GW – 001

Investigation Work Plan Background Concentrations

July 2010

Western Refining

WNR LISTED NYSE

RECEIVED OCD

2011 MAY -6 P 12:49

May 5, 2011

James Bearzi, Bureau Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Bldg 1
Santa Fe, NM 87505

Certified Mail #: 7009 3410 0000 3636 2459 (to NMED)
Certified Mail #: 7009 3410 0000 3636 2466 (to OCD)

RE: Response to Approval with Modifications
Investigation Work Plan for Determination of Background Concentrations
Western Refining Southwest, Inc., Bloomfield Refinery
EPA ID # NMD089416416
WRB-10-006

Dear Mr. Bearzi:

Western Refining Southwest, Inc., Bloomfield Refinery has enclosed a replacement page to the revised Investigation Work Plan Background Concentrations dated February 2011 as requested by the New Mexico Environment Department in the Approval with Modifications letter (refer to Comment 4) dated March 30, 2011.

If you have questions or would like to discuss the revised work plan, please feel free to contact me at (505) 632-4171.

Sincerely,

James R. Schmaltz
Health, Safety, Environmental, and Safety Director
Western Refining Southwest, Inc. - Bloomfield Refinery

cc: Hope Monzeglio – NMED HWB (w/attachment)
Carl Chavez – NMOCD (w/attachment)
Dave Cobrain – NMED HWB
John Kieling – NMED HWB
Allen Hains – Western Refining El Paso
Scott Crouch – RPS Austin

determined by monitoring, at a minimum, ground water pH, specific conductance, dissolved oxygen concentrations, oxidation-reduction potential, and temperature after every two gallons or each well volume, whichever is less, has been purged from the well. Purging will continue, as needed, until the specific conductance, pH, and temperature readings are within 10 percent between readings for three consecutive measurements. The volume of ground water purged, the instruments used, and the readings obtained at each interval will be recorded on the field-monitoring log. Well purging may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated).

4.3.4 Ground Water Sample Collection

Ground water samples will be collected within 24 hours of the completion of well purging using dedicated bailers or disposal bailers. Alternatively, well sampling may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated). Sample collection methods will be documented in the field monitoring reports. The samples will be transferred to the appropriate, clean, laboratory-prepared containers provided by the analytical laboratory. Sample handling and chain-of-custody procedures will be in accordance with the procedures presented below in Section 4.4.

Ground water samples intended for metals analysis will be submitted to the laboratory for both total and dissolved metals analyses as specified in Section 4.8. QA/QC samples will be collected to monitor the validity of the ground water sample collection procedures as follows:

- Field duplicate water samples will be obtained at a frequency of ten percent, with a minimum, of one duplicate sample per sampling event; and
- Equipment rinsate blanks will be obtained for chemical analysis at the rate of ten percent or a minimum of one rinsate blank per sampling day. Equipment rinsate blanks will be collected at a rate of one per sampling day if disposable sampling equipment is used. Rinsate samples will be generated by rinsing deionized water through unused or decontaminated sampling equipment. The rinsate sample will be placed in the appropriate sample container and submitted with the ground water samples to the analytical laboratory for the appropriate analyses.

4.4 Sample Handling

At a minimum, the following procedures will be used at all times when collecting samples during investigation, corrective action, and monitoring activities:

SUSANA MARTINEZ
Governor

JOHN A. SANCHEZ
Lieutenant Governor

NEW MEXICO
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303
Phone (505) 476-6000 Fax (505) 476-6030
www.nmenv.state.nm.us

DAVE MARTIN
Secretary

RAJ SOLOMON, P.E.
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

March 30, 2011

Mr. Randy Schmaltz
Environmental Manager
Western Refining, Southwest, Inc.
Bloomfield Refinery
P.O. Box 159
Bloomfield, New Mexico 87413

RE: APPROVAL WITH MODIFICATIONS
INVESTIGATION WORK PLAN FOR DETERMINATION OF BACKGROUND CONCENTRATIONS
WESTERN REFINING SOUTHWEST, INC., BLOOMFIELD REFINERY
EPA ID # NMD089416416
WRB-10-006

Dear Mr. Schmaltz:

The New Mexico Environment Department (NMED) has reviewed Western Refining Southwest, Inc., Bloomfield Refinery (Western) revised *Investigation Work Plan Background Concentrations* (Work Plan) dated February 2011. NMED hereby issues this Approval with the following modifications.

Comments 1-3 address the Comment/Response to NMED's November 19, 2010 Notice of Disapproval (NOD); the comment numbers correlate with the NOD.

1. Comment/Response 3:

In the response to Comment 3, Western explains that the two depth intervals that will be sampled (0-6 inches below ground surface [bgs] and 18-24 inches bgs) are representative of deeper soils due to similar lithology throughout the vadose zone.

If Western encounters differences in the subsurface lithology during the site investigation for which the established background data set is not appropriate, additional background samples representative of the new lithology must be collected and the background data set expanded to include these data.

2. Comment/Response 6:

This comment addressed the size of the background sample location area. This comment was discussed in a conference call on March 9, 2011 between NMED and Western. Western has expanded the background samples location area and submitted replacement Figures 2 and 9.

3. Comment/Response 14:

In the response to Comment 14, Western indicates that multiple groundwater samples will be collected from each background monitoring well over sufficient time to avoid auto correlated, non-independent data; however, the specific sampling events and frequencies were not specified.

After well development and initial groundwater sample collection from the two background wells, Western must collect groundwater samples on a quarterly basis for two years. The samples must be analyzed for the constituents proposed in the Work Plan. Upon the collection of two years of data, Western may then contact NMED to modify the sampling frequency. The background groundwater calculations and values must be submitted to NMED after collection of two years of data in a groundwater background report no later than December 1, 2013.

Additional Comments 4-6

4. Section 4.3.4 (Ground Water Sample Collection, page 4-5):

Western's Statement: "[g]round water samples intended for metals analysis will be submitted to the laboratory for both total and dissolved metals analyses as specified in Section 6.8."

NMED Comment: Reference to Section 6.8 appears to be in error and should likely reference Section 4.8. Western must correct this discrepancy and submit a replacement page(s).

5. Appendix A (Investigation Derived Waste (IDW) Management Plan), paragraph 3::

Western's Statement: "[d]rill cuttings generated during installation of soil borings and monitoring wells are not anticipated to be contaminated and will be spread on the land surface following customary water well drilling practices. If there is any indication of contamination (e.g., odors, elevated organic vapor monitoring readings, stained soil, presence of potential waste materials, etc.), then the cuttings will be placed directly into 55-gallon drums and staged in the satellite accumulation area pending results of the waste characterization sampling."

NMED Comment: Drill cuttings cannot be spread on the land surface solely on visual observation and organic vapor monitoring readings. The drill cuttings cannot be spread on the land surface until the cuttings have been properly characterized. This can be accomplished by analyzing the five foot depth and top of saturation samples for gasoline range organics (GRO) and diesel range organics (DRO). If GRO and DRO are not present in the drill cuttings, the soils may be spread on the land surface. The drill cuttings can be temporarily placed in 55-gallon drums or stockpiled onsite and covered with plastic sheeting until the soils have been properly characterized.

6. Statistics:

The Work Plan does not address how the data will be utilized once the soil and groundwater sampling results are obtained. For example, what statistics will be calculated and used as background metals concentrations and how will outliers and non-detects be handled. NMED recommends calculation of an upper tolerance limit (UTL) for background for comparison to the site maximum detected concentration, site attribution analyses, and/or geochemical plots and use of the Environmental Protection Agency's (EPA) ProUCL program. Western must adhere to the statistical requirements of Section VIII.H of the July, 27, 2007 Order and the suggested methods identified above.

Western must adhere to all modifications outlined in this Approval. Western must submit the required replacement pages to NMED on or before **May 3, 2011**. The Background Investigation Report must be submitted to NMED on or before **January 31, 2012**. The groundwater background report must be submitted to NMED no later than **December 1, 2013**.

If you have any questions regarding this letter, please contact Hope Petrie of my staff at (505) 476-6045.

Sincerely,

John E. Kieling
Program Manager
Permits Management Program
Hazardous Waste Bureau

JEK:hp

cc: J. Kieling, NMED HWB
D. Cobrain, NMED HWB
H. Petrie, NMED HWB
C. Chavez, OCD
A. Hains, Western
File: WRB-10-006 and Reading 2011

Western Refining

WNR LISTED NYSE

RECEIVED OCD

2011 FEB 18 P 12:38

February 16, 2011

James Bearzi, Bureau Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Bldg 1
Santa Fe, NM 87505

Certified Mail #: 7010 1870 0000 0709 4617

RE: Response to Notice of Disapproval
Investigation Work Plan for Determination of Background Concentrations
Western Refining Southwest, Inc., Bloomfield Refinery
EPA ID # NMD089416416
WRB-10-006

Dear Mr. Bearzi:

Western Refining Southwest, Inc., Bloomfield Refinery has prepared the following responses to your comments (dated November 19, 2010) on the above referenced work plan. The revised work plan is enclosed, along with a CD containing a red-line strikeout copy noting changes from the original version (July 2010).

Comment 1

In Section 2.2 (Site Conditions), page 2-1, Western states "[t]he conditions at the site, including surface and subsurface conditions that would affect the fate and transport of any contaminants, are discussed below." Western does not discuss the predominant wind direction at the facility. Chemicals (including metals) that are by-products of the various processes are released from the facility. The background soil location(s) should be in a place(s) that is not significantly impacted by facility emissions (e.g., upwind of building(s) that emit hydrocarbons and stack downwash). Western must revise the Work Plan to include a brief discussion of prevailing wind directions. Western must also discuss background soil locations with respect to wind-related disposition and the potential for impact from all past and current emission sources at the Refinery.

Comment 1 Response: Section 2.2 has been revised to include a discussion on the prevailing wind direction (from the east) and the fact that the background soil samples are located southeast of the main production area and thus should not be affected by past or current on-site emission sources.

Comment 2

In Section 2.2.2 (Subsurface Conditions), page 2-2, Western describes the stratigraphy at the site to include the Jackson Lake deposit and the Nacimiento Formation. Western does not discuss the unconsolidated surface soils, silts, and eolian deposits above the Jackson Lake Deposit. Western must revise the Work Plan to describe this uppermost unit and include the *approximate thickness of the eolian deposits, the Jackson Lake Terrace deposits, and the Nacimiento Formation.*

Comment 2 Response: Section 2.2.2 has been revised to include a discussion on the eolian deposits that overlie the Jackson Lake Terrace deposits. The estimated thickness of the Jackson Lake Terrace deposits and the Nacimiento Formation are already discussed in Section 2.2.2.

Comment 3

In Section 2.3.1 (Anticipated Activities), page 2-3 and Section 4.2 (Soil Sampling), page 4-2, Western states "[s]oil samples will be collected from the surface (0-6") and shallow subsurface (18-24") to establish background concentrations for inorganic constituents. Eight sample locations will be selected and two samples will be collected from each location to support the development of distinct background concentrations for surface and subsurface soils, if required."

Western proposes to collect soil samples from two intervals: 0-6 inches below ground surface (bgs) and 18-24 inches bgs. It appears background is being defined based on depth and not lithology. Background results from this study may be part of risk assessments to support corrective action complete determinations of the solid waste management units (SWMUs) and areas of concern (AOCs) being addressed under the corrective action portion of the July 27, 2007 Order (Order). For human health risk assessments, the residential and the construction worker scenarios are based upon a soil exposure interval of 0-10 feet bgs. For some ecological risk assessments, a soil interval up to 10 feet bgs may also be appropriate. In addition, as part of identifying nature and extent of contamination, soil samples will likely be collected at multiple subsurface intervals, some of which may be below a depth of 24 inches bgs. Using the limited surface and shallow subsurface soil data as proposed in this Work Plan, sufficient data will not likely be collected to adequately allow assessment of soil below 24 inches. Western must revise the Work Plan to clarify how the soil intervals currently defined will provide sufficient data to compare to the deeper subsurface soil samples (i.e., demonstrate the 18-24 inch interval is representative of the deeper subsurface soils). If the 18 to 24 inch interval is not representative of deeper subsurface soils; Western must propose to collect additional samples to characterize deeper subsurface soils. NMED suggests background soil be evaluated to a minimum depth of 15 feet bgs and that each lithologic unit present, down to and including the Nacimiento Formation be part of the study. See Also Comment 6.

Comment 3 Response: The collection of soil samples from the deeper interval (18-24") was proposed mainly to address concerns expressed by NMED during a meeting to discuss the background sampling effort. NMED expressed concerns about any possible impacts to surface (0-6") soils even though the background sample locations are located well away from historical or current site operations. To address this concern, Western proposed to add an additional sample interval below the 0-6" surface interval even though there is no significant change in lithology throughout the vadose zone that would suggest a statistically significant change in concentrations of target constituents. Western reviewed all available information, including the numerous soil borings and a soil survey prepared by the Natural Resource Conservation Service, to determine an appropriate depth for the deeper sample interval. As explained in Section 4.2 of the work plan, the 18-24" interval was selected based on a slight variation in the soil chemical properties with depth for the Doak-Avalon association soils.

Additional discussion has been added to Section 2.2.2 to further explain the similarity in soil type and lithology throughout the vadose zone. Western does not believe there is sufficient variation in the vadose zone materials to warrant establishing background concentrations for additional intervals. The Nacimiento Formation is below the depth of saturation and there is currently no need to establish background concentrations for the Nacimiento, nor is there any anticipated future benefit of having such data. If at some future time, there is a need to establish background concentrations for the Nacimiento Formation, then Western will propose such sample collection and analysis.

Comment 4

In Section 2.3.4 (Surveys), page 2-4, Western states "[t]he horizontal coordinates of each sample location and the locations of all other pertinent structures will be determined by a registered New Mexico Professional land surveyor in accordance with the State Plane Coordinate system (NMSA 1978 47-1-49-56 (Repl. Pamp. 1993))...Horizontal positions will be measured to the nearest 0.1 ft." Western does not discuss the vertical elevation measurements and how these measurements will be obtained. Western must revise the Work Plan to discuss vertical elevation measurements for the sample locations. Refer to and comply with the requirements of Section VIII.A7 of the Order.

Comment 4 Response: The vertical elevation measurements were omitted for the background soil sample locations because they provide no useful information; however, per NMED's direction, the vertical measurements have been added to Section 2.3.4.

Comment 5

In Section 4.1 (Well Drilling and Construction Activities), page 4-1, Western states "[t]he soil boring(s) to be completed as a background monitoring well will be drilled to the top of bedrock (Nacimiento Formation) and the anticipated completion depth ranges from 50 to 60 feet. Soil samples will be collected continuously and logged by a qualified geologist or engineer. Soil samples will not be collected for chemical analyses, only ground water samples will be collected from the soil boring(s) completed as background monitoring wells." In order to demonstrate that the area is not contaminated, Western must also collect soil samples from five feet bgs and at the top of saturation/water table. The soil samples must be analyzed for gasoline range organics (GRO) and diesel range organics (DRO). Western must revise the Work Plan to include the additional sample locations.

Comment 5 Response: Sections 2.3.1, 4.1, 4.2, and 4.8 have been revised to include the requested soil samples at the background monitoring well locations.

Comment 6

In Section 4.2 (Soil Sampling), page 4-2, Western states"... [e]ight sample locations will be selected and two samples will be collected from each location to support the development of distinct background concentrations for surface and subsurface soils, if required. The area in which the samples will be collected is located southeast of the Regional Transportation office (Figure 2). The background sample locations are shown in Figure 9. This area will be gridded into eight cells of approximately the same size with sample collection locations staked in the center of each grid cell." The proposed soil background location is a limited area of approximately 170 feet by 70 feet (approximately 0.27 acres). Given the size of the area *investigated (approximately 263 acres), it does not appear that eight samples in a relatively small area will provide sufficient representation of the natural variability of the soil across the site. Western must propose to collect additional background soil samples from areas that have not been impacted to allow for the evaluation of variability of inorganic constituents. Western may use the proposed monitoring well locations as additional locations for background soil samples. The soil samples collected from the additional locations must be from the same lithologic units as the other eight locations. See Comment 3.*

Comment 6 Response: As recommended by NMED, Western will incorporate additional background soil samples across a larger area by utilizing soil samples collected from the background monitoring well locations (see revisions to Section 4.1 and 4.2 pursuant to Comment 5). As explained above in response to Comment 3, the available information does not indicate significant variability in the lithology across the active areas of the refinery property. Also, the area where the background soil borings are located was purposefully selected to be representative of the on-site areas of investigation and is independent of the size of the respective areas. The lithology will be examined during installation of all borings but it is anticipated that the lithologic units will be the same at the background soil borings and the five-foot sample interval at the background monitoring well borings.

Comment 7

In Section 4.2 (Soil Sampling), page 4-2, Western states "[t]he area chosen for background samples was selected based on the fact that no site-related or other industrial activities are known to have taken place in this area and based on a review of soil survey information. As shown on the soil survey map included in Appendix B, the same soil map unit (Doak-Avalon association) occurs across most of the refinery complex (USDA, 2010). The area from which the background samples will be collected is within this same soil association. The two sample depths were selected based on the chemical soil properties reported in Appendix B, which show a slight variation with the depth for the Doak-Avalon association soils." Appendix B of the Work Plan contains a custom soil resource report for the site. Based on the soil map (page 8), the bulk of the soils across the site are members of the Doak-Avalon association, gently sloping (DN), Fruitland-Persayo-Sheppard complex (FX), and hilly Fruitland-Persayo-Sheppard complex, hilly (HA) soil units. In addition to physical properties for these units, Appendix B also provides profiles for these units, summarized below.

Soil Unit	***Profile***
DN	*0 to 14 inches: Loam* *14 to 60 inches: Loam*
FX	*0 to 4 inches: Sandy loam*
	4 to 60 inches: Fine sandy loam
HA	*0 to 7 inches: Cobbly sandy loam* *7 to 26 inches: Cobbly sandy clay loam* *26 to 60 inches: Cobbly sandy clay loam*

Western proposes to collect the background soil samples from the DN soil unit. Based on the physical properties provided for each of these units, it appears that there may be sufficient similarity between the units to allow for samples collected from the DN soil unit to be representative of samples from the FX and HA soil units. However, it is not clear that soil *comprised of mostly loam may be representative of soils with higher sand and/or cobble content as defined in some areas at the site. Figure 7 suggests that some of the sources of LNAPL may be located within soil units other than DN, FX, or HA. For example, the plume west of RW-1 and Hammond Ditch and the North Boundary Barrier Wall is located within the Avalon loam (Ay). Western must include additional discussion of the representativeness of the DN soil unit for all locations, and explain how the DN unit is representative of the FX and HA units.*

Comment 7 Response: In regards to the representativeness of the background soil samples in the DN soils, there may be little difference in the lithology of a loam and a sandy loam. A very slight increase in the percentage of sand (53% vs. 52%) could change the soil texture from a loam to a sandy loam. Based on the actual samples observed in the soil borings, there are not sufficient differences to denote distinct lithologic units in the vadose zone in the areas shown on page 8 of Appendix B for DN and HA. Additional discussion has been included in the third paragraph of Section 4.2. No recent borings have been completed in the areas representing the FX soil unit, so no site-specific information is available; however, none of the areas under investigation fall within the FX soil unit area.

Regarding the LNAPL west of RW-1, the LNAPL was not sourced in this location but migrated at depth from the east where the potential source(s) are within the larger area of DN soils. There is no need to establish background for the Ay soils, as there are no soil samples from this area that require a comparison to "background" concentrations.

Comment 8

Western discusses well development in Section 4.3.1. However, Western does not discuss the timeframe in which the well(s) will be developed in this Section. Western must revise the Work Plan to state the timeframe within which well development will be completed in accordance with Section IX.C.5 of the Order.

Comment 8 Response: Section 4.3.1 has been revised to note that the new monitoring well(s) will be developed within one week of completing all soil borings.

Comment 9

In Section 4.3 (Ground Water Sample Collection), page 4-5, Western states "Ground water samples intended for metals analysis will be submitted to the laboratory as total metals." In addition to total metals analysis, the groundwater samples must also be analyzed for dissolved metals. Western must revise the Work Plan accordingly.

Comment 9 Response: Sections 4.3.4 and 4.8 have been revised to include analyses for both total and dissolved metals analyses.

Comment 10

Western discusses the collection of groundwater level measurements in Section 4.3.2 (Ground Water Levels). Western must revise the Work Plan to include information about the instrument that will be used to collect the water level measurements.

Comment 10 Response: Section 4.3.2 has been revised to include a discussion on the use of a Keck KIR Interface Probe or similar instrument to measure groundwater levels.

Comment 11

In Section 5 (Schedule), page 5-1, Western states "[t]his background investigation Work Plan will be implemented concurrently with the next site investigation Work Plan that is approved by the NMED. At this time, this is anticipated to be the Group #4 Investigation Work Plan December 2008 (revised January 2010)." The background investigation cannot be conducted concurrently with the Group 4 Investigation, which has already been completed. Western must revise the Work Plan to state the Work Plan will be executed concurrently with the next investigation Work Plan approved by NMED.

Comment 11 Response: The discussion on the implementation schedule has been revised to separate the background investigation from any other RFI investigation activities. This will allow the work plan to be implemented as a separate effort.

Comment 12

In Section 5 (Schedule), page 5-1, Western states "[c]omputation of the required summary statistics pursuant to Section VIII.H. of the Order will be completed and the results will be included with the Group #4 Site Investigation Report." The background investigation Work Plan results must be included in a separate report. Western must revise the Work Plan to remove the Group 4 Report reference and state that the results will be included in a background investigation report.

Comment 12 Response: Section 5 has been revised to remove any reference to Group 4 and to state that the results will be included in a background investigation report.

Comment 13

In Appendix A (Investigation Derived Waste (IDW) Management Plan), Western states "[d]rill cuttings generated during installation of soil borings and monitoring wells are not anticipated to be contaminated and will be spread on the land surface following customary water well drilling practices." Western does not discuss field screening of the soil borings in the Work Plan. Although contamination is not anticipated, Western must conduct field screening of soils (using instrument, olfactory, and visual methods) during the installation of the soil borings and monitoring wells for evidence of hydrocarbons. The field screening results will assist in determining whether or not Western can dispose of contaminated soils on the land surface. Contaminated soils with values above the New Mexico Soil Screening Levels, residential scenario, must be disposed of properly at an off-site facility. Western must revise the Work Plan to include these changes.

Comment 13 Response: Sections 2.3.3 and 3.3.3, and Appendix A have been revised to incorporate and/or clarify the field screening during installation of the background soil borings and background monitoring wells. All soils will be field screened and any potentially impacted soils will be containerized and characterized to support proper management/ disposal of the soils. If there is no evidence of any impacts to the drill cuttings, then the soils will be spread on the land surface following customary water well drilling practices.

Comment 14

Based on the historical knowledge of the facility, NMED is aware that locating groundwater and locations for background wells is going to be difficult. As presented in the Work Plan, *background values for groundwater cannot be determined. The following concerns related to the limited groundwater data is listed below.*

a. *According to Section VIII.H of the Order, statistically defensible data must be collected for background determination. The (two) proposed wells are to be screened only in the shallow surface water, allowing for the collection of one groundwater sample per well. Two groundwater samples will not provide enough data to be statistically defensible, as statistical comparison of data cannot be conducted. Moreover, it is not likely that two wells would sufficiently capture the natural variability of inorganics in groundwater.*

b. *Because of the potential for refusal at the proposed background locations for groundwater, additional proposed well locations are warranted.*

c. *It is not clear how the data quality objectives and the quality control measures with respect to duplicates and blanks will be met with only two samples. It is therefore likely that the evaluation of groundwater will be limited to a qualitative assessment of inorganics with some limited quantitative analysis in the uncertainty section.*

d. *Western must propose additional locations for the installation of background monitoring wells.*

Comment 14 Response:

a) To address the issue of "statistically defensible data", Western proposes multiple samples to be collected over sufficient time to avoid auto correlated, non-independent data. This approach is commonly used for RCRA background monitoring wells and is discussed in EPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance (March, 2009). The two proposed locations for the background monitoring wells are separated by approximately 2,500 feet, which should be sufficient to evaluate spatial variability.

In its efforts to evaluate the concern raised by NMED, Western conducted a search of current written guidance issued by the State of New Mexico that deals with the issue of up-gradient background monitoring wells. The requirement for background wells is addressed in the following guidance issued by the New Mexico Environment Department in October 2004, Unified Guidance for Dairies Subject to State Ground Water Discharge Permits and Federal Concentrated Animal Feeding Operation Permits. The following requirement is found in Section 2.2.2 of this document, "Prior to discharging, an operator must install ground water monitoring wells at the facility. Typically, one well is located upgradient of the facility, one is located downgradient of the lagoons, and one is located downgradient of the land application areas." This guidance issued by NMED to ensure protection of groundwater indicates that "typically" a single background well is sufficient to evaluate potential releases to groundwater. Although this guidance was issued by NMED for a different type of facility, there is no apparent technical reason why NMED would mandate different requirements.

b) Because of the limited subsurface information in the potential background locations, Western is hesitant to include additional proposed well locations at this time. If the currently proposed locations fail to encounter groundwater, then Western will contact NMED to discuss the new subsurface information produced by the logging of the well soil borings and potential alternative locations.

c) The number of investigation samples does not have any bearing on achieving the data quality objectives or quality control measures regarding duplicates or blanks. Pursuant to the work plan, field duplicates for groundwater will be collected at a rate of 10% with a minimum of one field duplicate per sampling event. Based on the number of anticipated samples, one field duplicate will be collected for groundwater. Equipments blanks will be collected at a frequency of one per day on each day that samples are collected.

d) As explained above in response to Comments 14 a. and 14 b., Western believes that two background monitoring wells will be sufficient to provide "statistically defensible data" with data collected over multiple sampling events. It is also inadvisable to select alternative locations at this time without the potential benefit of the new subsurface information that will be obtained during the drilling of the two currently proposed wells.

If you have questions or would like to discuss the revised work plan, please feel free to contact me at (505) 632-4171.

Sincerely,

James R. Schmaltz
Environmental Manager
Western Refining Southwest, Inc., Bloomfield Refinery

cc: Hope Monzeglio – NMED HWB (w/attachment)
Carl Chavez – NMOCD (w/attachment)
Dave Cobrain – NMED HWB
John Kieling – NMED HWB
Laurie King – EPA Region 6 (w/attachment)
Allen Hains – Western Refining El Paso
Scott Crouch – RPS Austin

RPS
404 Camp Craft Rd., Austin, Texas 78746, USA
T +1 512 347 7588 F +1 512 347 8243 W www.rpsgroup.com

INVESTIGATION WORK PLAN
Background Concentrations

Bloomfield Refinery
Western Refining Southwest, Inc.
#50 Rd 4990
Bloomfield, New Mexico 87413

July 2010
(Revised February 2011)

James R. Schmaltz
Environmental Manager

Western Refining Southwest, Inc.
Bloomfield Refinery

Scott T. Crouch, P.G.
Senior Consultant

RPS
404 Camp Craft Rd.
Austin, Texas 78746

Table of Contents

List of Sections

Table of Contents (continued)

List of Figures

List of Appendices

Executive Summary

The Bloomfield Refinery, which is located in the Four Corners Area of New Mexico, has been in operation since the late 1950s. Past inspections by State and federal environmental inspectors have identified locations where releases to the environment may have occurred. These locations are generally referred to as Solid Waste Management Units (SWMUs) or Areas of Concern (AOCs).

Pursuant to the terms and conditions of an Order issued on July 27, 2007 by the New Mexico Environment Department (NMED) to San Juan Refining Company and Giant Industries Arizona, Inc. for the Bloomfield Refinery, this Investigation Work Plan has been prepared to describe sample collection and analyses methods that will be used to support development of site-specific background concentrations for inorganic constituents. A Class I permit modification was approved on June 10, 2008 to reflect the change in ownership of the refinery to Western Refining Southwest, Inc. The operator is now Western Refining Southwest, Inc. – Bloomfield Refinery.

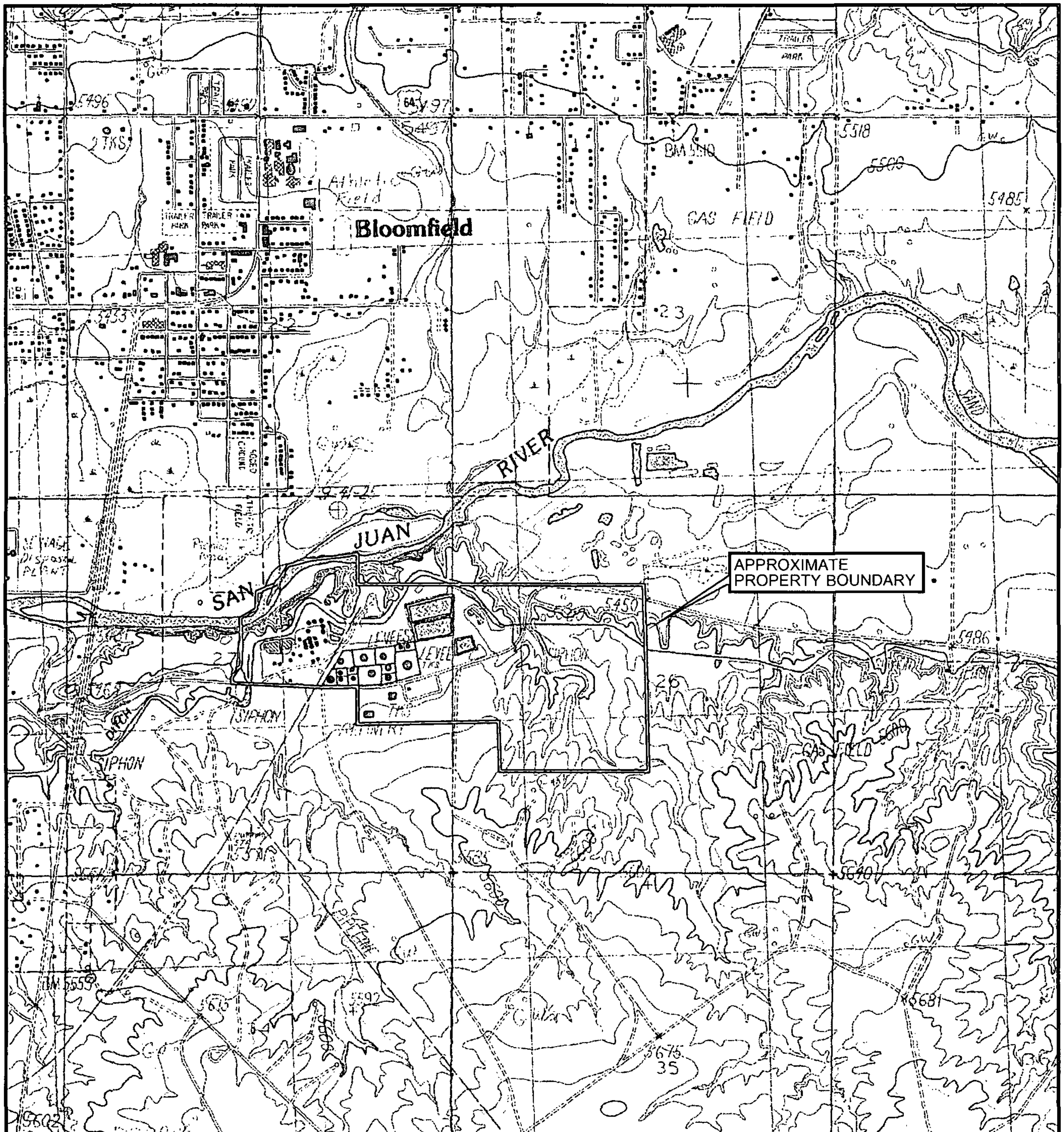
The planned investigation activities include collection of soil and potentially ground water samples, which will be analyzed for inorganic constituents. The specific sampling locations, sample collection procedures, and analytical methods are included.

