GW - 28

REPORTS

YEAR(S):

1995

1 of 2

INSTRUCTIONS FOR UPDATING THE NAVAJO REFINERY THREE MILE DITCH & EVAPORATION PONDS RFI PHASE III REPORT

The revised report, dated October, 1995, responds to EPA's Report Deficiency Comments and updates data tables to reflect June 1995 analytical sampling results. Only relevant sections are revised, and the updated material is arranged for easy replacement including pre-punched pages. This guide will assist in replacing and adding the new material. All new replacement pages are dated October 1, 1995 in the lower right-hand corner.

VOLUME I

Front Sections:

1. Replace notebook front cover sheet and side sheet with updated sheets.
2. Add Navajo Refining October 1, 1995, cover letter and Attachments 1 and 2 to Volume 1.
3. Replace inside cover sheet, "Certification Statement" and existing "Table of Contents" with updated material.

Chapter 3:

1. Remove and replace pages 3-19 through 3-27 with new material.
2. Remove and replace page 3-34.

Chapter 4:

1. Remove and replace pages 4-6 through 4-41 with new material.
2. Remove page 4-56 and replace with pages 4-56 through 4-60.

Chapter 7:

1. Remove and replace pages 7-1 and 7-2, the list of references.

Other:

Remove and replace Appendix tabs A through D in Volume I.

VOLUME II

Front Section:

1. Replace notebook front cover sheet and side sheet with updated sheets.

Appendices:

1. Remove and replace Appendix tab E
2. Add Appendices F (June groundwater sampling results) and G (Groundwater risk assessment) to Volume II.

VOLUME I
RCRA FACILITY INVESTIGATION
THREE-MILE DITCH & EVAPORATION PONDS
PHASE III REPORT
(Revised)
NAVAJO REFINERY
ARTESIA, NEW MEXICO

Topical Report RSI-0611

prepared for

Navajo Refining Company
501 East Main Street
Artesia, New Mexico 88210

October 1995

RE/SPEC INC.
RESEARCH SPECIALISTS

RSI-0611

VOLUME I
RCRA FACILITY INVESTIGATION, THREE-MILE DITCH & EVAPORATION PONDS
PHASE III REPORT (Revised)
NAVAJO REFINERY, ARTESIA, NEW MEXICO
OCTOBER, 1995

RE/SPEC Inc.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

AUG 2 2 1995

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Matthew P. Clifton
Senior Vice President
Navajo Refining Company
501 E. Main Street
Artesia, New Mexico 88210

RE: RFI Phase III Report Deficiency Comments

Dear Mr. Clifton:

The Environmental Protection Agency (EPA) has completed a technical review of the RFI Phase III Report received May 16, 1995, and has determined that the Report is deficient. Enclosed is a list of deficiencies for your review.

A revised RFI Report addressing the enclosed comments must be submitted to EPA by October 1, 1995. Also, the soil removal plan, as described in the enclosed comments, must be submitted to EPA by October 1, 1995. If you have any questions, please contact Mr. Rich Mayer of my staff at (214) 665-7442.

Sincerely yours,

Barbara Driscoll for DN

David Neleigh, Section Chief
New Mexico-Federal Facilities

Enclosure

cc: Mr. Benito Garcia,
New Mexico Environment Department
Mr. Dave Boyer,
RE/SPEC

Phase III RFI Report Deficiency Comments for Navajo Refining

Page 3-6: 4th paragraph: EPA agrees with Navajo that portions of the ditch that have not been "filled in" need to be mitigated. EPA will require Navajo to submit a soil removal plan for those portions of the ditch surficially exposing contaminated sludge and soil above 500 ppm lead. The soil removal plan can be submitted separately from the revised RFI Phase III report.

Also, EPA will require a survey plat of the Three Mile Ditch (entire length) according to procedures in 40 CFR 264.116. The plat should also have a short narrative describing the unit and any wastes left in place. A deed restriction prohibiting residential and surficial water (for storing or transporting water on or within the unit) uses will also be required.

