NE of North RO Reject Field	4/14/2010	<0.050	<5.0													216	2.77	3860
NP-5	NE of North RO Reject Field	4/7/2011	<0.050	<5.0													273	2.79	3010
NP-5	NE of North RO Reject Field	4/5/2012	<0.050	<5.0	<0.005	0.00801		<0.005	<0.005		<0.005						346	2.43	3170
NP-9	Interior of North RO Reject Field	11/6/2003		15													275		2420
NP-9	Interior of North RO Reject Field	6/29/2004																	
NP-9	Interior of North RO Reject Field	4/27/2005		<5.0															
NP-9	Interior of North RO Reject Field	9/27/2005		<5.0															
NP-9	Interior of North RO Reject Field	10/3/2006	<0.050	8.2													290	3.02	2310
NP-9	Interior of North RO Reject Field	12/27/2006	<0.050	<5.0													218	2.96	2180
NP-9	Interior of North RO Reject Field	4/27/2007	<0.010	<0.60	<0.0018	0.0138	<0.00015	<0.00050	<0.00020	354	<0.0010	<0.000042	<0.00030	0.0104	<0.00020	0.0224	234	2.9	2210
NP-9	Interior of North RO Reject Field	4/28/2008	< 0.02	<0.50	< 0.0012	0.0159	< 0.001	< 0.0007	< 0.0012	349	0.0608	< 0.000042	< 0.0011	< 0.0022	< 0.0007	0.0182	641	2.84	2460
NP-9	Interior of North RO Reject Field	9/30/2008	0.082	<0.50	< 0.0012	0.0174	< 0.001	< 0.0007	< 0.0012	357	0.00628	< 0.000042	< 0.0011	0.00667	< 0.0007	0.0281	393	2.37	2130
NP-9	Interior of North RO Reject Field	4/10/2009															403	2.7	2180
NP-9	Interior of North RO Reject Field	9/24/2009															420	2.72	2270
MW-29	W of South RO Reject Field	10/7/2003															400		1870
MW-29	W of South RO Reject Field	10/6/2004															395		1160
MW-29	W of South RO Reject Field	4/12/2005		<5.0													634		2950
MW-29	W of South RO Reject Field	10/3/2006		11													610	3.52	2480
MW-29	W of South RO Reject Field	12/27/2006		<5.0													564	3.68	2440
MW-29	W of South RO Reject Field	4/26/2007	0.52	<0.60	0.0270	0.0161	<0.00015	<0.00050	<0.00020	396	0.511	<0.000042	<0.00030	<0.0017	<0.00020	0.0222	574	3.39	2620
MW-29	W of South RO Reject Field	9/28/2007	0.78	<0.60	0.0208	0.0166	<0.00015	<0.00050	<0.00020	268	0.377	<0.000042	<0.00030	<0.0017	<0.00020	<0.00040	373	2.04	1540
MW-29	W of South RO Reject Field	4/9/2008	0.3	<0.50	0.0247	12.2	< 0.00015	< 0.0005	< 0.0002	135	0.0856	< 0.000042	< 0.0003	< 0.0017	< 0.0002	< 0.0004	495	2.54	2650
MW-29	W of South RO Reject Field	9/26/2008	0.85	<0.50	0.0249	14.4	< 0.001	< 0.0007	< 0.0012	134	0.0764	< 0.000042	< 0.0011	< 0.0022	< 0.0007	< 0.0014	481	2.07	2140
MW-29	W of South RO Reject Field	4/13/2009	0.53	<0.50	0.0274	0.0173	<0.0012	<0.0012	<0.0100	320		<0.000042		<0.0050	<0.0014		398	1.97	1890
MW-29	W of South RO Reject Field	9/24/2009	0.48	<5.0	0.0072	0.0222	<0.00200	<0.00500	<0.00500	333		<0.000200		<0.00500	<0.00500		454	1.69	2140
MW-29	W of South RO Reject Field	3/29/2010	0.22	<5.0	<0.005	0.0168	<0.00200	<0.00500	<0.00500	286		<0.000200		<0.00500	<0.00500		348	2.23	1760
MW-29	W of South RO Reject Field	10/28/2010	0.38	<5.0	<0.025	<0.0250		<0.0250	<0.0250	269	0.35			<0.0250			332	2.47	1670
MW-29	W of South RO Reject Field	4/12/2011	0.27	<5.0	<0.025	<0.025		<0.025	<0.025		0.419			<0.025			376	1.48	1740
MW-29	W of South RO Reject Field	9/27/2011	0.16	<5.0	<0.025	<0.0250		<0.0250	<0.0250		0.45			<0.0250			391	3.19	2300
MW-29	W of South RO Reject Field	4/17/2012	0.28	<5.0	<0.005	0.0206		<0.005	<0.005		0.438			<0.005			379	2.3	1900
MW-29	W of South RO Reject Field	10/3/2012	0.95	<5.0	<0.005	0.0185		<0.005	<0.005		0.318			<0.010			369	1.32	1590

Table 2 - Summary of Analytical Results from Groundwater Monitoring Wells Near the RO Reject Fields

Navajo Refining Company, Artesia Refinery

Well	Location	Date	TPH DRO (mg/L)	Benzene (ug/L)	Total As (mg/L)	Total Ba (mg/L)	Total Cd (mg/L)	Total Cr (mg/L)	Total Pb (mg/L)	Total Mg (mg/L)	Total Mn (mg/L)	Total Hg (mg/L)	Total Ni (mg/L)	Total Se (mg/L)	Total Ag (mg/L)	Total V (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)
		Screening Standard:	0.2	5	0.01	1	0.005	0.05	0.015	--	0.2	0.002	0.2	0.05	0.05	0.183	250	1.6	600
		Screening Standard Source:	NMED	EPAMCL	EPA MCL	GWQCC	EPA MCL	GWQCC	EPA MCL	--	GWQCC	EPA MCL	GWQCC	EPA MCL	GWQCC	NMED TW	GWQCC	GWQCC	GWQCC
MW-45	NW of South RO Reject Field	10/14/2003															320		1960
MW-45	NW of South RO Reject Field	12/18/2003		21.7															
MW-45	NW of South RO Reject Field	10/6/2004															375		1710
MW-45	NW of South RO Reject Field	4/12/2005		<5.0													473		2360
MW-45	NW of South RO Reject Field	4/26/2005		7.3															
MW-45	NW of South RO Reject Field	9/29/2005		8.4															
MW-45	NW of South RO Reject Field	9/29/2006		16													185	2.24	2080
MW-45	NW of South RO Reject Field	4/27/2007	0.73	<0.60	<0.0018	0.0301	<0.00015	0.00740	0.0400	198	0.374	<0.000042	0.00769	<0.0017	<0.00020	<0.00040	265	2.16	1780
MW-45	NW of South RO Reject Field	10/1/2007	0.30	<0.60	<0.0018	0.0288	<0.00015	<0.00050	0.0271	188	0.313	<0.000042	0.00530	<0.0017	<0.00020	<0.00040	324	1.69	1810
MW-45	NW of South RO Reject Field	4/9/2008	0.26	<0.50	< 0.0018	0.0163	< 0.00015	< 0.0005	0.00956	201	0.328	< 0.000042	0.0127	< 0.0017	< 0.0002	< 0.0004	204	1.8	1720
MW-45	NW of South RO Reject Field	9/25/2008	0.42	<0.50	0.00539	0.016	< 0.001	< 0.0007	0.00816	184	0.296	< 0.000042	< 0.0011	< 0.0022	< 0.0007	< 0.0014	223	1.86	1580
MW-45	NW of South RO Reject Field	4/6/2009	0.37	<0.50	<0.010	0.0147	<0.0012	<0.0100	<0.0100	209				0.0112	<0.0014		264	1.75	1690
MW-45	NW of South RO Reject Field	9/24/2009	0.33	<5.0	<0.005	0.0146	<0.00200	<0.00500	<0.00500	257		<0.000200		<0.005	<0.00500		343	2	1840
MW-45	NW of South RO Reject Field	3/31/2010	0.29	<5.0	<0.005	0.0137	<0.00200	<0.00500	<0.00500	257		<0.000200		<0.005	<0.00500		353	1.65	2060
MW-45	NW of South RO Reject Field	11/2/2010	0.38	<5.0	<0.025	<0.0250		<0.0250	<0.0250	268	0.39	<0.000200	<0.0250	<0.025		<0.025	377	1.96	1920
MW-45	NW of South RO Reject Field	4/14/2011	0.16	<5.0	<0.025	<0.025		<0.025	<0.025		0.488	<0.0002	<0.025	<0.025		<0.025	371	1.67	2160
MW-45	NW of South RO Reject Field	9/26/2011	< 0.050	<5.0	<0.025	<0.0250		<0.0250	<0.0250		0.392	<0.000200	<0.0250	<0.025		<0.025	330	1.58	2070
MW-45	NW of South RO Reject Field	4/11/2012	0.17	<5.0	<0.005	0.0143		<0.005	<0.005		0.4	<0.000200	0.00684	<0.005		<0.005	378	1.91	2140
MW-45	NW of South RO Reject Field	10/4/2012	0.70	<5.0	<0.005	0.0177		<0.005	<0.005		0.454	<0.000200	0.00633	<0.005		<0.005	373	1.97	2240
MW-56	NW of South RO Reject Field	9/29/2006		9.9													300	1.29	1860
MW-56	NW of South RO Reject Field	12/27/2006		<5.0													248	1.19	1830
MW-56	NW of South RO Reject Field	4/30/2007	0.48	<0.60	0.00771	0.0150	<0.00015	<0.00050	<0.00020	214	0.304	<0.000042	0.00753	<0.0017	<0.00020	0.0224	273	1.04	1700
MW-56	NW of South RO Reject Field	10/1/2007	0.23	<0.60	0.00961	0.0139	<0.00015	<0.00050	<0.00020	230	0.358	<0.000042	0.00677	0.0053	<0.00020	0.0187	325	0.922	1630
MW-56	NW of South RO Reject Field	4/9/2008	0.52	<0.50	0.00755	0.015	< 0.00015	< 0.0005	< 0.0002	230	0.278	< 0.000042	0.0136	0.00553	< 0.0002	0.0232	426	<0.01	1780
MW-56	NW of South RO Reject Field	9/16/2008	0.3	<0.50	0.0079	0.0184	< 0.001	< 0.0007	< 0.0012	254	0.314	< 0.000042	0.00721	0.00548	< 0.0007	0.0242	310	1.01	1830
MW-56	NW of South RO Reject Field	4/10/2009	<0.020	<0.50	<0.0100	0.0142	<0.0012	<0.0012	<0.00080	270		<0.000042		<0.0050	<0.0014		329	0.75	1920
MW-56	NW of South RO Reject Field	9/24/2009	0.073	<5.0	0.00685	0.0136	<0.00200	<0.00500	<0.00500	262	0.347	<0.000200		<0.00500	<0.00500		337	0.854	1850
MW-56	NW of South RO Reject Field	3/31/2010	0.23	<5.0	0.00654	0.0122	<0.00200	<0.00500	<0.00500	223		<0.000200		<0.00500	<0.00500		306	0.863	1790
MW-56	NW of South RO Reject Field	10/27/2010	0.089	<5.0	<0.0250	<0.0250		<0.0250	<0.0250	229	0.304			<0.0250			360	1.1	1800
MW-56	NW of South RO Reject Field	4/11/2011	<0.05	<5.0	<0.025	<0.025		<0.025	<0.025		0.347			<0.025			350	1.07	2070
MW-56	NW of South RO Reject Field	9/29/2011	<0.050	<5.0	<0.0250	<0.0250		<0.0250	<0.0250		0.282			<0.0250			311	0.863	1890
MW-56	NW of South RO Reject Field	4/13/2012	0.071	<5.0	0.00623	0.0135		<0.005	<0.005		0.328			<0.005			331	1.22	1830
MW-56	NW of South RO Reject Field	10/10/2012	<0.050	<5.0	0.00764	0.0126		<0.005	<0.005	233	0.331			<0.005			258	1.14	2070

Table 2 - Summary of Analytical Results from Groundwater Monitoring Wells Near the RO Reject Fields

Navajo Refining Company, Artesia Refinery

Well	Location	Date	TPH DRO (mg/L)	Benzene (ug/L)	Total As (mg/L)	Total Ba (mg/L)	Total Cd (mg/L)	Total Cr (mg/L)	Total Pb (mg/L)	Total Mg (mg/L)	Total Mn (mg/L)	Total Hg (mg/L)	Total Ni (mg/L)	Total Se (mg/L)	Total Ag (mg/L)	Total V (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)
		Screening Standard:	0.2	5	0.01	1	0.005	0.05	0.015	--	0.2	0.002	0.2	0.05	0.05	0.183	250	1.6	600
		Screening Standard Source:	NMED	EPAMCL	EPA MCL	GWQCC	EPA MCL	GWQCC	EPA MCL	--	GWQCC	EPA MCL	GWQCC	EPA MCL	GWQCC	NMED TW	GWQCC	GWQCC	GWQCC
KWB-1A	SE of South RO Reject Field	9/30/2003															233		**2160**
KWB-1A	SE of South RO Reject Field	10/15/2004															**395**		**2480**
KWB-1A	SE of South RO Reject Field	4/7/2005		<5													229		**2250**
KWB-1A	SE of South RO Reject Field	10/17/2006	0.062	<10	0.00772	0.0104	<0.002	<0.005	<0.005	340		<0.0002		<0.005	<0.005	0.0171	190	1.14	**2090**
KWB-1A	SE of South RO Reject Field	4/20/2007	0.094	<0.60	<0.0018	0.00784	<0.00015	<0.00050	<0.00020	356	0.224	<0.000042	0.00600	<0.0017	<0.00020	0.0104	186	1.13	**2080**
KWB-1A	SE of South RO Reject Field	9/27/2007	0.053	<0.60	<0.0018	0.00813	<0.00015	<0.00050	<0.00020	305	0.212	<0.000042	0.00727	<0.0017	<0.00020	0.0147	172	<0.100	**1820**
KWB-1A	SE of South RO Reject Field	4/28/2008	<0.020	<0.50	< 0.0012	0.00963	< 0.001	< 0.0007	< 0.0012	309	0.222	< 0.000042	0.00682	< 0.0022	< 0.0007	0.0152	**250**	1.04	**2220**
KWB-1A	SE of South RO Reject Field	9/24/2008	<0.020	<0.50	< 0.0012	0.00863	< 0.001	< 0.0007	< 0.0012	338	0.231	< 0.000042	0.00907	< 0.0022	< 0.0007	0.0149	210	1.01	**1830**
KWB-1A	SE of South RO Reject Field	4/7/2009	<0.020	<0.50	<0.0100	<0.0100	<0.0012	<0.0012	<0.00080	308				<0.0050	<0.0014		210	0.784	**1890**
KWB-1A	SE of South RO Reject Field	9/29/2009	<0.050	<5.0	0.00709	0.00975	<0.00200	<0.00500	<0.00500	322		<0.000200		<0.00500	<0.00500		198	0.955	**1850**
KWB-1A	SE of South RO Reject Field	4/13/2010	<0.050	<5.0	<0.0250	0.0101	<0.00400	<0.0250	<0.0100	303		<0.000200		<0.0250	<0.0100		223	1.11	**1950**
KWB-1A	SE of South RO Reject Field	10/15/2010	<0.050	<5.0	<0.00500	0.00887		<0.00500	<0.00500	314	0.234	<0.000200	0.0114	<0.00500		0.0166	220	1.15	**1490**
KWB-1A	SE of South RO Reject Field	4/8/2011	<0.050	<5.0	<0.025	<0.025		<0.025	<0.025		0.275	<0.0002	<0.025	<0.025		<0.025	**301**	1.09	**1580**
KWB-1A	SE of South RO Reject Field	9/26/2011	<0.050	<5.0	<0.0250	<0.0250		<0.0250	<0.0250		0.251	<0.000200	<0.0250	<0.0250		<0.0250	**314**	1.19	**2080**
KWB-1A	SE of South RO Reject Field	4/10/2012	<0.050	<5.0	<0.005	0.00804		<0.005			0.285	<0.0002	0.00766	<0.005		0.0184	**382**	1.23	**2320**
KWB-1A	SE of South RO Reject Field	9/26/2012	<0.051	<5.0	<0.005	0.0088		<0.005	<0.005		0.311	<0.000200	0.0121	<0.005		0.0192	**398**	1.32	**2360**

Notes:

Blank cells indicate that the sample was not analyzed for this compound during this event.