Section 1
Introduction

The Bloomfield Refinery is located immediately south of Bloomfield, New Mexico in San Juan County (Figure 1). The physical address is #50 Road 4990, Bloomfield, New Mexico 87413. The Bloomfield Refinery is located on approximately 263 acres. Bordering the facility is a combination of federal and private properties. Public property managed by the Bureau of Land Management lies to the south. The majority of undeveloped land in the vicinity of the facility is used extensively for oil and gas production and, in some instances, grazing. U.S. Highway 44 is located approximately one-half mile west of the facility. The topography of the main portion of the site is generally flat with steep bluffs to the north where the San Juan River intersects Tertiary terrace deposits.

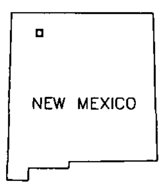
The Bloomfield Refinery is a crude oil refinery currently owned by San Juan Refining Company, a New Mexico Corporation,, and it is operated by Western Refining Southwest, Inc., formerly known as Giant Industries Arizona, Inc., an Arizona corporation. The Bloomfield Refinery had an approximate refining capacity of 18,000 barrels per day. Various process units operated at the facility, included crude distillation, reforming, fluidized catalytic cracking, sulfur recovery, merox treater, catalytic polymerization, and diesel hydrotreating. The refinery produced gasoline, diesel fuels, jet fuels, kerosene, propane, butane, naphtha, residual fuel, fuel oils, and LPG.

On July 27, 2007, the New Mexico Environment Department (NMED) issued an Order to San Juan Refining Company and Giant Industries Arizona, Inc. ("Western") requiring investigation and corrective action at the Bloomfield Refinery. This Investigation Work Plan has been prepared for the sole purpose of collecting soil and ground water samples to support development of site-specific background concentrations pursuant to Section VIII.H. of the Order.



Map Source: USGS 7.5 Min. Quad Sheet BLOOMFIELD, NM., 1985.

0 2000
SCALE IN FEET



QUADRANGLE LOCATION

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef–A42

FIGURE 1
SITE LOCATION MAP
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Section 2
Soil Background Concentrations

This section presents background information, a discussion on site conditions, and a scope of services for establishment of site-specific background concentrations for inorganic constituents.

2.1 Background

This section presents background information, including a review of historical waste management activities to identity the following:

- Type and characteristics of all waste and all contaminants handled in the background investigation area;
- Known and possible sources of contamination;
- History of releases; and
- Known extent of contamination.

The area targeted for collection of soil samples to establish background concentrations is located on the far southeastern portion of the refinery property so as to avoid any potential for current or historical impacts from refinery operations. The selected area is located south of the Regional Transportation office, which is located south the County Rd 4990 and east of Wooten Rd. (Figure 2). There is no current commercial or industrial activity in this area and no historical commercial or industrial activities are known to have occurred in this area. The proposed sample collection area is located on a separate tract of land owned by Western, just south of the Refinery property.

2.2 Site Conditions

The conditions at the site, including surface and subsurface conditions that could affect the fate and transport of any contaminants, are discussed below. This information is based on recent visual observations and historical subsurface investigations.

2.2.1 Surface Conditions

Regionally, the surface topography slopes toward the floodplain of the San Juan River, which runs along the northern boundary of the refinery complex. To the south of the refinery, the drainage is generally to the northwest. North of the refinery complex, across the San Juan

River, surface water flows in a southeasterly direction toward the San Juan River. The central and eastern portions of the refinery property, where the process units, storage tanks and background soil sample collection area are located, is generally of low relief with an overall northwest gradient of approximately 0.02 ft/ft. The refinery sits on an alluvial floodplain terrace deposit and there is a steep bluff (approx. drop of 90 feet) at the northern boundary of the refinery where the San Juan River intersects the floodplain terrace.

There are two locally significant arroyos, one immediately east and another immediately west of the refinery, which collect most of the surface water flows in the area, thus significantly reducing surface water flows across the refinery and background soil sample collection area. A minor drainage feature is located on the eastern portion of the refinery, where the Landfill Pond (SWMU No. 9) was located and there are several steep arroyos along the northern refinery boundary that primarily capture only local surface water flows and minor ground water discharges. The land surface at the proposed location for collection of background soil slopes north/northeast and feeds into the larger arroyo that runs along the east portion of the refinery property.

The land surface is characterized by sparse shrubby vegetation, which is adapted to the arid conditions. Bare soil is exposed in many areas, consisting of a loam in the upper five inches and a clay loam to a depth of 60 inches (USDA, 2010).

The prevailing wind direction for the area is from the east as measured at the nearby Farmington, New Mexico airport (WRCC, 2011). The Farmington airport is located approximately 17 miles west of the refinery and both locations are along the east-west trending San Juan River Valley. The soil sample collection locations discussed in Sections 2.3.1 and 4.2 are located southeast of the refinery process area and thus are in a generally upwind location from potential on-site air emission sources.

2.2.2 Subsurface Conditions

Numerous soil borings and monitoring wells have been completed across the refinery property during previous site investigations and installation of the slurry wall, which runs along the northern and western refinery boundary. Based on the available site-specific and regional subsurface information, the site is underlain by the Recent eolian deposits and Quaternary Jackson Lake terrace deposits, which unconformably overlie the Tertiary Nacimiento Formation. The Recent eolian deposits are predominantly silt and fine to medium grained sand that is poorly sorted. The thickness of the eolian deposits has not been determined as the underlying Jackson Lake deposits similarly are composed of silt and fine grained sand and there is no clear demarcation between the two deposits. The Jackson Lake deposits consist of fine grained sand, silt and clay that grades to coarse sand, gravel and cobble size material closer to the contact with the Nacimiento Formation. The eolian deposits and the Jackson Lake Formation combined are over 40 feet thick near the southeast portion of the site and generally thin to the northwest toward the San Juan River. The thickness of the eolian deposits and the Jackson Lake Formation may be anticipated to be as great at 50 feet in the area of the background sample locations. The Nacimiento Formation is primarily composed of fine grained materials (e.g., carbonaceous mudstone/claystone with interbedded sandstones) with a reported local thickness of approximately 570 feet (Groundwater Technology Inc., 1994).

A review of the vadose zone materials as examined in the numerous soil borings located across the refinery property indicates a similar lithology (e.g., color, mineralogical composition, and grain size) above the horizon within the Jackson Lake Formation where there is a marked increase in grain size with the introduction of gravel and cobble sized material. The vadose zone above the gravel and cobble is composed predominantly of silt and fine to medium grained sand with minor portions of clay sized material. Across the site, there are minor variations in the percentages of the various sized fractions but it is commonly a difficult field judgment whether to classify a particular sample as sandy silt or silty sand, with some minor portion of clay present in most samples. The sand and silt sized grains are predominantly composed of quartz.

Within the deeper interval that includes the gravel and cobble sized material, the matrix is similar to the finer grained material discussed above. While the gravel and cobble materials are composed of both quartz and igneous rocks of various composition, the finer grained matrix material will have the dominant influence on contaminant fate and transport through this interval. Also, the finer grained matrix material would represent the potential exposure medium in this deeper interval and not the gravel and cobble sized fraction, thus any evaluation of background constituent concentrations should be performed on the finer grained matrix material.

A review of the soil survey information (see Section 4.2) also shows similar lithology within the upper five feet (USDA, 2010). The Doak soil map unit is described as a loam from 0 – 5" and a clay loam from 5 – 60". The Avalon soil map unit is described as a loam from 0 – 60" and a gravelly loam from 60 – 64".

2.3 Scope of Services

This subsection presents a brief description of the anticipated sample collection activities to be performed during the background soil sample collection activities, background information research conducted to develop the Scope of Services, a description of the collection and management of investigation derived waste, and surveying to be conducted to record sample location data.

2.3.1 Anticipated Activities

Pursuant to Section VIII.H. of the Order, soil samples will be collected from the surface (0-6") and shallow subsurface (18-24") to establish background concentrations for inorganic constituents. Eight sample locations will be selected and two samples will be collected from each location to support the development of distinct background concentrations for surface and subsurface soils, if required. The area in which the samples will be collected is located southeast of the Regional Transportation office and the individual sample locations will be surveyed following the procedures in Section 2.3.4 (Figure 2). In addition, soil samples will be collected at the background monitoring well borings from five feet below ground surface and at the top of saturation as discussed in Section 4.2.

2.3.2 Background Information Research

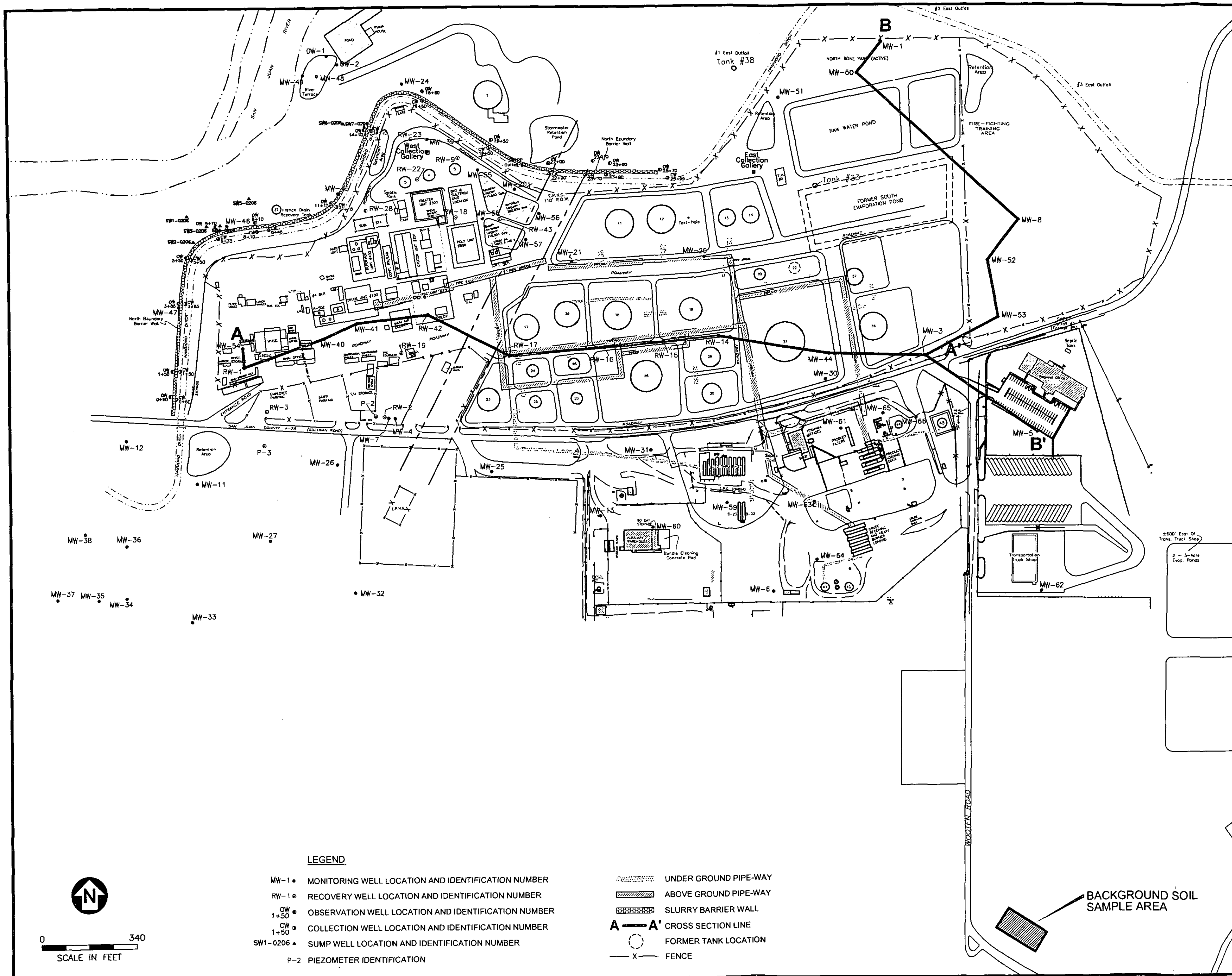
Scoping documents that provided information on historical operations and documents containing the results of previous investigations were reviewed to facilitate development of this work plan. The previously collected data provides very good information on the overall surface and subsurface conditions, including verification of areas with past industrial operations.

2.3.3 Collection and Management of Investigation Derived Waste

Minimal, if any, excess sample material is anticipated to be associated with the collection of the shallow (e.g. up to two feet) soil samples. As there will be minimal excess material and it is being collected in areas that are fully anticipated to be devoid of any contamination, the excess sample material will be placed back into the hole from which the sample was retrieved, unless field screening results (e.g., organic vapor monitoring, olfactory or visual) indicates potential impacts. If potential impacts are observed, then the soil will be placed into steel drums pending waste characterization sampling. The IDW will be characterized using methods based on the boring location, boring depth, drilling method, and type of constituents suspected or encountered in the borings. All decontamination water will be characterized prior to disposal unless it is disposed in the refinery wastewater treatment system upstream of the API Separator. An IDW management plan is included as Appendix A.

2.3.4 Surveys

The horizontal coordinates and elevation of each soil sample location and the locations of all other pertinent structures will be determined by a registered New Mexico professional land surveyor in accordance with the State Plane Coordinate System (NMSA 1978 47-1-49-56 (Repl. Pamp. 1993)). The surveys will be conducted in accordance with Sections 500.1 through 500.12 of the Regulations and Rules of the Board of Registration for Professional Engineers and Surveyors Minimum Standards for Surveying in New Mexico. Horizontal positions will be measured to the nearest 0.1-ft and vertical elevations will be measured to the nearest 0.01-ft pursuant to Section VIII.A7 of the Order.



Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining | DATE: 04/01/10 | FILE: WestRef-852

FIGURE 2
BACKGROUND SOIL SAMPLE AREA
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Section 3
Ground Water Background Concentrations

This section presents background information, a discussion on site conditions, and a scope of services for establishment of site-specific background concentrations for inorganic constituents in ground water.

3.1 Background

This section presents background information, including a review of historical waste management activities to identity the following:

- Type and characteristics of all waste and all contaminants handled in the background investigation area;
- Known and possible sources of contamination;
- History of releases; and
- Known extent of contamination.

The areas targeted for collection of ground water samples to established background concentrations are located at the far eastern portion of the refinery property and south of the refinery property on a separate tract of land owned by San Juan Refining Company. This separate tract covers approximately 32.4 acres and is located approximately 200 feet south of the southern most evaporation pond (Figure 3). These areas were selected because they are anticipated to be up-gradient of the refinery operations and as such ground water samples collected from these areas will not be affected by any current or historical refinery operations (Figure 3). There is no current commercial or industrial activity in this area and no known historical commercial or industrial activities are known to have occurred in these areas with the exception of a single gas well. The southern most proposed location for a background monitoring well is approximately 700 feet southwest of the gas well, which should place it beyond any potential impacts from operations near the gas well.

3.2 Site Conditions

The conditions at the site, including surface and subsurface conditions that could affect the fate and transport of any contaminants, are discussed below. This information is based on recent visual observations and historical subsurface investigations.

3.2.1 Surface Conditions

Regionally, the surface topography slopes toward the floodplain of the San Juan River, which runs along the northern boundary of the refinery complex. To the south of the refinery, the drainage is generally to the northwest. North of the refinery complex, across the San Juan River, surface water flows in a southeasterly direction toward the San Juan River. The active portion of the refinery property, where the process units and storage tanks are located, is generally of low relief with an overall northwest gradient of approximately 0.02 ft/ft. The refinery sits on an alluvial floodplain terrace deposit and there is a steep bluff (approx. drop of 90 feet) at the northern boundary of the refinery where the San Juan River intersects the floodplain terrace.

There are two locally significant arroyos, one immediately east and another immediately west of the refinery, which collect most of the surface water flows in the area, thus significantly reducing surface water flows across the refinery. A minor drainage feature is located on the eastern portion of the refinery, where the Landfill Pond (SWMU No. 9) was located and there are several steep arroyos along the northern refinery boundary that primarily capture only local surface water flows and minor ground water discharges. The southern most proposed location for a background monitoring well is situated along a northwest/southeast trending topographic high, which is higher in elevation than any of the other refinery property. Moving off this topographic high toward the refinery, the slope is predominantly to the northeast where surface runoff would feed the arroyo than runs along the eastern portion of the refinery property. The proposed location to the east is near an arroyo that runs along the eastern portion of the refinery property.

The land surface is characterized by sparse shrubby vegetation, which is adapted to the arid conditions. Bare soil is exposed in many areas, consisting of a loam in the upper five inches and a clay loam to a depth of 60 inches (USDA, 2010).

3.2.2 Subsurface Conditions

Numerous soil borings and monitoring wells have been completed across the refinery property during previous site investigations and installation of the slurry wall, which runs along the northern and western refinery boundary. Based on the available site-specific and regional subsurface information, the site is underlain by the Quaternary Jackson Lake terrace deposits, which unconformably overlie the Tertiary Nacimiento Formation. The Jackson Lake deposits consist of fine grained sand, silt and clay that grades to coarse sand, gravel and cobble size material closer to the contact with the Nacimiento Formation. The Jackson Lake Formation is over 40 feet thick near the southeast portion of the site and generally thins to the northwest toward the San Juan River. The Nacimiento Formation is primarily composed of fine grained materials (e.g., carbonaceous mudstone/claystone with interbedded sandstones) with a reported local thickness of approximately 570 feet (Groundwater Technology Inc., 1994).

Figures 4 and 5 present cross-sections of the shallow subsurface based on borings logs from on-site monitoring well completions. The uppermost aquifer is under water table conditions and occurs within the sand and gravel deposits of the Jackson Lake Formation. The Nacimiento Formation functions as an aquitard at the site and prevents site related contaminants from migrating to deeper aquifers. The potentiometric surface as measured in August 2009 is presented as Figure 6 and shows the ground water flowing to the northwest. The saturated thickness of the shallow aquifer within the Jackson Lake Formation is greatest near and along the Hammond Irrigation Ditch and other potential sources of recharge (e.g., the raw water ponds), and decreases to the southeast in the up-gradient portions of the refinery property. Two potential drilling locations have been selected instead of a single location because of the uncertainty of locating shallow ground water in these up-gradient locations.

Previous site investigations have identified and delineated impacts to ground water from historical site operations. Figure 7 shows the distribution of SPH in the subsurface based on the apparent thickness of SPH measured in monitoring wells. Dissolved-phase impacts are depicted on Figure 8.

3.3 Scope of Services

This subsection presents a brief description of the anticipated sample collection activities to be performed, background information research conducted to develop the Scope of Services, a description of the collection and management of investigation derived waste, and surveying to be conducted to record sample location and elevation data.

3.3.1 Anticipated Activities

Pursuant to Section VIII.H. of the Order, soil boring(s) will be drilled to the south and/or east of the active portions of the refinery property. If the first boring is dry, then Western may attempt to drill a second boring. The boring(s) will be drilled to the Nacimiento Formation with well screen set to monitor shallow ground water, which has accumulated on top of the Nacimiento Formation. If ground water is present, then the boring will be completed as a permanent monitoring well and ground water samples will be collected from the new well(s) and analyzed for inorganic constituents as described in Section 4.3.4. The location and elevation of the well(s) will be surveyed following the procedures in Section 3.3.4.

3.3.2 Background Information Research

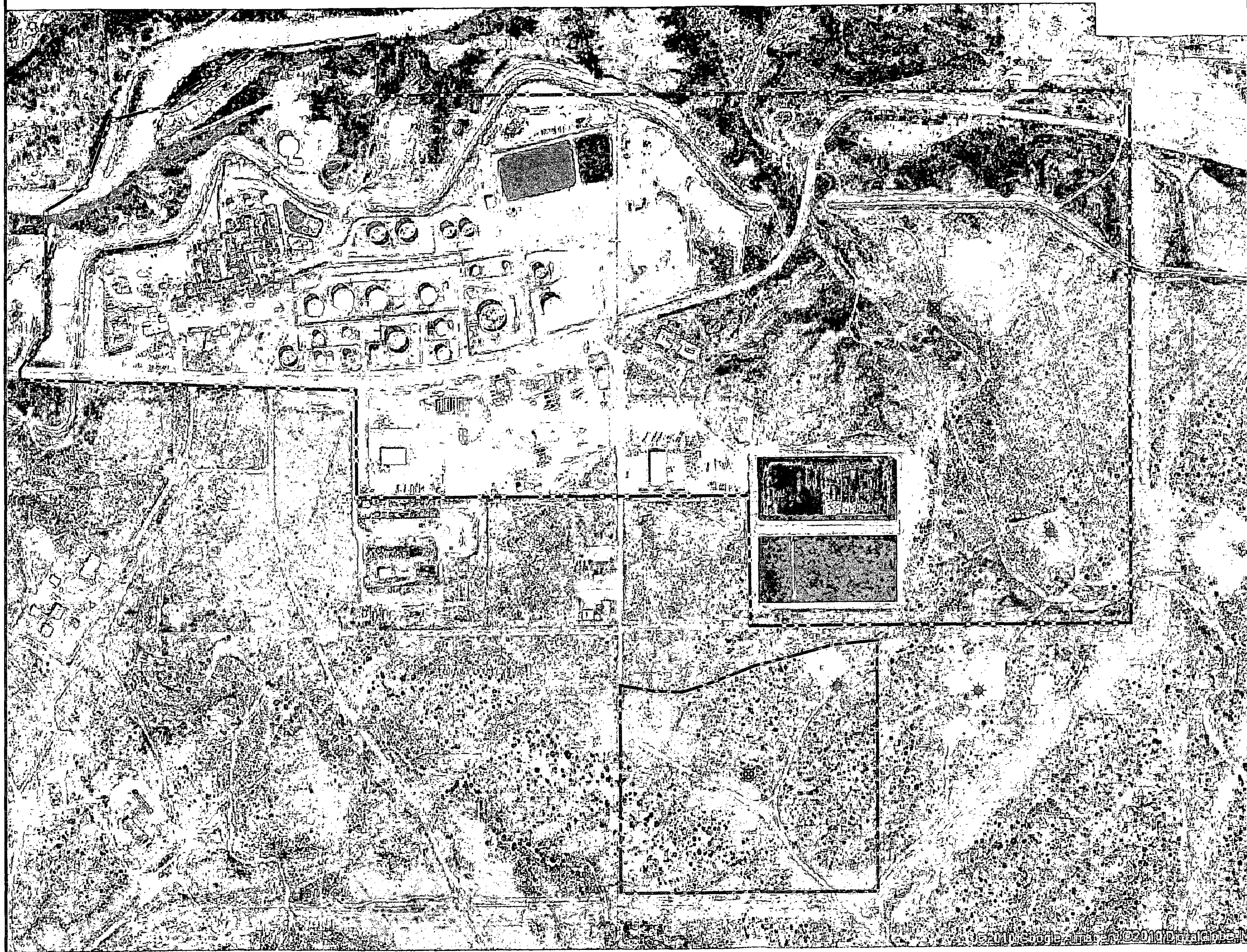
Documents containing the results of previous investigations and subsequent routine ground water monitoring data from monitoring wells were reviewed to facilitate development of this work plan. The previously collected data provides very good information on the overall subsurface conditions, including hydrogeology and contaminant distribution within ground water on a site-wide basis.

3.3.3 Collection and Management of Investigation Derived Waste

Excess soil sample material associated with the monitoring well installation will be field screened and if there is indication of potential impacts, then the soil will be contained and characterized for disposal pursuant to the IDW Management Plan in Appendix A. All purged ground water and decontamination water will be characterized prior to disposal unless it is disposed in the refinery wastewater treatment system upstream of the API Separator. An IDW management plan is included as Appendix A.

3.3.4 Surveys

The horizontal coordinates and elevation of the background monitoring well(s) and the locations of all other pertinent structures will be determined by a registered New Mexico professional land surveyor in accordance with the State Plane Coordinate System (NMSA 1978 47-1-49-56 (Repl. Pamp. 1993)). The surveys will be conducted in accordance with Sections 500.1 through 500.12 of the Regulations and Rules of the Board of Registration for Professional Engineers and Surveyors Minimum Standards for Surveying in New Mexico. Horizontal positions will be measured to the nearest 0.1-ft and vertical elevations will be measured to the nearest 0.01-ft.



Aerial Map Source: Google Maps, 2008 DigitalGlobe.

0 500
SCALE IN FEET

LEGEND

PROPOSED BACKGROUND MONITORING WELL LOCATION

GAS WELL LOCATION

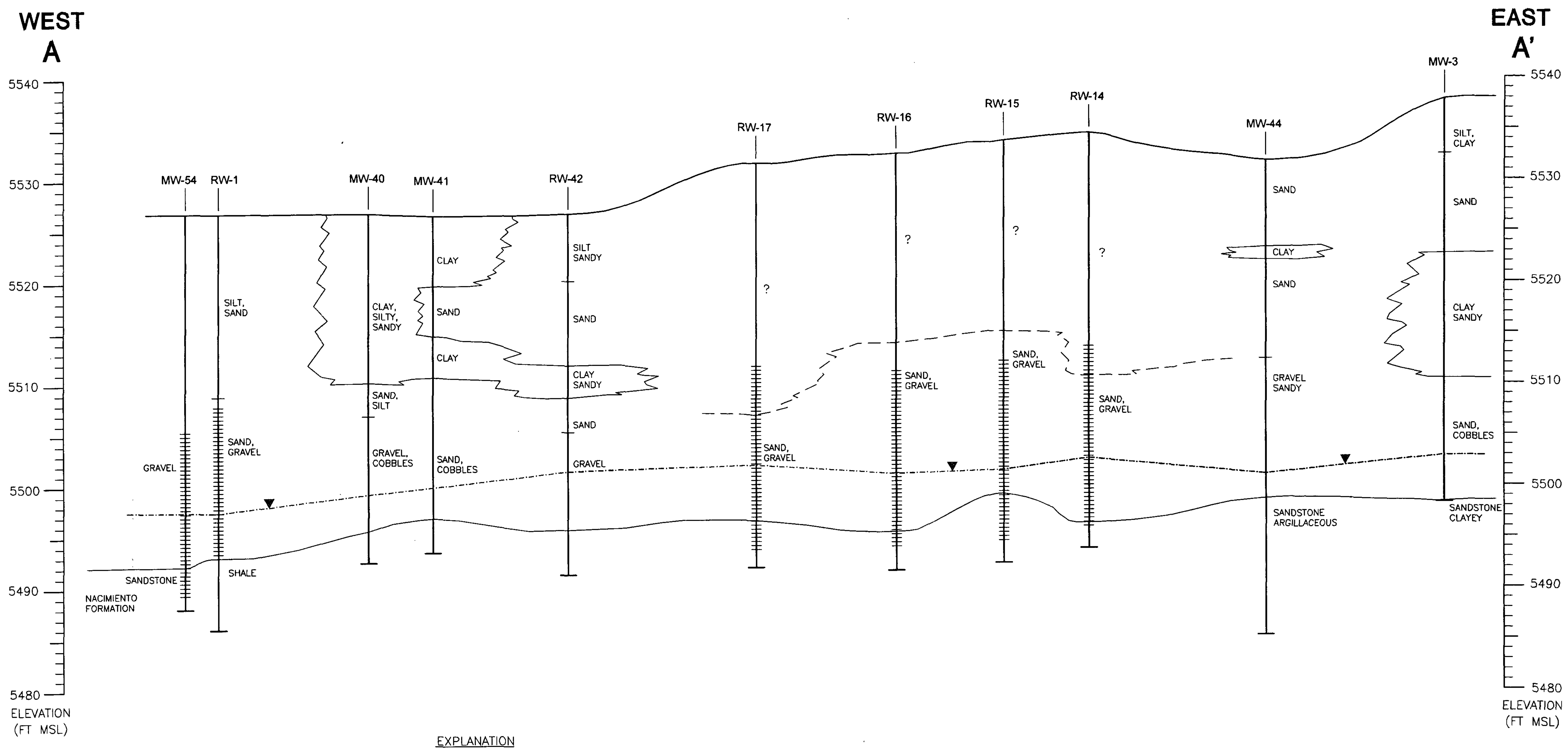
WESTERN PROPERTY BOUNDARY

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRefB53

FIGURE 3
BACKGROUND MONITORING WELL LOCATIONS
BLOOMFIELD REFINERY

RPS 404 Camp Craft Road
Austin, Texas 78746



EXPLANATION

MW-54 ← WELL IDENTIFICATION

← WELL

← SCREEN INTERVAL

LITHOLOGIC CONTACTS

▼ – POTENTIOMETRIC SURFACE MEASURED AUGUST–OCTOBER 2008

10 / 0 / 200

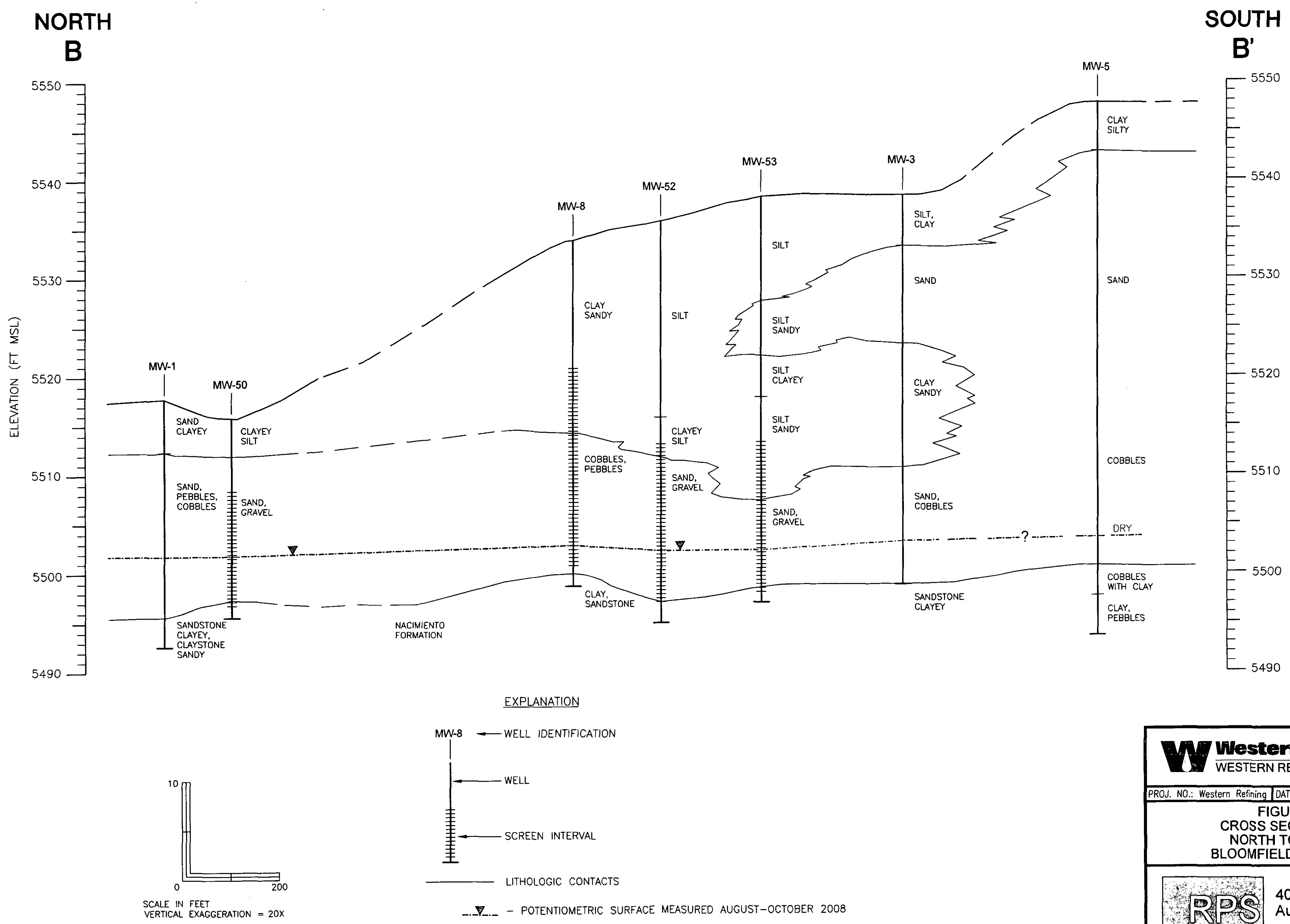
SCALE IN FEET
VERTICAL EXAGGERATION = 20X