Page 3-34: Navajo needs to include in the revised report a groundwater monitoring plan for the wells along the Three Mile Ditch.

Page 4-56: Navajo needs to include in the revised report a groundwater monitoring plan for the groundwater monitoring wells associated with the ponds.

Also, Navajo needs to include in the revised report a groundwater risk assessment. This risk assessment should be similar or identical to the one being developed in the CMS for pond 1.

Page 5-5: Navajo needs to include in the revised report a sediment and surface water monitoring plan for the Pecos River.

TELEPHONE
(505) 748-3311

Navajo REFINING COMPANY
501 EAST MAIN STREET • P. O. DRAWER 159
ARTESIA, NEW MEXICO 88210

TELETYPE
(910) 986-0990

September 29, 1995

Mr. Rich Mayer, Environmental Engineer
RCRA Permits Branch
U.S. Environmental Protection Agency
1445 Ross Avenue Suite 1200
Dallas TX 75202-2733

Re: Transmittal of Revised RFI Phase III Report, Three-Mile Ditch and Evaporation Ponds, Navajo Refinery, Artesia, New Mexico, October 1995

Dear Mr. Mayer:

Enclosed please find revisions to the RFI Phase III Report and response to comments for the above Solid Waste Management Units. The original report was submitted to EPA in April 1995 and was the culmination of a series of EPA-required RFI studies that began in 1990. The revisions include proposed future monitoring schedules for groundwater along Three-Mile Ditch and at the evaporation ponds, together with the groundwater quality risk assessment recently submitted to EPA as part of the Pond 1 Corrective Measures Study (CMS). Data tables in the revised Phase III report have been updated to include results of June 1995 groundwater sampling in the vicinity of the ponds which show that levels of total arsenic generally exhibit significant reduction when the wells are first purged using a low-flow technique. A separate submittal is included which presents a proposed soil removal plan for areas along Three-Mile Ditch which have elevated levels of residual lead.

As documented in the previous studies, the native shallow groundwater in the vicinity of the ponds is naturally salty (approaching or in excess of 10,000 mg/L total dissolved solids) and, therefore, is unusable for human consumption without extensive treatment. The nearby Pecos river remains severely salt-impacted from other sources and unusable for domestic use. The area of the ponds also continues to be subject to frequent flooding events that are sometimes severe. This combination of factors prevents use of the area for human habitation and restricts groundwater withdrawal for any purpose. Therefore, use of human health-based standards to evaluate any remaining groundwater pollutants upon pond closure is inappropriate.

Because the report revisions are minor in nature, the large two-volume report was not reproduced, but revised sections are provided for insertion in the document. New title pages, cover sheets, and appendix dividers are also included for insertion in the notebook binders containing the original document.

If you have any questions, please do not hesitate to contact me at (505) 748-3311.

Sincerely,

Phillip L. Youngblood
Director of Environmental Affairs

PLY:prn
Enclosures

ATTACHMENT 1

RESPONSE TO AUGUST 22, 1995 EPA REGION 6 DEFICIENCY COMMENTS ON THE RFI PHASE III REPORT FOR THREE-MILE DITCH AND EVAPORATION PONDS
NAVAJO REFINING COMPANY
ARTESIA, NEW MEXICO

COMMENT:

Page 3-6: 4th paragraph: ***EPA agrees with Navajo that portions of the ditch that have not been "filled in" need to be mitigated. EPA will require Navajo to submit a soil removal plan for those portions of the ditch surficially exposing contaminated sludge and soil above 500 ppm lead. The soil removal plan can be submitted separately from the revised RFI Phase III report. Also, EPA will require a survey plat of the Three-Mile Ditch (entire length) according to procedures in 40 CFR 264.116. The plat should also have a short narrative describing the unit and any wastes left in place. A deed restriction prohibiting residential and surficial water (for storing and transporting water on or within the unit) uses will also be required.***

RESPONSE:

Concurrent with the submittal of the revised RFI Phase III Report, a removal plan for surficial soils and residual waste materials at those portions of the ditch at which lead concentrations in excess of 500 ppm have previously been reported has been submitted to EPA Region 6 as a separate document.