Values shown in bold font with yellow highlight exceed the screening standard.

Cells with blue highlight indicate that the sample result was below detection limit but the detection limit was above the screening standard.

Abbreviations:

-- = No standard available
Ag = Silver
As = Arsenic
Ba = Barium
Cd = Cadmium
Cr = Chromium
DRO = Diesel Range Organics
E = East
EPA MCL = United States Environmental Protection Agency maximum contaminant level
GWQCC = Groundwater Quality Control Commission
Hg = Mercury
Mg = Magnesium
mg/L = milligrams per liter
Mn = Manganese
Ni = Nickel
NMED TPH = New Mexico Environment Department screening standard for TPH
NMED TW = New Mexico Environment Department tapwater screening level
NW = Northwest
Pb = Lead
RO = Reverse Osmosis
Se = Selenium
SE = Southeast
TPH = Total Petroleum Hydrocarbons
V = Vanadium
W = West

Table 3 - Laboratory Analytical Methods for Soil and Groundwater Samples

Navajo Refining Company, Artesia Refinery

Sample Matrix	Method	Analyte Group	Specific Compounds
Soil / Groundwater	8015 Mod	Total Petroleum Hydrocarbons	Gasoline Range Organics Diesel Range Organics Oil Range Organics
Soil / Groundwater	6020 and 7470/7471	Metals	Arsenic Aluminum Barium Boron Cadmium Calcium Chromium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Potassium Selenium Silver Sodium Vanadium Zinc
Soil / Groundwater	8260	Volatile Organic Compounds	Target Compound List to include specific compounds listed in 20.6.2.7(WW), 20.6.2.3103.A, 20.6.2.3103.B, and 20.6.2.3103.C
Soil / Groundwater	8270	Semivolatile Organic Compounds	Target Compound List to include specific compounds listed in 20.6.2.7(WW), 20.6.2.3103.A, 20.6.2.3103.B, and 20.6.2.3103.C
Soil / Groundwater	9014	Cyanide	Cyanide
Soil / Groundwater	300	Anions/Cations	Chloride Fluoride Sulfate Nitrite/Nitrate
Soil	2540	Moisture	Percent Moisture
Groundwater	2540C	Water Quality	Total Dissolved Solids
Groundwater	Field instrument	Water Quality	pH

Figures

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\HOUSTON\ACT\TX000836\0003\00001\site location map2.dwg LAYOUT: 1 SAVED: 10/25/2012 6:41 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 10/25/2012 7:09 PM BY: INNISS, HAYDEN
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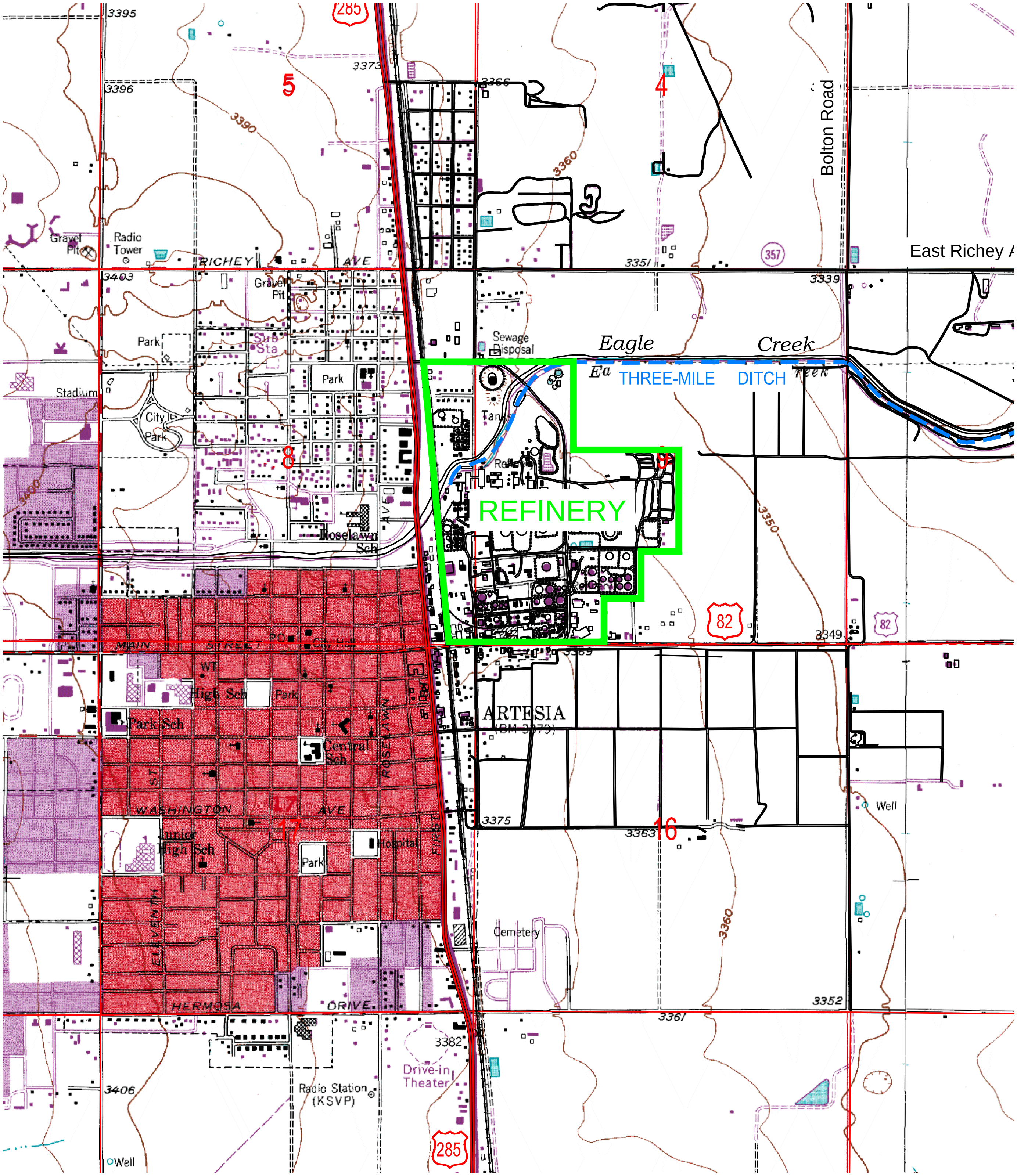


0 2000' 4000'

GRAPHIC SCALE

REFERENCE: BASE MAP SOURCE USGS 7.5 MINUTE SERIES QUADS ARTESIA AND SPRINGLAKE QUADRANGLES, 1955, PHOTOREVISED 1983.

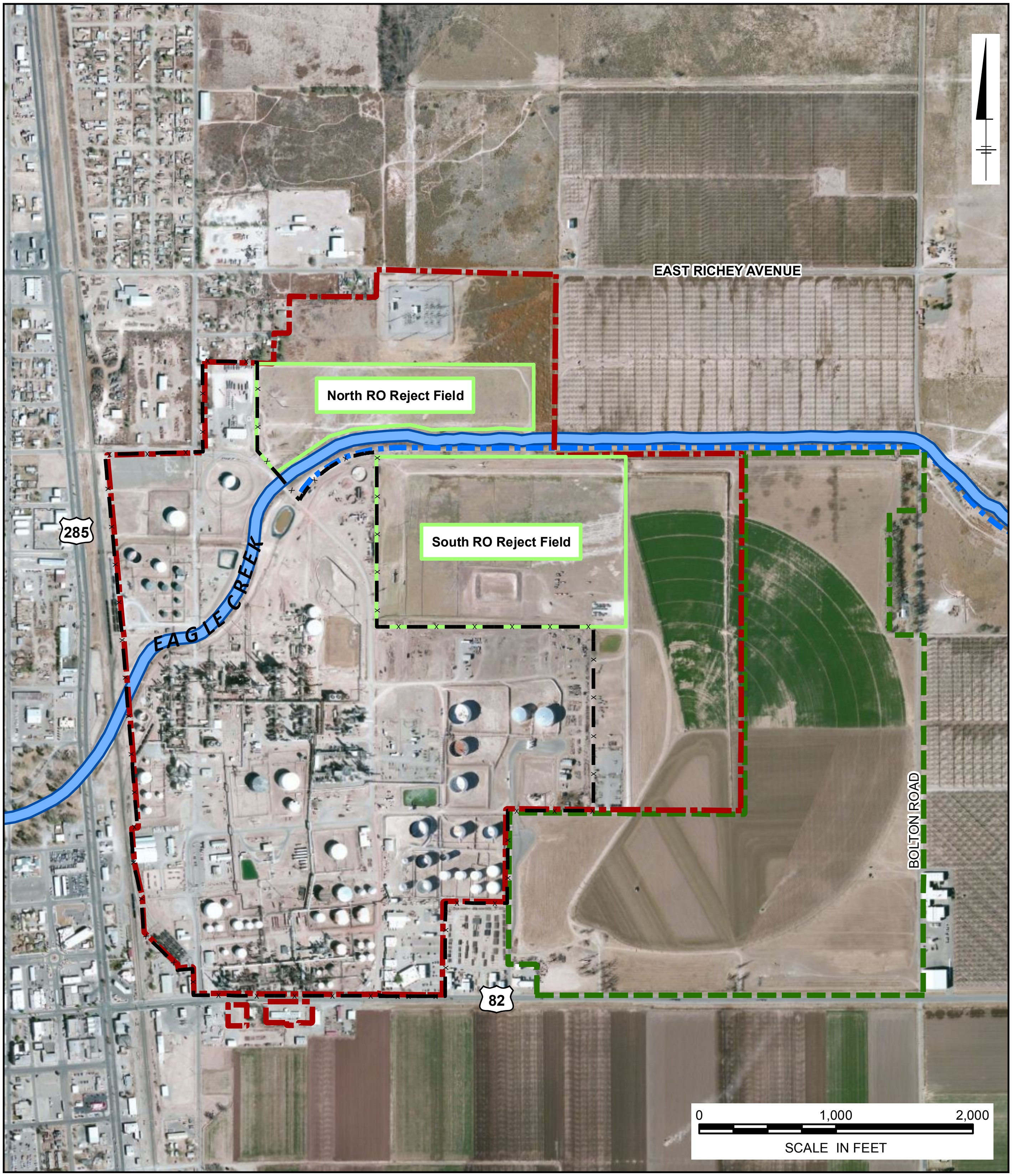
NEW MEXICO
AREA LOCATION

NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
RO REJECT FIELDS SITE INVESTIGATION

SITE LOCATION MAP

ARCADIS

FIGURE
1



LEGEND:

- REFINERY FENCELINE
- REJECT FIELD
- NAVAJO REFINING PROPERTY LINE
- MONTANA REFINING PROPERTY LINE
- APPROXIMATE LOCATION OF FORMER THREE-MILE DITCH AND EXISTING UNDERGROUND DISCHARGE PIPING
- WATERWAYS

NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

RO REJECT FIELDS SITE INVESTIGATION WORK PLAN

SITE FEATURES

ARCADIS

FIGURE **2**

CITY: (KNOXVILLE) DIV/GROUP:(ENV/GIS) DB:(B.ALTOM) LD:(S.SUTTON) PIC: PM: TM:(P.KRUEGER)
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C096.jpg