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-B54

FIGURE 4
CROSS SECTION A-A'
WEST TO EAST
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746



Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-B55

FIGURE 5
CROSS SECTION B-B'
NORTH TO SOUTH
BLOOMFIELD REFINERY

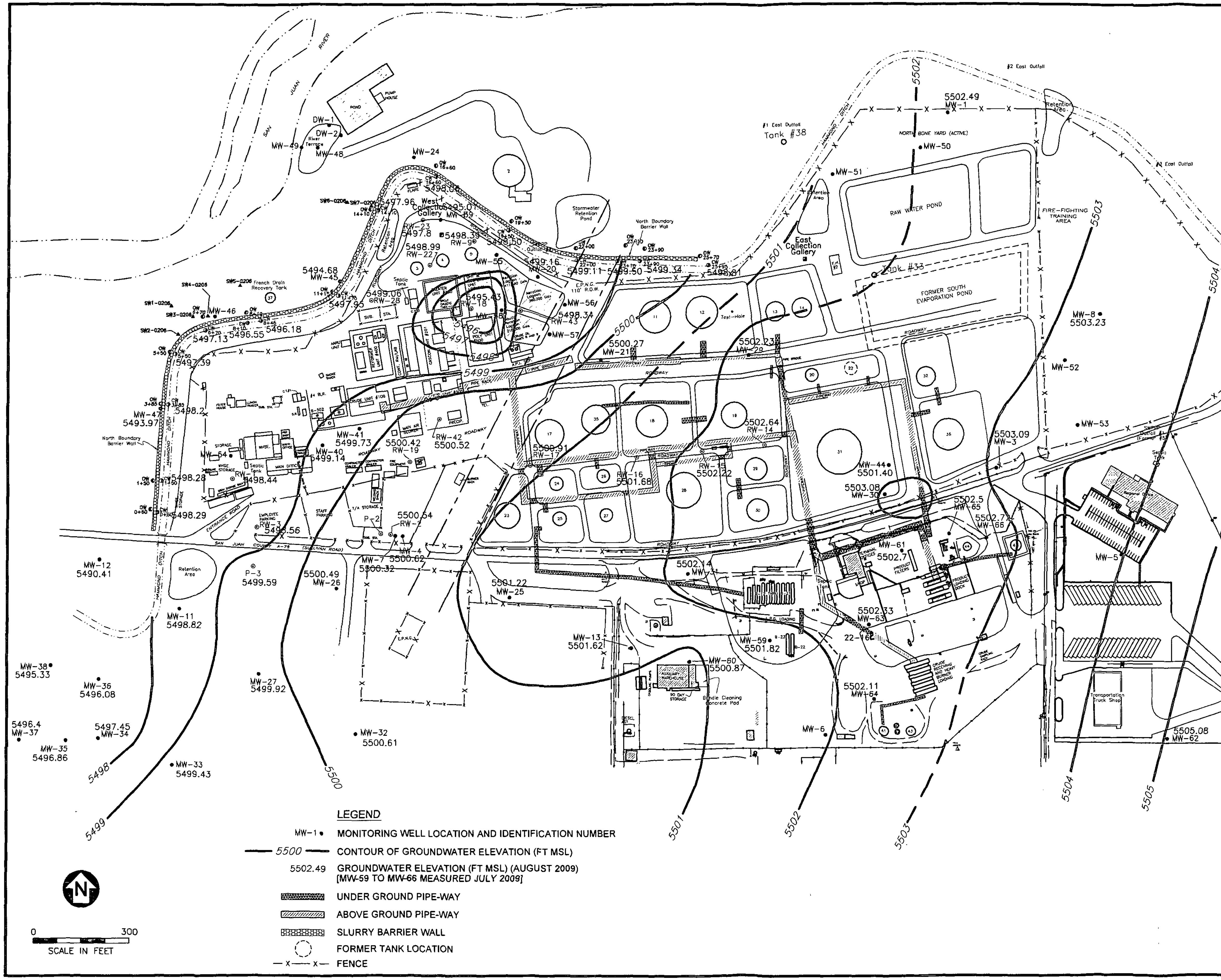
RPS
404 Camp Craft Road
Austin, Texas 78746

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-B56

FIGURE 6
POTENTIOMETRIC SURFACE MAP
AUGUST 2009
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746



LEGEND

MW-1 ● MONITORING WELL LOCATION AND IDENTIFICATION NUMBER
—— 5500 —— CONTOUR OF GROUNDWATER ELEVATION (FT MSL)
5502.49 GROUNDWATER ELEVATION (FT MSL) (AUGUST 2009) [MW-59 TO MW-66 MEASURED JULY 2009]
UNDER GROUND PIPE-WAY
ABOVE GROUND PIPE-WAY
SLURRY BARRIER WALL
FORMER TANK LOCATION
—x—x— FENCE

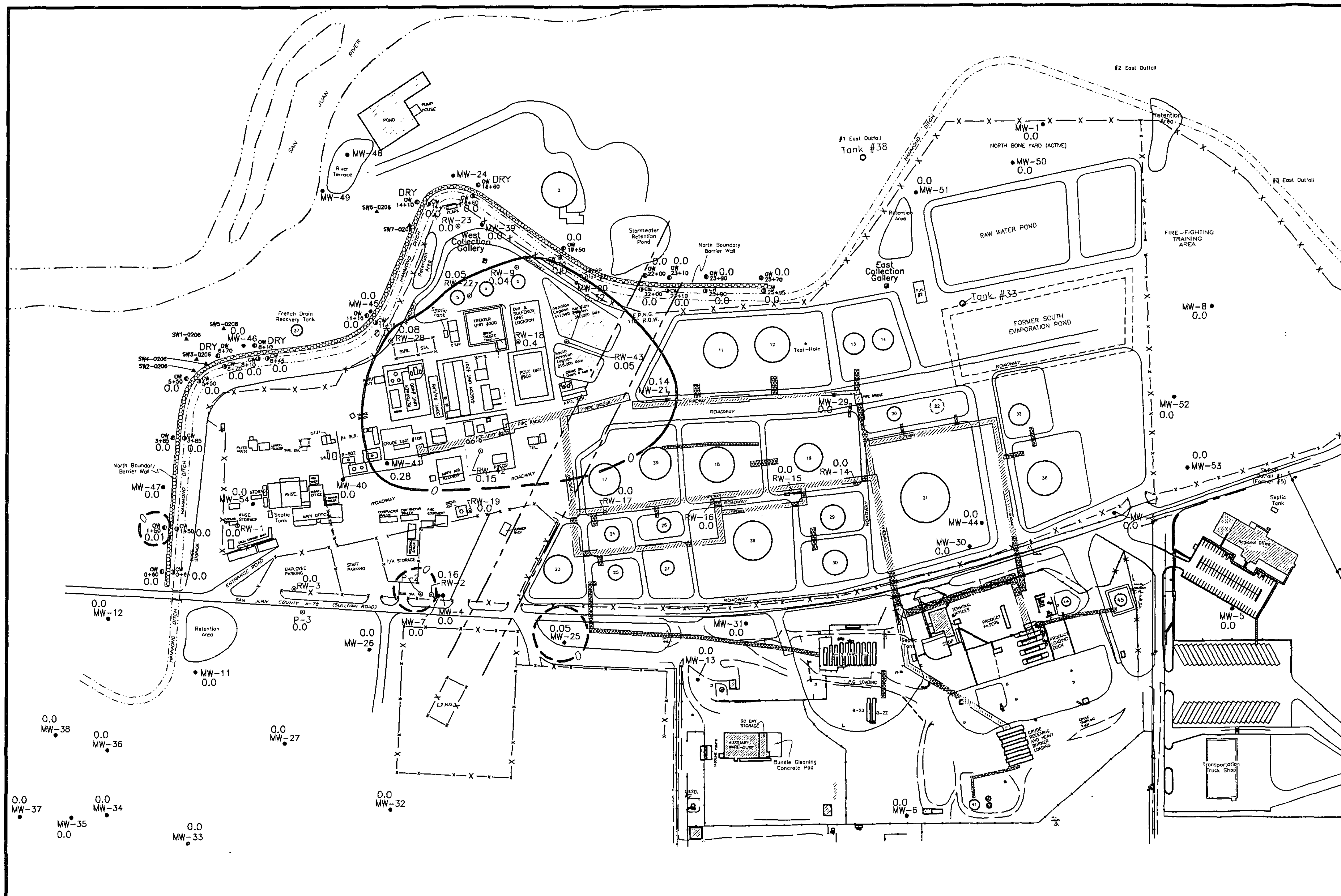
0 300
SCALE IN FEET

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-B57

FIGURE 7
SEPARATE PHASE
HYDROCARBON THICKNESS MAP
AUGUST 2008
BLOOMFIELD REFINERY

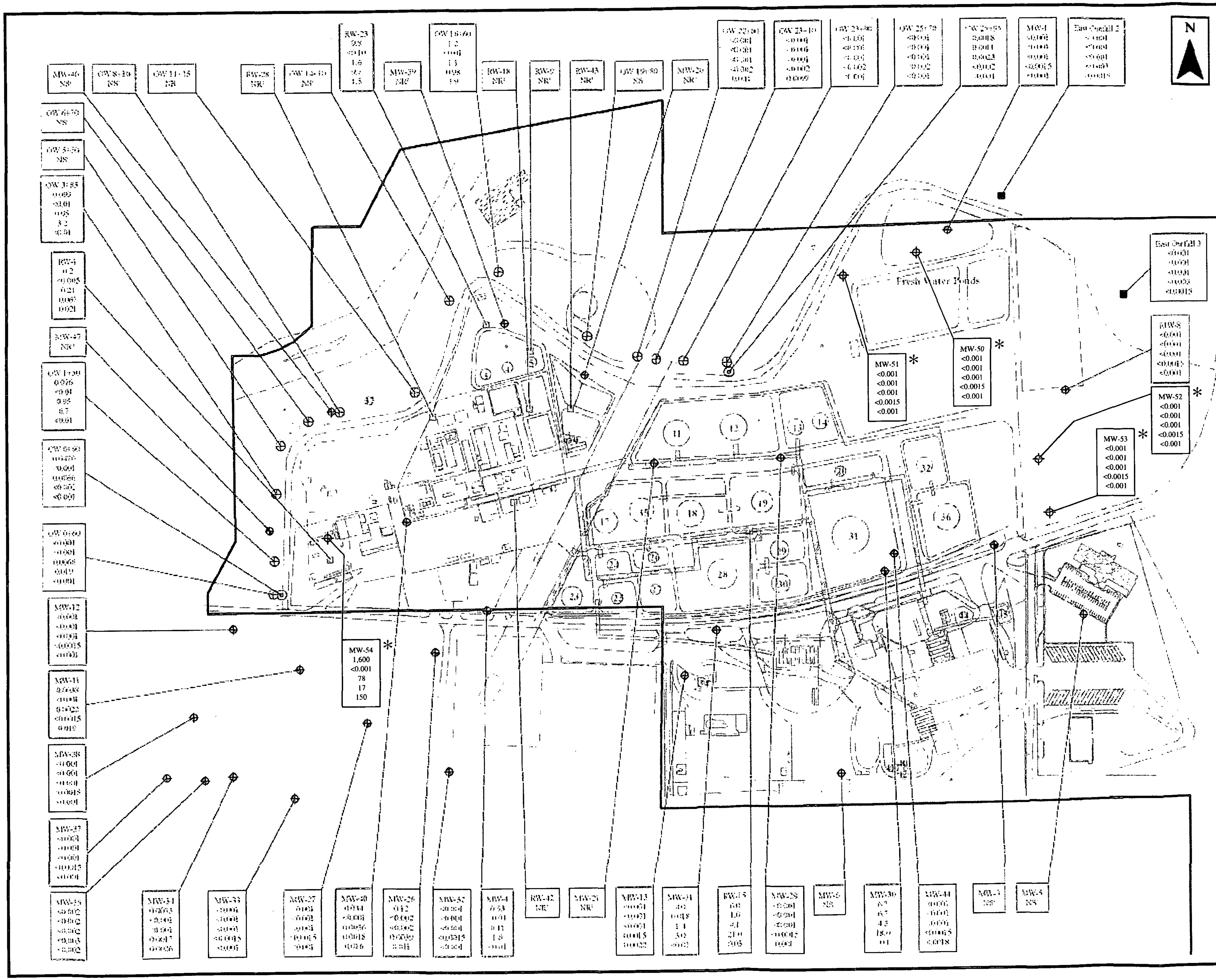
RPS
404 Camp Craft Road
Austin, Texas 78746



LEGEND

- MW-1 ● MONITORING WELL LOCATION AND IDENTIFICATION NUMBER
- RW-1 ◎ RECOVERY WELL LOCATION AND IDENTIFICATION NUMBER
- OW 1+50 ● OBSERVATION WELL LOCATION AND IDENTIFICATION NUMBER
- CW 1+50 ● COLLECTION WELL LOCATION AND IDENTIFICATION NUMBER
- SW1-0206 ▲ SUMP WELL LOCATION AND IDENTIFICATION NUMBER
- P-2 PIEZOMETER IDENTIFICATION
- —0— LNAPL THICKNESS CONTOUR (FT MSL)
- 0.15 APPARENT LNAPL THICKNESS IN WELL (FT)
- UNDER GROUND PIPE-WAY
- ABOVE GROUND PIPE-WAY
- SLURRY BARRIER WALL
- FORMER TANK LOCATION
- —x—x— FENCE

0 300
SCALE IN FEET



Map Source: Western Refining Southwest, Inc. 2008 Facility-Wide Groundwater Monitoring Report, Fig 14.

0 360
APPROXIMATE SCALE IN FEET

Legend

- Monitoring Well
- Observation Well
- Recovery Well
- Collection Well
- Outfall
- Site
- Approximate Property Line

MW-38	- Well Id
<0.001	- Benzene
<0.001	- Toluene
<0.001	- Ethylbenzene
<0.0015	- Xylenes, Total
0.001	- MTBE

Notes:

All concentrations in milligrams per liter (mg/L)

NS[1] = Well is Dry or Not Enough Water to Sample- No sample

NS[2] = Sample Inadvertently not Collected this Sampling Event

NR[1] = No Sample Required - Well Contains Separate Phase Hydrocarbon

NR[2] = No Sample Required per OCD and NMED Conditions

* = October 2008, All Other Samples Collected August 2008

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-B58

FIGURE 8
DISSOLVED-PHASE GROUNDWATER DATA
AUGUST AND OCTOBER 2008
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Section 4
Investigation Methods

The purpose of the background investigation is to determine concentrations of inorganic constituents in soil and ground water that are unaffected by any site-related operations, due to either historical or current operations. Guidance on selecting and developing sampling plans as provided in Guidance for Choosing a Sampling Design for Environmental Data Collection (EPA, 2000) was utilized to select the appropriate sampling strategy for background soil samples.

4.1 Well Drilling and Construction Activities

The background monitoring well(s) will be drilled using either hollow-stem auger or if necessary, air rotary methods including ODEX. The monitoring well construction/completion will be conducted in accordance with the requirements of Section IX of the Order. The preferred method will be hollow-stem auger to increase the ability to recover undisturbed samples. The drilling equipment will be properly decontaminated before drilling the boring(s).

The NMED will be notified as early as practicable if conditions arise or are encountered that do not allow the advancement of the boring(s) to the specified depth or at the planned drilling location. The soil boring(s) to be completed as a background monitoring well will be drilled to the top of bedrock (Nacimiento Formation) and the anticipated completion depth ranges from 50 to 60 feet. Soil samples will be collected continuously and logged by a qualified geologist or engineer. Slotted (0.01 inch) PVC well screen will be placed at the bottom of the well and will extend for 10 feet to ensure that the well is screened across the water table and to the extent possible the entire saturated zone is open to the well, with approximately five feet of screen above the water table. A 10/20 sand filter pack will be installed to two feet over the top of the well screen.

If ground water is present in the well(s) upon installation of the well screen, then the well(s) will be completed as permanent monitoring well(s). If ground water is not present immediately after installation of the well screen, then the well will be monitored periodically during the remaining background investigation activities. If ground water is subsequently found to be present in the well casing, then the well will be completed as a permanent monitoring well. If no water enters the well throughout this time period, then Western may remove the well casing and plug the boring in accordance with New Mexico Administrative Code 19.27.4.30.

The drilling and sampling will be accomplished under the direction of a qualified engineer or geologist who will maintain a detailed log of the materials and conditions encountered in each boring. Both sample information and visual observations of the cuttings and core samples will be recorded on the boring log. Known site features and/or site survey grid markers will be used as references to locate each boring prior to surveying the location. The boring locations will be measured to the nearest foot, and locations will be recorded on a scaled site map upon completion of each boring.

4.2 Soil Sampling

Soil samples will be collected at the shallow background soil borings from the surface (0-6") and shallow subsurface (18-24") to establish background concentrations for inorganic constituents. Eight sample locations will be selected and two samples will be collected from each location to support the development of distinct background concentrations for surface and subsurface soils, if required. The area in which the samples will be collected is located southeast of the Regional Transportation office (Figure 2). The background sample locations are shown in Figure 9. This area will be gridded into eight cells of approximately the same size with sample collection locations staked in the center of each grid cell.

Soil samples will be collected at the background monitoring well borings from five feet below ground surface and at the top of saturation. These samples will be used to verify the monitoring wells are placed in locations without any historical impacts, and if no historic impacts are observed, to supplement the eight aforementioned background soil borings.

The area chosen for background samples was selected based on the fact that no site-related or other industrial activities are known to have taken place in this area and based on a review of soil survey information. As shown on the soil survey map included in Appendix B, the same soil map unit (Doak-Avalon association) occurs across most of the refinery complex (USDA, 2010). The area from which the background samples will be collected is within this same soil association (i.e., DN). Based on the actual soils samples observed in the soil borings completed the areas represented by the Doak-Avalon association (DN) and Haplargids-Blackston-Torriorthents complex (HA),there are not sufficient differences to denote distinct lithologic units in the vadose zone in these areas and the background soil samples collected from the "DN" area should also be representative of the areas shown on page 8 of Appendix B as HA. The two sample depths were selected based on the chemical soil properties reported in Appendix B, which show a slight variation with depth for the Doak-Avalon association soils. The slight difference appears to be related to leaching of soluble constituents (e.g., calcium carbonate) from the surface soils (e.g., 0-6") and precipitation in deeper intervals(e.g., 18-24").

Background soil borings will be completed to a depth of two feet using a decontaminated split spoon, hand-auger or sharp shooter shovel, whichever is more efficient in allowing the collection of undisturbed soil samples from the 18-24" interval. Soil samples will be collected using a decontaminated, hand-held stainless steel sampling device or a pre-cleaned disposable sampling device. For the monitoring well soil borings, a decontaminated split-barrel sampler or continuous five-foot core barrel will be used to obtain samples during the drilling of each boring. Soil samples may be collected using decontaminated, a hand-held stainless steel sampling device, shelby tube, or thin-wall sampler, or a pre-cleaned disposable sampling device.

A portion of the sample will be placed in pre-cleaned, laboratory-prepared sample containers for laboratory chemical analysis. The remaining portions of the samples will be used for logging as discussed in Section 4.2.1. Sample handling and chain-of-custody procedures will be in accordance with the procedures presented below in Section 4.4.

Quality Assurance/Quality Control (QA/QC) samples will be collected to monitor the validity of the soil sample collection procedures as follows:

- Field duplicates will be collected at a rate of 10 percent; and
- Equipment blanks will be collected from all sampling apparatus at a frequency of one per day.

4.2.1 Soil Sample Logging

The soil borings will be continuously logged. The physical characteristics of the samples (such as mineralogy, ASTM soil classification, moisture content, texture, color, and/or presence of stains or odors), depth where each sample was obtained, method of sample collection, and other observations will be recorded in the field log by a qualified geologist or engineer. Detailed logs of each boring will be completed in the field by a qualified engineer or geologist. Additional information, such as the presence of water-bearing zones and any unusual or noticeable conditions encountered during drilling, will be recorded on the logs.

4.3 Ground Water Monitoring

4.3.1 Monitoring Well Development

The new monitoring well(s) will be developed within one week of completing all soil borings using a combination of mechanical surging and air-lift techniques. Initially, a surge block attached to the end of the drill rod will be used to swab the inside of the well casing within the screen interval. The repeated plunging motion will draw filter pack fines and loosened sediment into the well casing, improving the water quality within the surrounding formation and filter pack.

Once the well(s) is surged, an air-lift apparatus may be used to remove the loosened sediment and fines from inside the well casing. Using an air compressor and dedicated 1-inch PVC eductor piping, compressed air may be injected into the well. The air flow rate will be manually adjusted to produce a continuous flow of water/sediment mixture out the top of the well casing via the 1-inch eductor piping. Air lifting will cease once the purge water is relatively clear and free of sediment.

4.3.2 Ground Water Levels

Ground water level measurements will be obtained at the new monitoring well(s) prior to purging in preparation for a sampling event using a Keck KIR Interface Probe or similar instrument with equal capabilities. The Keck KIR Interface Probe is capable of accurately measuring water and hydrocarbon levels and hydrocarbon layer thickness to 1/100 of a foot. Measurement data and the date and time of each measurement will be recorded on a site monitoring data sheet. The depth to ground water levels will be measured to the nearest 0.01 ft. The depth to ground water will be recorded relative to the surveyed well casing rim or other surveyed datum. During regularly scheduled ground water monitoring events, ground water levels will be measured in all wells within 48 hours of the start of obtaining water level measurements.

4.3.3 Well Purging

Wells will be purged and ground water samples collected no later than five days after the completion of well development. A second round of ground water monitoring and sampling will be conducted no sooner than 30 days and not later than 75 days of the initial sampling event.

All zones in each monitoring well will be purged by removing ground water with a dedicated bailer or disposable bailer prior to sampling in order to ensure that formation water is being sampled. Purge volumes (a minimum of three well volumes including filter pack) will be determined by monitoring, at a minimum, ground water pH, specific conductance, dissolved oxygen concentrations, oxidation-reduction potential, and temperature after every two gallons or each well volume, whichever is less, has been purged from the well. Purging will continue, as needed, until the specific conductance, pH, and temperature readings are within 10 percent between readings for three consecutive measurements. The volume of ground water purged, the instruments used, and the readings obtained at each interval will be recorded on the field-monitoring log. Well purging may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated).

4.3.4 Ground Water Sample Collection

Ground water samples will be collected within 24 hours of the completion of well purging using dedicated bailers or disposal bailers. Alternatively, well sampling may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated). Sample collection methods will be documented in the field monitoring reports. The samples will be transferred to the appropriate, clean, laboratory-prepared containers provided by the analytical laboratory. Sample handling and chain-of-custody procedures will be in accordance with the procedures presented below in Section 4.4.

Ground water samples intended for metals analysis will be submitted to the laboratory for both total and dissolved metals analyses as specified in Section 6.8. QA/QC samples will be collected to monitor the validity of the ground water sample collection procedures as follows:

- Field duplicate water samples will be obtained at a frequency of ten percent, with a minimum, of one duplicate sample per sampling event; and
- Equipment rinsate blanks will be obtained for chemical analysis at the rate of ten percent or a minimum of one rinsate blank per sampling day. Equipment rinsate blanks will be collected at a rate of one per sampling day if disposable sampling equipment is used. Rinsate samples will be generated by rinsing deionized water through unused or decontaminated sampling equipment. The rinsate sample will be placed in the appropriate sample container and submitted with the ground water samples to the analytical laboratory for the appropriate analyses.

4.4 Sample Handling

At a minimum, the following procedures will be used at all times when collecting samples during investigation, corrective action, and monitoring activities:

1. Neoprene, nitrile, or other protective gloves will be worn when collecting samples. New disposable gloves will be used to collect each sample;

2. All samples collected of each medium for chemical analysis will be transferred into clean sample containers supplied by the project analytical laboratory. Sample container volumes and preservation methods will be in accordance with the most recent standard EPA and industry accepted practices for use by accredited analytical laboratories. Sufficient sample volume will be obtained for the laboratory to complete the method-specific QC analyses on a laboratory-batch basis; and

3. Sample labels and documentation will be completed for each sample following procedures discussed below. Immediately after the samples are collected, they will be stored in a cooler with ice or other appropriate storage method until they are delivered to the analytical laboratory. Standard chain-of-custody procedures, as described below, will be followed for all samples collected. All samples will be submitted to the laboratory soon enough to allow the laboratory to conduct the analyses within the method holding times. At a minimum, all samples will be submitted to the laboratory within 48 hours after their collection.

Chain-of-custody and shipment procedures will include the following:

1. Chain-of-custody forms will be completed at the end of each sampling day, prior to the transfer of samples off site.

2. Individual sample containers will be packed to prevent breakage and transported in a sealed cooler with ice or other suitable coolant or other EPA or industry-wide accepted method. The drainage hole at the bottom of the cooler will be sealed and secured in case of sample container leakage.

3. Each cooler or other container will be delivered directly to the analytical laboratory.

4. Glass bottles will be separated in the shipping container by cushioning material to prevent breakage.

5. Plastic containers will be protected from possible puncture during shipping using cushioning material.

6. The chain-of-custody form and sample request form will be shipped inside the sealed storage container to be delivered to the laboratory.

7. Chain-of-custody seals will be used to seal the sample-shipping container in conformance with EPA protocol.

8. Signed and dated chain-of-custody seals will be applied to each cooler prior to transport of samples from the site.

9. Upon receipt of the samples at the laboratory, the custody seals will be broken, the chain-of-custody form will be signed as received by the laboratory, and the conditions of the samples will be recorded on the form. The original chain-of-custody form will remain with the laboratory and copies will be returned to the relinquishing party.

10. Copies of all chain-of-custody forms generated as part of sampling activities will be maintained on-site.

4.5 Decontamination Procedures

The objective of the decontamination procedures is to minimize the potential for cross-contamination. A designated decontamination area will be established for decontamination of drilling equipment, reusable sampling equipment and well materials. The drilling rig will be decontaminated prior to entering the site. Drilling equipment or other exploration equipment that may come in contact with the borehole will be decontaminated by high pressure washing prior to drilling each new boring.

Sampling or measurement equipment, including but not limited to, stainless steel sampling tools, split-barrel or core samplers, non-dedicated well developing or purging equipment, ground water quality measurement instruments, and water level measurement instruments, will be decontaminated in accordance with the following procedures or other methods approved by the Department before each sampling attempt or measurement:

1. Brush equipment with a wire or other suitable brush, if necessary or practicable, to remove large particulate matter;
2. Rinse with potable tap water;
3. Wash with nonphosphate detergent or other detergent approved by the Department (examples include Fantastik™, Liqui-Nox®);
4. Rinse with potable tap water; and
5. Double rinse with deionized water.

All decontamination solutions will be collected and stored temporarily as described in Appendix A. Decontamination procedures and the cleaning agents used will be documented in the daily field log.