The second paragraph of this review comment references requirements for a survey plat and associated descriptive narrative of the unit, and a property deed restriction prohibiting certain land usages associated with the former ditch structure. At the time of unit operations, Navajo possessed a prescriptive easement which allowed the conveyance of facility wastewater to the evaporation ponds. However, upon cessation of unit operations, the easement privilege expired. Navajo does not possess ownership and control over all of the private property through which the ditch extends, and therefore does not have the legal authority to modify legal records for those properties owned by other private entities. Consequently, Navajo is unable to comply with those requirements cited at 40 CFR 264.116.

In addition, Navajo also notes that the regulatory standards set forth at 40 CFR 264.116 are related to regulated hazardous waste disposal units. Navajo and EPA Region 6 agree that the residual waste materials and contaminated media remaining at the unit do contain variable levels of Appendix VIII hazardous constituents. However, while those materials and media within and adjacent to the unit have been well characterized, no evidence has been obtained to indicate that existing criteria used to formally identify materials as hazardous waste are applicable to them.

Consequently, the regulatory standards set forth at 40 CFR 264.116 may not be appropriate for the current situation.

Furthermore, it is noted that the future utilization of the former unit as a water storage or conveyance facility is not considered to be a feasible possibility. With the exception of localized depressions occurring sporadically along the former unit, the ditch no longer exists as a functional structure, and the likelihood that one or more linear intervals of the former ditch would coincidentally be selected as a location for such water management activities at some future date would appear to be extremely remote.

These points notwithstanding, Navajo recognizes the reviewers concerns related to future land use issues along the former unit, and is prepared to work with EPA Region 6 and other relevant entities in order to try to resolve these issues.

COMMENT:

Page 3-34: ***Navajo needs to include in the revised report a groundwater monitoring plan for the groundwater monitoring wells along the Three-Mile Ditch.***

RESPONSE:

The requested section is included at Section 3.2.6 of the revised report. The ditch monitor wells are proposed to be sampled annually for a five-year period beginning in the winter of 1995-96 with a summary report submitted to EPA by April 1 of each year. At the end of the five-year period it is proposed to discontinue ditch monitor well sampling unless a review and evaluation of the monitoring results indicates that selected monitoring should be continued.

COMMENT:

Page 4-56: ***Navajo needs to include in the revised report a groundwater monitoring plan for the groundwater monitoring wells associated with the ponds.***

Also, Navajo needs to include in the revised report a groundwater risk assessment. This risk assessment should be similar or identical to the one being developed in the CMS for pond 1.

RESPONSE:

A groundwater monitoring program for wells in the vicinity of the ponds is proposed at Section 4.6 which has been incorporated in the revised report. The program includes continuing quarterly water level measurements of nested-monitor wells, and annual sampling of selected wells for hazardous constituents which might be expected to be present based on extensive RFI sampling conducted since 1990. The target monitor wells are proposed to be sampled annually during the active use of the ponds and for a five-year period thereafter. During the time the pond is in continued use, sampling for some wells will be staggered with some wells sampled in Spring and others in Fall to allow coordination with the current NM Oil Conservation Division sampling program. A summary report will be submitted to EPA by April 1 of each year. At the end of the five-year period it is proposed to discontinue monitor well sampling unless a review and evaluation of the monitoring results indicates that selected monitoring should be continued.

Section 4.7 references the risk assessment work conducted as part of the Pond 1 Corrective Measures Study (CMS). The pertinent sections of the CMS are reproduced as Appendix G of the revised Phase III RFI. The CMS, dated 8/31/95, included the results of a groundwater risk assessment for a human residential scenario that utilized maximum concentration data from selected Pond 1 monitor wells collected during the Phase I and II RFI investigations. A review of Phase III data for all monitor wells in the vicinity of the ponds does not show concentration levels exceeding data in the earlier reports, so the CMS risk assessment represents the worst-case analysis.