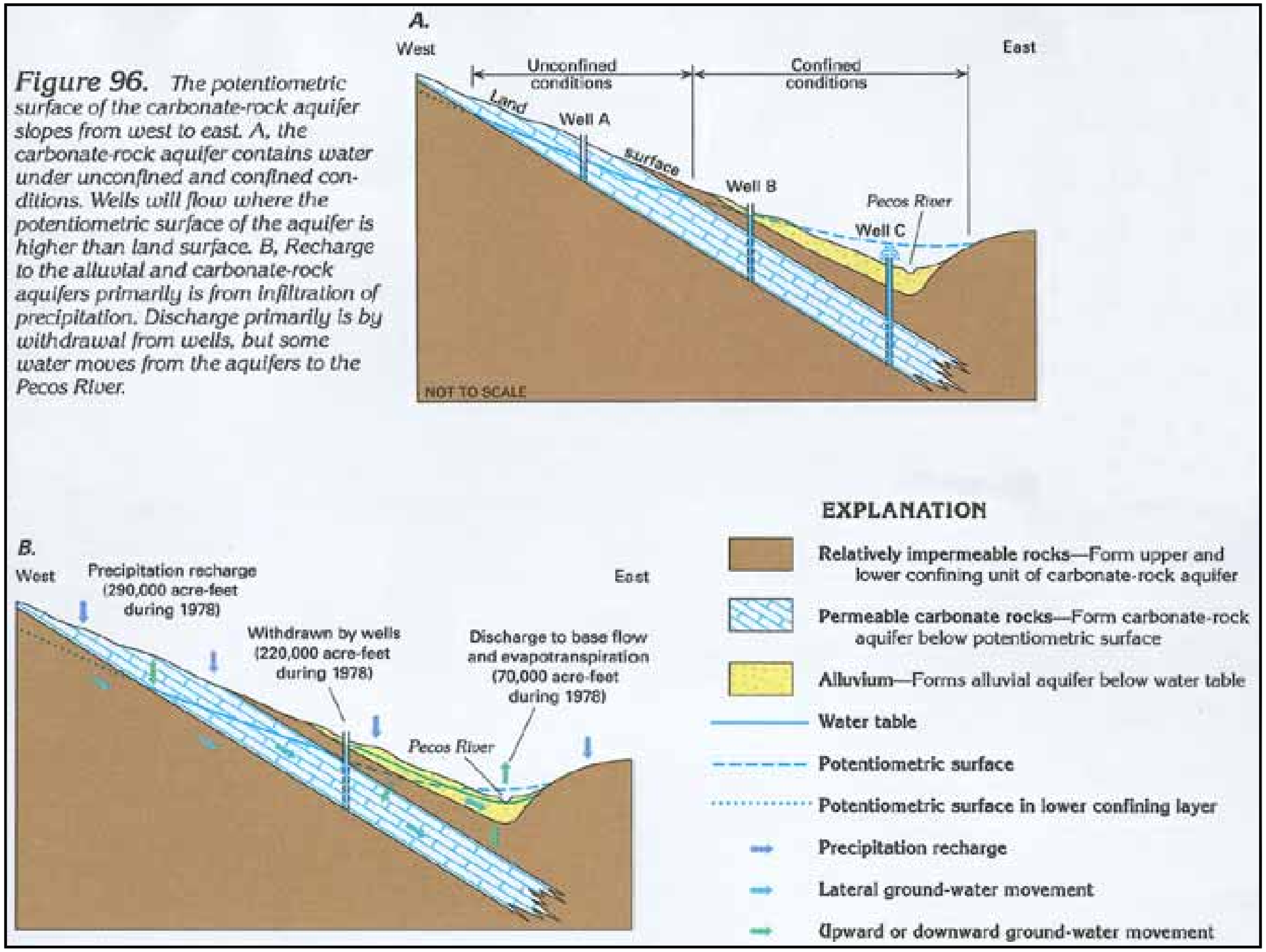


Figure 96. The potentiometric surface of the carbonate-rock aquifer slopes from west to east. A, the carbonate-rock aquifer contains water under unconfined and confined conditions. Wells will flow where the potentiometric surface of the aquifer is higher than land surface. B, Recharge to the alluvial and carbonate-rock aquifers primarily is from infiltration of precipitation. Discharge primarily is by withdrawal from wells, but some water moves from the aquifers to the Pecos River.

SOURCE:

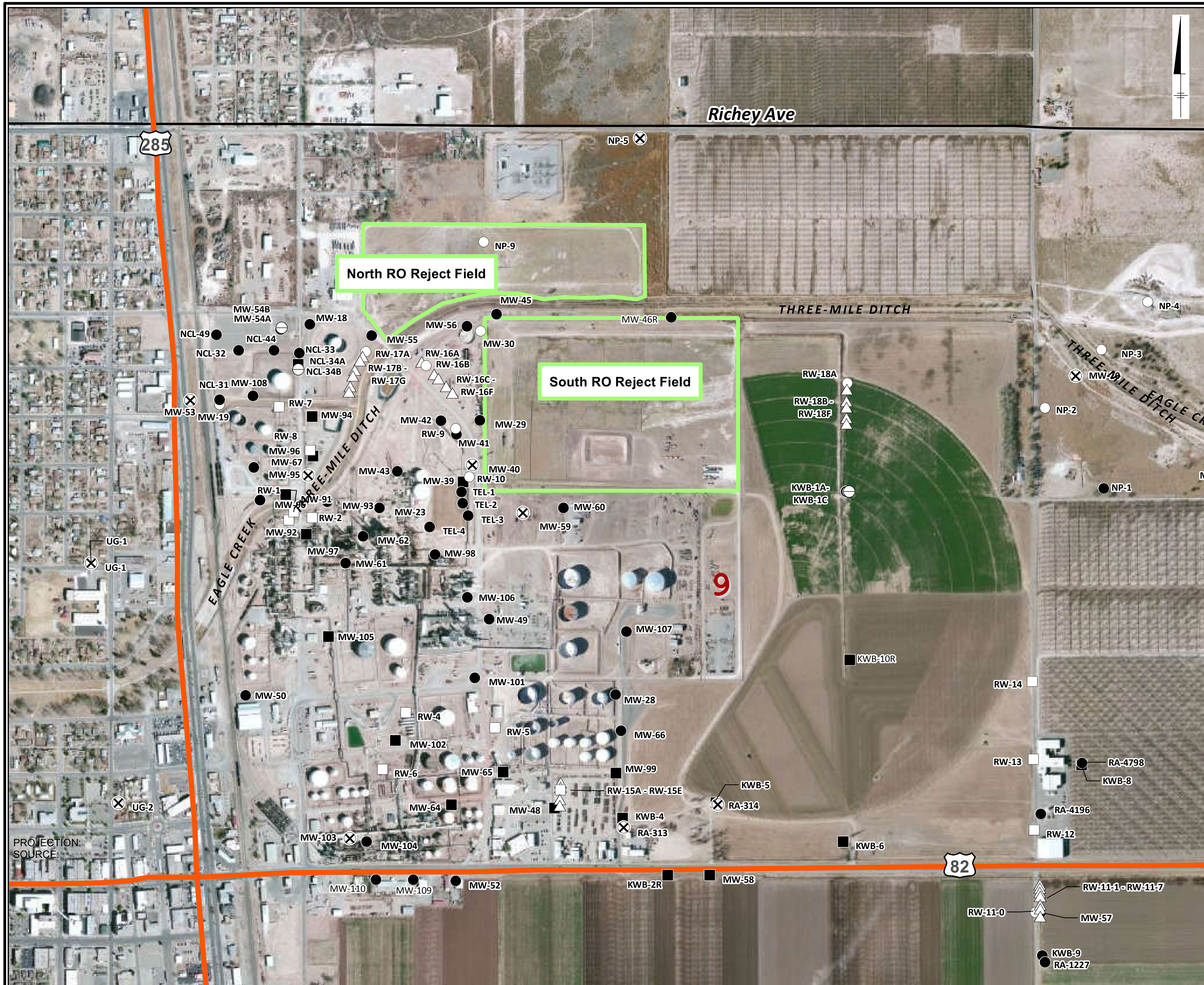
CROSS SECTIONS FROM "WELDER, 1993".

NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
RO REJECT FIELDS SITE INVESTIGATION WORK PLAN

ROSWELL BASIN CONCEPTUALIZATION

ARCADIS

FIGURE
3



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Legend

- NOT SAMPLED AS PART OF ROUTINE MONITORING PROGRAM
- SAMPLES COLLECTED BIENNIALLY
- SAMPLES COLLECTED ANNUALLY
- SAMPLES COLLECTED SEMIANNUALLY
- SAMPLES COLLECTED ANNUALLY IF PSH <0.03 FT
- SAMPLES COLLECTED SEMIANNUALLY IF PSH <0.03 FT
- RECOVERY TRENCH WELL LOCATION NOT SAMPLED AS PART OF ROUTINE MONITORING PROGRAM
- US HIGHWAY
- LOCAL ROADS
- REJECT FIELD

NOTES:
1. SEE FACILITY WIDE GROUNDWATER MONITORING WORK PLAN FOR ANALYTICAL SUITE

2. PSH = PHASE SEPARATED HYDROCARBONS

0 1,000 2,000

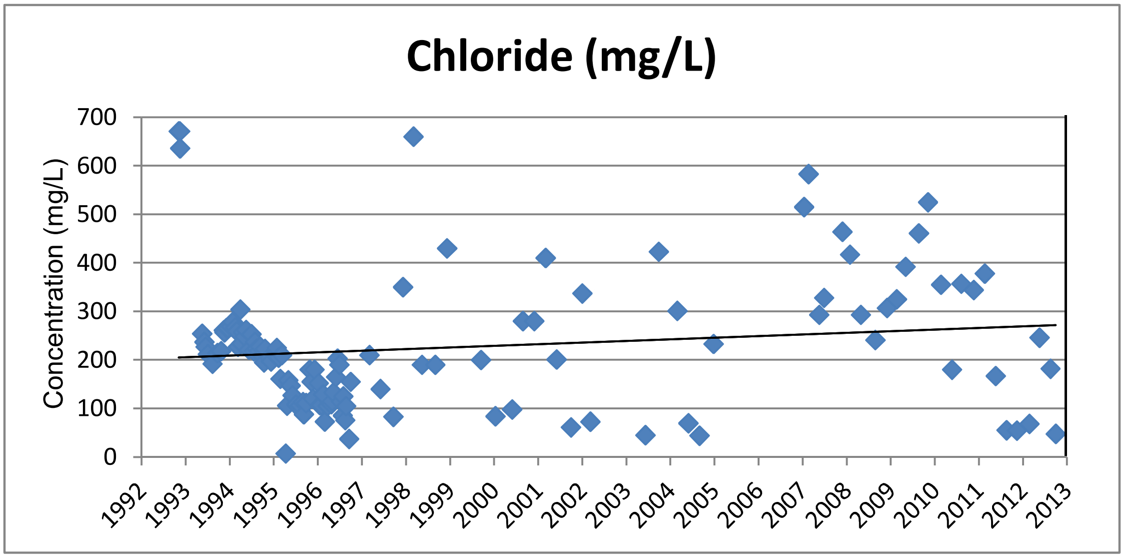
SCALE IN FEET

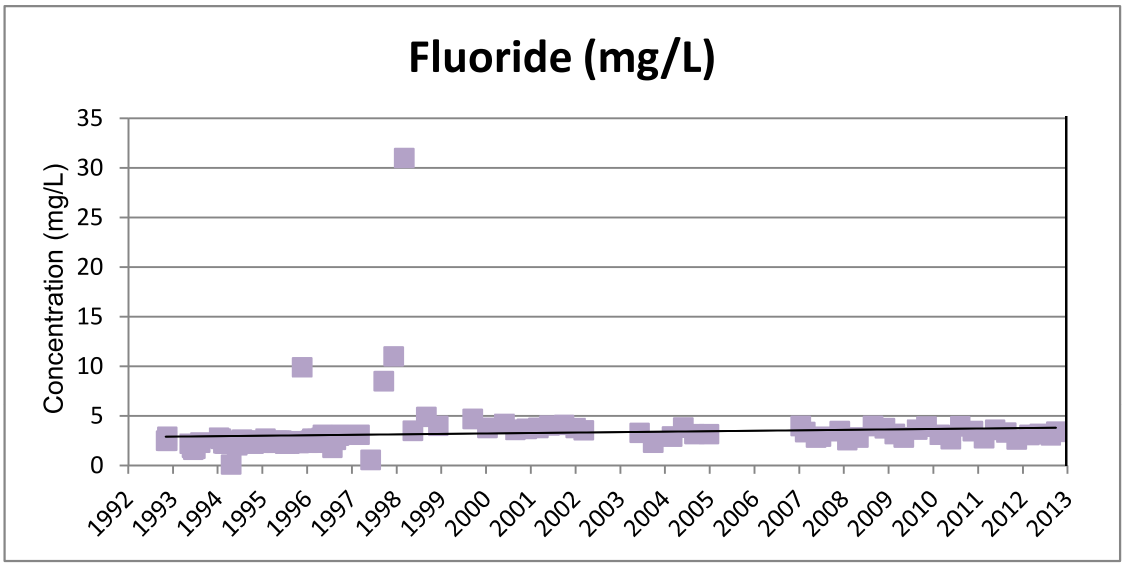
NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
RO REJECT FIELDS SITE INVESTIGATION WORK PLAN