4.6 Field Equipment Calibration Procedures

Field equipment requiring calibration will be calibrated to known standards, in accordance with the manufacturers' recommended schedules and procedures. At a minimum, calibration checks will be conducted daily and the instruments will be recalibrated, if necessary. Calibration measurements will be recorded in the daily field logs. If field equipment becomes inoperable, its use will be discontinued until the necessary repairs are made. In the interim, a properly calibrated replacement instrument will be used.

4.7 Documentation of Field Activities

Daily field activities, including observations and field procedures, will be recorded in a field log book. The original field forms will be maintained at the Facility. Copies of the completed forms will be maintained in a bound and sequentially numbered field file for reference during field activities. Indelible ink will be used to record all field activities. Photographic documentation of field activities will be performed, as appropriate. The daily record of field activities will include the following:

1. Site or unit designation;
2. Date;
3. Time of arrival and departure;
4. Field investigation team members including subcontractors and visitors;
5. Weather conditions;
6. Daily activities and times conducted;
7. Observations;
8. Record of samples collected with sample designations and locations specified;
9. Photographic log, as appropriate;
10. Field monitoring data, including health and safety monitoring;
11. Equipment used and calibration records, if appropriate;
12. List of additional data sheets and maps completed;
13. An inventory of the waste generated and the method of storage or disposal; and
14. Signature of personnel completing the field record.

4.8 Chemical Analyses

All samples collected for laboratory analysis will be submitted to an accredited laboratory. The laboratory will use the most recent standard EPA and industry-accepted analytical methods for target analytes as the testing methods for each medium sampled. Chemical analyses will be performed in accordance with the most recent EPA standard analytical methodologies and extraction methods.

Ground water and soil samples will also be analyzed for the following metals using the indicated analytical methods. The ground water analyses will be reported for dissolved and total metals.

Analyte	Analytical Method
Antimony	SW-846 method 6010/6020
Arsenic	SW-846 method 6010/6020
Barium	SW-846 method 6010/6020
Beryllium	SW-846 method 6010/6020
Cadmium	SW-846 method 6010/6020
Chromium	SW-846 method 6010/6020
Cobalt	SW-846 method 6010/6020

Analyte	Analytical Method
Cyanide	SW-846 method 335.4/335.2 mod
Lead	SW-846 method 6010/6020
Mercury	SW-846 method 7470/7471
Nickel	SW-846 method 6010/6020
Selenium	SW-846 method 6010/6020
Silver	SW-846 method 6010/6020
Thallium	SW846 method 6010/6020
Vanadium	SW-846 method 6010/6020
Zinc	SW-846 method 6010/6020

Ground water samples will also be analyzed for the following additional general chemistry parameters.

Analyte	Analytical Method
Total Dissolved Solids	SM-2540C
Bicarbonate	SM-2320B (dissolved)
Chloride	EPA method 300.0 (dissolved & total)
Sulfate	EPA method 300.0 (dissolved & total)
Calcium	EPA method 6010/6020 (dissolved)
Magnesium	EPA method 6010/6020 (dissolved & total)
Sodium	EPA method 6010/6020 (dissolved)
Potassium	EPA method 6010/6020 (dissolved)
Manganese	SW-846 method 6010/6020 (dissolved & total)
Nitrate/nitrite	EPA method 300.0 (dissolved)
Iron	SW-846 method 6010/6020 (dissolved & total)

Soil samples and ground water samples will be analyzed for the following constituents in addition to those listed above to support possible development of background for SWMU No. 16 (Active Landfill). The ground water analyses will be reported as both total and dissolved phase.

Analyte	Analytical Method
Aluminum	SW-846 method 6010/6020
Boron	SW-846 method 6010/6020
Copper	SW-846 method 6010/6020
Molybdenum	SW-846 method 6010/6020
Uranium	SW-846 method 6020
Fluoride	SW-846 method 300

Soil samples collected at the background monitoring well borings will also be analyzed for gasoline range organics and diesel range organics using SW-846 8015B. As discussed in section 4.3.3, field measurements will be obtained for pH, specific conductance, dissolved oxygen concentrations, oxidation-reduction potential, and temperature.

4.9 Data Quality Objectives

The Data Quality Objectives (DQOs) were developed to ensure that newly collected data are of sufficient quality and quantity to address the projects goals, including Quality Assurance/Quality Control (QA/QC) issues (EPA, 2006). The project goals are established in the Order and are to determine and evaluate the presence, nature, and extent of releases of contaminants at specified SWMUs/AOCs and pursuant to Section VIII. H. to determine an appropriate background data set. The type of data required to meet the project goals includes chemical analyses of soil and ground water to determine background concentrations of inorganic constituents in soil and ground water.

The quantity of data is dependant upon the soil type and geology at the site. As discussed above, a single soil type is predominant across most of the refinery and the geology is also relatively consistent such that only two background data sets (surface – 0-6" and subsurface – 18-24') are required. The quality of data that is required is consistent across locations and is specified in Section VIII.D.7.c of the Order. In general, method detection limits should be 20% or less of the applicable cleanup standards and screening levels.

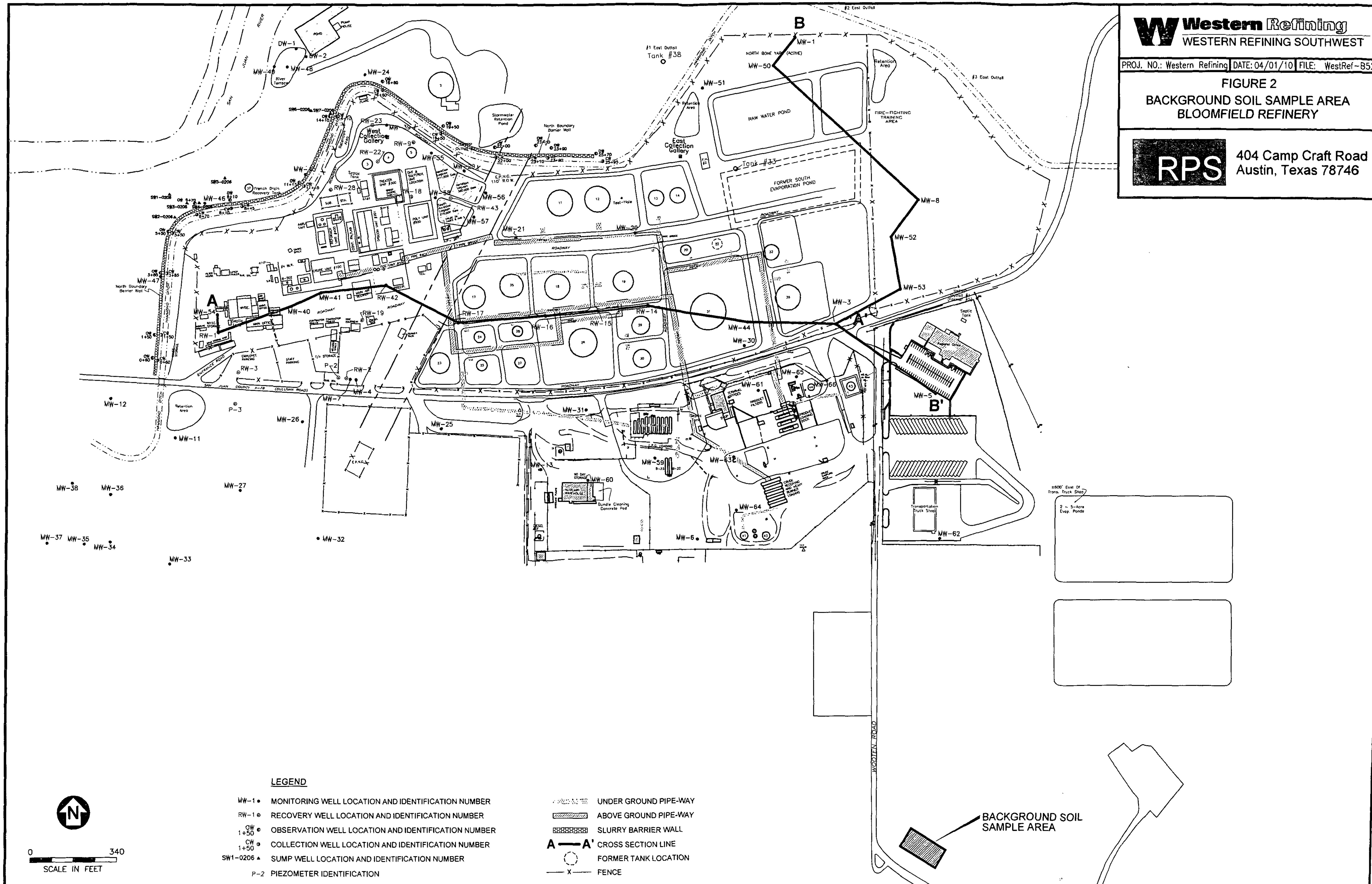
Additional DQOs include precision, accuracy, representativeness, completeness, and comparability. Precision is a measurement of the reproducibility of measurements under a given set of circumstances and is commonly stated in terms of standard deviation or coefficient of variation (EPA, 1987). Precision is also specific to sampling activities and analytical performance. Sampling precision will be evaluated through the analyses of duplicate field samples and laboratory replicates will be utilized to assess laboratory precision.

Accuracy is a measurement in the bias of a measurement system and may include many sources of potential error, including the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis techniques (EPA, 1987). An evaluation of the accuracy will be performed by reviewing the results of field/trip blanks, matrix spikes, and laboratory QC samples.

Representativeness is an expression of the degree to which the data accurately and precisely represent the true environmental conditions. Sample locations and the number of samples have been selected to ensure the data is representative of actual environmental conditions. Sample collection techniques (e.g., purging of monitoring wells to collect formation water) will be utilized to help ensure representative results.

Completeness is defined as the percentage of measurements taken that are actually valid measurements, considering field QA and laboratory QC problems. EPA Contract Laboratory Program (CLP) data has been found to be 80-85% complete on a nationwide basis and this has been extrapolated to indicate that Level III, IV, and V analytical techniques will generate data that are approximately 80% complete (EPA, 1987). As an overall project goal, the completeness goal is 85%; however, some samples may be critical base on location or field screening results and thus a sample–by-sample evaluation will be performed to determine if the completeness goals have been obtained.

Comparability is a qualitative parameter, which expresses the confidence with which one data set can be compared to another. Industry standard sample collection techniques and routine EPA analytical methods will be utilized to help ensure data are comparable to historical and future data. Analytical results will be reported in appropriate units for comparison to historical data and cleanup levels.



Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining | DATE: 04/01/10 | FILE: WestRef-B52

FIGURE 2
BACKGROUND SOIL SAMPLE AREA
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

LEGEND

MW-1 ● MONITORING WELL LOCATION AND IDENTIFICATION NUMBER
RW-1 ⊚ RECOVERY WELL LOCATION AND IDENTIFICATION NUMBER
OW 1+50 ● OBSERVATION WELL LOCATION AND IDENTIFICATION NUMBER
CW 1+50 ● COLLECTION WELL LOCATION AND IDENTIFICATION NUMBER
SW1-0206 ▲ SUMP WELL LOCATION AND IDENTIFICATION NUMBER
P-2 PIEZOMETER IDENTIFICATION

UNDER GROUND PIPE-WAY
ABOVE GROUND PIPE-WAY
SLURRY BARRIER WALL
A — A' CROSS SECTION LINE
FORMER TANK LOCATION
—x— FENCE

0 340
SCALE IN FEET

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRefB59

FIGURE 9
BACKGROUND SOIL SAMPLE LOCATIONS
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Section 5
Schedule

This background investigation Work Plan will be implemented concurrently with the next site investigation Work Plan that is approved by the NMED. The estimated timeframes for each of the planned activities is as shown below:

- Field work (inclusive of all soil and initial ground water sampling) -- two weeks;
- Laboratory analyses for initial sampling event – four weeks;
- Data reduction and validation (soils and initial ground water event) – three weeks;
- Second ground water sampling event – one week;
- Laboratory analyses for second ground water sampling event – three weeks; and
- Data reduction and validation (second ground water event) – two weeks.

Computation of the required summary statistics pursuant to Section VIII.H. of the Order will be completed and the results will be included in a background investigation report.

Section 6
References

EPA, 1987, Data Quality Objectives for Remedial Response Activities; United States Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, OSWER Directive 9355.0-7B, 85p

EPA, 2000, Guidance on Choosing a Sampling Design for Environmental Data Collection, EPA/240/R-02/005, EPA QA/G-5S, 168 p.

EPA, 2006, Guidance on Systematic Planning Using the Data Quality Objectives Process, United States Environmental Protection Agency, Office of Environmental Information; EPA/240/B-06/001, p. 111.

Groundwater Technology Inc., 1994, RCRA Facility Investigation/Corrective Measures Study Report Bloomfield Refining Company #50 County Road 4990 Bloomfield, New Mexico, p.51.

USDA, 2010, Soil Resource Report for San Juan County, New Mexico, Eastern Part; Natural Resources Conservation Service, Web Soil Survey 2.0, http://websoilsurvey.sc.egov.usda.gov/app/HomePage.htm, p. 39.

WRCC, 2011, Western Regional Climate Center; http://www.wrcc.dri.edu/htmlfiles/westwinddir.html

Appendix A

Investigation Derived Waste (IDW) Management Plan

IDW Management Plan

All IDW will be properly characterized and disposed of in accordance with all federal, State, and local rules and regulations for storage, labeling, handling, transport, and disposal of waste. The IDW may be characterized for disposal based on the known or suspected contaminants potentially present in the waste. It is assumed that there are no wastes or contaminants present in environmental media at any of the planned background investigation areas.

A dedicated decontamination area will be setup prior to any sample collection activities. The decontamination facility will be constructed so as to capture and contain all decontamination fluids (e.g., wash water and rinse water) and foreign materials washed off the sampling equipment. The fluids will be pumped directly into suitable storage containers (e.g., labeled 55-gallon drums), which will be located at satellite accumulation areas until the fluids are disposed in the refinery wastewater treatment system upstream of the API separator. The solids captured in the decontamination pad will be shoveled into 55-gallon drums and stored at the designated satellite accumulation area pending proper waste characterization for off-site disposal.

Drill cuttings generated during installation of soil borings and monitoring wells are not anticipated to be contaminated and will be spread on the land surface following customary water well drilling practices. If there is any indication of contamination (e.g., odors, elevated organic vapor monitoring readings, stained soil, presence of potential waste materials, etc.), then the cuttings will be placed directly into 55-gallon drums and staged in the satellite accumulation area pending results of the waste characterization sampling. The drill cuttings will be characterized by testing to determine if there are any hazardous characteristics in accordance with 40 Code of Federal Regulations (CFR) Part 261. This includes tests for ignitability, corrosivity, reactivity, and toxicity. If the materials are not characteristically hazardous, then further testing will be performed pursuant to the requirements of the facility to which the materials will be transported. Depending upon the results of analyses for individual investigation soil samples, additional analyses may include TPH and polynuclear aromatic hydrocarbons.

Purge water generated during ground water sampling activities will be containerized in 55-gallon drums and then disposed in the refinery wastewater treatment system upstream of the API separator. All miscellaneous waste materials (e.g., discarded gloves, packing materials, etc.) will be placed into the refinery's solid waste storage containers for off-site disposal.

Appendix B

Soils Data

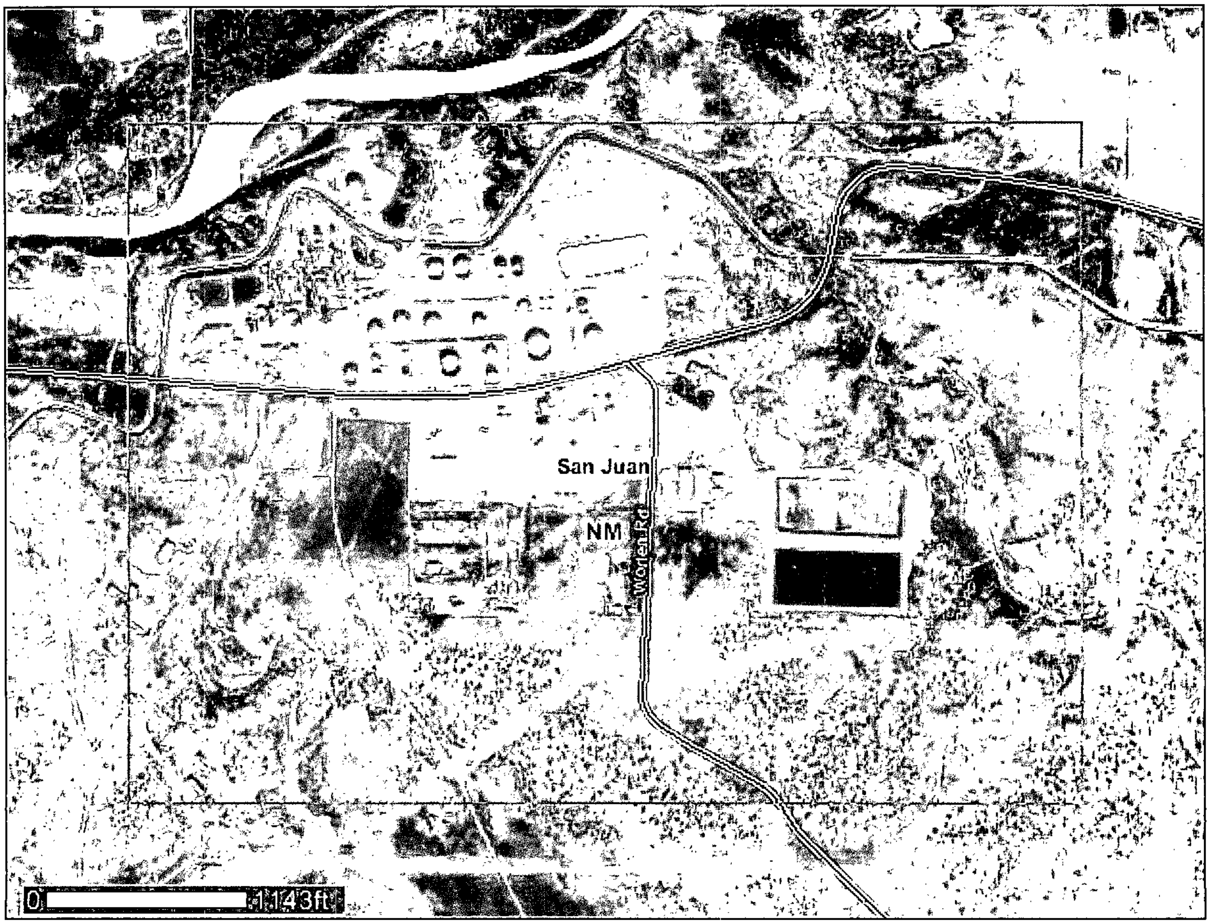
USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for San Juan County, New Mexico, Eastern Part

Bloomfield Refinery Soils Report



March 30, 2010

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

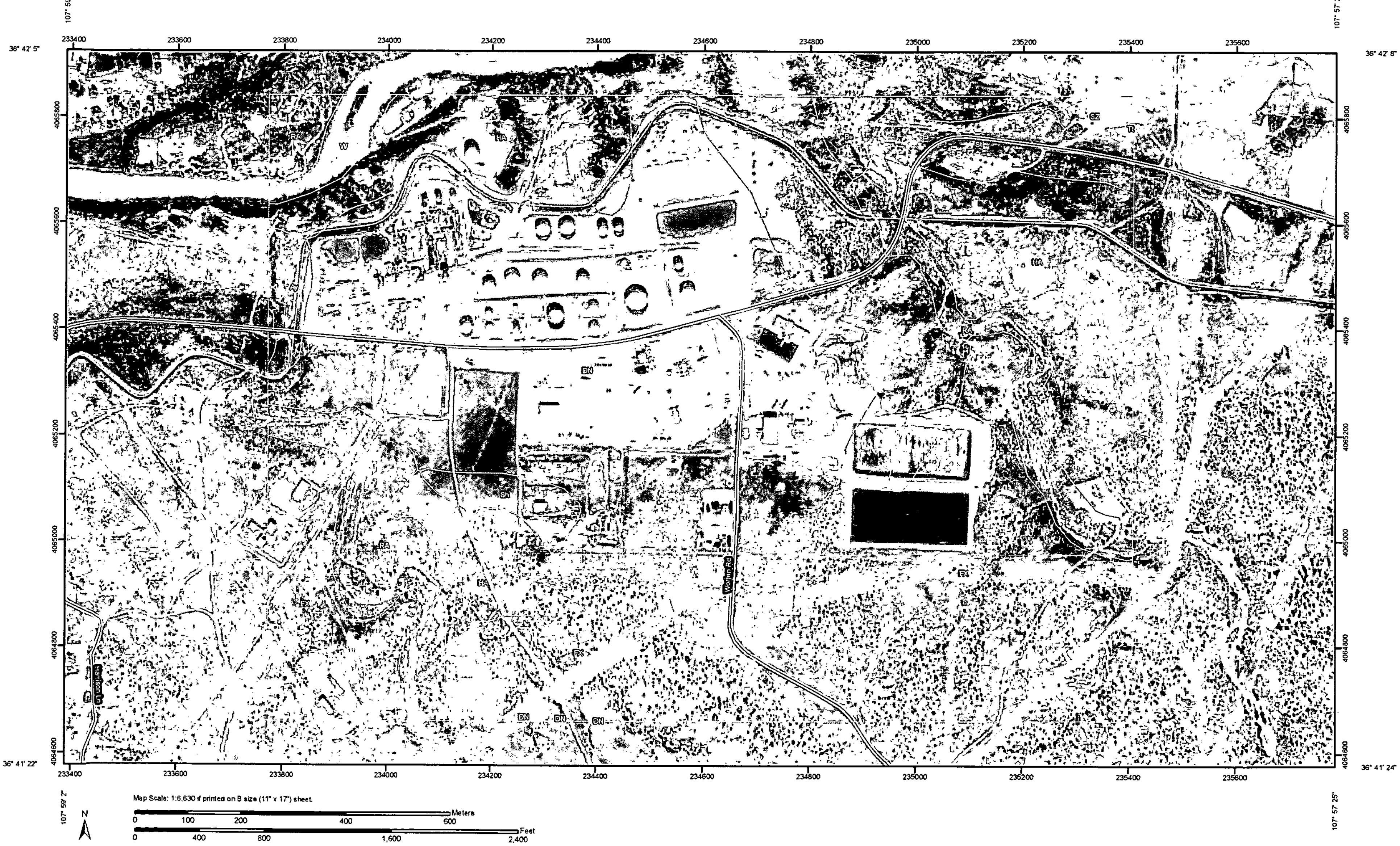
The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

Custom Soil Resource Report
Soil Map (Soil Map - San Juan County, NM, Eastern Part)



Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:6,630 if printed on B size (11" × 17") sheet.

The soil surveys that comprise your AOI were mapped at 1:63,360.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Juan County, New Mexico, Eastern Part
Survey Area Data: Version 10, Sep 23, 2009

Date(s) aerial images were photographed: 10/9/1997

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Soil Map - San Juan County, NM, Eastern Part)

San Juan County, New Mexico, Eastern Part (NM618)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ay	Avalon loam, 0 to 3 percent slopes	3.8	0.8%
Be	Beebe loamy sand	6.7	1.4%
DN	Doak-Avalon association, gently sloping	168.8	35.4%
FX	Fruitland-Persayo-Sheppard complex, hilly	134.6	28.2%
HA	Haplargids-Blackston-Torriorthents complex, very steep	100.7	21.1%
RA	Riverwash	37.8	7.9%
Sh	Shiprock loamy fine sand, 0 to 2 percent slopes	5.5	1.1%
St	Stumble loamy sand, 0 to 3 percent slopes	12.4	2.6%
SZ	Stumble-Slickspots complex, gently sloping	2.1	0.4%
Tt	Turley clay loam, wet, 0 to 2 percent slopes	0.1	0.0%
W	Lakes, rivers, reservoirs	4.4	0.9%
Totals for Area of Interest		**477.0**	**100.0%**

Map Unit Descriptions (Soil Map - San Juan County, NM, Eastern Part)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used.

Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

San Juan County, New Mexico, Eastern Part

Ay—Avalon loam, 0 to 3 percent slopes

Map Unit Setting

Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Avalon and similar soils: 90 percent

Description of Avalon

Setting

Landform: Mesas
Landform position (three-dimensional): Talf
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits over slope alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Available water capacity: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability (nonirrigated): 7e
Ecological site: Limy (R035XB003NM)

Typical profile

0 to 18 inches: Loam
18 to 60 inches: Sandy clay loam
60 to 64 inches: Gravelly sandy loam

Be—Beebe loamy sand

Map Unit Setting

Elevation: 4,800 to 6,000 feet

Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Beebe and similar soils: 90 percent

Description of Beebe

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e
Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 6 inches: Loamy sand
6 to 81 inches: Sand

DN—Doak-Avalon association, gently sloping

Map Unit Setting

Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Doak and similar soils: 50 percent
Avalon and similar soils: 35 percent

Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Beebe and similar soils: 90 percent

Description of Beebe

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e
Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 6 inches: Loamy sand
6 to 81 inches: Sand

DN—Doak-Avalon association, gently sloping

Map Unit Setting

Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Doak and similar soils: 50 percent
Avalon and similar soils: 35 percent

Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability (nonirrigated): 7e
Ecological site: Limy (R035XB003NM)

Typical profile

0 to 14 inches: Loam
14 to 60 inches: Loam
60 to 64 inches: Gravelly loam

FX—Fruitland-Persayo-Sheppard complex, hilly

Map Unit Setting

Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Fruitland and similar soils: 40 percent
Persayo and similar soils: 30 percent
Sheppard and similar soils: 25 percent

Description of Fruitland

Setting

Landform: Alluvial fans, stream terraces
Landform position (three-dimensional): Riser, rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone and shale

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e

Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability (nonirrigated): 7e
Ecological site: Limy (R035XB003NM)

Typical profile

0 to 14 inches: Loam
14 to 60 inches: Loam
60 to 64 inches: Gravelly loam

FX—Fruitland-Persayo-Sheppard complex, hilly

Map Unit Setting

Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Fruitland and similar soils: 40 percent
Persayo and similar soils: 30 percent
Sheppard and similar soils: 25 percent

Description of Fruitland

Setting

Landform: Alluvial fans, stream terraces
Landform position (three-dimensional): Riser, rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone and shale

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e

Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 4 inches: Sandy loam
4 to 60 inches: Fine sandy loam

Description of Persayo

Setting

Landform: Breaks, hills, ridges
Landform position (two-dimensional): Backslope, footslope, shoulder, toeslope
Landform position (three-dimensional): Side slope, nose slope, head slope, crest
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from shale

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: 5 to 20 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Very low (about 2.9 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Shale Hills (R035XA130NM)

Typical profile

0 to 18 inches: Clay loam
18 to 20 inches: Bedrock

Description of Sheppard

Setting

Landform: Dunes
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits over mixed alluvium

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)

Typical profile

0 to 7 inches: Cobbly sandy loam
7 to 26 inches: Cobbly sandy clay loam
26 to 60 inches: Cobbly sandy clay loam

Description of Blackston

Setting

Landform: Escarpments
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Mixed alluvium

Properties and qualities

Slope: 8 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Very slightly saline to slightly saline (4.0 to 8.0 mmhos/cm)
Available water capacity: Low (about 4.5 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Limy (R035XB003NM)

Typical profile

0 to 11 inches: Gravelly loam
11 to 26 inches: Very gravelly loam
26 to 60 inches: Very gravelly sand

Description of Torriorthents

Setting

Landform: Escarpments
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Mixed alluvium

Properties and qualities

Slope: 8 to 50 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)

Sodium adsorption ratio, maximum: 2.0
Available water capacity: Very low (about 2.2 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Hills (R042XB027NM)

Typical profile

0 to 3 inches: Cobbly loam
3 to 15 inches: Cobbly clay loam
15 to 60 inches: Bedrock

RA—Riverwash

Map Unit Setting

Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Riverwash, clayey: 35 percent
Riverwash, sandy: 35 percent
Riverwash, gravelly: 30 percent

Description of Riverwash, Sandy

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 3 percent
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: Frequent
Available water capacity: Very low (about 2.9 inches)

Interpretive groups

Land capability (nonirrigated): 8w

Typical profile

0 to 6 inches: Sand
6 to 60 inches: Stratified coarse sand to sandy loam

Description of Riverwash, Clayey

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 1 percent
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Frequent
Available water capacity: Low (about 6.0 inches)

Interpretive groups

Land capability (nonirrigated): 8w

Typical profile

0 to 6 inches: Clay
6 to 60 inches: Clay

Description of Riverwash, Gravelly

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 3 percent
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: Frequent
Available water capacity: Very low (about 1.9 inches)

Interpretive groups

Land capability (nonirrigated): 8w

Typical profile

0 to 6 inches: Gravelly sand
6 to 60 inches: Stratified extremely gravelly coarse sand to gravelly sand

Sh—Shiprock loamy fine sand, 0 to 2 percent slopes

Map Unit Setting

Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Shiprock and similar soils: 85 percent

Description of Shiprock

Setting

Landform: Mesas
Landform position (three-dimensional): Talf
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits over alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 6.3 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability (nonirrigated): 7e
Ecological site: Deep Sand (R035XB007NM)

Typical profile

0 to 10 inches: Loamy fine sand
10 to 60 inches: Fine sandy loam

St—Stumble loamy sand, 0 to 3 percent slopes

Map Unit Setting

Elevation: 4,800 to 6,400 feet

Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Stumble and similar soils: 90 percent
Fruitland and similar soils: 10 percent

Description of Stumble

Setting

Landform: Dunes
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits derived from sandstone

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 3.7 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e
Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 5 inches: Loamy sand
5 to 29 inches: Loamy sand
29 to 49 inches: Gravelly loamy sand
49 to 81 inches: Loamy sand

Description of Fruitland

Setting

Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fan alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 7.5 inches)

Interpretive groups
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 7e
Ecological site: Loamy (R035XB001NM)

Typical profile
0 to 8 inches: Loam
8 to 60 inches: Fine sandy loam

SZ—Stumble-Slickspots complex, gently sloping

Map Unit Setting
Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition
Stumble and similar soils: 70 percent
Slickspots: 20 percent

Description of Stumble

Setting
Landform: Dunes
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits derived from sandstone

Properties and qualities
Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 1 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups
Land capability classification (irrigated): 4e

Land capability (nonirrigated): 7e
Ecological site: Sandy (R035XB002NM)

Typical profile
0 to 4 inches: Loamy sand
4 to 60 inches: Loamy sand

Description of Slickspots

Setting
Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from sandstone

Properties and qualities
Slope: 0 to 5 percent
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Maximum salinity: Slightly saline to moderately saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0

Interpretive groups
Land capability (nonirrigated): 8w

Typical profile
0 to 2 inches: Clay
2 to 60 inches: Clay

Tt—Turley clay loam, wet, 0 to 2 percent slopes

Map Unit Setting
Elevation: 4,800 to 6,000 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition
Turley variant and similar soils: 90 percent

Description of Turley Variant

Setting
Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fan alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 24 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 2w
Land capability (nonirrigated): 6w
Ecological site: Clayey (R035XB004NM)

Typical profile

0 to 9 inches: Clay loam
9 to 60 inches: Clay loam

W—Lakes, rivers, reservoirs

Map Unit Setting

Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Water: 95 percent

Description of Water

Setting

Landform: Channels
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Chemical Properties

This folder contains a collection of tabular reports that present soil chemical properties. The reports (tables) include all selected map units and components for each map unit. Soil chemical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil chemical properties include pH, cation exchange capacity, calcium carbonate, gypsum, and electrical conductivity.