Of overwhelming significance, however, is the discussion in the CMS which demonstrates that, because of flood risks residential use of the property will not occur. The CMS also documents that the naturally occurring groundwater in the vicinity of the ponds is unfit for human consumption without extensive treatment to remove salts which also would eliminate any hazardous constituents. In EPA Region 6 comments of April 1995 in response to earlier CMS submittals, EPA recognizes that the human residential scenario is inappropriate for the evaporation pond area and is allowing an agricultural-based use as the default risk scenario.

COMMENT:

Page 5-5: ***Navajo needs to include in the revised report a sediment and surface water monitoring plan for the Pecos River.***

RESPONSE:

Navajo respectfully requests that EPA reconsider this requirement based on the discussion presented below.

Sampling performed during the Phase III report did not show any surface water impacts to the Pecos River from the use of the evaporation ponds. Likewise, the sediment sampling did not show any obvious impact although one sample was slightly elevated at a location downstream in an area near a pipeline crossing and where there was significant bank erosion due to cattle impacts.

The recently completed CMS presented groundwater seepage calculations which demonstrated that there will be no significant impact on the river due to constituent migration, especially of arsenic. No surface water standards for any metals will be exceeded, even during periods of extremely low flow. As documented by the current monitoring program, hazardous organic constituents from the active ponds are not present in the groundwater monitor wells adjacent to the river, and any organics which may occur at low concentrations in these wells will be degraded prior to reaching the river.

The U.S. Geological Survey (USGS) monitors major constituents in surface water and sediment at their downstream Pecos River gauging station which is less than 2,000 feet from the closest Navajo monitor well and approximately 5,600 feet from the main pond complex. The below table presents maximum concentration levels for arsenic in water and sediment for the past 15 years. The data do not indicate that a problem currently exists, nor do they show a trend of any type except that total arsenic concentrations generally increase during periods of high flow, likely due to increased turbidity. Because a problem is not shown to exist now, or likely to occur in the future based on the seepage calculations, and because the water and sediments are sampled by the USGS at a location in close proximity to the ponds, Navajo believes that additional monitoring is unnecessary.

Table A1-1. Pecos River Arsenic Measurements, 1980-1994

Water Year	Maximum Total Arsenic (ug/l)	River Flow At Sampling (cfs)	Maximum Dissolved Arsenic (ug/l)	River Flow At Sampling (cfs)	Maximum Sediment Concentration (ug/g)
1980	10	419	1	17	<1
1981	2	7.8	2	7.8	<1
1982	8	862	2	862	NA
1983	2	13	1	13	1
1984	1	75	1	75	1
1985	2	131	<1	100	2
1986	3	34	2	34	2
1987	4	367	1	367	NA
1988	4	848	3	848	3
1989	2	138	2	100	2
1990	2	39	2	39	<1
1991	<1	52	2	52	<1
1992	3	86	3	86	2
1993	3	253	2	253	1
1994	2	98	1	98	2

Source: U.S. Geological Survey, Water Resources Data For New Mexico, annual reports

Abbreviations: ug/l - micrograms per liter; cfs - cubic feet per second; ug/g - micrograms per gram; NA - Not analyzed

ATTACHMENT 2

PROPOSED WORKPLAN FOR REMOVAL OF SURFICIAL WASTE DEPOSITS AT THREE-MILE DITCH

NAVAJO REFINING COMPANY
ARTESIA, NEW MEXICO

1.0 INTRODUCTION

This document presents the proposed workplan for RCRA Corrective Action Program activities associated with the Solid Waste Management Unit (SWMU) identified as Three-Mile Ditch, which was formerly operated by Navajo Refining Company, Artesia, New Mexico.