WELL LOCATIONS AND MONITORING FREQUENCY

ARCADIS

FIGURE
4





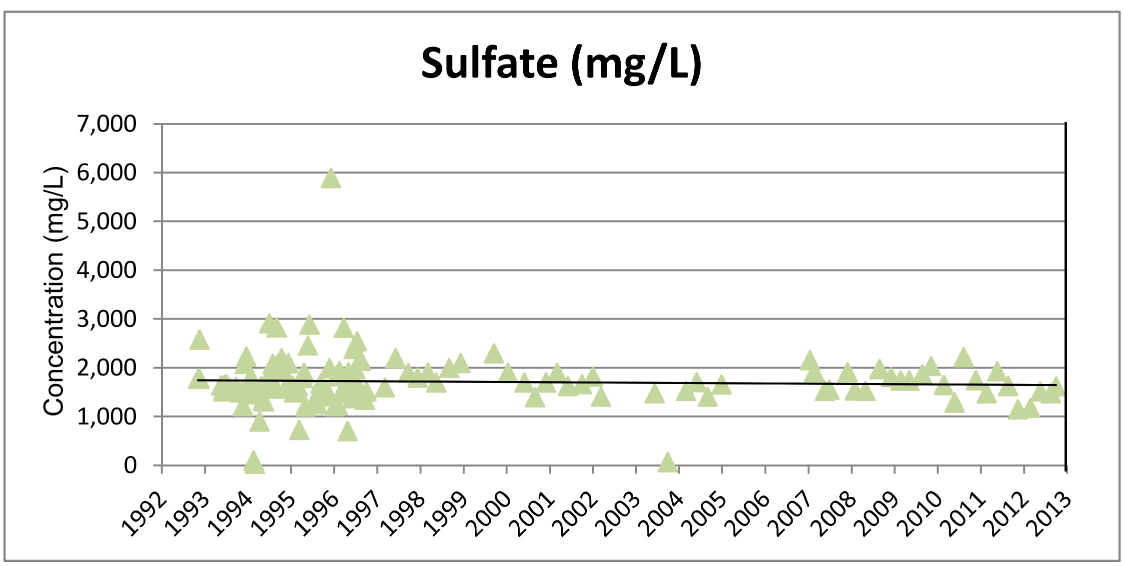
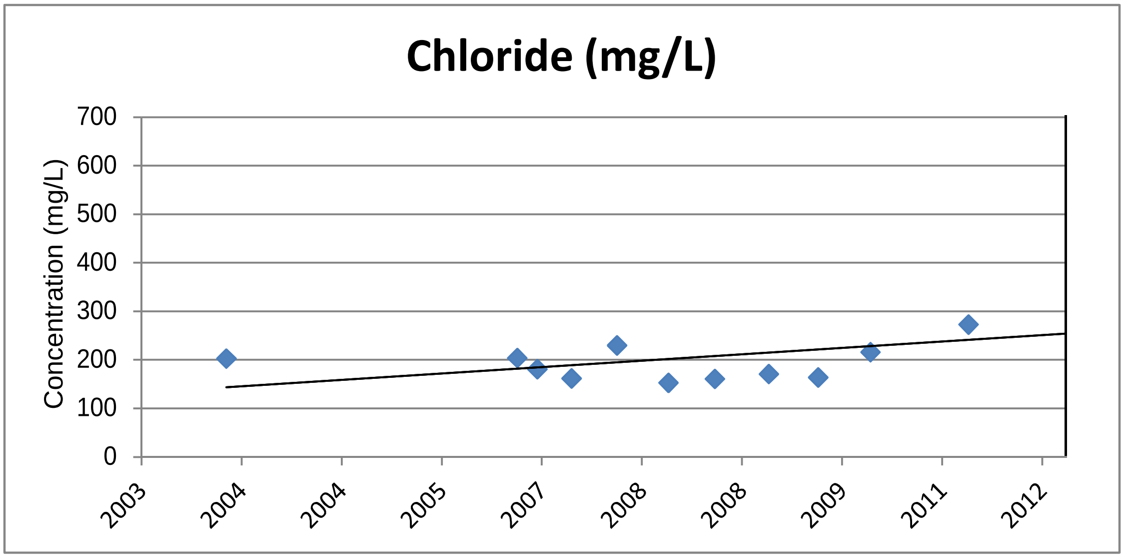
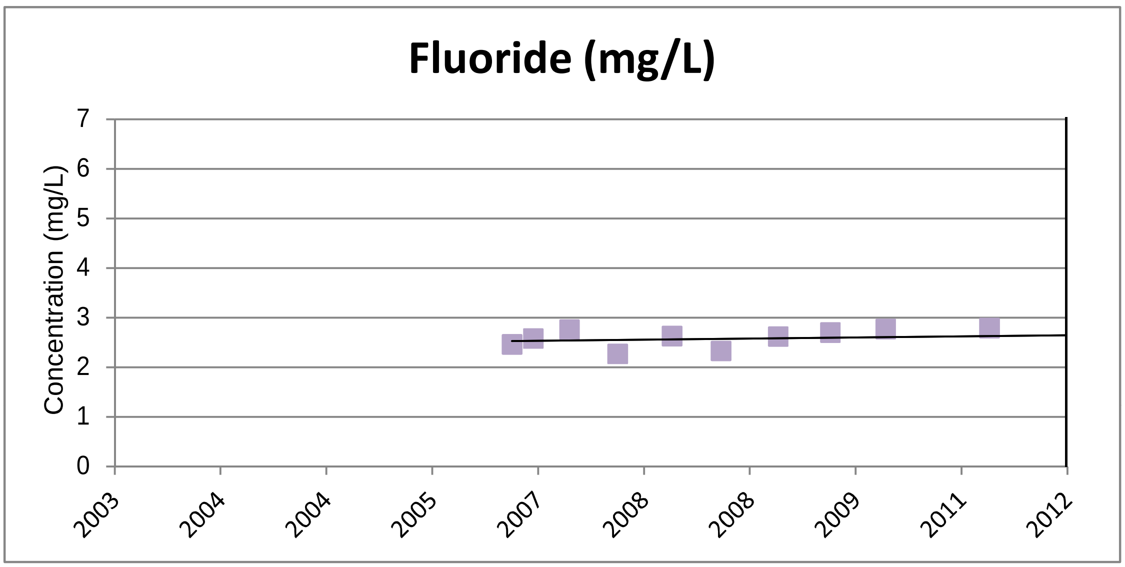


Figure 5 - RO Reject Discharge Concentration Trends





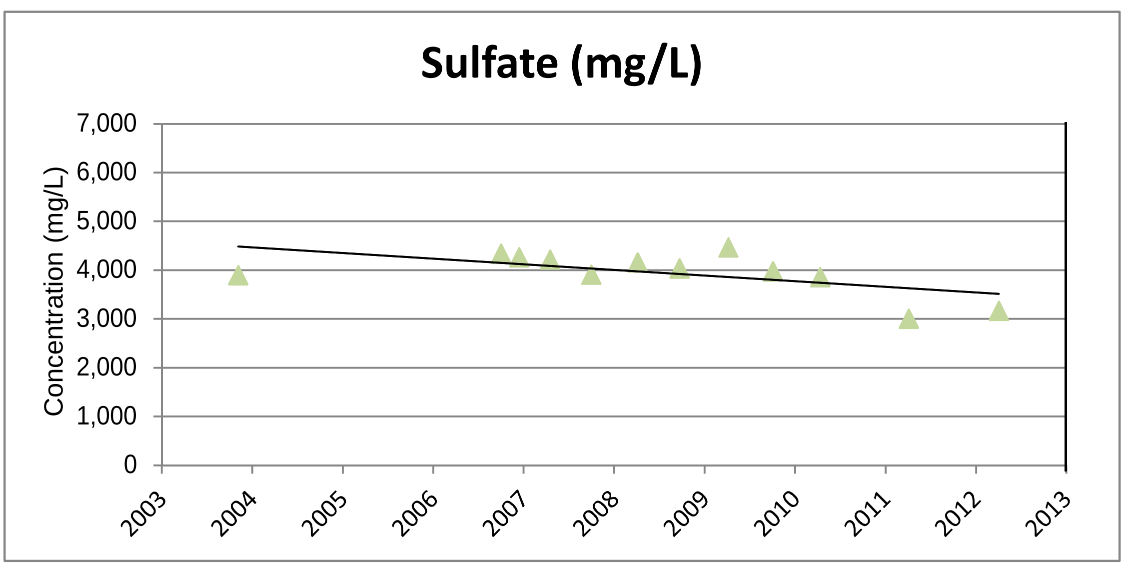


Figure 6 - NP-5 Concentration Trends

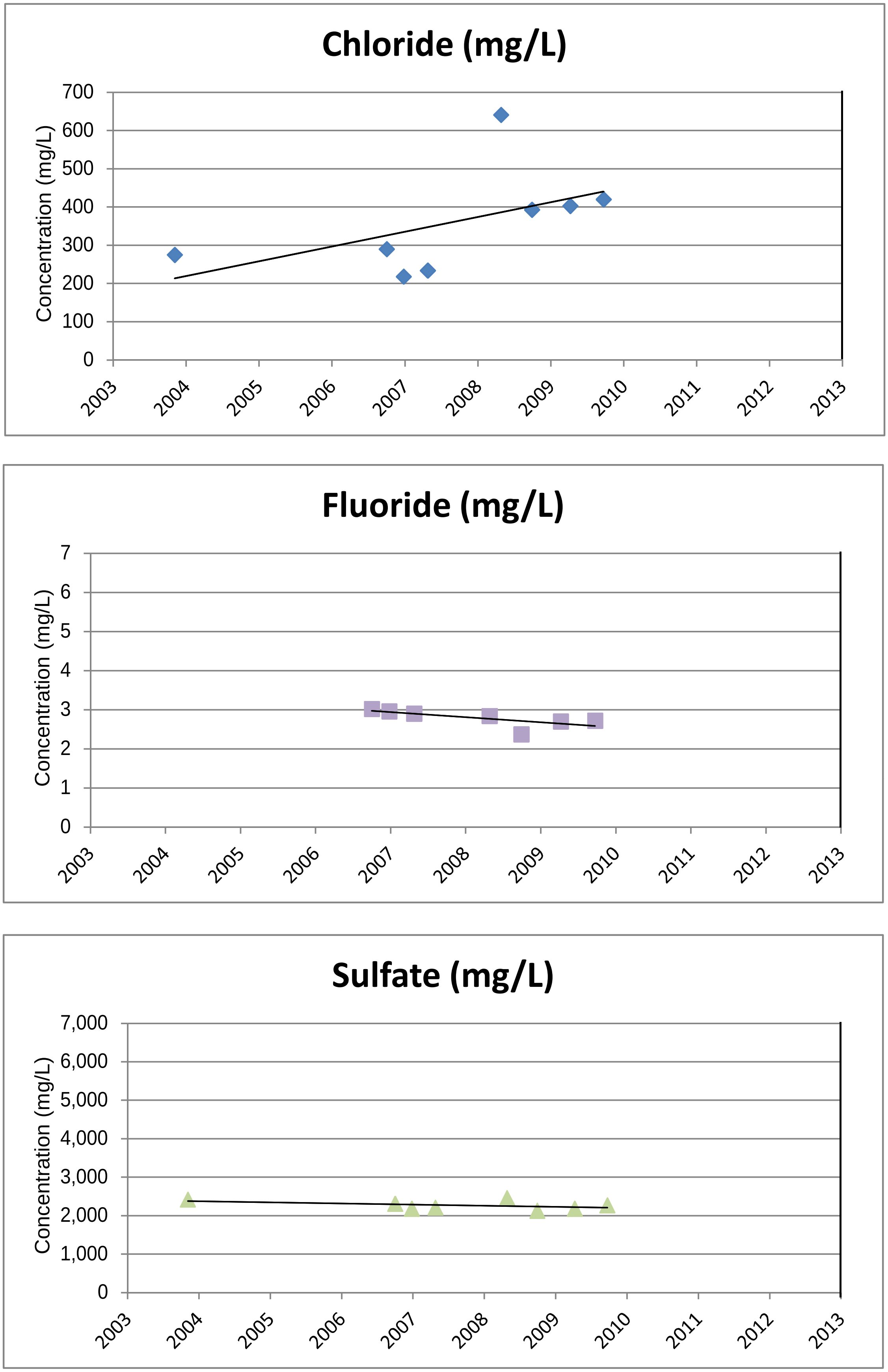
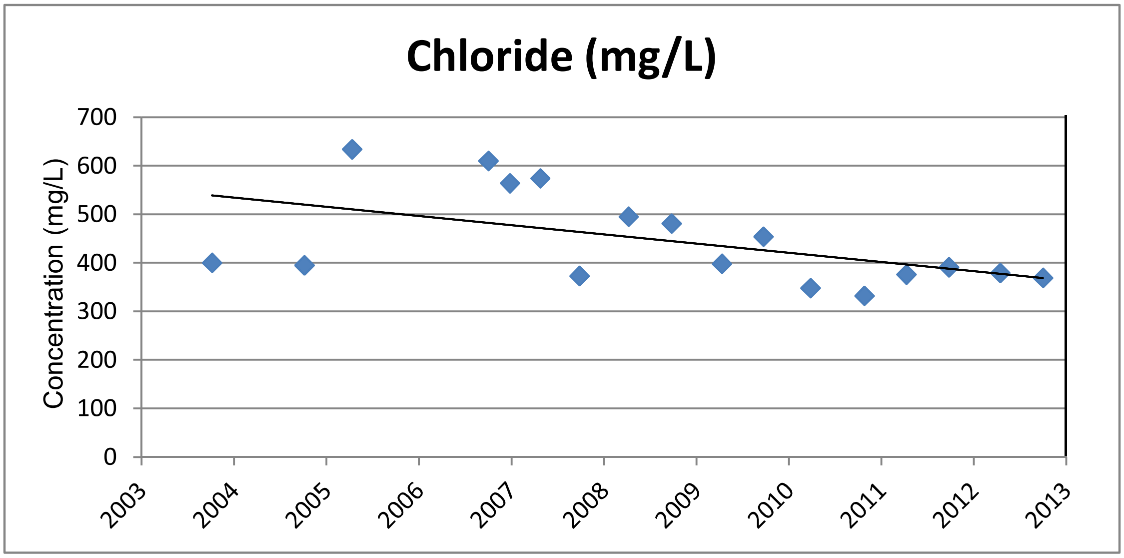
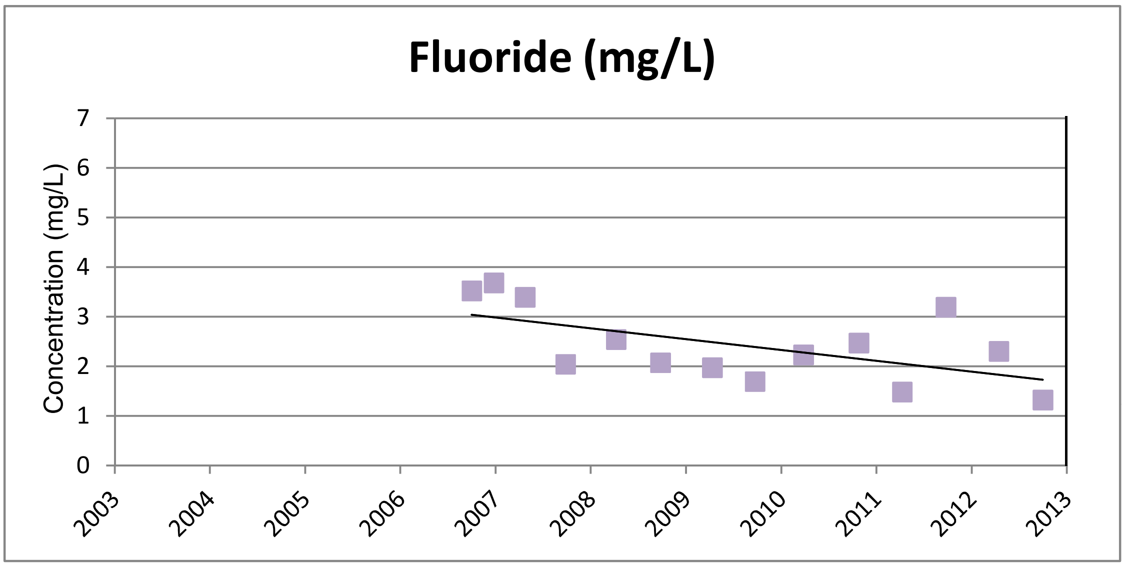