Chemical Soil Properties (Soil Map - San Juan County, NM, Eastern Part)

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

Chemical Soil Properties– San Juan County, New Mexico, Eastern Part

Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
Ay—Avalon loam, 0 to 3 percent slopes								
Avalon	0-18	9.8-15	—	7.9-8.4	1-5	0-2	2.0-8.0	0
	18-60	11-23	—	7.9-8.4	10-20	0-2	2.0-8.0	0
	60-64	4.0-11	—	7.9-8.4	15-20	0-2	2.0-8.0	0
Be—Beebe loamy sand								
Beebe	0-6	3.1-7.4	—	7.4-8.4	0-1	0	2.0-4.0	0
	6-81	0.8-7.4	—	7.4-8.4	0-1	0	2.0-4.0	0
DN—Doak-Avalon association, gently sloping								
Doak	0-5	11-19	—	7.4-8.4	0-5	0	0.0-2.0	0
	5-43	15-23	—	7.4-9.0	1-10	0	2.0-4.0	0
	43-60	15-23	—	7.9-9.0	5-10	0-2	2.0-4.0	0-2
Avalon	0-14	11-15	—	7.9-8.4	0-5	0	2.0-8.0	0
	14-60	11-23	—	7.9-8.4	10-20	0-2	2.0-8.0	0
	60-64	4.0-11	—	7.9-8.4	15-20	0-2	2.0-8.0	0-2
FX—Fruitland-Persayo-Sheppard complex, hilly								
Fruitland	0-4	4.1-7.6	—	7.4-8.4	5-10	0-1	0.0-4.0	0-2
	4-60	3.1-12	—	7.4-8.4	5-10	0-1	0.0-4.0	0-2
Persayo	0-18	18-23	—	7.9-9.0	0-2	0-2	0.0-8.0	0-2
	18-20	—	—	—	—	—	—	—
Sheppard	0-4	2.5-5.4	—	7.9-8.4	0	0	0.0-2.0	0
	4-60	2.5-5.4	—	7.9-8.4	0	0	0.0-2.0	0

Chemical Soil Properties– San Juan County, New Mexico, Eastern Part								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
St—Stumble loamy sand, 0 to 3 percent slopes								
Stumble	0-5	0.0-7.4	—	7.9-8.4	0-2	0	0.0-2.0	0
	5-29	0.0-7.4	—	7.9-9.0	0-2	0	0.0-2.0	0
	29-49	0.0-3.1	—	7.9-9.0	0-2	0	0.0-2.0	0
	49-81	0.0-5.7	—	7.9-9.0	0-2	0	0.0-2.0	0
Fruitland	0-8	5.7-16	—	7.4-8.4	5-10	0	0.0-4.0	0
	8-60	3.1-12	—	7.4-8.4	5-10	0	0.0-4.0	0
SZ—Stumble-Slickspots complex, gently sloping								
Stumble	0-4	0.0-7.4	—	7.9-8.4	0-1	0	0.0-2.0	0
	4-60	0.0-7.4	—	7.9-9.0	0-1	0	0.0-2.0	0
Slickspots	0-2	—	—	7.9-9.6	0	0	0.0-8.0	2-6
	2-60	—	—	7.9-9.6	0	0	8.0-16.0	4-12
Tt—Turley clay loam, wet, 0 to 2 percent slopes								
Turley variant	0-9	14-22	—	7.4-8.4	1-5	0-2	2.0-4.0	0-2
	9-60	14-22	—	7.4-8.4	1-5	0-2	2.0-4.0	0-2
W—Lakes, rivers, reservoirs								
Water	—	—	—	—	—	—	—	—

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Physical Soil Properties (Soil Map - San Juan County, NM, Eastern Part)

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Physical Soil Properties– San Juan County, New Mexico, Eastern Part														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
Ay—Avalon loam, 0 to 3 percent slopes														
Avalon	0-18	-43-	-40-	15-18- 20	1.40-1.50	4.23-14.11	0.16-0.18	0.0-2.9	0.0-1.0	.43	.43	3	4L	86
	18-60	-56-	-18-	18-27- 35	1.40-1.50	4.23-14.11	0.15-0.17	3.0-5.9	0.0-0.5	.43	.43			
	60-64	-67-	-23-	5-10- 15	1.50-1.65	14.11-42.34	0.10-0.12	0.0-2.9	0.0-0.5	.32	.37			
Be—Beebe loamy sand														
Beebe	0-6	-84-	- 9-	5- 8- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.20	.20	5	2	134
	6-81	-93-	- 2-	1- 6- 10	1.45-1.55	141.14	0.03-0.08	0.0-2.9	0.0-0.5	.17	.17			
DN—Doak-Avalon association, gently sloping														
Doak	0-5	-42-	-37-	15-21- 27	1.20-1.30	4.23-14.11	0.15-0.17	0.0-2.9	0.5-0.6	.37	.37	5	5	56
	5-43	-34-	-37-	25-30- 35	1.45-1.55	1.41-4.23	0.15-0.18	3.0-5.9	0.0-0.5	.37	.37			
	43-60	-34-	-37-	25-30- 35	1.40-1.50	1.41-4.23	0.15-0.18	3.0-5.9	0.0-0.5	.37	.37			
Avalon	0-14	-43-	-40-	15-18- 20	1.40-1.50	4.23-14.11	0.16-0.18	0.0-2.9	0.5-1.0	.43	.43	3	4L	86
	14-60	-38-	-36-	18-27- 35	1.40-1.50	4.23-14.11	0.15-0.17	3.0-5.9	0.0-0.5	.43	.43			
	60-64	-46-	-44-	5-10- 15	1.50-1.65	14.11-42.34	0.10-0.12	0.0-2.9	0.0-0.5	.32	.37			

Physical Soil Properties– San Juan County, New Mexico, Eastern Part

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
FX—Fruitland-Persayo-Sheppard complex, hilly														
Fruitland	0-4	-69-	-24-	5- 8- 10	1.45-1.55	14.11-42.34	0.11-0.13	0.0-2.9	0.6-0.8	.28	.28	5	3	86
	4-60	-68-	-21-	5-12- 18	1.45-1.55	14.11-42.34	0.11-0.13	0.0-2.9	0.0-0.5	.28	.28			
Persayo	0-18	-35-	-34-	27-31- 35	1.35-1.45	1.41-4.23	0.15-0.17	3.0-5.9	0.5-1.0	.37	.37	1	8	0
	18-20	—	—	—	—	0.00-1.41	—	—	—					
Sheppard	0-4	-79-	-16-	4- 5- 7	1.45-1.60	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15	5	2	134
	4-60	-79-	-16-	4- 5- 7	1.45-1.60	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15			
HA—Haplargids-Blackston-Torriorthents complex, very steep														
Haplargids	0-7	-66-	-19-	10-15- 20	1.45-1.55	14.11-42.34	0.08-0.10	0.0-2.9	0.0-0.5	.15	.28	4	4	86
	7-26	-55-	-17-	20-28- 35	1.35-1.45	4.23-14.11	0.11-0.13	0.0-2.9	0.0-0.5	.15	.28			
	26-60	-59-	-18-	20-24- 27	1.35-1.45	4.23-14.11	0.12-0.14	0.0-2.9	0.0-0.5	.20	.37			
Blackston	0-11	-42-	-38-	15-20- 25	1.45-1.55	4.23-14.11	0.11-0.14	0.0-2.9	0.5-1.0	.10	.17	3	8	0
	11-26	-42-	-38-	15-20- 25	1.35-1.45	4.23-14.11	0.07-0.10	0.0-2.9	0.0-0.5	.10	.28			
	26-60	-96-	- 2-	0- 3- 5	1.35-1.45	42.34-141.14	0.03-0.06	0.0-2.9	0.0-0.5	.10	.28			
Torriorthents	0-3	-42-	-38-	15-20- 25	1.40-1.50	4.23-14.11	0.12-0.14	0.0-2.9	0.6-0.8	.20	.37	1	6	48
	3-15	-34-	-37-	10-30- 30	1.40-1.50	1.41-42.34	0.10-0.20	0.0-2.9	0.0-0.5	.20	.32			
	15-60	—	—	—	—	0.00-1.40	—	—	—					

Chemical Soil Properties– San Juan County, New Mexico, Eastern Part								
Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
HA—Haplargids-Blackston-Torriorthents complex, very steep								
Haplargids	0-7	7.0-14	—	7.4-8.4	0	0	0.0-4.0	0
	7-26	13-23	—	7.4-8.4	0-5	0	0.0-4.0	0
	26-60	13-18	—	7.4-8.4	1-10	0	0.0-4.0	0
Blackston	0-11	11-18	—	7.9-8.4	0-2	0	0.0-2.0	0
	11-26	9.8-17	—	7.9-8.4	10-20	0	4.0-8.0	0
	26-60	0.0-4.6	—	7.9-8.4	15-30	0	4.0-8.0	0
Torriorthents	0-3	11-17	—	7.4-8.4	0-2	0-2	0.0-4.0	0
	3-15	5.7-19	—	7.4-8.4	0-2	0-2	0.0-4.0	0-2
	15-60	—	—	—	—	—	—	—
RA—Riverwash								
Riverwash, clayey	0-6	—	—	—	—	—	—	—
	6-60	—	—	—	—	—	—	—
Riverwash, sandy	0-6	—	—	—	—	—	—	—
	6-60	—	—	—	—	—	—	—
Riverwash, gravelly	0-6	—	—	—	—	—	—	—
	6-60	—	—	—	—	—	—	—
Sh—Shiprock loamy fine sand, 0 to 2 percent slopes								
Shiprock	0-10	8.1-11	—	7.4-8.4	0-2	0	0.0-2.0	0
	10-60	7.0-13	—	7.4-9.0	0-2	0	0.0-4.0	0

Physical Soil Properties– San Juan County, New Mexico, Eastern Part

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
RA—Riverwash														
Riverwash, clayey	0-6	-12-	-28-	40-60- 80	1.65-1.75	0.00-1.41	0.09-0.11	6.0-8.9	0.0-0.1	.20	.20	5	4	86
	6-60	-12-	-28-	40-60- 80	1.65-1.75	0.00-1.41	0.09-0.11	6.0-8.9	0.0-0.1	.28	.32			
Riverwash, sandy	0-6	-98-	- 2-	0- 1- 1	1.65-1.75	42.34-141.14	0.03-0.04	0.0-2.9	0.0-0.1	.10	.10	5	4	86
	6-60	-68-	-30-	0- 3- 5	1.65-1.75	42.34-141.14	0.04-0.06	0.0-2.9	0.0-0.1	.10	.10			
Riverwash, gravelly	0-6	-98-	- 2-	0- 1- 1	1.65-1.75	42.34-141.14	0.03-0.04	0.0-2.9	0.0-0.1	.05	.10	5	4	86
	6-60	-93-	- 7-	0- 1- 1	1.65-1.75	42.34-141.14	0.02-0.03	0.0-2.9	0.0-0.1	.05	.10			
Sh—Shiprock loamy fine sand, 0 to 2 percent slopes														
Shiprock	0-10	-83-	- 5-	10-13- 15	1.40-1.50	42.34-141.14	0.06-0.09	0.0-2.9	0.5-0.6	.20	.20	5	2	134
	10-60	-70-	-16-	10-14- 18	1.45-1.55	14.11-42.34	0.09-0.12	0.0-2.9	0.0-0.5	.28	.28			
St—Stumble loamy sand, 0 to 3 percent slopes														
Stumble	0-5	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.17	.17	5	2	134
	5-29	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15			
	29-49	-81-	-17-	0- 3- 5	1.45-1.55	42.34-141.14	0.04-0.06	0.0-2.9	0.0	.10	.24			
	49-81	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06	0.0-2.9	0.0	.15	.15			
Fruitland	0-8	-43-	-40-	10-18- 25	1.40-1.50	4.23-14.11	0.15-0.17	0.0-2.9	0.0-0.5	.37	.37	5	5	56
	8-60	-68-	-21-	5-12- 18	1.45-1.55	14.11-42.34	0.11-0.13	0.0-2.9	0.0-0.5	.28	.28			

Physical Soil Properties– San Juan County, New Mexico, Eastern Part														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
SZ—Stumble-Slickspots complex, gently sloping														
Stumble	0-4	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.17	.17	5	2	134
	4-60	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15			
Slickspots	0-2	-32-	-31-	15-37- 45	1.45-1.55	0.00-0.42	—	—	0.5-1.0					
	2-60	-32-	-31-	15-37- 45	1.45-1.55	0.00-1.41	—	—	0.0-0.5					
Tt—Turley clay loam, wet, 0 to 2 percent slopes														
Turley variant	0-9	-35-	-33-	28-32- 35	1.40-1.50	1.41-4.23	0.15-0.19	3.0-5.9	0.0-0.5	.32	.32	5	4L	86
	9-60	-35-	-33-	28-32- 35	1.40-1.50	1.41-4.23	0.15-0.19	3.0-5.9	0.0-0.5	.32	.32			
W—Lakes, rivers, reservoirs														
Water	—	—	—	—	—	—	—	—	—					

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://soils.usda.gov/

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://soils.usda.gov/

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://soils.usda.gov/

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://soils.usda.gov/

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.glti.nrcs.usda.gov/

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://soils.usda.gov/

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://soils.usda.gov/

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210.

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Thursday, July 29, 2010 2:08 PM
To: Monzeglio, Hope, NMENV
Cc: VonGonten, Glenn, EMNRD
Subject: Bloomfield Refinery (GW-001) Investigation Work Plan Background Concentrations (July 2010)

Hope:

A couple of recommendations:

1) Page 4-6, top bullet: The Chain-of-Custody form should be filled out before, during (as they are sampling- dates, time of sample collection, etc.) and after sampling until the samples are received at the lab with proper sign-off. I don't think it was their intent to phrase their protocol in the context of they collect samples and then work recording the information of the sample containers before they deliver samples to the lab?

2) OCD recommends that they include the 20.6.2.3103 constituents with the exception of the organics, which seems reasonable if they are sampling in a background location there should not be organics present. NMED may want to specify that they use a field PID/FID to qualitatively scan for organics or use BPJ (olfactory and visual observations, etc.). Your call.

Please contact me if you have questions. Thank you.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

July 2, 2010

James Bearzi, Bureau Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Bldg 1
Santa Fe, NM 87505

Re: Investigation Work Plan – Background Concentrations
July 27, 2007 NMED Order
Western Refining Southwest, Inc., Bloomfield Refinery
EPA ID# NMD089416416

Dear Mr. Bearzi:

Western Refining Southwest, Inc., Bloomfield Refinery has prepared the enclosed Investigation Work Plan to support development of site-specific background concentrations in accordance with Section VIII. H. of the referenced Order. The content of the Investigation Work Plan was developed pursuant to a meeting with your staff, which was held on March 4, 2010.

If you have questions or would like to discuss the Investigation Work Plan, please contact me at (505) 632-4171.

Sincerely,

James R. Schmaltz
Environmental Manager
Western Refining Southwest, Inc., Bloomfield Refinery

cc: Hope Monzeglio – NMED HWB
Carl Chavez - NMOCD
Dave Cobrain – NMED HWB
John Kieling – NMED HWB
Laurie King – EPA Region 6
Allen Hains – Western Refining El Paso
Scott Crouch – RPS Austin

RPS

404 Camp Craft Rd., Austin, Texas 78746, USA
T +1 512 347 7588 **F** +1 512 347 8243 **W** www.rpsgroup.com

INVESTIGATION WORK PLAN
Background Concentrations

Bloomfield Refinery
Western Refining Southwest, Inc.
#50 Rd 4990
Bloomfield, New Mexico 87413

July 2010

James R. Schmaltz
Environmental Manager

Western Refining Southwest, Inc.
Bloomfield Refinery

Scott T. Crouch, P.G.
Senior Consultant

RPS
404 Camp Craft Rd.
Austin, Texas 78746

Table of Contents

List of Sections

Table of Contents (continued)

List of Figures

List of Appendices

Executive Summary

The Bloomfield Refinery, which is located in the Four Corners Area of New Mexico, has been in operation since the late 1950s. Past inspections by State and federal environmental inspectors have identified locations where releases to the environment may have occurred. These locations are generally referred to as Solid Waste Management Units (SWMUs) or Areas of Concern (AOCs).

Pursuant to the terms and conditions of an Order issued on July 27, 2007 by the New Mexico Environment Department (NMED) to San Juan Refining Company and Giant Industries Arizona, Inc. for the Bloomfield Refinery, this Investigation Work Plan has been prepared to describe sample collection and analyses methods that will be used to support development of site-specific background concentrations for inorganic constituents. A Class I permit modification was approved on June 10, 2008 to reflect the change in ownership of the refinery to Western Refining Southwest, Inc. The operator is now Western Refining Southwest, Inc. – Bloomfield Refinery.

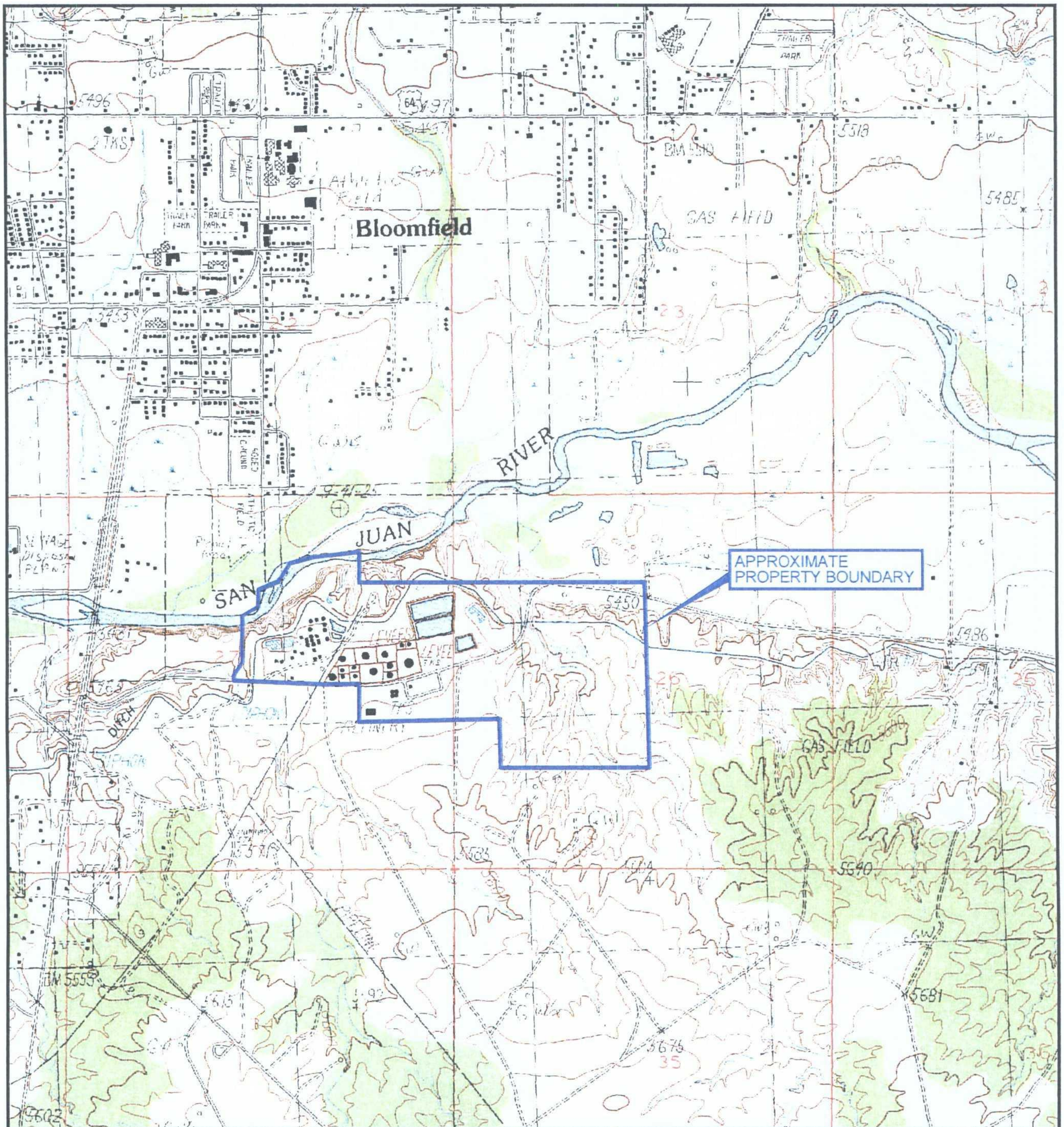
The planned investigation activities include collection of soil and potentially ground water samples, which will be analyzed for inorganic constituents. The specific sampling locations, sample collection procedures, and analytical methods are included.

Section 1
Introduction

The Bloomfield Refinery is located immediately south of Bloomfield, New Mexico in San Juan County (Figure 1). The physical address is #50 Road 4990, Bloomfield, New Mexico 87413. The Bloomfield Refinery is located on approximately 263 acres. Bordering the facility is a combination of federal and private properties. Public property managed by the Bureau of Land Management lies to the south. The majority of undeveloped land in the vicinity of the facility is used extensively for oil and gas production and, in some instances, grazing. U.S. Highway 44 is located approximately one-half mile west of the facility. The topography of the main portion of the site is generally flat with steep bluffs to the north where the San Juan River intersects Tertiary terrace deposits.

The Bloomfield Refinery is a crude oil refinery currently owned by Western Refining Southwest, Inc., which is a wholly owned subsidiary of Western Refining Company, and it is operated by Western Refining Southwest, Inc. – Bloomfield Refinery. The Bloomfield Refinery had an approximate refining capacity of 18,000 barrels per day. Various process units operated at the facility, included crude distillation, reforming, fluidized catalytic cracking, sulfur recovery, merox treater, catalytic polymerization, and diesel hydrotreating. The refinery produced gasoline, diesel fuels, jet fuels, kerosene, propane, butane, naphtha, residual fuel, fuel oils, and LPG.

On July 27, 2007, the New Mexico Environment Department (NMED) issued an Order to San Juan Refining Company and Giant Industries Arizona, Inc. ("Western") requiring investigation and corrective action at the Bloomfield Refinery. This Investigation Work Plan has been prepared for the sole purpose of collecting soil and ground water samples to support development of site-specific background concentrations pursuant to Section VIII.H. of the Order.



Map Source: USGS 7.5 Min. Quad Sheet BLOOMFIELD, NM., 1985.

N

0 2000
SCALE IN FEET

QUADRANGLE LOCATION

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-A42

FIGURE 1
SITE LOCATION MAP
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Section 2
Soil Background Concentrations

This section presents background information, a discussion on site conditions, and a scope of services for establishment of site-specific background concentrations for inorganic constituents.

2.1 Background

This section presents background information, including a review of historical waste management activities to identity the following:

- Type and characteristics of all waste and all contaminants handled in the background investigation area;
- Known and possible sources of contamination;
- History of releases; and
- Known extent of contamination.

The area targeted for collection of soil samples to establish background concentrations is located on the far southeastern portion of the refinery property so as to avoid any potential for current or historical impacts from refinery operations. The selected area is located south of the Regional Transportation office, which is located south the County Rd 4990 and east of Wooten Rd. (Figure 2). There is no current commercial or industrial activity in this area and no historical commercial or industrial activities are known to have occurred in this area. The proposed sample collection area is located on a separate tract of land owned by Western, just south of the Refinery property.

2.2 Site Conditions

The conditions at the site, including surface and subsurface conditions that could affect the fate and transport of any contaminants, are discussed below. This information is based on recent visual observations and historical subsurface investigations.

2.2.1 Surface Conditions

Regionally, the surface topography slopes toward the floodplain of the San Juan River, which runs along the northern boundary of the refinery complex. To the south of the refinery, the drainage is generally to the northwest. North of the refinery complex, across the San Juan River, surface water flows in a southeasterly direction toward the San Juan River. The central and eastern portions of the refinery property, where the process units, storage tanks and background soil sample collection area are located, is generally of low relief with an overall northwest gradient of approximately 0.02 ft/ft. The refinery sits on an alluvial floodplain terrace deposit and there is a steep bluff (approx. drop of 90 feet) at the northern boundary of the refinery where the San Juan River intersects the floodplain terrace.

There are two locally significant arroyos, one immediately east and another immediately west of the refinery, which collect most of the surface water flows in the area, thus significantly reducing surface water flows across the refinery and background soil sample collection area. A minor drainage feature is located on the eastern portion of the refinery, where the Landfill Pond (SWMU No. 9) was located and there are several steep arroyos along the northern refinery boundary that primarily capture only local surface water flows and minor ground water discharges. The land surface at the proposed location for collection of background soil slopes north/northeast and feeds into the larger arroyo that runs along the east portion of the refinery property.

The land surface is characterized by sparse shrubby vegetation, which is adapted to the arid conditions. Bare soil is exposed in many areas, consisting of a loam in the upper five inches and a clay loam to a depth of 60 inches (USDA, 2010).

2.2.2 Subsurface Conditions

Numerous soil borings and monitoring wells have been completed across the refinery property during previous site investigations and installation of the slurry wall, which runs along the northern and western refinery boundary. Based on the available site-specific and regional subsurface information, the site is underlain by the Quaternary Jackson Lake terrace deposits, which unconformably overlie the Tertiary Nacimiento Formation. The Jackson Lake deposits consist of fine grained sand, silt and clay that grades to coarse sand, gravel and cobble size material closer to the contact with the Nacimiento Formation. The Jackson Lake Formation is over 40 feet thick near the southeast portion of the site and generally thins to the northwest toward the San Juan River. The Nacimiento Formation is primarily composed of fine grained materials (e.g., carbonaceous mudstone/claystone with interbedded sandstones) with a reported local thickness of approximately 570 feet (Groundwater Technology Inc., 1994).

2.3 Scope of Services

This subsection presents a brief description of the anticipated sample collection activities to be performed during the background soil sample collection activities, background information research conducted to develop the Scope of Services, a description of the collection and management of investigation derived waste, and surveying to be conducted to record sample location data.

2.3.1 Anticipated Activities

Pursuant to Section VIII.H. of the Order, soil samples will be collected from the surface (0-6") and shallow subsurface (18-24") to establish background concentrations for inorganic constituents. Eight sample locations will be selected and two samples will be collected from each location to support the development of distinct background concentrations for surface and subsurface soils, if required. The area in which the samples will be collected is located southeast of the Regional Transportation office and the individual sample locations will be surveyed following the procedures in Section 2.3.4 (Figure 2).

2.3.2 Background Information Research

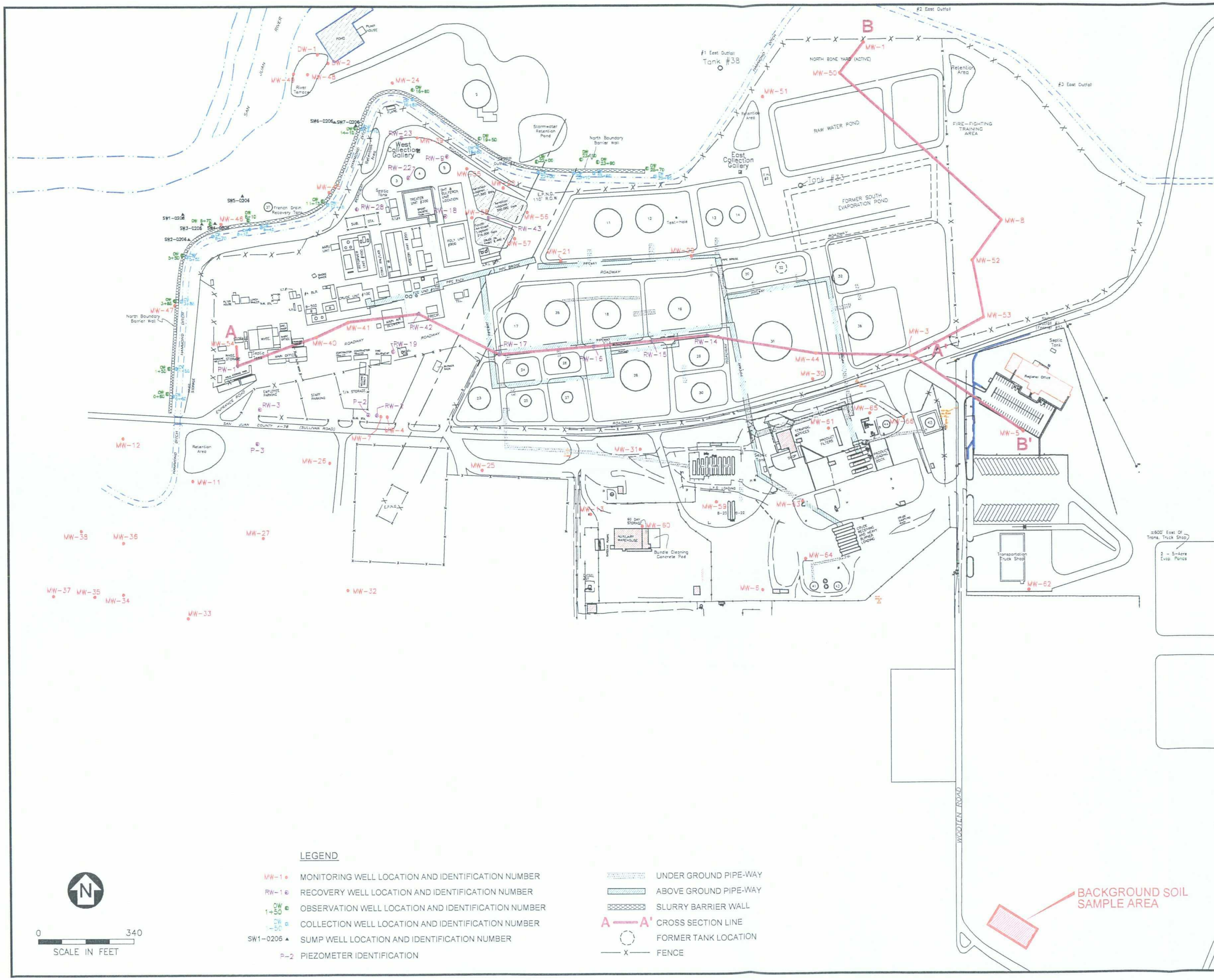
Scoping documents that provided information on historical operations and documents containing the results of previous investigations were reviewed to facilitate development of this work plan. The previously collected data provides very good information on the overall surface and subsurface conditions, including verification of areas with past industrial operations.