In EPA's August 22, 1995 deficiency comments to the Navajo Refining RCRA Facility Investigation-for Three-Mile Ditch and Evaporation Ponds Phase III report (RE/SPEC Inc., April 1995), EPA has required that Navajo prepare a soil removal plan for those portions of the ditch at which residual deposits of surficial waste materials have been found to exhibit lead concentrations in excess of 500 mg/kg. In response to this requirement, Navajo proposes to conduct soil excavation activities along an identified ditch interval of concern which extends eastward from Bolton Road for approximately 0.5 miles, and at which surface soil lead concentrations in excess of 500 mg/kg have been documented. Environmental sampling and analysis of surficial dredge spoils material along this segment of the unit indicated that sample lead ranged from 530 to 11,600 mg/kg (Table 3-1, RFI Phase III Report). As discussed in Section 3.1.4 of the RFI Phase III report, the most upgradient interval of concern coincides with a significant decrease in the surface slope along the ditch that resulted in significant deposition of waste solids. Deposition in this area required periodic dredging to maintain a proper flow channel. The dredged deposits were placed on the ditch bank adjacent to the channel sections being cleared.

Details of the soil removal workplan for this identified ditch interval of concern are presented in the following sections. Section 2.0 describes the sampling and analysis strategy to be employed in delineating those soils targeted for excavation and removal, equipment and procedures to be employed in those excavation operations, disposition of the excavated materials, and post-excavation sampling and analysis used to verify the efficacy of the corrective actions. Discussion of project health and safety requirements are presented in Section 3.0 and details of information to be presented in a post-corrective action report to be submitted to EPA Region 6 are described in Section 4.0.

2.0 CORRECTIVE ACTION PLAN

This section details the workplan approach to identifying and excavating soil contaminants along the unit interval of concern at the Three-Mile Ditch. In brief, soil materials exceeding the acceptance criteria (500 mg/kg) will be characterized and delineated primarily on the basis of on-site sample analyses. A field-portable X-ray fluorescence analyzer will be used to quantify total lead content of soil samples. Delineation of soils targeted for removal will begin immediately (within one to two days) prior to the beginning of soil excavation and removal operations. Subsequent to excavation completion at discrete intervals, verification sampling will be immediately conducted so that any follow-up excavation of residual hot spots can be accomplished while excavation equipment remains in the vicinity.

Excavated soils will be transported to Pond 1 by dump truck, where they will be dumped at intervals across the surface of the pond. Earth moving equipment will then distribute the excavated soils over the Pond 1 unit surface in a thin (3-5 inches) application layer, and the surface-applied materials will then be disced into the receiving soil to complete the incorporation process.

The various features of the workplan are described in further detail in the following sections.

2.1 Sampling and Analysis Strategy

A field-portable X-ray fluorescence analyzer (Spectrace 9000, TN Technologies, Inc.) will be used to obtain on-site measurements of the total lead content of surficial soil materials located adjacent to the unit. The Spectrace 9000 is well-demonstrated to be a reliable analytical tool for on-site applications. It has been employed by organizations such as the USEPA Environmental Response Team (ERT) and numerous state environmental agencies. For the current proposed application, on-site equipment operating and decontamination procedures for the Spectrace 9000 unit will follow USEPA ERT Standard Operating Procedure (SOP) No. 1713.

Methods used to delineate soils targeted for excavation will be left to the discretion of the Navajo on-site field team leader, but are expected to be based on a combination of systematic random and biased sampling. However, post-excavation verification sampling will be conducted according to a formal plan. Starting at the designated terminus of the ditch interval of concern, a series of consecutive 50-foot intervals will be physically defined, and a random number chart will be used to generate two random sample locations between a distance of 5 and 45 feet within each interval (this proscribed internal sample interval will ensure that samples obtained from adjacent 50-foot intervals will be separated by a minimum distance of 10 feet). At each sampling location, a composite sample will be obtained by combining three subsamples collected at a sample depth extending from approximately 0-6 inches, as measured from surface grade. The subsamples will be collected along an axis perpendicular to the ditch orientation, and will be separated by a distance of three-feet or less (depending upon the width of the soil excavation corridor). In the event that the excavation width at the sample collection point exceeds a total length of 12 feet, a second independent grab sample will also be collected within one foot of the outer edge of the excavation corridor at either side, with the location to be decided by the field team leader in consultation with on-site EPA oversight personnel (if present).