Figure 7 - NP-9 Concentration Trends





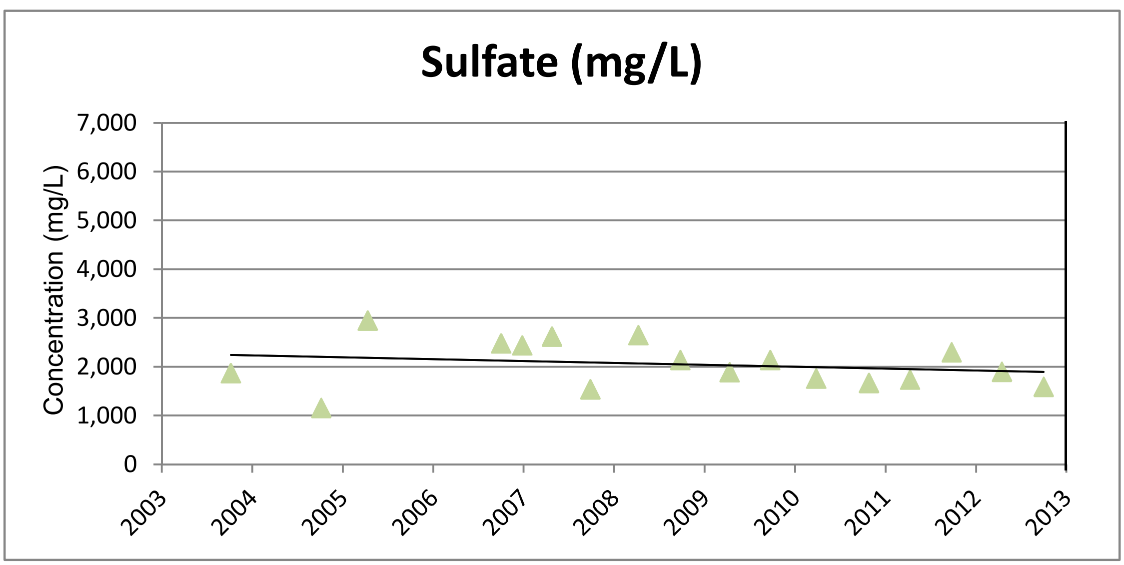
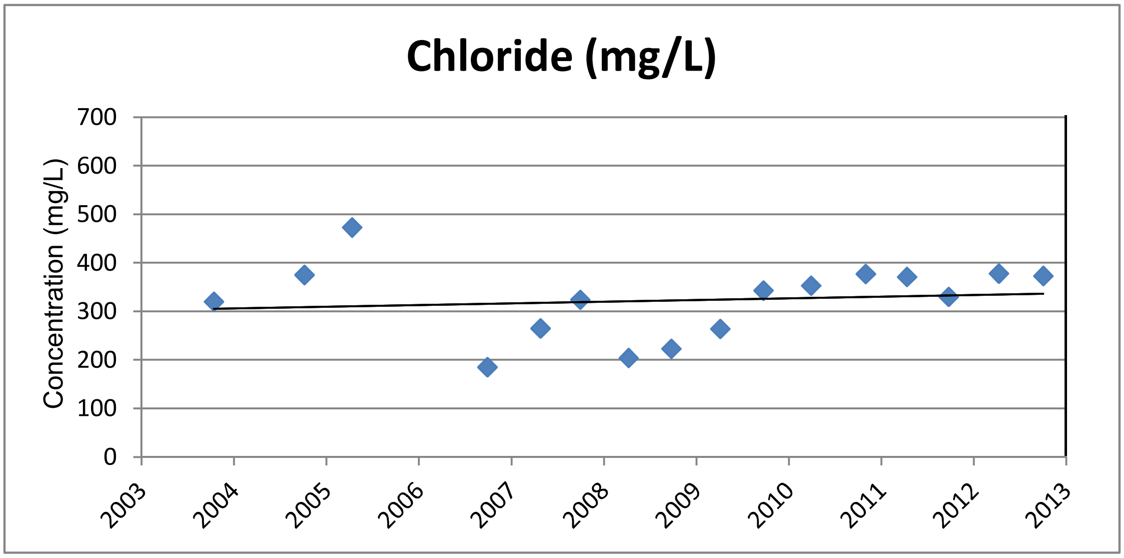
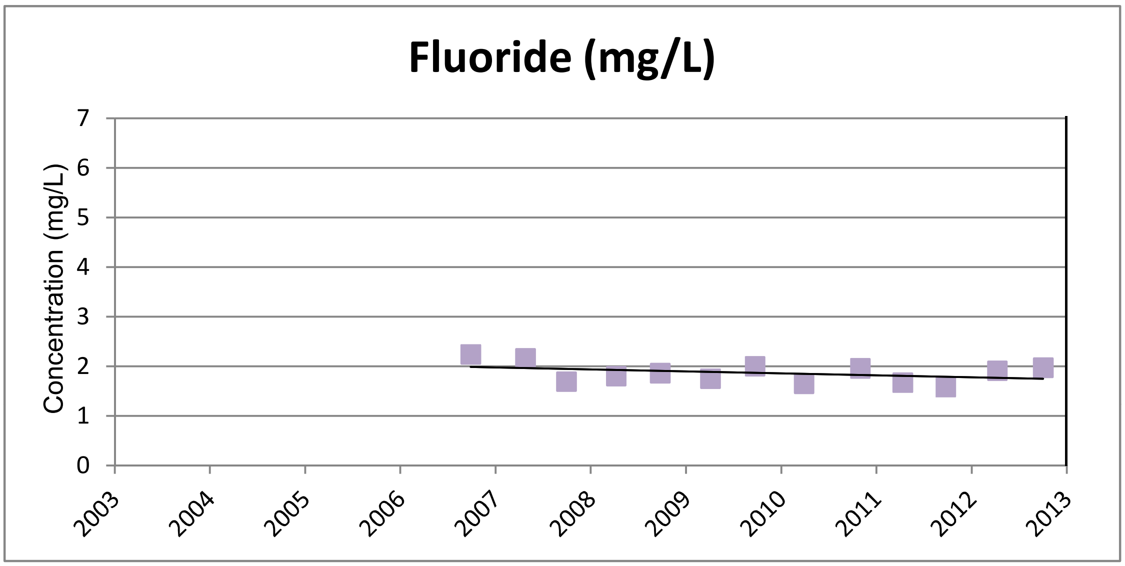


Figure 8 - MW-29 Concentration Trends





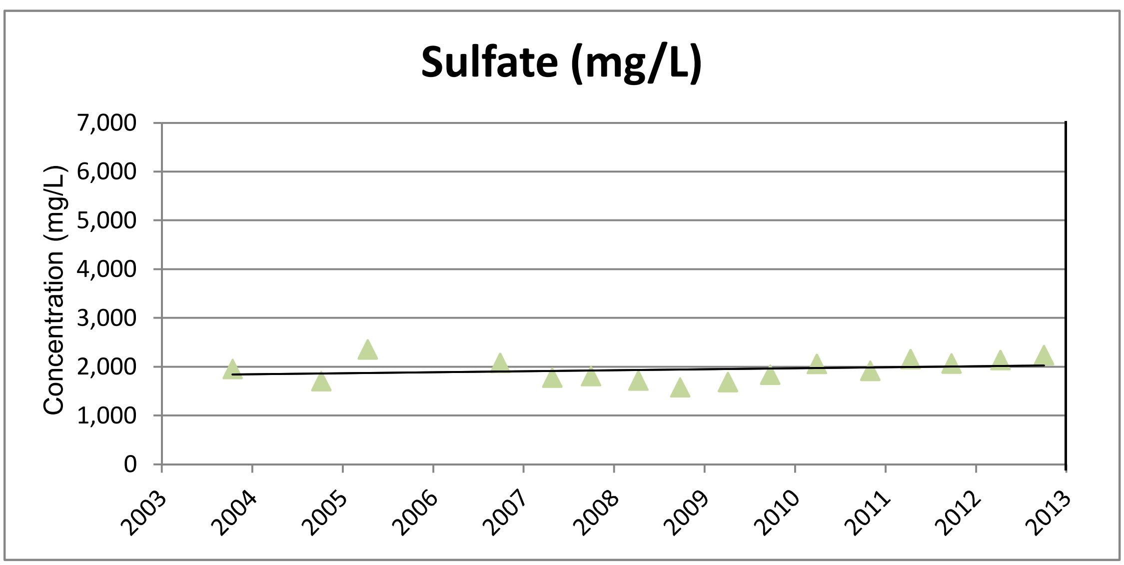
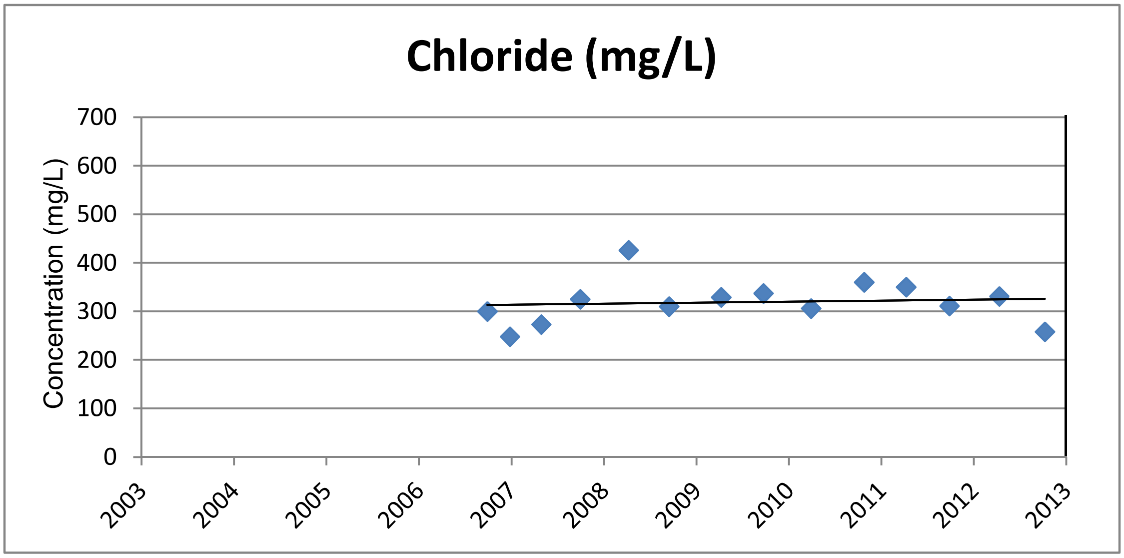
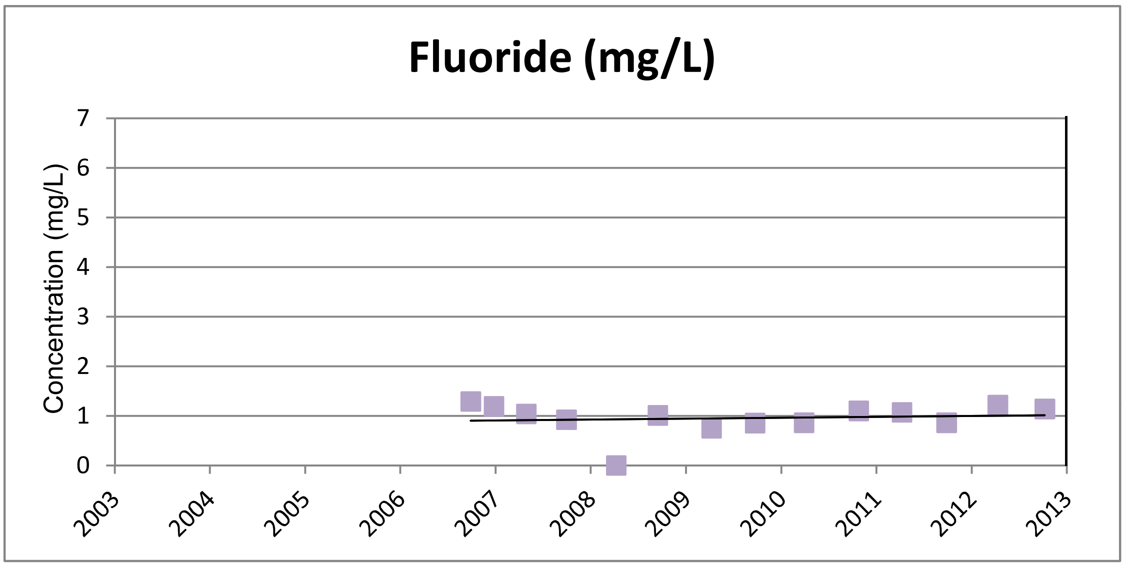