2.3.3 Collection and Management of Investigation Derived Waste

Minimal, if any, excess sample material is anticipated to be associated with the collection of the shallow (e.g. up to two feet) soil samples. As there will be minimal excess material and it is being collected in areas that are fully anticipated to be devoid of any contamination, the excess sample material will be placed back into the hole from which the sample was retrieved. This Work Plan will be implemented concurrently with one of the approved Work Plans for designated SWMUs/AOCs, thus any decontamination fluids and all other investigation derived waste (IDW) associated with background soil borings will be contained and managed with other IDW that is generated from sample collection activities at the designated SWMUs/AOCs. As such, the IDW will be characterized using methods based on the boring location, boring depth, drilling method, and type of constituents suspected or encountered in the SWMU/AOC borings. All decontamination water will be characterized prior to disposal unless it is disposed in the refinery wastewater treatment system upstream of the API Separator. An IDW management plan is included as Appendix A.

2.3.4 Surveys

The horizontal coordinates of each soil sample location and the locations of all other pertinent structures will be determined by a registered New Mexico professional land surveyor in accordance with the State Plane Coordinate System (NMSA 1978 47-1-49-56 (Repl. Pamp. 1993)). The surveys will be conducted in accordance with Sections 500.1 through 500.12 of the Regulations and Rules of the Board of Registration for Professional Engineers and Surveyors Minimum Standards for Surveying in New Mexico. Horizontal positions will be measured to the nearest 0.1-ft.



Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-B52

FIGURE 2
BACKGROUND SOIL SAMPLE AREA
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Section 3
Ground Water Background Concentrations

This section presents background information, a discussion on site conditions, and a scope of services for establishment of site-specific background concentrations for inorganic constituents in ground water.

3.1 Background

This section presents background information, including a review of historical waste management activities to identity the following:

- Type and characteristics of all waste and all contaminants handled in the background investigation area;
- Known and possible sources of contamination;
- History of releases; and
- Known extent of contamination.

The areas targeted for collection of ground water samples to established background concentrations are located at the far eastern portion of the refinery property and south of the refinery property on a separate tract of land owned by Western. This separate tract covers approximately 32.4 acres and is located approximately 200 feet south of the southern most evaporation pond (Figure 3). These areas were selected because they are anticipated to be up-gradient of the refinery operations and as such ground water samples collected from these areas will not be affected by any current or historical refinery operations (Figure 3). There is no current commercial or industrial activity in this area and no known historical commercial or industrial activities are known to have occurred in these areas with the exception of a single gas well. The southern most proposed location for a background monitoring well is approximately 700 feet southwest of the gas well, which should place it beyond any potential impacts from operations near the gas well.

3.2 Site Conditions

The conditions at the site, including surface and subsurface conditions that could affect the fate and transport of any contaminants, are discussed below. This information is based on recent visual observations and historical subsurface investigations.

3.2.1 Surface Conditions

Regionally, the surface topography slopes toward the floodplain of the San Juan River, which runs along the northern boundary of the refinery complex. To the south of the refinery, the drainage is generally to the northwest. North of the refinery complex, across the San Juan River, surface water flows in a southeasterly direction toward the San Juan River. The active portion of the refinery property, where the process units and storage tanks are located, is generally of low relief with an overall northwest gradient of approximately 0.02 ft/ft. The refinery sits on an alluvial floodplain terrace deposit and there is a steep bluff (approx. drop of 90 feet) at the northern boundary of the refinery where the San Juan River intersects the floodplain terrace.

There are two locally significant arroyos, one immediately east and another immediately west of the refinery, which collect most of the surface water flows in the area, thus significantly reducing surface water flows across the refinery. A minor drainage feature is located on the eastern portion of the refinery, where the Landfill Pond (SWMU No. 9) was located and there are several steep arroyos along the northern refinery boundary that primarily capture only local surface water flows and minor ground water discharges. The southern most proposed location for a background monitoring well is situated along a northwest/southeast trending topographic high, which is higher in elevation than any of the other refinery property. Moving off this topographic high toward the refinery, the slope is predominantly to the northeast where surface runoff would feed the arroyo than runs along the eastern portion of the refinery property. The proposed location to the east is near an arroyo that runs along the eastern portion of the refinery property.

The land surface is characterized by sparse shrubby vegetation, which is adapted to the arid conditions. Bare soil is exposed in many areas, consisting of a loam in the upper five inches and a clay loam to a depth of 60 inches (USDA, 2010).

3.2.2 Subsurface Conditions

Numerous soil borings and monitoring wells have been completed across the refinery property during previous site investigations and installation of the slurry wall, which runs along the northern and western refinery boundary. Based on the available site-specific and regional subsurface information, the site is underlain by the Quaternary Jackson Lake terrace deposits, which unconformably overlie the Tertiary Nacimiento Formation. The Jackson Lake deposits consist of fine grained sand, silt and clay that grades to coarse sand, gravel and cobble size material closer to the contact with the Nacimiento Formation. The Jackson Lake Formation is over 40 feet thick near the southeast portion of the site and generally thins to the northwest toward the San Juan River. The Nacimiento Formation is primarily composed of fine grained materials (e.g., carbonaceous mudstone/claystone with interbedded sandstones) with a reported local thickness of approximately 570 feet (Groundwater Technology Inc., 1994).

Figures 4 and 5 present cross-sections of the shallow subsurface based on borings logs from on-site monitoring well completions. The uppermost aquifer is under water table conditions and occurs within the sand and gravel deposits of the Jackson Lake Formation. The Nacimiento Formation functions as an aquitard at the site and prevents site related contaminants from migrating to deeper aquifers. The potentiometric surface as measured in August 2009 is presented as Figure 6 and shows the ground water flowing to the northwest. The saturated thickness of the shallow aquifer within the Jackson Lake Formation is greatest near and along the Hammond Irrigation Ditch and other potential sources of recharge (e.g., the raw water ponds), and decreases to the southeast in the up-gradient portions of the refinery property. Two potential drilling locations have been selected instead of a single location because of the uncertainty of locating shallow ground water in these up-gradient locations.

Previous site investigations have identified and delineated impacts to ground water from historical site operations. Figure 7 shows the distribution of SPH in the subsurface based on the apparent thickness of SPH measured in monitoring wells. Dissolved-phase impacts are depicted on Figure 8.

3.3 Scope of Services

This subsection presents a brief description of the anticipated sample collection activities to be performed, background information research conducted to develop the Scope of Services, a description of the collection and management of investigation derived waste, and surveying to be conducted to record sample location and elevation data.

3.3.1 Anticipated Activities

Pursuant to Section VIII.H. of the Order, soil boring(s) will be drilled to the south and/or east of the active portions of the refinery property. If the first boring is dry, then Western may attempt to drill a second boring. The boring(s) will be drilled to the Nacimiento Formation with well screen set to monitor shallow ground water, which has accumulated on top of the Nacimiento Formation. If ground water is present, then the boring will be completed as a permanent monitoring well and ground water samples will be collected from the new well(s) and analyzed for inorganic constituents as described in Section 4.3.4. The location and elevation of the well(s) will be surveyed following the procedures in Section 3.3.4.

3.3.2 Background Information Research

Documents containing the results of previous investigations and subsequent routine ground water monitoring data from monitoring wells were reviewed to facilitate development of this work plan. The previously collected data provides very good information on the overall subsurface conditions, including hydrogeology and contaminant distribution within ground water on a site-wide basis.

3.3.3 Collection and Management of Investigation Derived Waste

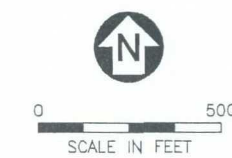
Excess sample material and decontamination fluids, and all other investigation derived waste (IDW) associated with the monitoring well installation will be contained and characterized using methods based on the field screening data and type of contaminants detected in any ground water samples. All purged ground water and decontamination water will be characterized prior to disposal unless it is disposed in the refinery wastewater treatment system upstream of the API Separator. An IDW management plan is included as Appendix A.

3.3.4 Surveys

The horizontal coordinates and elevation of the background monitoring well(s) and the locations of all other pertinent structures will be determined by a registered New Mexico professional land surveyor in accordance with the State Plane Coordinate System (NMSA 1978 47-1-49-56 (Repl. Pamp. 1993)). The surveys will be conducted in accordance with Sections 500.1 through

500.12 of the Regulations and Rules of the Board of Registration for Professional Engineers and Surveyors Minimum Standards for Surveying in New Mexico. Horizontal positions will be measured to the nearest 0.1-ft and vertical elevations will be measured to the nearest 0.01-ft.

Aerial Map Source: Google Maps, 2008 DigitalGlobe.



LEGEND

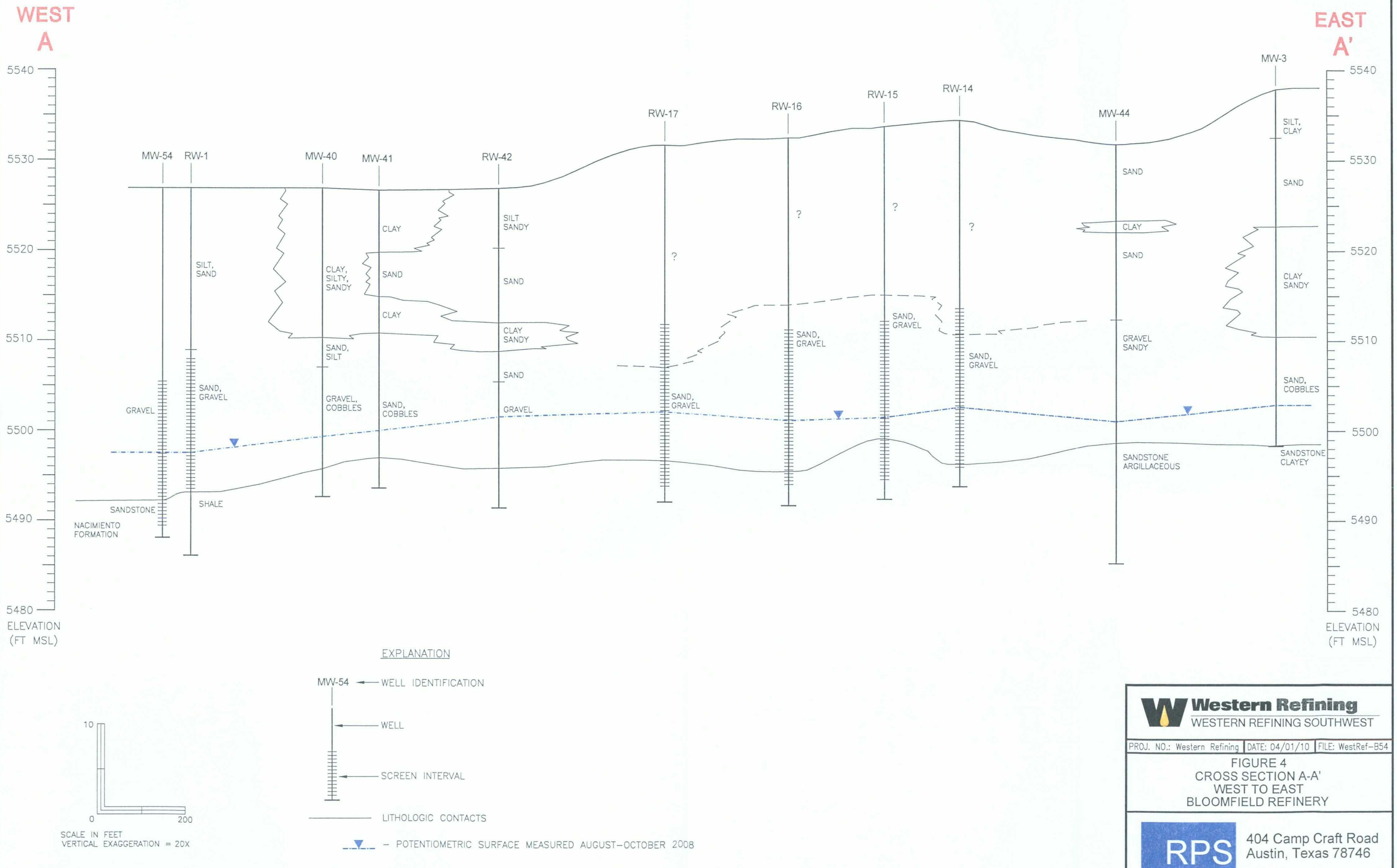
- PROPOSED BACKGROUND MONITORING WELL LOCATION
- GAS WELL LOCATION
- WESTERN PROPERTY BOUNDARY

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRefB53

FIGURE 3
BACKGROUND MONITORING WELL LOCATIONS
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

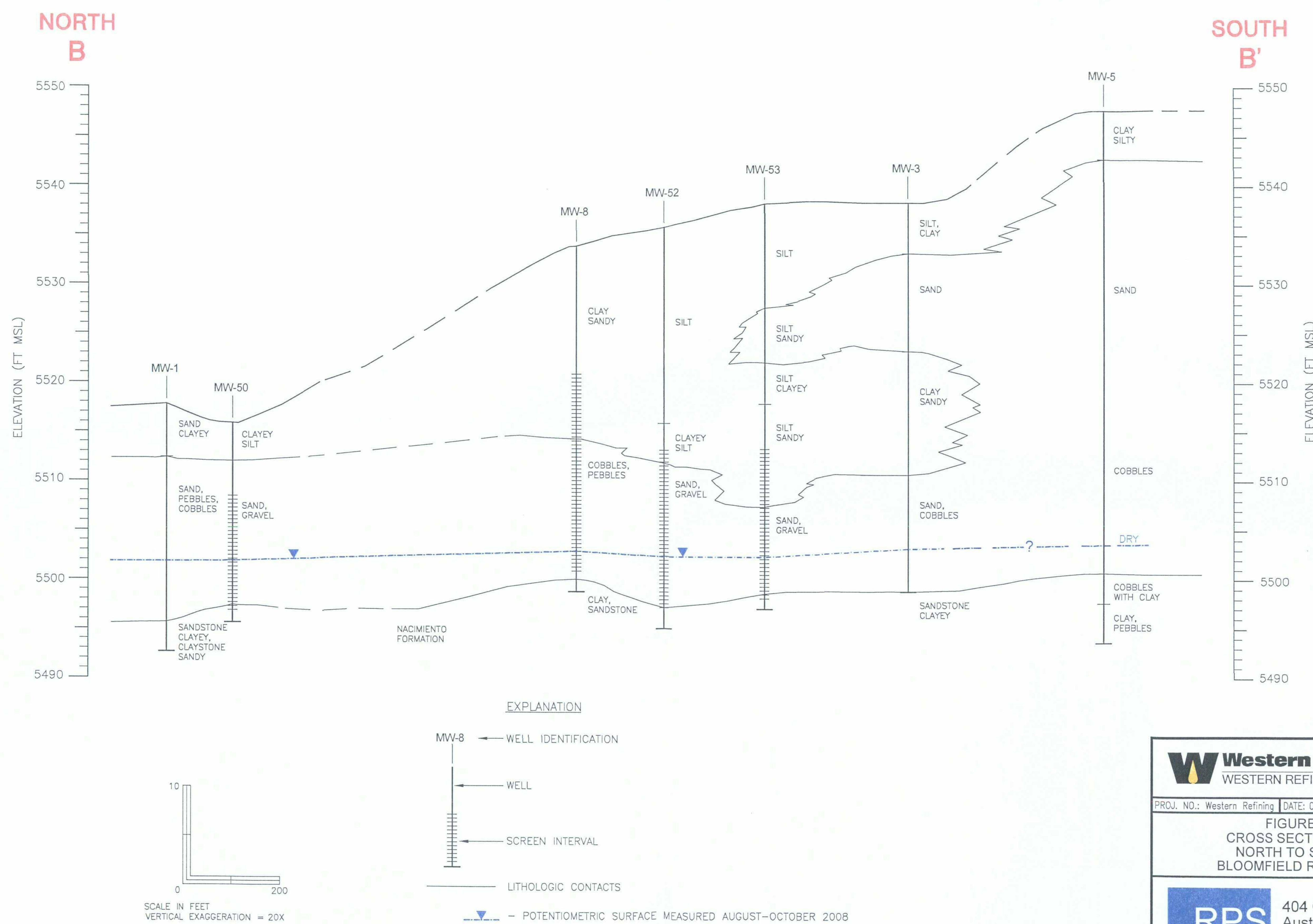


Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef-B54

FIGURE 4
CROSS SECTION A-A'
WEST TO EAST
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746



Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining | DATE: 04/01/10 | FILE: WestRef-B55

FIGURE 5
CROSS SECTION B-B'
NORTH TO SOUTH
BLOOMFIELD REFINERY

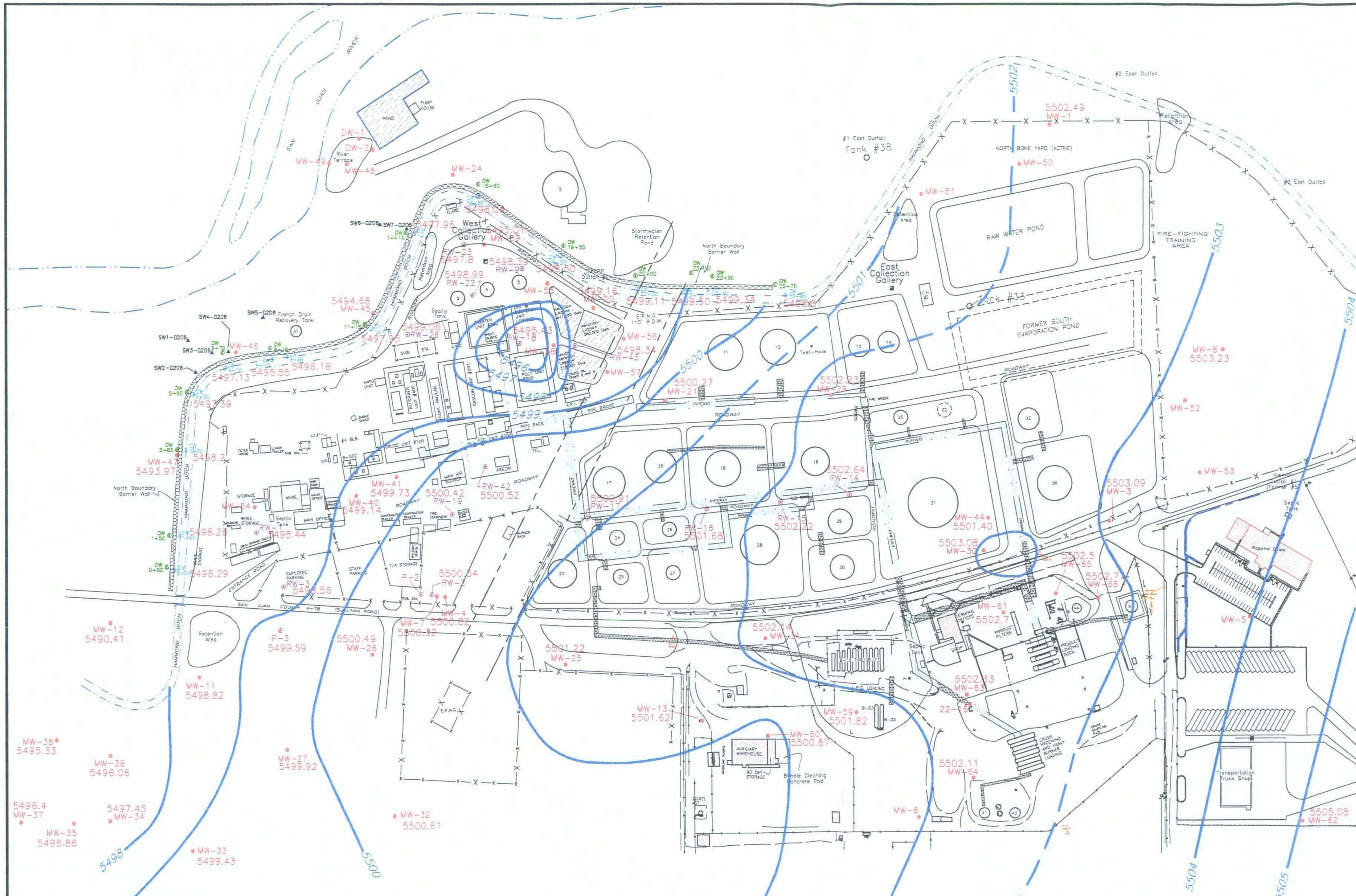
RPS
404 Camp Craft Road
Austin, Texas 78746

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRef–B56

FIGURE 6
POTENTIOMETRIC SURFACE MAP
AUGUST 2009
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

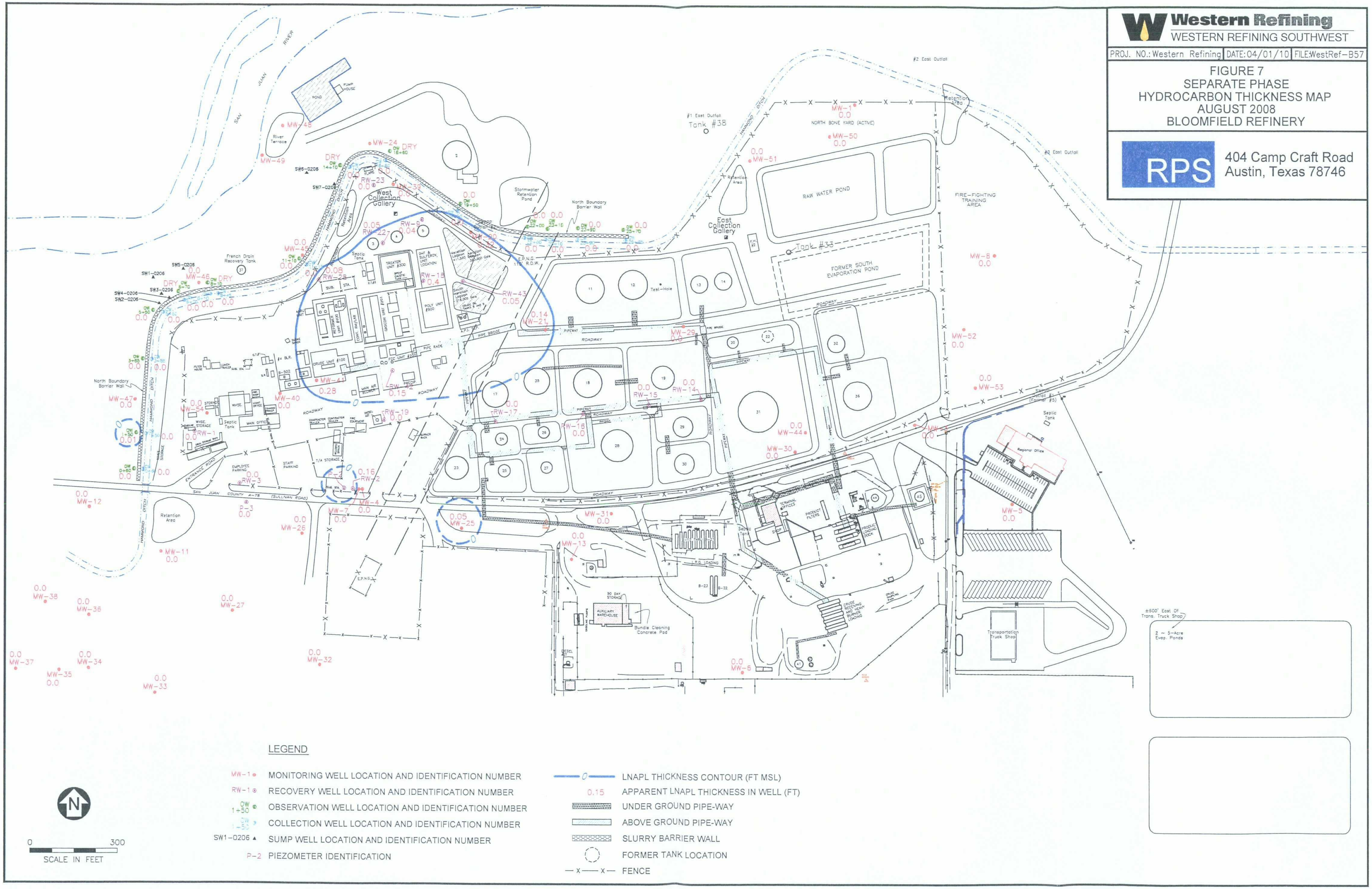


LEGEND

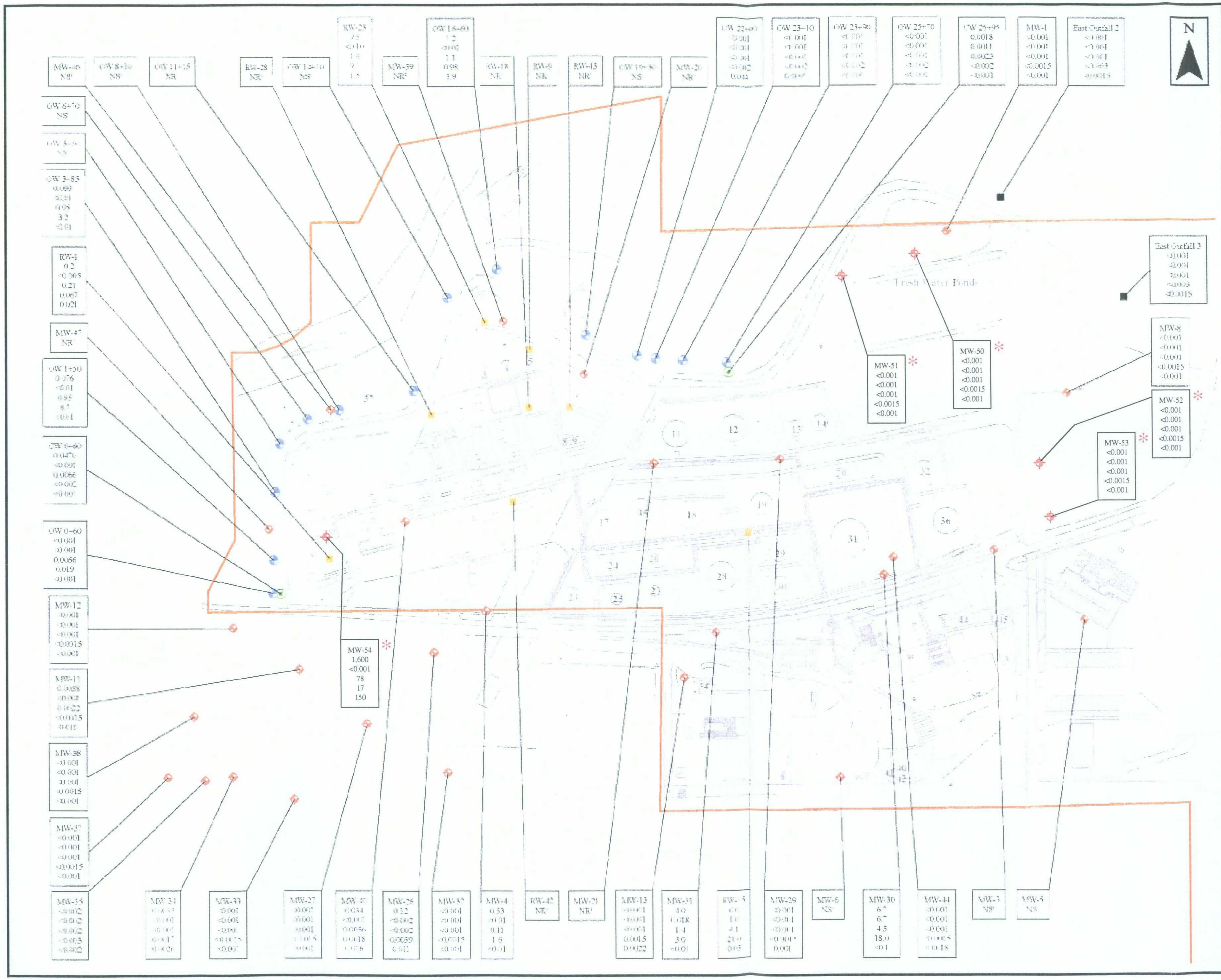
- MW-1 ● MONITORING WELL LOCATION AND IDENTIFICATION NUMBER
- 5500 CONTOUR OF GROUNDWATER ELEVATION (FT MSL)
- 5502.49 GROUNDWATER ELEVATION (FT MSL) (AUGUST 2009) [MW-59 TO MW-66 MEASURED JULY 2009]
- UNDER GROUND PIPE-WAY
- ABOVE GROUND PIPE-WAY
- SLURRY BARRIER WALL
- FORMER TANK LOCATION
- —x—x— FENCE

N

0 300
SCALE IN FEET



Western Refining
WESTERN REFINING SOUTHWEST
PROJ. NO.: Western Refining
DATE: 04/01/10
FILE: WestRef-B57
FIGURE 7
SEPARATE PHASE
HYDROCARBON THICKNESS MAP
AUGUST 2008
BLOOMFIELD REFINERY
RPS
404 Camp Craft Road
Austin, Texas 78746
LEGEND
MW-1 MONITORING WELL LOCATION AND IDENTIFICATION NUMBER
RW-1 RECOVERY WELL LOCATION AND IDENTIFICATION NUMBER
OW 1+50 OBSERVATION WELL LOCATION AND IDENTIFICATION NUMBER
COLLECTION WELL LOCATION AND IDENTIFICATION NUMBER
SW1-0206 SUMP WELL LOCATION AND IDENTIFICATION NUMBER
P-2 PIEZOMETER IDENTIFICATION
0 LNAPL THICKNESS CONTOUR (FT MSL)
0.15 APPARENT LNAPL THICKNESS IN WELL (FT)
UNDER GROUND PIPE-WAY
ABOVE GROUND PIPE-WAY
SLURRY BARRIER WALL
FORMER TANK LOCATION
FENCE
0
300
SCALE IN FEET
N
SAN JUAN RIVER
RAW WATER POND
FORMER SOUTH EVAPORATION POND
FIRE-FIGHTING TRAINING AREA
NORTH BONE YARD (ACTIVE)
West Collection Gallery
East Collection Gallery
Stormwater Retention Pond
North Boundary Barrier Wall
River Terrace
French Drain Recovery Tank
Retention Area
SAN JUAN COUNTY A-78 (SULLIVAN ROAD)
ENTRANCE ROAD
HAMMOND DITCH
Tank #38
Tank #33
#1 East Outfall
#2 East Outfall
#3 East Outfall
Regional Office
Transportation Truck Shop
±600' East Of Trans. Truck Shop
2 - 5-Acre Evap. Ponds
Bundle Cleaning Concrete Pad
90 DAY STORAGE
AUXILIARY WAREHOUSE
MW-1 0.0
MW-50 0.0
MW-51 0.0
MW-8 0.0
MW-52 0.0
MW-53 0.0
MW-5 0.0
MW-44 0.0
MW-30 0.0
MW-6 0.0
MW-31 0.0
MW-13 0.0
MW-29 0.0
RW-14 0.0
RW-15 0.0
RW-16 0.0
RW-17 0.0
RW-21 0.14
RW-43 0.05
MW-25 0.05
RW-2 0.16
MW-4 0.0
MW-7 0.0
MW-26 0.0
MW-27 0.0
MW-32 0.0
MW-33 0.0
MW-34 0.0
MW-35 0.0
MW-36 0.0
MW-37 0.0
MW-38 0.0
MW-12 0.0
MW-11 0.0
P-3 0.0
RW-3 0.0
RW-1 0.0
MW-40 0.0
MW-41 0.28
RW-20 0.15
RW-19 0.0
RW-18 0.4
RW-9 0.04
RW-22 0.05
RW-28 0.08
RW-23 0.0
MW-24 DRY
MW-46 0.0
MW-45 0.0
MW-47 0.0
MW-48
MW-49
MW-54 0.0



Map Source: Western Refining Southwest, Inc. 2008 Facility-Wide Groundwater Monitoring Report, Fig 14.