In the event that a verification sample yields a lead concentration value in excess of the remediation target, the sample location will be flagged and additional samples will be collected at a distance of 10 feet to each side of the identified hot spot, and proceeding outwards thereafter from the initial sample exceedance location until no further exceedances are reported. The field team leader will then rely on the on-site sample analyses together with visual observations to delineate the additional surface area for which excavation will be required. Subsequent to the follow-up excavation, all sample locations that yielded a target concentration exceedance will be resampled to verify the efficacy of the follow-up excavation action. This process will be repeated as necessary until no further target level exceedances are reported.

In addition to the samples to be collected during the execution of the sampling strategy described above, additional duplicate samples will be collected for purposes of quality assurance and quality control, as described in Section 2.3 of this workplan.

2.2 Soil Excavation and Hauling Equipment

Depending on site access conditions, either a diesel trackhoe or backhoe will be used to excavate the delineated surficial wastes and waste-contaminated soils, and a 12 or 14 cubic-yard capacity dump truck will transport the excavated materials to Pond 1. Should excavation activities result in an excessive amount of airborne dust, an 80-barrel bob-tail water truck will also be available as needed for the purpose of dust suppression.

2.3 Establishment of Remediation Acceptance Criteria

As described above, the proposed verification sampling will identify any residual areas exceeding the cleanup criteria at the time of excavation. Therefore, corrective action activities will be considered complete when all verification sampling is completed and no further samples yield lead concentration values in exceedance of the 500 mg/kg target criteria. Based on a minimum of two samples per 50-feet interval and an approximate length of 0.5 miles for the designated interval of concern, approximately 105 soil samples (minimum) will be documented during the verification sampling process. In order to verify the accuracy of the on-site sample analyses, a number of additional duplicate samples will also be evaluated, as described in the next section.

Assessment of the environmental status of Pond 1 surface soils following the receipt of the materials excavated from Three-Mile Ditch will be undertaken under a separate program in conjunction with formal unit closure activities at Pond 1.

2.4 Data Documentation and Quality Assurance/Quality Control

All sampling intervals, sample locations and associated analytical data will be recorded in the project log book along with the date and time at which each sample was collected. Each of the 50-foot verification sampling intervals will be assigned a unique identifying designator, and each sample collected from within the various intervals will also be assigned a unique designator according to a hierarchical arrangement. The following nomenclature will be employed: TMD-VSI(x), where TMD, VS and (x) signify Three-Mile Ditch, Verification Sample Interval, and the specific interval, respectively, and specific sample locations within each interval will follow the nomenclature TMD-VSI(x)-x. To the extent possible, verification sampling intervals and specific locations will be related to distinguishing landmarks (adjacent monitoring wells, fence lines, etc.). For the case in which verification samples yield lead target exceedance and secondary excavation and resampling is required, re-samples obtained at previous sample locations will be appended with the designation ‘R’ to indicate a re-sampling event. Sample locations selected at 10-foot intervals at each side of the sample initially yielding a target exceedance will be designated as TMD-VSI(x)-xR-10E or -10W, where E and W correspond to their orientation from the central sample location (the unit extends along an east-west orientation) and where the numerical assignment represents the distance from the originating central sample.

Precision and repeatability of the on-site analytical measurements will be confirmed by analysis of duplicate samples at sample locations that will be selected at random at a frequency of 5 percent.

The accuracy of on-site analytical measurements will be assessed by the collection of additional duplicate samples (also randomly selected at a frequency of 5 percent), which will be placed in appropriate sample storage containers and shipped to a designated analytical laboratory, accompanied by chain-of-custody documentation.

In accordance with the Spectrace 9000 equipment calibration recommendations presented at Sections 7.3.1 and 7.3.2 of USEPA ERT SOP 1713, an initial energy calibration will be conducted at the initiation of field activities, and subsequent energy calibration checks, resolution checks, and blank sample checks will be conducted on a daily basis prior to the initiation of field activities. All calibration-related activities will be noted in the project log book.

In addition to the documentation of field activities, analytical test results and QA/QC procedures and measurements, the total volume of contaminated materials excavated from the unit and transported to Pond 1 will be tracked by recording the total number of dump truck trips to Pond 1.