Figure 9 - MW-45 Concentration Trends





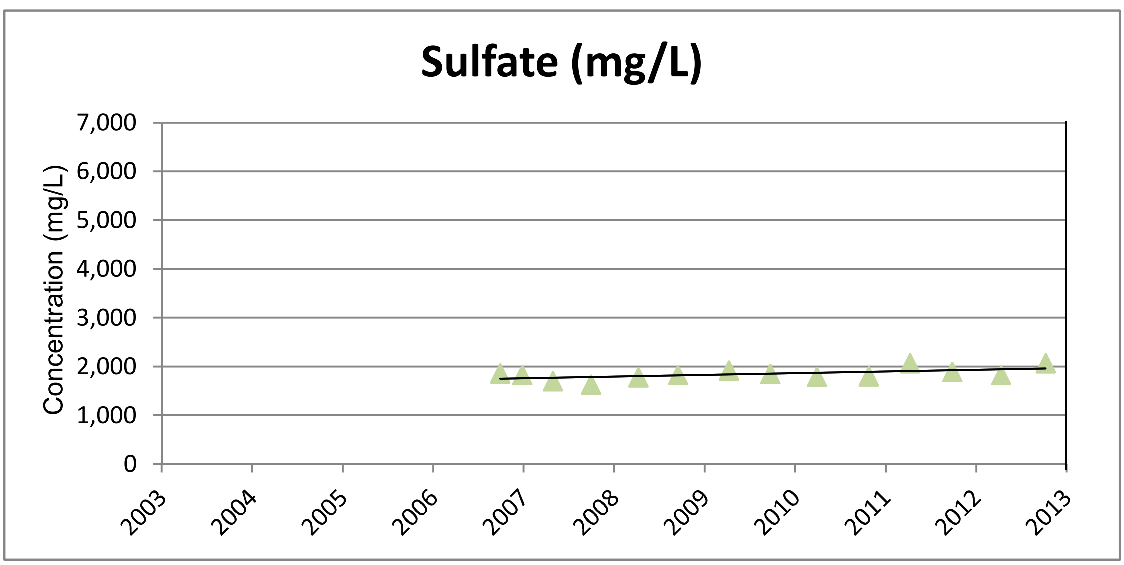
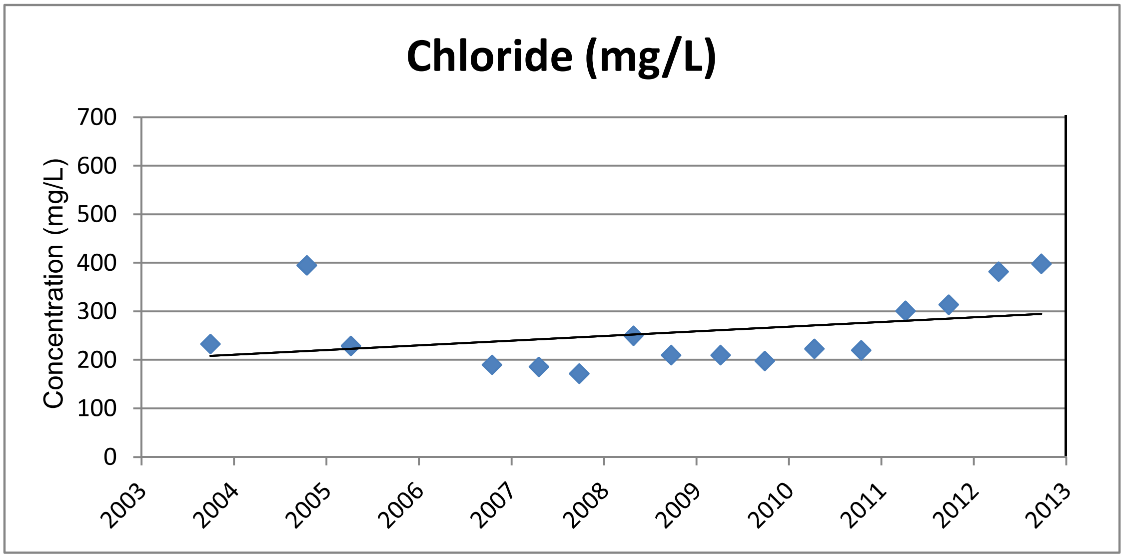
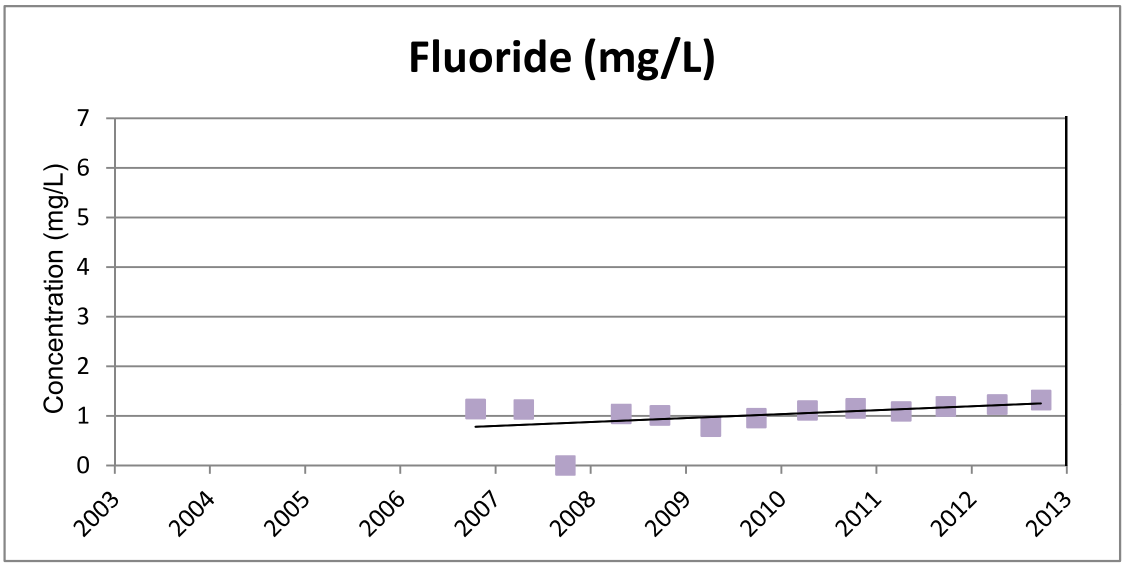