0 — 360
APPROXIMATE SCALE IN FEET

Legend

- Monitoring Well
- Observation Well
- Recovery Well
- Collection Well
- Outfall
- Site
- Approximate Property Line

MW-38	- Well Id
< 0.001	- Benzene
< 0.001	- Toluene
< 0.001	- Ethylbenzene
< 0.0015	- Xylenes, Total
0.001	- MTBE

Notes:

All concentrations in milligrams per liter (mg/L)

NS¹ = Well is Dry or Not Enough Water to Sample- No sample

NS² = Sample Inadvertently not Collected this Sampling Event

NR¹ = No Sample Required - Well Contains Separate Phase Hydrocarbon

NR² = No Sample Required per OCD and NMED Conditions

* = October 2008, All Other Samples Collected August 2008

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining | DATE: 04/01/10 | FILE: WestRef–B58

FIGURE 8
DISSOLVED-PHASE GROUNDWATER DATA
AUGUST AND OCTOBER 2008
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Section 4
Investigation Methods

The purpose of the background investigation is to determine concentrations of inorganic constituents in soil and ground water that are unaffected by any site-related operations, due to either historical or current operations. Guidance on selecting and developing sampling plans as provided in Guidance for Choosing a Sampling Design for Environmental Data Collection (EPA, 2000) was utilized to select the appropriate sampling strategy for background soil samples.

4.1 Well Drilling and Construction Activities

The background monitoring well(s) will be drilled using either hollow-stem auger or if necessary, air rotary methods including ODEX. The monitoring well construction/completion will be conducted in accordance with the requirements of Section IX of the Order. The preferred method will be hollow-stem auger to increase the ability to recover undisturbed samples. The drilling equipment will be properly decontaminated before drilling the boring(s).

The NMED will be notified as early as practicable if conditions arise or are encountered that do not allow the advancement of the boring(s) to the specified depth or at the planned drilling location. The soil boring(s) to be completed as a background monitoring well will be drilled to the top of bedrock (Nacimiento Formation) and the anticipated completion depth ranges from 50 to 60 feet. Soil samples will be collected continuously and logged by a qualified geologist or engineer. Soil samples will not be collected for chemical analyses, only ground water samples will be collected from the soil boring(s) completed as background monitoring wells. Slotted (0.01 inch) PVC well screen will be placed at the bottom of the well and will extend for 10 feet to ensure that the well is screened across the water table and to the extent possible the entire saturated zone is open to the well, with approximately five feet of screen above the water table. A 10/20 sand filter pack will be installed to two feet over the top of the well screen.

If ground water is present in the well(s) upon installation of the well screen, then the well(s) will be completed as permanent monitoring well(s). If ground water is not present immediately after installation of the well screen, then the well will be monitored periodically during the remaining RCRA Facility Investigation activities, which could take another two weeks to complete. If ground water is subsequently found to be present in the well casing, then the well will be completed as a permanent monitoring well. If no water enters the well throughout this time period, then Western may remove the well casing and plug the boring in accordance with New Mexico Administrative Code 19.27.4.30.

The drilling and sampling will be accomplished under the direction of a qualified engineer or geologist who will maintain a detailed log of the materials and conditions encountered in each boring. Both sample information and visual observations of the cuttings and core samples will be recorded on the boring log. Known site features and/or site survey grid markers will be used as references to locate each boring prior to surveying the location. The boring locations will be measured to the nearest foot, and locations will be recorded on a scaled site map upon completion of each boring.

4.2 Soil Sampling

The soil samples will be collected from the surface (0-6") and shallow subsurface (18-24") to establish background concentrations for inorganic constituents. Eight sample locations will be selected and two samples will be collected from each location to support the development of distinct background concentrations for surface and subsurface soils, if required. The area in which the samples will be collected is located southeast of the Regional Transportation office (Figure 2). The background sample locations are shown in Figure 9. This area will be gridded into eight cells of approximately the same size with sample collection locations staked in the center of each grid cell.

The area chosen for background samples was selected based on the fact that no site-related or other industrial activities are known to have taken place in this area and based on a review of soil survey information. As shown on the soil survey map included in Appendix B, the same soil map unit (Doak-Avalon association) occurs across most of the refinery complex (USDA, 2010). The area from which the background samples will be collected is within this same soil association. The two sample depths were selected based on the chemical soil properties reported in Appendix B, which show a slight variation with depth for the Doak-Avalon association soils.

Soil borings will be completed to a depth of two feet using a decontaminated hand-auger or sharp shooter shovel, whichever is more efficient in allowing the collection of undisturbed soil samples from the 18-24" interval. Soil samples will be collected using a decontaminated, hand-held stainless steel sampling device or a pre-cleaned disposable sampling device. A portion of the sample will be placed in pre-cleaned, laboratory-prepared sample containers for laboratory chemical analysis. The remaining portions of the samples will be used for logging as discussed in Section 4.2.1. Sample handling and chain-of-custody procedures will be in accordance with the procedures presented below in Section 4.4.

Quality Assurance/Quality Control (QA/QC) samples will be collected to monitor the validity of the soil sample collection procedures as follows:

- Field duplicates will be collected at a rate of 10 percent; and
- Equipment blanks will be collected from all sampling apparatus at a frequency of one per day.

4.2.1 Soil Sample Logging

The soil borings will be continuously logged. The physical characteristics of the samples (such as mineralogy, ASTM soil classification, moisture content, texture, color, and/or presence of stains or odors), depth where each sample was obtained, method of sample collection, and other observations will be recorded in the field log by a qualified geologist or engineer. Detailed logs of each boring will be completed in the field by a qualified engineer or geologist. Additional information, such as the presence of water-bearing zones and any unusual or noticeable conditions encountered during drilling, will be recorded on the logs.

4.3 Ground Water Monitoring

4.3.1 Monitoring Well Development

The new monitoring well(s) will be developed using a combination of mechanical surging and air-lift techniques. Initially, a surge block attached to the end of the drill rod will be used to swab the inside of the well casing within the screen interval. The repeated plunging motion will draw filter pack fines and loosened sediment into the well casing, improving the water quality within the surrounding formation and filter pack.

Once the well(s) is surged, an air-lift apparatus may be used to remove the loosened sediment and fines from inside the well casing. Using an air compressor and dedicated 1-inch PVC eductor piping, compressed air may be injected into the well. The air flow rate will be manually adjusted to produce a continuous flow of water/sediment mixture out the top of the well casing via the 1-inch eductor piping. Air lifting will cease once the purge water is relatively clear and free of sediment.

4.3.2 Ground Water Levels

Ground water level measurements will be obtained at the new monitoring well(s) prior to purging in preparation for a sampling event. Measurement data and the date and time of each measurement will be recorded on a site monitoring data sheet. The depth to ground water levels will be measured to the nearest 0.01 ft. The depth to ground water will be recorded relative to the surveyed well casing rim or other surveyed datum. During regularly scheduled ground water monitoring events, ground water levels will be measured in all wells within 48 hours of the start of obtaining water level measurements.

4.3.3 Well Purging

Wells will be purged and ground water samples collected no later than five days after the completion of well development. A second round of ground water monitoring and sampling will be conducted no sooner than 30 days and not later than 75 days of the initial sampling event.

All zones in each monitoring well will be purged by removing ground water with a dedicated bailer or disposable bailer prior to sampling in order to ensure that formation water is being sampled. Purge volumes (a minimum of three well volumes including filter pack) will be determined by monitoring, at a minimum, ground water pH, specific conductance, dissolved oxygen concentrations, oxidation-reduction potential, and temperature after every two gallons or each well volume, whichever is less, has been purged from the well. Purging will continue, as needed, until the specific conductance, pH, and temperature readings are within 10 percent between readings for three consecutive measurements. The volume of ground water purged, the instruments used, and the readings obtained at each interval will be recorded on the field-monitoring log. Well purging may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated).

4.3.4 Ground Water Sample Collection

Ground water samples will be collected within 24 hours of the completion of well purging using dedicated bailers or disposal bailers. Alternatively, well sampling may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated). Sample collection methods will be documented in the field monitoring reports. The samples will be transferred to the appropriate, clean, laboratory-prepared containers provided by the analytical laboratory. Sample handling and chain-of-custody procedures will be in accordance with the procedures presented below in Section 4.4.

Ground water samples intended for metals analysis will be submitted to the laboratory as total metals samples. QA/QC samples will be collected to monitor the validity of the ground water sample collection procedures as follows:

- Field duplicate water samples will be obtained at a frequency of ten percent, with a minimum, of one duplicate sample per sampling event; and
- Equipment rinsate blanks will be obtained for chemical analysis at the rate of ten percent or a minimum of one rinsate blank per sampling day. Equipment rinsate blanks will be collected at a rate of one per sampling day if disposable sampling equipment is used. Rinsate samples will be generated by rinsing deionized water through unused or decontaminated sampling equipment. The rinsate sample will be placed in the appropriate sample container and submitted with the ground water samples to the analytical laboratory for the appropriate analyses.

4.4 Sample Handling

At a minimum, the following procedures will be used at all times when collecting samples during investigation, corrective action, and monitoring activities:

1. Neoprene, nitrile, or other protective gloves will be worn when collecting samples. New disposable gloves will be used to collect each sample;
2. All samples collected of each medium for chemical analysis will be transferred into clean sample containers supplied by the project analytical laboratory. Sample container volumes and preservation methods will be in accordance with the most recent standard EPA and industry accepted practices for use by accredited analytical laboratories. Sufficient sample volume will be obtained for the laboratory to complete the method-specific QC analyses on a laboratory-batch basis; and
3. Sample labels and documentation will be completed for each sample following procedures discussed below. Immediately after the samples are collected, they will be stored in a cooler with ice or other appropriate storage method until they are delivered to the analytical laboratory. Standard chain-of-custody procedures, as described below, will be followed for all samples collected. All samples will be submitted to the laboratory soon enough to allow the laboratory to conduct the analyses within the method holding times. At a minimum, all samples will be submitted to the laboratory within 48 hours after their collection.

Chain-of-custody and shipment procedures will include the following:

1. Chain-of-custody forms will be completed at the end of each sampling day, prior to the transfer of samples off site.

2. Individual sample containers will be packed to prevent breakage and transported in a sealed cooler with ice or other suitable coolant or other EPA or industry-wide accepted method. The drainage hole at the bottom of the cooler will be sealed and secured in case of sample container leakage. Temperature blanks will be included with each shipping container.

3. Each cooler or other container will be delivered directly to the analytical laboratory.

4. Glass bottles will be separated in the shipping container by cushioning material to prevent breakage.

5. Plastic containers will be protected from possible puncture during shipping using cushioning material.

6. The chain-of-custody form and sample request form will be shipped inside the sealed storage container to be delivered to the laboratory.

7. Chain-of-custody seals will be used to seal the sample-shipping container in conformance with EPA protocol.

8. Signed and dated chain-of-custody seals will be applied to each cooler prior to transport of samples from the site.

9. Upon receipt of the samples at the laboratory, the custody seals will be broken, the chain-of-custody form will be signed as received by the laboratory, and the conditions of the samples will be recorded on the form. The original chain-of-custody form will remain with the laboratory and copies will be returned to the relinquishing party.

10. Copies of all chain-of-custody forms generated as part of sampling activities will be maintained on-site.

4.5 Decontamination Procedures

The objective of the decontamination procedures is to minimize the potential for cross-contamination. A designated decontamination area will be established for decontamination of drilling equipment, reusable sampling equipment and well materials. The drilling rig will be decontaminated prior to entering the site. Drilling equipment or other exploration equipment that may come in contact with the borehole will be decontaminated by high pressure washing prior to drilling each new boring.

Sampling or measurement equipment, including but not limited to, stainless steel sampling tools, split-barrel or core samplers, non-dedicated well developing or purging equipment, ground water quality measurement instruments, and water level measurement instruments, will be decontaminated in accordance with the following procedures or other methods approved by the Department before each sampling attempt or measurement:

1. Brush equipment with a wire or other suitable brush, if necessary or practicable, to remove large particulate matter;
2. Rinse with potable tap water;
3. Wash with nonphosphate detergent or other detergent approved by the Department (examples include Fantastik™, Liqui-Nox®);
4. Rinse with potable tap water; and
5. Double rinse with deionized water.

All decontamination solutions will be collected and stored temporarily as described in Appendix A. Decontamination procedures and the cleaning agents used will be documented in the daily field log.

4.6 Field Equipment Calibration Procedures

Field equipment requiring calibration will be calibrated to known standards, in accordance with the manufacturers' recommended schedules and procedures. At a minimum, calibration checks will be conducted daily and the instruments will be recalibrated, if necessary. Calibration measurements will be recorded in the daily field logs. If field equipment becomes inoperable, its use will be discontinued until the necessary repairs are made. In the interim, a properly calibrated replacement instrument will be used.

4.7 Documentation of Field Activities

Daily field activities, including observations and field procedures, will be recorded in a field log book. The original field forms will be maintained at the Facility. Copies of the completed forms will be maintained in a bound and sequentially numbered field file for reference during field activities. Indelible ink will be used to record all field activities. Photographic documentation of field activities will be performed, as appropriate. The daily record of field activities will include the following:

1. Site or unit designation;
2. Date;
3. Time of arrival and departure;
4. Field investigation team members including subcontractors and visitors;
5. Weather conditions;

6. Daily activities and times conducted;
7. Observations;
8. Record of samples collected with sample designations and locations specified;
9. Photographic log, as appropriate;
10. Field monitoring data, including health and safety monitoring;
11. Equipment used and calibration records, if appropriate;
12. List of additional data sheets and maps completed;
13. An inventory of the waste generated and the method of storage or disposal; and
14. Signature of personnel completing the field record.

4.8 Chemical Analyses

All samples collected for laboratory analysis will be submitted to an accredited laboratory. The laboratory will use the most recent standard EPA and industry-accepted analytical methods for target analytes as the testing methods for each medium sampled. Chemical analyses will be performed in accordance with the most recent EPA standard analytical methodologies and extraction methods.

Ground water and soil samples will also be analyzed for the following metals using the indicated analytical methods.

Analyte	Analytical Method
Antimony	SW-846 method 6010/6020
Arsenic	SW-846 method 6010/6020
Barium	SW-846 method 6010/6020
Beryllium	SW-846 method 6010/6020
Cadmium	SW-846 method 6010/6020
Chromium	SW-846 method 6010/6020
Cobalt	SW-846 method 6010/6020
Cyanide	SW-846 method 335.4/335.2 mod
Lead	SW-846 method 6010/6020
Mercury	SW-846 method 7470/7471
Nickel	SW-846 method 6010/6020
Selenium	SW-846 method 6010/6020
Silver	SW-846 method 6010/6020
Thallium	SW846 method 6010/6020
Vanadium	SW-846 method 6010/6020
Zinc	SW-846 method 6010/6020

Ground water samples will also be analyzed for the following additional general chemistry parameters.

Analyte	Analytical Method
Total Dissolved Solids	SM-2540C
Bicarbonate	SM-2320B
Chloride	EPA method 300.0
Sulfate	EPA method 300.0
Calcium	EPA method 6010/6020
Magnesium	EPA method 6010/6020
Sodium	EPA method 6010/6020
Potassium	EPA method 6010/6020
Manganese	SW-846 method 6010/6020
Nitrate/nitrite	EPA method 300.0
Ferric/ferrous Iron	SW-846 method 6010/6020 & SM 3500Fe2+

Soil samples and ground water samples will be analyzed for the following constituents in addition to those listed above to support possible development of background for SWMU No. 16 (Active Landfill).

Analyte	Analytical Method
Aluminum	SW-846 method 6010/6020
Boron	SW-846 method 6010/6020
Copper	SW-846 method 6010/6020
Manganese	SW-846 method 6010/6020
Molybdenum	SW-846 method 6010/6020
Iron	SW-846 method 6010/6020
Uranium	SW-846 method 6020
Chloride	SW-846 method 300
Sulfate	SW-846 method 300
Fluoride	SW-846 method 300

As discussed in section 4.3.3, field measurements will be obtained for pH, specific conductance, dissolved oxygen concentrations, oxidation-reduction potential, and temperature.

4.9 Data Quality Objectives

The Data Quality Objectives (DQOs) were developed to ensure that newly collected data are of sufficient quality and quantity to address the projects goals, including Quality Assurance/Quality Control (QA/QC) issues (EPA, 2006). The project goals are established in the Order and are to determine and evaluate the presence, nature, and extent of releases of contaminants at specified SWMUs/AOCs and pursuant to Section VIII. H. to determine an appropriate background data set. The type of data required to meet the project goals includes chemical analyses of soil and ground water to determine background concentrations of inorganic constituents in soil and ground water.

The quantity of data is dependant upon the soil type and geology at the site. As discussed above, a single soil type is predominant across most of the refinery and the geology is also relatively consistent such that only two background data sets (surface – 0-6" and subsurface – 18-24') are required. The quality of data that is required is consistent across locations and is specified in Section VIII.D.7.c of the Order. In general, method detection limits should be 20% or less of the applicable cleanup standards and screening levels.

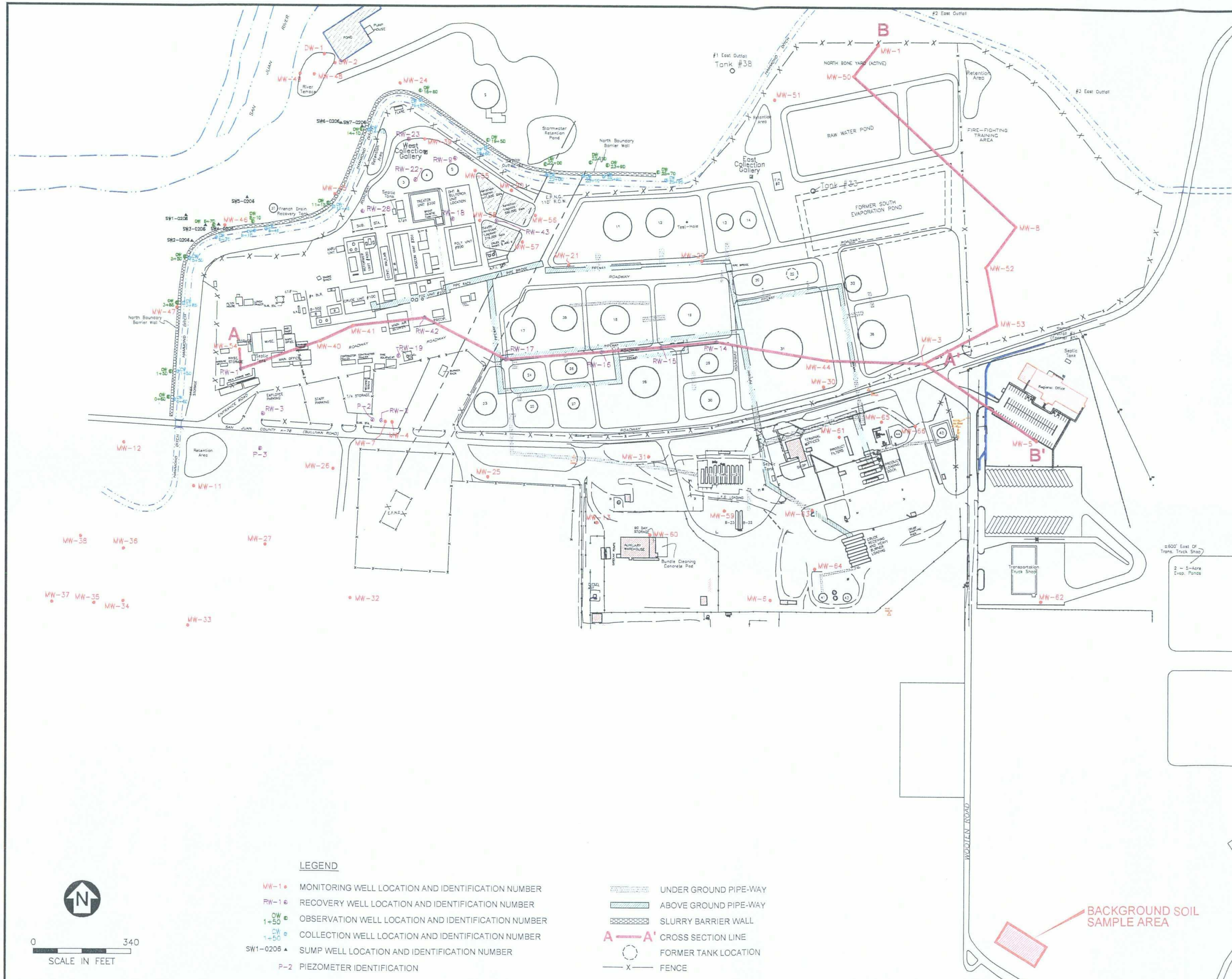
Additional DQOs include precision, accuracy, representativeness, completeness, and comparability. Precision is a measurement of the reproducibility of measurements under a given set of circumstances and is commonly stated in terms of standard deviation or coefficient of variation (EPA, 1987). Precision is also specific to sampling activities and analytical performance. Sampling precision will be evaluated through the analyses of duplicate field samples and laboratory replicates will be utilized to assess laboratory precision.

Accuracy is a measurement in the bias of a measurement system and may include many sources of potential error, including the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis techniques (EPA, 1987). An evaluation of the accuracy will be performed by reviewing the results of field/trip blanks, matrix spikes, and laboratory QC samples.

Representativeness is an expression of the degree to which the data accurately and precisely represent the true environmental conditions. Sample locations and the number of samples have been selected to ensure the data is representative of actual environmental conditions. Sample collection techniques (e.g., purging of monitoring wells to collect formation water) will be utilized to help ensure representative results.

Completeness is defined as the percentage of measurements taken that are actually valid measurements, considering field QA and laboratory QC problems. EPA Contract Laboratory Program (CLP) data has been found to be 80-85% complete on a nationwide basis and this has been extrapolated to indicate that Level III, IV, and V analytical techniques will generate data that are approximately 80% complete (EPA, 1987). As an overall project goal, the completeness goal is 85%; however, some samples may be critical base on location or field screening results and thus a sample–by-sample evaluation will be performed to determine if the completeness goals have been obtained.

Comparability is a qualitative parameter, which expresses the confidence with which one data set can be compared to another. Industry standard sample collection techniques and routine EPA analytical methods will be utilized to help ensure data are comparable to historical and future data. Analytical results will be reported in appropriate units for comparison to historical data and cleanup levels.



LEGEND

MW-1 ●	MONITORING WELL LOCATION AND IDENTIFICATION NUMBER
RW-1 ⊕	RECOVERY WELL LOCATION AND IDENTIFICATION NUMBER
OW 1+50 ●	OBSERVATION WELL LOCATION AND IDENTIFICATION NUMBER
CW 1+50 ●	COLLECTION WELL LOCATION AND IDENTIFICATION NUMBER
SW1-0206 ▲	SUMP WELL LOCATION AND IDENTIFICATION NUMBER
P-2	PIEZOMETER IDENTIFICATION
	UNDER GROUND PIPE-WAY
	ABOVE GROUND PIPE-WAY
	SLURRY BARRIER WALL
A —— A'	CROSS SECTION LINE
◯	FORMER TANK LOCATION
—X—	FENCE

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining | DATE: 04/01/10 | FILE: WestRef-B52

FIGURE 2
BACKGROUND SOIL SAMPLE AREA
BLOOMFIELD REFINERY

RPS
404 Camp Craft Road
Austin, Texas 78746

Aerial Map Source: Google Maps, 2008 DigitalGlobe.

N

0 200
SCALE IN FEET

LEGEND

SAMPLE GRID

BACKGOUND SOIL SAMPLE LOCATION

FENCE

PP ABOVE GROUND ELECTRIC LINE AND POWER POLE

Western Refining
WESTERN REFINING SOUTHWEST

PROJ. NO.: Western Refining	DATE: 04/01/10	FILE: WestRefB59

FIGURE 9

BACKGROUND SOIL SAMPLE LOCATIONS
BLOOMFIELD REFINERY

RPS 404 Camp Craft Road
Austin, Texas 78746

Section 5
Schedule

This background investigation Work Plan will be implemented concurrently with the next site investigation Work Plan that is approved by the NMED. At this time, this is anticipated to be the Group #4 Investigation Work Plan December 2008 (revised January 2010). The estimated timeframes for each of the planned activities is as shown below:

- Field work (inclusive of all soil and initial ground water sampling) -- two weeks;
- Laboratory analyses for initial sampling event – four weeks;
- Data reduction and validation (soils and initial ground water event) – three weeks;
- Second ground water sampling event – one week;
- Laboratory analyses for second ground water sampling event – three weeks; and
- Data reduction and validation (second ground water event) – two weeks.

Computation of the required summary statistics pursuant to Section VIII.H. of the Order will be completed and the results will be included with the Group #4 Site Investigation Report.

Section 6
References

EPA, 1987, Data Quality Objectives for Remedial Response Activities; United States Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, OSWER Directive 9355.0-7B, 85p

EPA, 2000, Guidance on Choosing a Sampling Design for Environmental Data Collection, EPA/240/R-02/005, EPA QA/G-5S, 168 p.

EPA, 2006, Guidance on Systematic Planning Using the Data Quality Objectives Process, United States Environmental Protection Agency, Office of Environmental Information; EPA/240/B-06/001, p. 111.

Groundwater Technology Inc., 1994, RCRA Facility Investigation/Corrective Measures Study Report Bloomfield Refining Company #50 County Road 4990 Bloomfield, New Mexico, p.51.

USDA, 2010, Soil Resource Report for San Juan County, New Mexico, Eastern Part; Natural Resources Conservation Service, Web Soil Survey 2.0, http://websoilsurvey.sc.egov.usda.gov/app/HomePage.htm, p. 39.

Appendix A

Investigation Derived Waste (IDW) Management Plan

IDW Management Plan

All IDW will be properly characterized and disposed of in accordance with all federal, State, and local rules and regulations for storage, labeling, handling, transport, and disposal of waste. The IDW may be characterized for disposal based on the known or suspected contaminants potentially present in the waste. It is assumed that there are no wastes or contaminants present in environmental media at any of the planned background investigation areas.

A dedicated decontamination area will be setup prior to any sample collection activities. The decontamination facility will be constructed so as to capture and contain all decontamination fluids (e.g., wash water and rinse water) and foreign materials washed off the sampling equipment. The fluids will be pumped directly into suitable storage containers (e.g., labeled 55-gallon drums), which will be located at satellite accumulation areas until the fluids are disposed in the refinery wastewater treatment system upstream of the API separator. The solids captured in the decontamination pad will be shoveled into 55-gallon drums and stored at the designated satellite accumulation area pending proper waste characterization for off-site disposal.

Drill cuttings generated during installation of soil borings and monitoring wells are not anticipated to be contaminated and will be spread on the land surface following customary water well drilling practices. If there is any indication of contamination (e.g., odors, stained soil, presence of potential waste materials, etc.), then the cuttings will be placed directly into 55-gallon drums and staged in the satellite accumulation area pending results of the waste characterization sampling. The drill cuttings will be characterized by testing to determine if there are any hazardous characteristics in accordance with 40 Code of Federal Regulations (CFR) Part 261. This includes tests for ignitability, corrosivity, reactivity, and toxicity. If the materials are not characteristically hazardous, then further testing will be performed pursuant to the requirements of the facility to which the materials will be transported. Depending upon the results of analyses for individual investigation soil samples, additional analyses may include TPH and polynuclear aromatic hydrocarbons.

Purge water generated during ground water sampling activities will be containerized in 55-gallon drums and then disposed in the refinery wastewater treatment system upstream of the API separator. All miscellaneous waste materials (e.g., discarded gloves, packing materials, etc.) will be placed into the refinery's solid waste storage containers for off-site disposal.