Figure 10 - MW-56 Concentration Trends





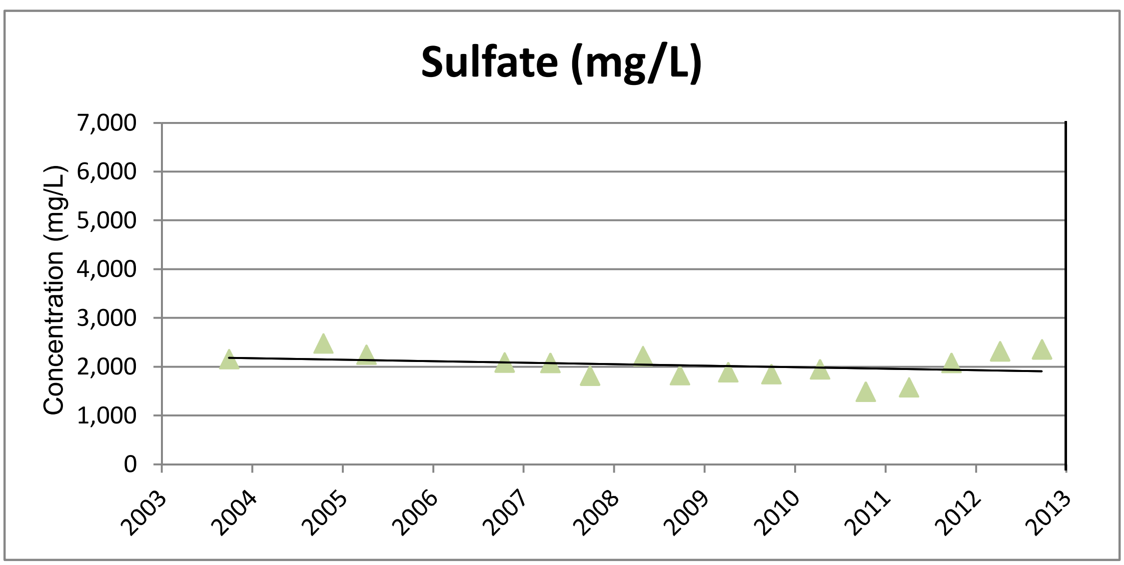


Figure 11 - KWB-1A Concentration Trends

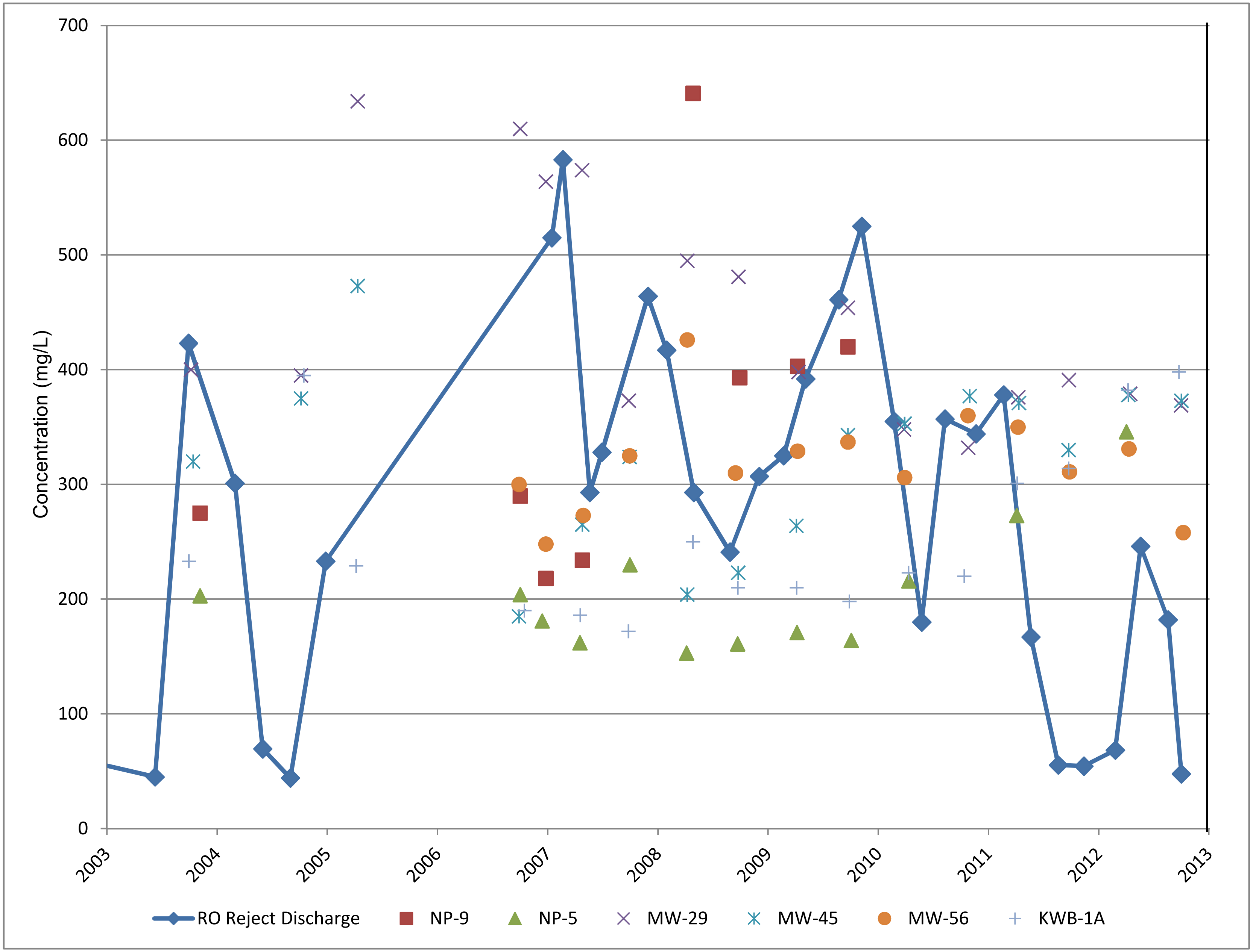


Figure 12 - Chloride Concentrations

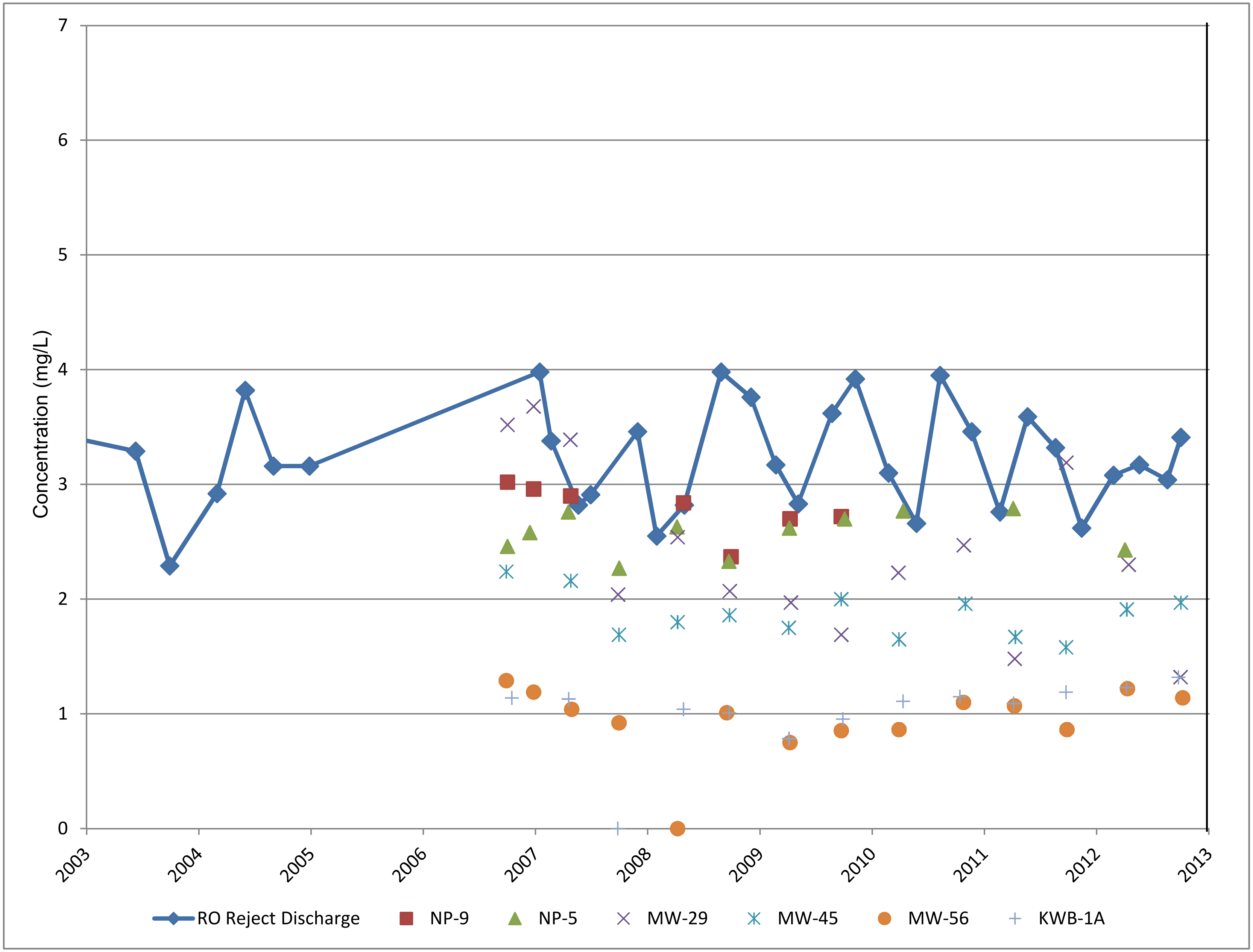


Figure 13 - Fluoride Concentrations

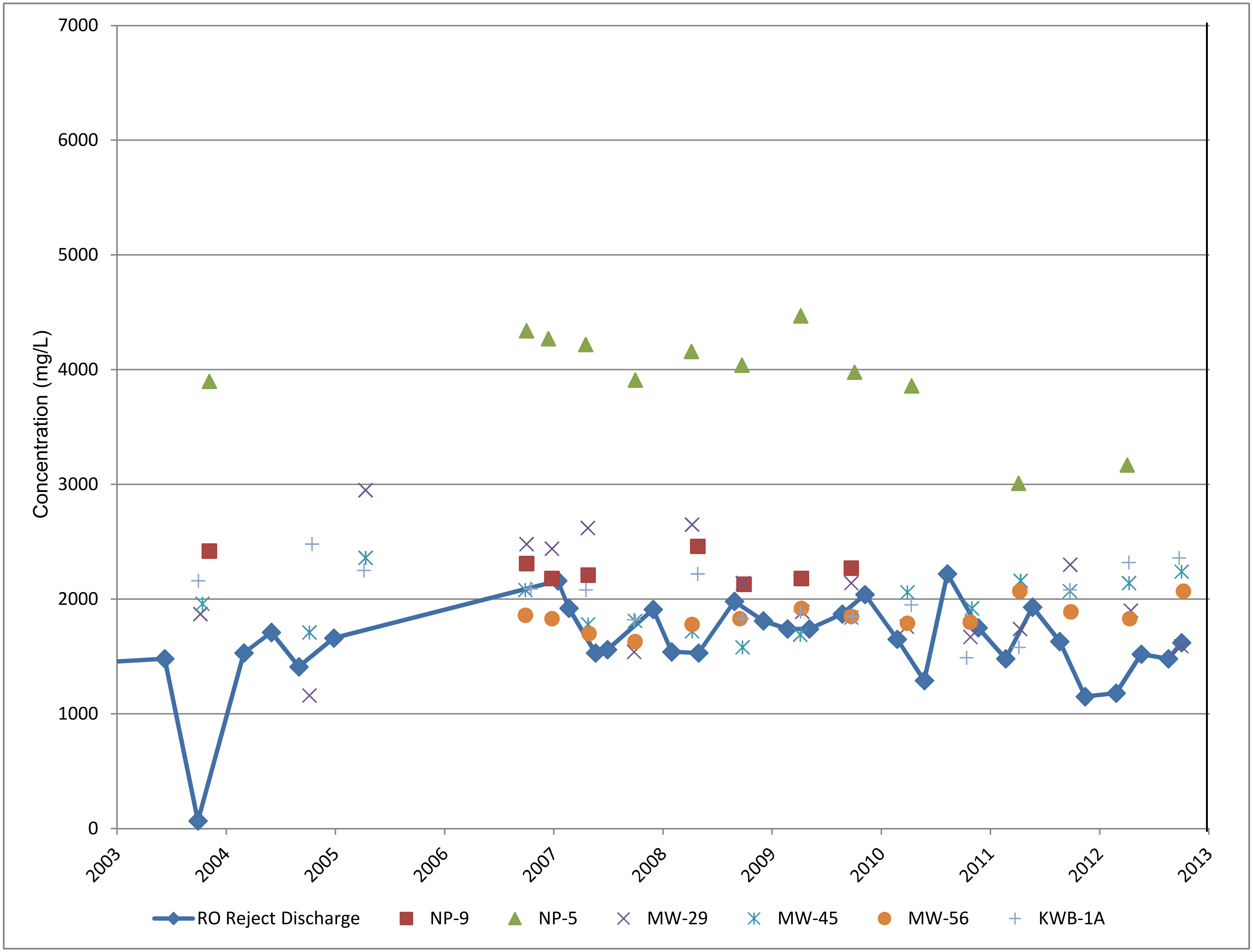


Figure 14 - Sulfate Concentrations

LEGEND:

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL
- ABANDONED WELL
- SHALLOW AQUIFER POTENTIOMETRIC SURFACE CONTOURS
- REJECT FIELD

NOTE:

POTENTIOMETRIC SURFACE ELEVATION IN FEET AVERAGE MEAN SEA LEVEL.

0 800 1,600 2,400 3,200 Feet

GRAPHIC SCALE

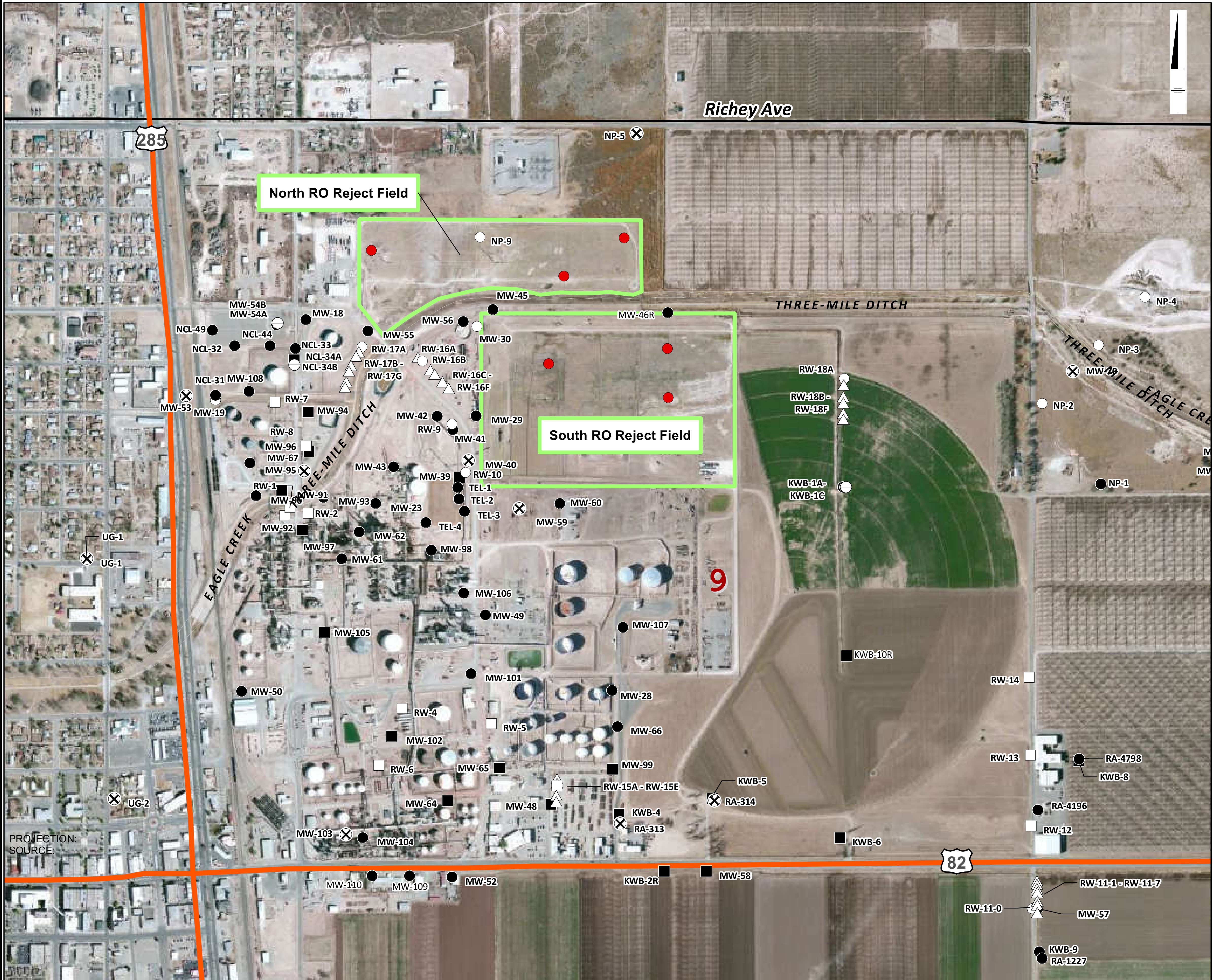
NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
RO REJECT FIELDS SITE INVESTIGATION WORK PLAN

SHALLOW SATURATED ZONE POTENTIOMETRIC SURFACE MAP FIRST SEMIANNUAL EVENT 2012 (MAR-APR)

ARCADIS

FIGURE
15

CITY: SF DIV/GROUP: IM DB: K ERNST LD: PIC: PM: TM: TR:
Project (Project #)
C:\NavajoRefining\ArtesiaRefinery\RO_RejectFieldWorkPlan\mxd\GWcntrs_Awbz_SA1_2012.mxd - 11/13/2012 @ 3:55:36 PM



Legend

- PROPOSED WELL LOCATIONS
- NOT SAMPLED AS PART OF ROUTINE MONITORING PROGRAM
- SAMPLES COLLECTED BIENNIALLY
- SAMPLES COLLECTED ANNUALLY
- SAMPLES COLLECTED SEMIANNUALLY
- SAMPLES COLLECTED ANNUALLY IF PSH <0.03 FT
- SAMPLES COLLECTED SEMIANNUALLY IF PSH <0.03 FT
- RECOVERY TRENCH WELL LOCATION NOT SAMPLED AS PART OF ROUTINE MONITORING PROGRAM
- US HIGHWAY
- LOCAL ROADS
- REJECT FIELD

NOTES:
1. SEE FACILITY WIDE GROUNDWATER MONITORING WORK PLAN FOR ANALYTICAL SUITE
2. PSH = PHASE SEPARATED HYDROCARBONS

0 1,000 2,000

SCALE IN FEET

NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
RO REJECT FIELDS SITE INVESTIGATION WORK PLAN

PROPOSED WELL LOCATIONS

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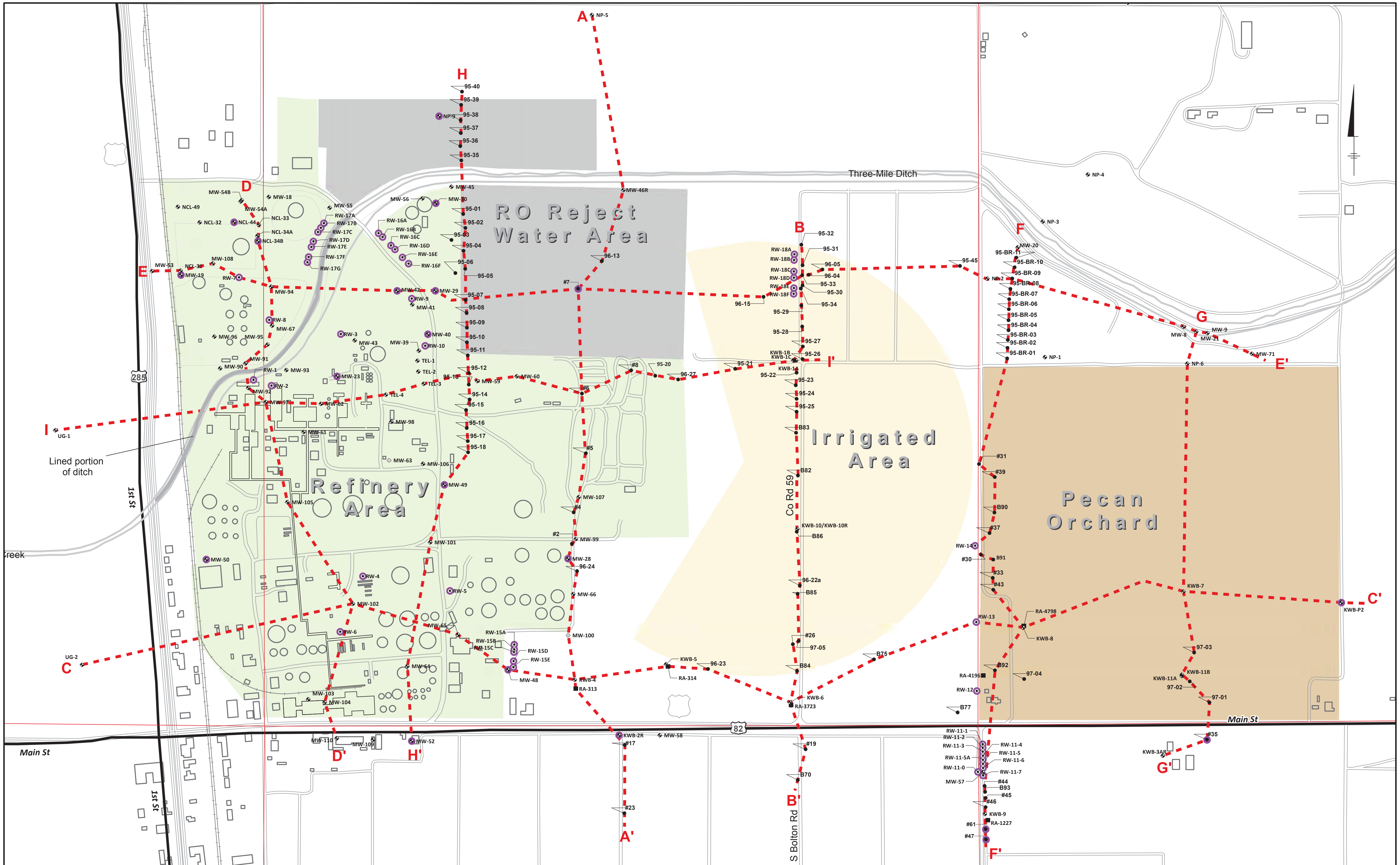
FIGURE
16

CITY:(GREENVILLE) DIV/GROUP:(ENV/GIS) DB: LD: PIC: PM: TM:
PROJECT: XX000000.0000.00000 PATH: C:\NavajoRefining\ArtesiaRefinery\RO_RejectFieldWorkPlan\mxd\Proposed Well Locs.mxd

ARCADIS

Appendix A

Lithologic Cross-Sections from Conceptual Site Model



LEGEND:

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL
- ABANDONED WELL
- BORING LOCATION
- WELL/BORING LOCATIONS: MISSING LOG OR NO SOIL DESCRIPTIONS
- STRATIGRAPHIC CROSS-SECTION LINES
- IRRIGATED AREA
- PEACH ORCHARD
- RO REJECT WATER AREA
- REFINERY AREA