Appendix B

Soils Data

United States Department of Agriculture

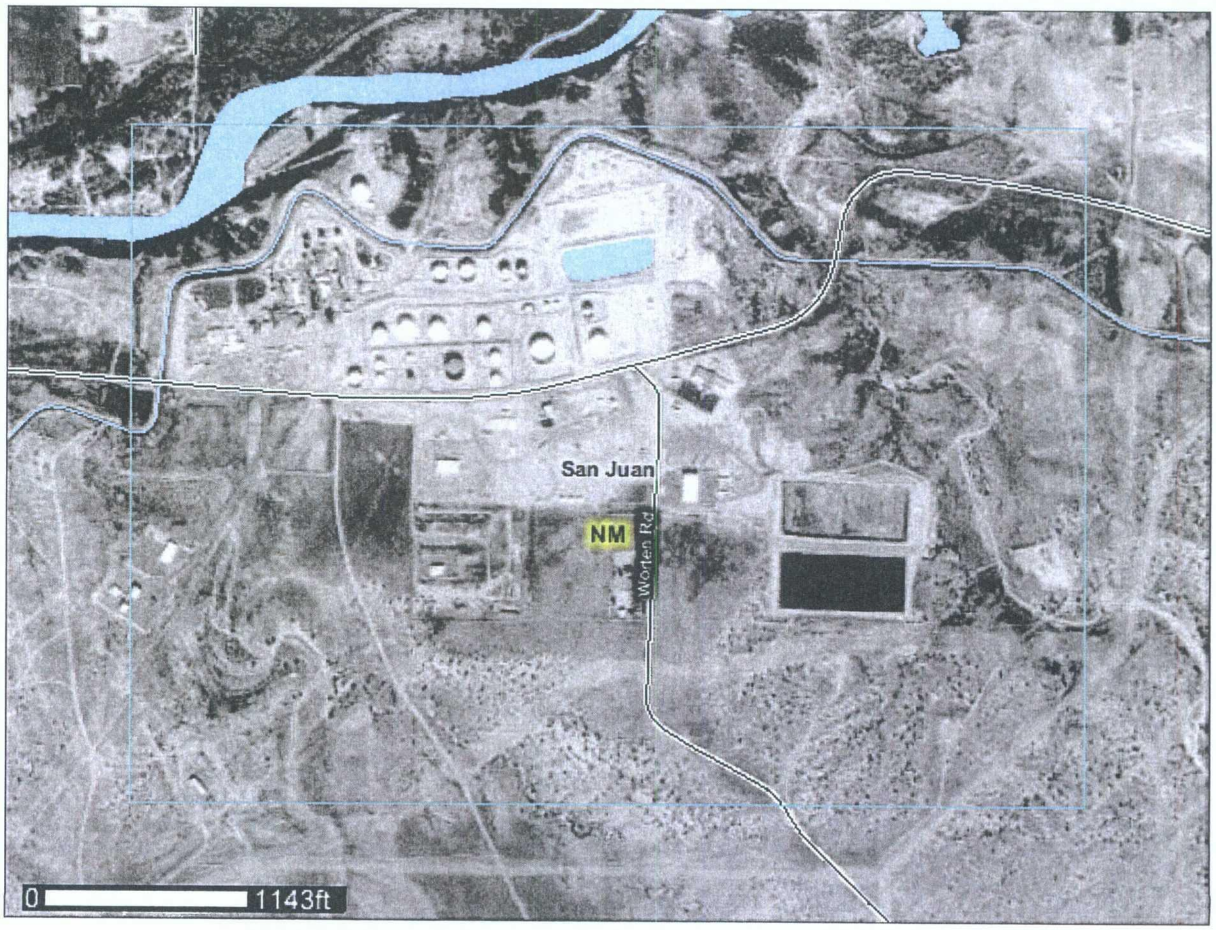
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
San Juan County, New Mexico, Eastern Part

Bloomfield Refinery Soils Report



March 30, 2010

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

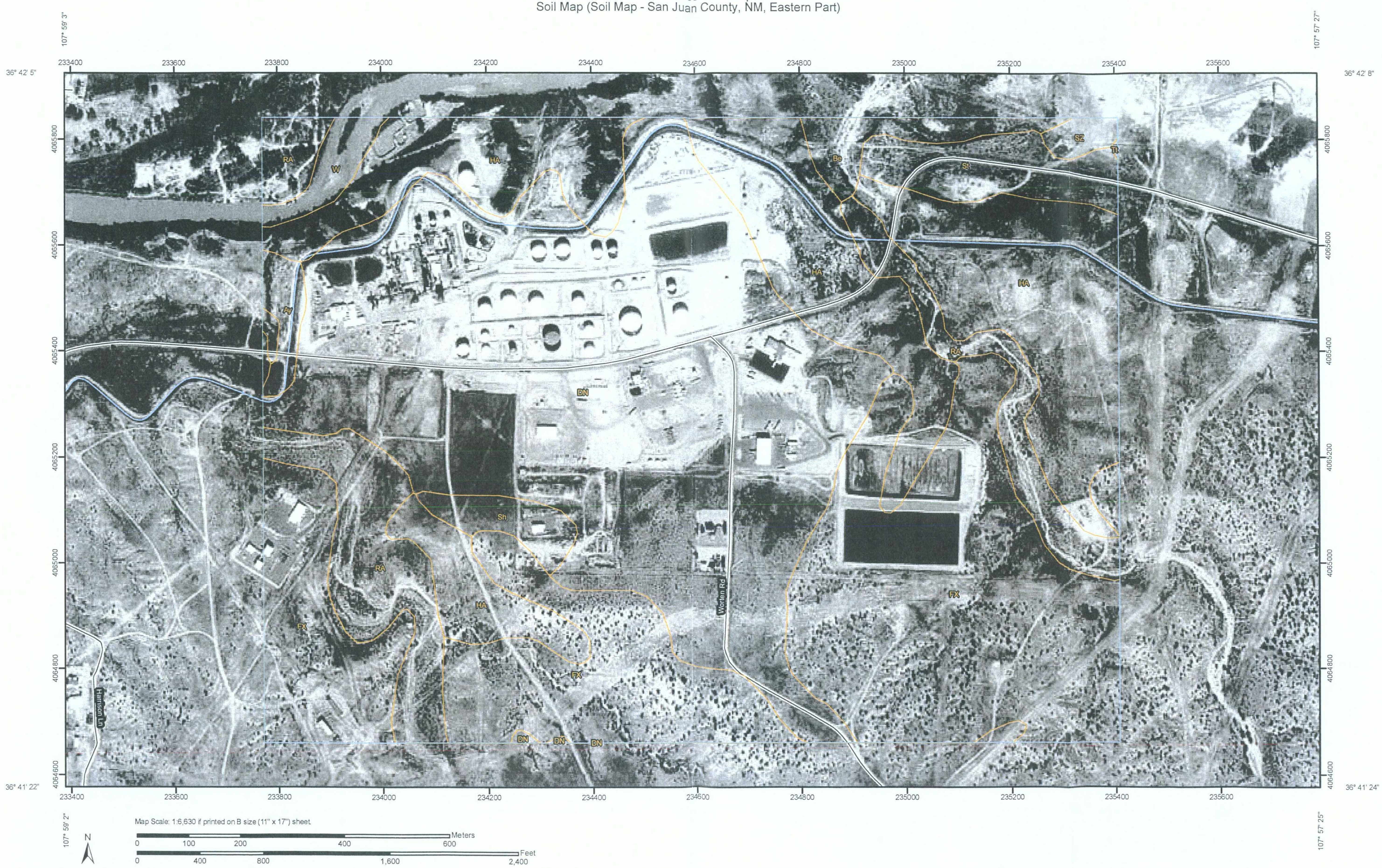
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report

Soil Map (Soil Map - San Juan County, NM, Eastern Part)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

- Gully
- Short Steep Slope
- Other

Political Features

- Cities

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:6,630 if printed on B size (11" × 17") sheet.

The soil surveys that comprise your AOI were mapped at 1:63,360.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Juan County, New Mexico, Eastern Part
Survey Area Data: Version 10, Sep 23, 2009

Date(s) aerial images were photographed: 10/9/1997

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Soil Map - San Juan County, NM, Eastern Part)

San Juan County, New Mexico, Eastern Part (NM618)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ay	Avalon loam, 0 to 3 percent slopes	3.8	0.8%
Be	Beebe loamy sand	6.7	1.4%
DN	Doak-Avalon association, gently sloping	168.8	35.4%
FX	Fruitland-Persayo-Sheppard complex, hilly	134.6	28.2%
HA	Haplargids-Blackston-Torriorthents complex, very steep	100.7	21.1%
RA	Riverwash	37.8	7.9%
Sh	Shiprock loamy fine sand, 0 to 2 percent slopes	5.5	1.1%
St	Stumble loamy sand, 0 to 3 percent slopes	12.4	2.6%
SZ	Stumble-Slickspots complex, gently sloping	2.1	0.4%
Tt	Turley clay loam, wet, 0 to 2 percent slopes	0.1	0.0%
W	Lakes, rivers, reservoirs	4.4	0.9%
Totals for Area of Interest		**477.0**	**100.0%**

Map Unit Descriptions (Soil Map - San Juan County, NM, Eastern Part)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used.

Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

San Juan County, New Mexico, Eastern Part

Ay—Avalon loam, 0 to 3 percent slopes

Map Unit Setting

Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Avalon and similar soils: 90 percent

Description of Avalon

Setting

Landform: Mesas
Landform position (three-dimensional): Talf
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits over slope alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Available water capacity: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability (nonirrigated): 7e
Ecological site: Limy (R035XB003NM)

Typical profile

0 to 18 inches: Loam
18 to 60 inches: Sandy clay loam
60 to 64 inches: Gravelly sandy loam

Be—Beebe loamy sand

Map Unit Setting

Elevation: 4,800 to 6,000 feet

Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Beebe and similar soils: 90 percent

Description of Beebe

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e
Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 6 inches: Loamy sand
6 to 81 inches: Sand

DN—Doak-Avalon association, gently sloping

Map Unit Setting

Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Doak and similar soils: 50 percent
Avalon and similar soils: 35 percent

Description of Doak

Setting

Landform: Fan remnants, mesas, stream terraces
Landform position (three-dimensional): Tread, talf
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.1 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability (nonirrigated): 7e
Ecological site: Loamy (R035XB001NM)

Typical profile

0 to 5 inches: Loam
5 to 43 inches: Clay loam
43 to 60 inches: Clay loam

Description of Avalon

Setting

Landform: Fan remnants, mesas, stream terraces
Landform position (three-dimensional): Tread, talf
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Eolian deposits over alluvium derived from sandstone and shale

Properties and qualities

Slope: 3 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0

Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability (nonirrigated): 7e
Ecological site: Limy (R035XB003NM)

Typical profile

0 to 14 inches: Loam
14 to 60 inches: Loam
60 to 64 inches: Gravelly loam

FX—Fruitland-Persayo-Sheppard complex, hilly

Map Unit Setting

Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Fruitland and similar soils: 40 percent
Persayo and similar soils: 30 percent
Sheppard and similar soils: 25 percent

Description of Fruitland

Setting

Landform: Alluvial fans, stream terraces
Landform position (three-dimensional): Riser, rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone and shale

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e

Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 4 inches: Sandy loam
4 to 60 inches: Fine sandy loam

Description of Persayo

Setting

Landform: Breaks, hills, ridges
Landform position (two-dimensional): Backslope, footslope, shoulder, toeslope
Landform position (three-dimensional): Side slope, nose slope, head slope, crest
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from shale

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: 5 to 20 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Very low (about 2.9 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Shale Hills (R035XA130NM)

Typical profile

0 to 18 inches: Clay loam
18 to 20 inches: Bedrock

Description of Sheppard

Setting

Landform: Dunes
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits over mixed alluvium

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)

Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e
Ecological site: Deep Sand (R035XB007NM)

Typical profile

0 to 4 inches: Loamy fine sand
4 to 60 inches: Loamy fine sand

HA—Haplargids-Blackston-Torriorthents complex, very steep

Map Unit Setting

Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Haplargids and similar soils: 45 percent
Blackston and similar soils: 30 percent
Torriorthents and similar soils: 20 percent

Description of Haplargids

Setting

Landform: Escarpments
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Mixed alluvium

Properties and qualities

Slope: 8 to 50 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Loamy (R035XB001NM)

Typical profile

0 to 7 inches: Cobbly sandy loam
7 to 26 inches: Cobbly sandy clay loam
26 to 60 inches: Cobbly sandy clay loam

Description of Blackston

Setting

Landform: Escarpments
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Mixed alluvium

Properties and qualities

Slope: 8 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Very slightly saline to slightly saline (4.0 to 8.0 mmhos/cm)
Available water capacity: Low (about 4.5 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Limy (R035XB003NM)

Typical profile

0 to 11 inches: Gravelly loam
11 to 26 inches: Very gravelly loam
26 to 60 inches: Very gravelly sand

Description of Torriorthents

Setting

Landform: Escarpments
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Mixed alluvium

Properties and qualities

Slope: 8 to 50 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)

Sodium adsorption ratio, maximum: 2.0
Available water capacity: Very low (about 2.2 inches)

Interpretive groups
Land capability (nonirrigated): 7e
Ecological site: Hills (R042XB027NM)

Typical profile
0 to 3 inches: Cobbly loam
3 to 15 inches: Cobbly clay loam
15 to 60 inches: Bedrock

RA—Riverwash

Map Unit Setting
Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition
Riverwash, clayey: 35 percent
Riverwash, sandy: 35 percent
Riverwash, gravelly: 30 percent

Description of Riverwash, Sandy

Setting
Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities
Slope: 0 to 3 percent
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: Frequent
Available water capacity: Very low (about 2.9 inches)

Interpretive groups
Land capability (nonirrigated): 8w

Typical profile
0 to 6 inches: Sand
6 to 60 inches: Stratified coarse sand to sandy loam

Description of Riverwash, Clayey

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 1 percent
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Frequent
Available water capacity: Low (about 6.0 inches)

Interpretive groups

Land capability (nonirrigated): 8w

Typical profile

0 to 6 inches: Clay
6 to 60 inches: Clay

Description of Riverwash, Gravelly

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stream alluvium derived from igneous and sedimentary rock

Properties and qualities

Slope: 0 to 3 percent
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: Frequent
Available water capacity: Very low (about 1.9 inches)

Interpretive groups

Land capability (nonirrigated): 8w

Typical profile

0 to 6 inches: Gravelly sand
6 to 60 inches: Stratified extremely gravelly coarse sand to gravelly sand

Sh—Shiprock loamy fine sand, 0 to 2 percent slopes

Map Unit Setting

Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Shiprock and similar soils: 85 percent

Description of Shiprock

Setting

Landform: Mesas
Landform position (three-dimensional): Talf
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits over alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 6.3 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability (nonirrigated): 7e
Ecological site: Deep Sand (R035XB007NM)

Typical profile

0 to 10 inches: Loamy fine sand
10 to 60 inches: Fine sandy loam

St—Stumble loamy sand, 0 to 3 percent slopes

Map Unit Setting

Elevation: 4,800 to 6,400 feet

Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Stumble and similar soils: 90 percent
Fruitland and similar soils: 10 percent

Description of Stumble

Setting

Landform: Dunes
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits derived from sandstone

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 3.7 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 7e
Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 5 inches: Loamy sand
5 to 29 inches: Loamy sand
29 to 49 inches: Gravelly loamy sand
49 to 81 inches: Loamy sand

Description of Fruitland

Setting

Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fan alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 7.5 inches)

Interpretive groups
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 7e
Ecological site: Loamy (R035XB001NM)

Typical profile
0 to 8 inches: Loam
8 to 60 inches: Fine sandy loam

SZ—Stumble-Slickspots complex, gently sloping

Map Unit Setting
Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition
Stumble and similar soils: 70 percent
Slickspots: 20 percent

Description of Stumble

Setting
Landform: Dunes
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits derived from sandstone

Properties and qualities
Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 1 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups
Land capability classification (irrigated): 4e

Land capability (nonirrigated): 7e
Ecological site: Sandy (R035XB002NM)

Typical profile

0 to 4 inches: Loamy sand
4 to 60 inches: Loamy sand

Description of Slickspots

Setting

Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from sandstone

Properties and qualities

Slope: 0 to 5 percent
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Maximum salinity: Slightly saline to moderately saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0

Interpretive groups

Land capability (nonirrigated): 8w

Typical profile

0 to 2 inches: Clay
2 to 60 inches: Clay

Tt—Turley clay loam, wet, 0 to 2 percent slopes

Map Unit Setting

Elevation: 4,800 to 6,000 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Turley variant and similar soils: 90 percent

Description of Turley Variant

Setting

Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fan alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 24 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 2w
Land capability (nonirrigated): 6w
Ecological site: Clayey (R035XB004NM)

Typical profile

0 to 9 inches: Clay loam
9 to 60 inches: Clay loam

W—Lakes, rivers, reservoirs

Map Unit Setting

Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Water: 95 percent

Description of Water

Setting

Landform: Channels
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Chemical Properties

This folder contains a collection of tabular reports that present soil chemical properties. The reports (tables) include all selected map units and components for each map unit. Soil chemical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil chemical properties include pH, cation exchange capacity, calcium carbonate, gypsum, and electrical conductivity.

Chemical Soil Properties (Soil Map - San Juan County, NM, Eastern Part)

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

Chemical Soil Properties– San Juan County, New Mexico, Eastern Part								
Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	In	meq/100g	meq/100g	pH	Pct	Pct	mmhos/cm	
Ay—Avalon loam, 0 to 3 percent slopes								
Avalon	0-18	9.8-15	—	7.9-8.4	1-5	0-2	2.0-8.0	0
	18-60	11-23	—	7.9-8.4	10-20	0-2	2.0-8.0	0
	60-64	4.0-11	—	7.9-8.4	15-20	0-2	2.0-8.0	0
Be—Beebe loamy sand								
Beebe	0-6	3.1-7.4	—	7.4-8.4	0-1	0	2.0-4.0	0
	6-81	0.8-7.4	—	7.4-8.4	0-1	0	2.0-4.0	0
DN—Doak-Avalon association, gently sloping								
Doak	0-5	11-19	—	7.4-8.4	0-5	0	0.0-2.0	0
	5-43	15-23	—	7.4-9.0	1-10	0	2.0-4.0	0
	43-60	15-23	—	7.9-9.0	5-10	0-2	2.0-4.0	0-2
Avalon	0-14	11-15	—	7.9-8.4	0-5	0	2.0-8.0	0
	14-60	11-23	—	7.9-8.4	10-20	0-2	2.0-8.0	0
	60-64	4.0-11	—	7.9-8.4	15-20	0-2	2.0-8.0	0-2
FX—Fruitland-Persayo-Sheppard complex, hilly								
Fruitland	0-4	4.1-7.6	—	7.4-8.4	5-10	0-1	0.0-4.0	0-2
	4-60	3.1-12	—	7.4-8.4	5-10	0-1	0.0-4.0	0-2
Persayo	0-18	18-23	—	7.9-9.0	0-2	0-2	0.0-8.0	0-2
	18-20	—	—	—	—	—	—	—
Sheppard	0-4	2.5-5.4	—	7.9-8.4	0	0	0.0-2.0	0
	4-60	2.5-5.4	—	7.9-8.4	0	0	0.0-2.0	0

Chemical Soil Properties– San Juan County, New Mexico, Eastern Part								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
HA—Haplargids-Blackston-Torriorthents complex, very steep								
Haplargids	0-7	7.0-14	—	7.4-8.4	0	0	0.0-4.0	0
	7-26	13-23	—	7.4-8.4	0-5	0	0.0-4.0	0
	26-60	13-18	—	7.4-8.4	1-10	0	0.0-4.0	0
Blackston	0-11	11-18	—	7.9-8.4	0-2	0	0.0-2.0	0
	11-26	9.8-17	—	7.9-8.4	10-20	0	4.0-8.0	0
	26-60	0.0-4.6	—	7.9-8.4	15-30	0	4.0-8.0	0
Torriorthents	0-3	11-17	—	7.4-8.4	0-2	0-2	0.0-4.0	0
	3-15	5.7-19	—	7.4-8.4	0-2	0-2	0.0-4.0	0-2
	15-60	—	—	—	—	—	—	—
RA—Riverwash								
Riverwash, clayey	0-6	—	—	—	—	—	—	—
	6-60	—	—	—	—	—	—	—
Riverwash, sandy	0-6	—	—	—	—	—	—	—
	6-60	—	—	—	—	—	—	—
Riverwash, gravelly	0-6	—	—	—	—	—	—	—
	6-60	—	—	—	—	—	—	—
Sh—Shiprock loamy fine sand, 0 to 2 percent slopes								
Shiprock	0-10	8.1-11	—	7.4-8.4	0-2	0	0.0-2.0	0
	10-60	7.0-13	—	7.4-9.0	0-2	0	0.0-4.0	0

Chemical Soil Properties– San Juan County, New Mexico, Eastern Part								
Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
St—Stumble loamy sand, 0 to 3 percent slopes								
Stumble	0-5	0.0-7.4	—	7.9-8.4	0-2	0	0.0-2.0	0
	5-29	0.0-7.4	—	7.9-9.0	0-2	0	0.0-2.0	0
	29-49	0.0-3.1	—	7.9-9.0	0-2	0	0.0-2.0	0
	49-81	0.0-5.7	—	7.9-9.0	0-2	0	0.0-2.0	0
Fruitland	0-8	5.7-16	—	7.4-8.4	5-10	0	0.0-4.0	0
	8-60	3.1-12	—	7.4-8.4	5-10	0	0.0-4.0	0
SZ—Stumble-Slickspots complex, gently sloping								
Stumble	0-4	0.0-7.4	—	7.9-8.4	0-1	0	0.0-2.0	0
	4-60	0.0-7.4	—	7.9-9.0	0-1	0	0.0-2.0	0
Slickspots	0-2	—	—	7.9-9.6	0	0	0.0-8.0	2-6
	2-60	—	—	7.9-9.6	0	0	8.0-16.0	4-12
Tt—Turley clay loam, wet, 0 to 2 percent slopes								
Turley variant	0-9	14-22	—	7.4-8.4	1-5	0-2	2.0-4.0	0-2
	9-60	14-22	—	7.4-8.4	1-5	0-2	2.0-4.0	0-2
W—Lakes, rivers, reservoirs								
Water	—	—	—	—	—	—	—	—

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Physical Soil Properties (Soil Map - San Juan County, NM, Eastern Part)

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Physical Soil Properties– San Juan County, New Mexico, Eastern Part														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
Ay—Avalon loam, 0 to 3 percent slopes														
Avalon	0-18	-43-	-40-	15-18- 20	1.40-1.50	4.23-14.11	0.16-0.18	0.0-2.9	0.0-1.0	.43	.43	3	4L	86
	18-60	-56-	-18-	18-27- 35	1.40-1.50	4.23-14.11	0.15-0.17	3.0-5.9	0.0-0.5	.43	.43			
	60-64	-67-	-23-	5-10- 15	1.50-1.65	14.11-42.34	0.10-0.12	0.0-2.9	0.0-0.5	.32	.37			
Be—Beebe loamy sand														
Beebe	0-6	-84-	- 9-	5- 8- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.20	.20	5	2	134
	6-81	-93-	- 2-	1- 6- 10	1.45-1.55	141.14	0.03-0.08	0.0-2.9	0.0-0.5	.17	.17			
DN—Doak-Avalon association, gently sloping														
Doak	0-5	-42-	-37-	15-21- 27	1.20-1.30	4.23-14.11	0.15-0.17	0.0-2.9	0.5-0.6	.37	.37	5	5	56
	5-43	-34-	-37-	25-30- 35	1.45-1.55	1.41-4.23	0.15-0.18	3.0-5.9	0.0-0.5	.37	.37			
	43-60	-34-	-37-	25-30- 35	1.40-1.50	1.41-4.23	0.15-0.18	3.0-5.9	0.0-0.5	.37	.37			
Avalon	0-14	-43-	-40-	15-18- 20	1.40-1.50	4.23-14.11	0.16-0.18	0.0-2.9	0.5-1.0	.43	.43	3	4L	86
	14-60	-38-	-36-	18-27- 35	1.40-1.50	4.23-14.11	0.15-0.17	3.0-5.9	0.0-0.5	.43	.43			
	60-64	-46-	-44-	5-10- 15	1.50-1.65	14.11-42.34	0.10-0.12	0.0-2.9	0.0-0.5	.32	.37			

Physical Soil Properties– San Juan County, New Mexico, Eastern Part														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
FX—Fruitland-Persayo-Sheppard complex, hilly														
Fruitland	0-4	-69-	-24-	5- 8- 10	1.45-1.55	14.11-42.34	0.11-0.13	0.0-2.9	0.6-0.8	.28	.28	5	3	86
	4-60	-68-	-21-	5-12- 18	1.45-1.55	14.11-42.34	0.11-0.13	0.0-2.9	0.0-0.5	.28	.28			
Persayo	0-18	-35-	-34-	27-31- 35	1.35-1.45	1.41-4.23	0.15-0.17	3.0-5.9	0.5-1.0	.37	.37	1	8	0
	18-20	—	—	—	—	0.00-1.41	—	—	—					
Sheppard	0-4	-79-	-16-	4- 5- 7	1.45-1.60	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15	5	2	134
	4-60	-79-	-16-	4- 5- 7	1.45-1.60	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15			
HA—Haplargids-Blackston-Torriorthents complex, very steep														
Haplargids	0-7	-66-	-19-	10-15- 20	1.45-1.55	14.11-42.34	0.08-0.10	0.0-2.9	0.0-0.5	.15	.28	4	4	86
	7-26	-55-	-17-	20-28- 35	1.35-1.45	4.23-14.11	0.11-0.13	0.0-2.9	0.0-0.5	.15	.28			
	26-60	-59-	-18-	20-24- 27	1.35-1.45	4.23-14.11	0.12-0.14	0.0-2.9	0.0-0.5	.20	.37			
Blackston	0-11	-42-	-38-	15-20- 25	1.45-1.55	4.23-14.11	0.11-0.14	0.0-2.9	0.5-1.0	.10	.17	3	8	0
	11-26	-42-	-38-	15-20- 25	1.35-1.45	4.23-14.11	0.07-0.10	0.0-2.9	0.0-0.5	.10	.28			
	26-60	-96-	-2-	0- 3- 5	1.35-1.45	42.34-141.14	0.03-0.06	0.0-2.9	0.0-0.5	.10	.28			
Torriorthents	0-3	-42-	-38-	15-20- 25	1.40-1.50	4.23-14.11	0.12-0.14	0.0-2.9	0.6-0.8	.20	.37	1	6	48
	3-15	-34-	-37-	10-30- 30	1.40-1.50	1.41-42.34	0.10-0.20	0.0-2.9	0.0-0.5	.20	.32			
	15-60	—	—	—	—	0.00-1.40	—	—	—					

Physical Soil Properties– San Juan County, New Mexico, Eastern Part														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
RA—Riverwash														
Riverwash, clayey	0-6	-12-	-28-	40-60- 80	1.65-1.75	0.00-1.41	0.09-0.11	6.0-8.9	0.0-0.1	.20	.20	5	4	86
	6-60	-12-	-28-	40-60- 80	1.65-1.75	0.00-1.41	0.09-0.11	6.0-8.9	0.0-0.1	.28	.32			
Riverwash, sandy	0-6	-98-	-2-	0- 1- 1	1.65-1.75	42.34-141.14	0.03-0.04	0.0-2.9	0.0-0.1	.10	.10	5	4	86
	6-60	-68-	-30-	0- 3- 5	1.65-1.75	42.34-141.14	0.04-0.06	0.0-2.9	0.0-0.1	.10	.10			
Riverwash, gravelly	0-6	-98-	- 2-	0- 1- 1	1.65-1.75	42.34-141.14	0.03-0.04	0.0-2.9	0.0-0.1	.05	.10	5	4	86
	6-60	-93-	- 7-	0- 1- 1	1.65-1.75	42.34-141.14	0.02-0.03	0.0-2.9	0.0-0.1	.05	.10			
Sh—Shiprock loamy fine sand, 0 to 2 percent slopes														
Shiprock	0-10	-83-	- 5-	10-13- 15	1.40-1.50	42.34-141.14	0.06-0.09	0.0-2.9	0.5-0.6	.20	.20	5	2	134
	10-60	-70-	-16-	10-14- 18	1.45-1.55	14.11-42.34	0.09-0.12	0.0-2.9	0.0-0.5	.28	.28			
St—Stumble loamy sand, 0 to 3 percent slopes														
Stumble	0-5	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.17	.17	5	2	134
	5-29	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15			
	29-49	-81-	-17-	0- 3- 5	1.45-1.55	42.34-141.14	0.04-0.06	0.0-2.9	0.0	.10	.24			
	49-81	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06	0.0-2.9	0.0	.15	.15			
Fruitland	0-8	-43-	-40-	10-18- 25	1.40-1.50	4.23-14.11	0.15-0.17	0.0-2.9	0.0-0.5	.37	.37	5	5	56
	8-60	-68-	-21-	5-12- 18	1.45-1.55	14.11-42.34	0.11-0.13	0.0-2.9	0.0-0.5	.28	.28			

Physical Soil Properties– San Juan County, New Mexico, Eastern Part														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
SZ—Stumble-Slickspots complex, gently sloping														
Stumble	0-4	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.17	.17	5	2	134
	4-60	-79-	-17-	0- 5- 10	1.45-1.55	42.34-141.14	0.06-0.08	0.0-2.9	0.0-0.5	.15	.15			
Slickspots	0-2	-32-	-31-	15-37- 45	1.45-1.55	0.00-0.42	—	—	0.5-1.0					
	2-60	-32-	-31-	15-37- 45	1.45-1.55	0.00-1.41	—	—	0.0-0.5					
Tt—Turley clay loam, wet, 0 to 2 percent slopes														
Turley variant	0-9	-35-	-33-	28-32- 35	1.40-1.50	1.41-4.23	0.15-0.19	3.0-5.9	0.0-0.5	.32	.32	5	4L	86
	9-60	-35-	-33-	28-32- 35	1.40-1.50	1.41-4.23	0.15-0.19	3.0-5.9	0.0-0.5	.32	.32			
W—Lakes, rivers, reservoirs														
Water	—	—	—	—	—	—	—	—	—					

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://soils.usda.gov/

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://soils.usda.gov/

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://soils.usda.gov/

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://soils.usda.gov/

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.glti.nrcs.usda.gov/

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://soils.usda.gov/

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://soils.usda.gov/

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210.