0 500 1,000 Feet

GRAPHIC SCALE

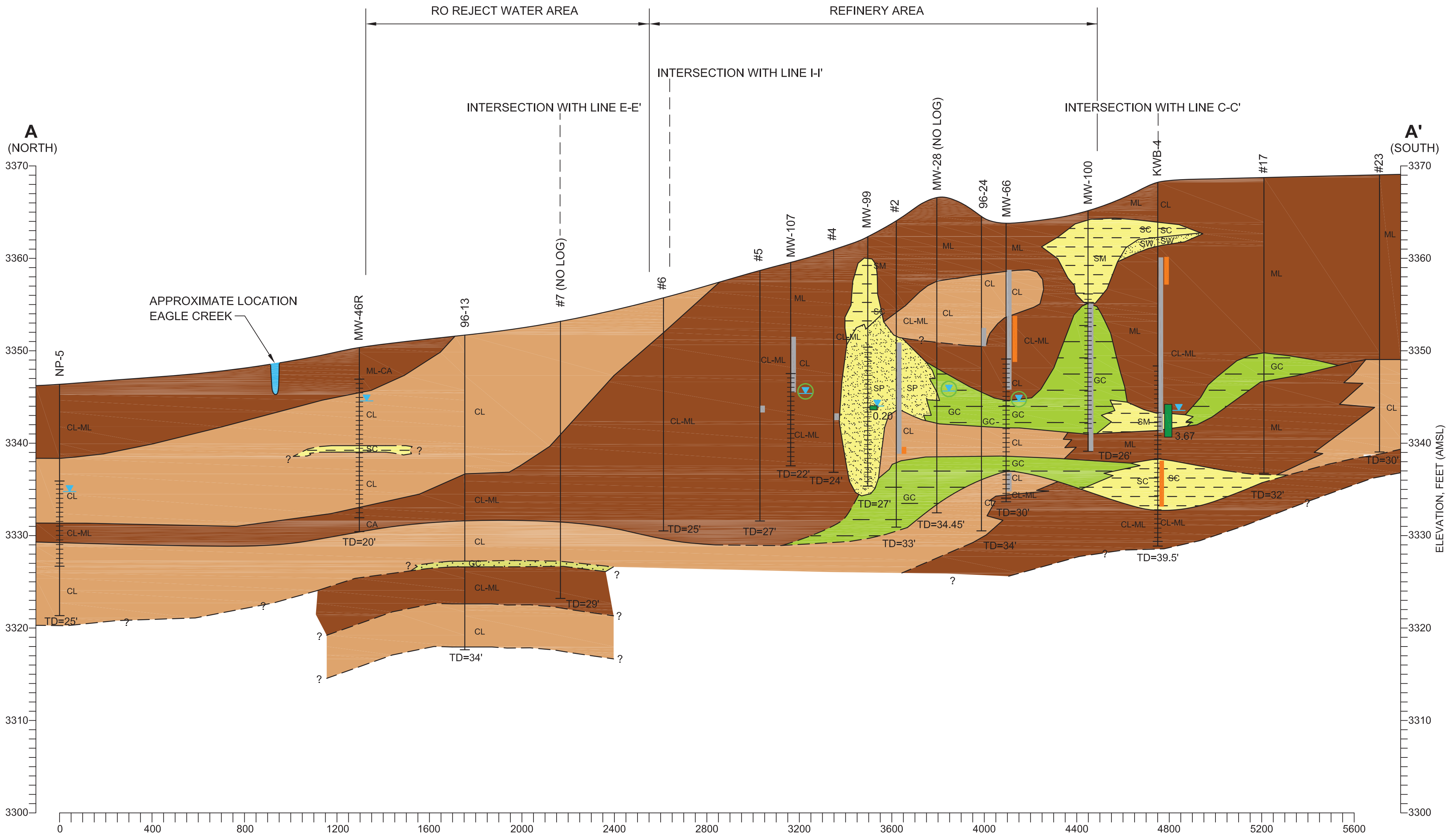
NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

CONTAMINANT MIGRATION EVALUATION WORK PLAN

STRATIGRAPHIC CROSS-SECTION LOCATIONS

ARCADIS

FIGURE
A-1



LEGEND:

- KWB-6 — WELL/BORING ID
- ODOR (OBSERVED DURING DRILLING)
- STAINING/PRODUCT (OBSERVED DURING DRILLING)
- 2.58 — THICKNESS OF FREE PRODUCT (FEET)
- POTENTIOMETRIC WATER SURFACE CORRECTED ASSUMING SPECIFIC GRAVITY OF 0.8 (MARCH 2012)
- GROUNDWATER DRO EXCEEDANCE
- WELL SCREEN
- TD=39.5'

DRO = DIESEL RANGE ORGANICS

TD = TOTAL DEPTH OF BOREHOLE IN FEET BELOW GROUND SURFACE

- CLAY/CALICHE (CL, CH, CA)
- CLAYEY/SILTY SAND (SC, SM)
- SAND (SP, SW)
- SILT (ML)
- GRAVEL (GP, GW)
- CLAYEY/SILTY GRAVEL (GM, GC)
- FILL/ASPHALT

NOTE:

TOTAL DEPTH FOR ALL WELLS FROM BORING LOGS WHERE A BORING LOG IS NOT AVAILABLE, THE TOTAL DEPTH IS BASED ON THE MOST RECENT GAUGING EVENT (MARCH/APRIL 2012).

0 10 20
VERTICAL SCALE IN FEET

0 400 800
HORIZONTAL SCALE IN FEET

VERTICAL EXAGGERATION: X40

NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
CONTAMINANT MIGRATION EVALUATION WORK PLAN

CROSS-SECTION A-A'

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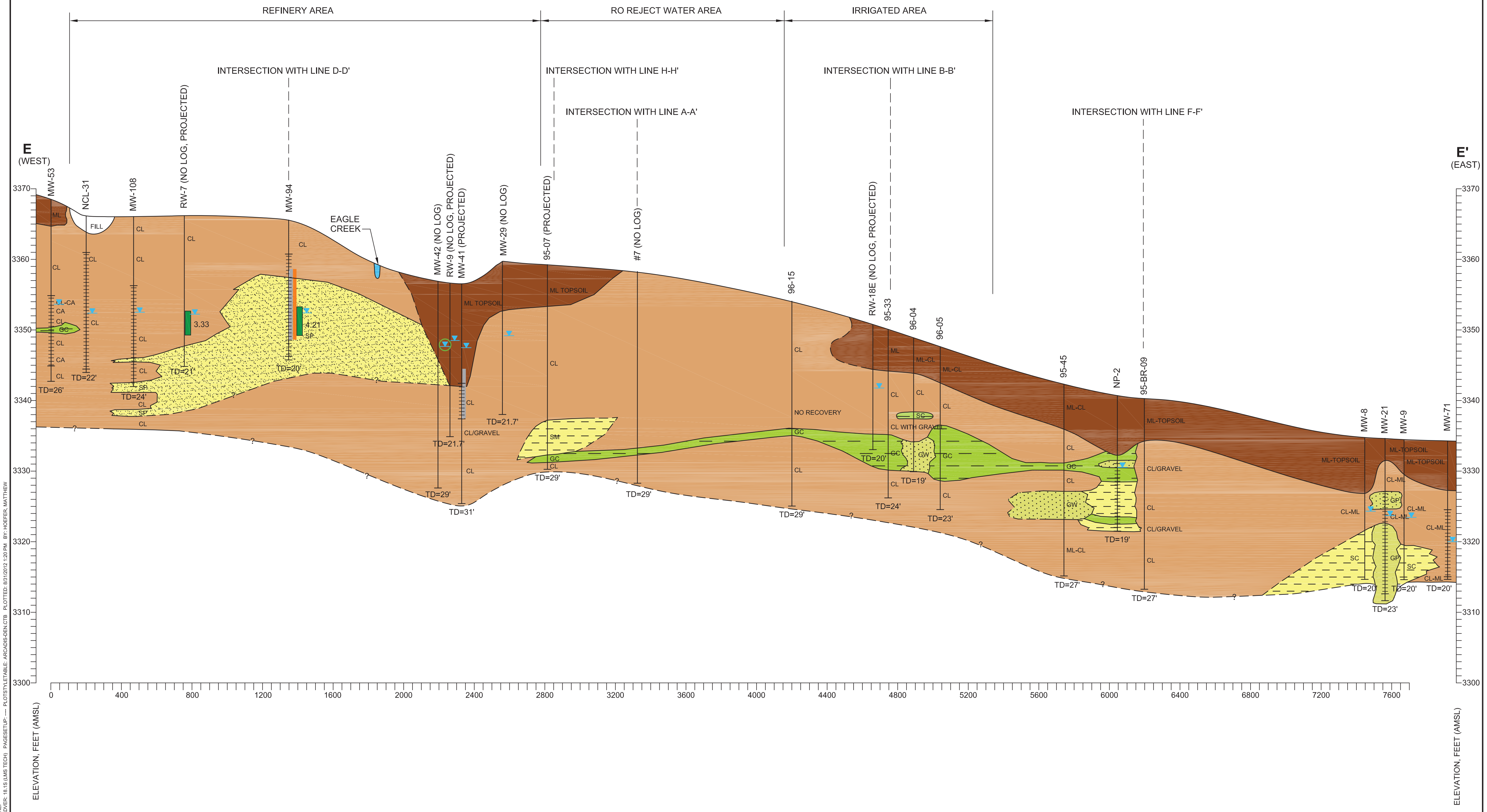
FIGURE
A-2



LEGEND:

KWB-6 — WELL/BORING ID

ODOR (OBSERVED DURING DRILLING)

STAINING/PRODUCT (OBSERVED DURING DRILLING)

2.58 — THICKNESS OF FREE PRODUCT (FEET)

POTENTIOMETRIC WATER SURFACE CORRECTED ASSUMING SPECIFIC GRAVITY OF 0.8 (MARCH 2012)

GROUNDWATER DRO EXCEEDANCE

WELL SCREEN

TD=39.5'

DRO = DIESEL RANGE ORGANICS

TD = TOTAL DEPTH OF BOREHOLE IN FEET BELOW GROUND SURFACE

CLAY/CALICHE (CL, CH, CA)

CLAYEY/SILTY SAND (SC, SM)

SAND (SP, SW)

SILT (ML)

GRAVEL (GP, GW)

CLAYEY/SILTY GRAVEL (GM, GC)

FILL/ASPHALT

NOTE:

TOTAL DEPTH FOR ALL WELLS FROM BORING LOGS WHERE A BORING LOG IS NOT AVAILABLE, THE TOTAL DEPTH IS BASED ON THE MOST RECENT GAUGING EVENT (MARCH/APRIL 2012).

0 10 20
VERTICAL SCALE IN FEET

0 400 800
HORIZONTAL SCALE IN FEET

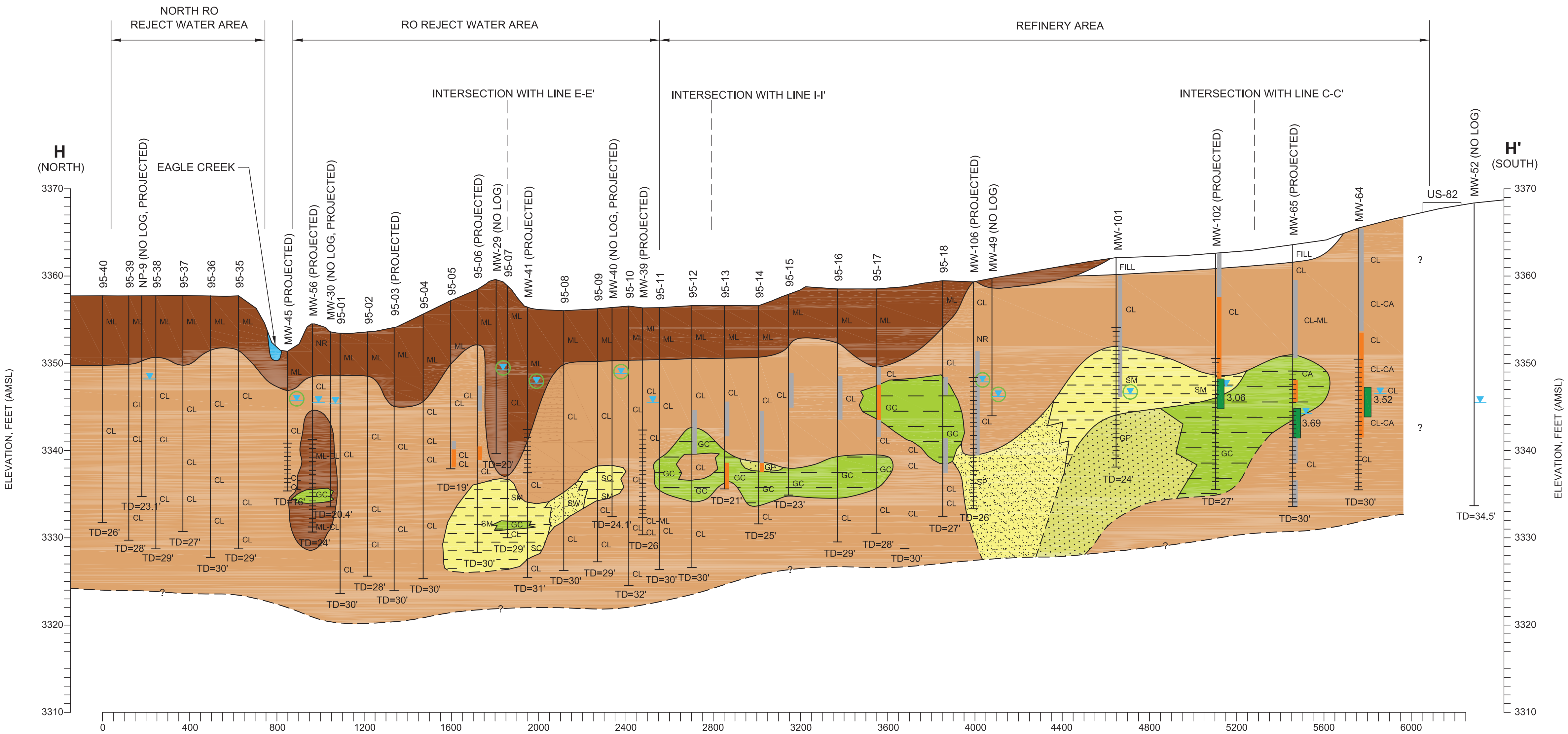
VERTICAL EXAGGERATION: X40

NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
CONTAMINANT MIGRATION EVALUATION WORK PLAN

CROSS-SECTION E-E'

ARCADIS

FIGURE
A-3



LEGEND:

- KWB-6 — WELL/BORING ID
- ODOR (OBSERVED DURING DRILLING)
- STAINING/PRODUCT (OBSERVED DURING DRILLING)
- 2.58 — THICKNESS OF FREE PRODUCT (FEET)
- POTENTIOMETRIC WATER SURFACE CORRECTED ASSUMING SPECIFIC GRAVITY OF 0.8 (MARCH 2012)
- GROUNDWATER DRO EXCEEDANCE
- WELL SCREEN
- TD=39.5'

DRO = DIESEL RANGE ORGANICS
TD = TOTAL DEPTH OF BOREHOLE IN FEET BELOW GROUND SURFACE

- CLAY/CALICHE (CL, CH, CA)
- CLAYEY/SILTY SAND (SC, SM)
- SAND (SP, SW)
- SILT (ML)
- GRAVEL (GP, GW)
- CLAYEY/SILTY GRAVEL (GM, GC)
- FILL/ASPHALT

NOTE:

TOTAL DEPTH FOR ALL WELLS FROM BORING LOGS WHERE A BORING LOG IS NOT AVAILABLE, THE TOTAL DEPTH IS BASED ON THE MOST RECENT GAUGING EVENT (MARCH/APRIL 2012).

0 10 20
VERTICAL SCALE IN FEET

0 400 800
HORIZONTAL SCALE IN FEET

VERTICAL EXAGGERATION: X40

NAVAJO REFINING COMPANY
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
CONTAMINANT MIGRATION EVALUATION WORK PLAN

CROSS-SECTION H-H'

ARCADIS

FIGURE
A-4