3.0 PROJECT HEALTH AND SAFETY PROGRAM

Prior to the initiation of the on-site activities at Three-Mile Ditch described above, a site-specific Project Health and Safety (H&S) Plan will be developed. Primary hazards associated with the proposed field activities involve physical proximity to heavy equipment operations, and potential inhalation exposure to contaminant-bearing dust particulates. The latter concern will be addressed in the project H&S plan through the use of appropriate personal protective equipment (PPE). In particular, respirators equipped with High Efficiency Particulate-Absolute (HEPA) grade cartridge filters will be available for equipment operators directly engaged in excavation activities, and NIOSH-approved disposable dust-respirators will be available for on-site personnel engaged in auxiliary sampling and oversight activities.

The unit is located in an area which is remote from human residences or other areas of intense activities. Therefore, minimal environmental hazard to the general public is anticipated as a result of the proposed remediation activities. Since transport of excavated materials will require its passage on public roads and highways for limited distances, the bed of the dump truck will be tightly secured with a tarp cover in order to ensure that fugitive dusts are not released in public contact areas during transport of contaminated materials to Pond 1. The dump truck will be visually observed on a periodic basis during transit in order to visually confirm the containment integrity of the transported materials.

4.0 REPORTING REQUIREMENTS

A summary report describing remedial activities at the designated ditch interval of concern along the unit will be prepared and submitted to EPA Region 6 within 60 days of the completion of filed activities. The report will describe all activities associated with the execution of the remediation project, including all sample locations and associated analytical data, and total volume of excavated soil materials. A photocopy of the project log book, a photographic log, and analytical laboratory reports will also be included as appendices to the report.

RCRA FACILITY INVESTIGATION THREE-MILE DITCH & EVAPORATION PONDS PHASE III REPORT

(Revised)

prepared for

Navajo Refining Company
Artesia, New Mexico

by

RE/SPEC, Inc.
4775 Indian School Road, NE #300
Albuquerque, New Mexico 87110

October 1995

David G. Boyer
David G. Boyer
Project Manager

Brian P. Sullivan
Brian P. Sullivan
Assistant Project Manager

CERTIFICATION STATEMENT

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Phillip L. Youngblood
Phillip L. Youngblood
Director of Environmental Affairs

September 29, 1995

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Below MW-28 to the vicinity of the river, contour spacing changes with wider spacing, indicating a flatter gradient once again. In this area, both the topographic and hydrologic gradients are flatter. In addition to mimicking the topographic surface gradient, the groundwater contours may be flatter due to recharge effects from the Artesia wastewater plant. In the vicinity of the junction between Eagle Creek and the river, the contours are approximated due to the lack of hydrologic control. In this area, it is likely that changes in groundwater flow direction occur during the year due to changes in river water level elevation from irrigation releases or runoff events in response to severe precipitation.

3.2.4.3 Groundwater Quality

Results of the RFI Phase III groundwater sampling of the ditch monitoring wells are presented in this section, with the data included in Appendix D. Relevant results from prior sampling events and from the Phase I and Phase II studies are included in Appendix A. Results from MW-15 and MW-1, which are located in the vicinity of the evaporation ponds, are included in the data presentations for both TMD and the evaporation ponds. Data from the June 1995 sampling of MW-15 is presented in Appendix F.

Field parameters of pH, conductivity, and temperature were measured at each monitor well sampled. As described in the protocol in Section 3.2.3, sampling was performed after these field parameters had stabilized during pumping. The final readings taken for samples from the monitor wells along TMD are shown in Table 3-4.

3.2.4.3.1 Organic Constituents

Based on the results of the Phase II investigation, which did not detect chlorinated or exotic compounds in monitor wells, samples taken from the existing and new wells installed along TMD were analyzed for a lessor number of volatile and semi-volatile organic compounds. Volatile compound analysis was limited to benzene, toluene, ethylbenzene, and total xylenes (BTEX) as well as methyl ethyl ketone (2-butanone) and carbon disulfide. Semi-volatile analyses were limited to 16 polynuclear aromatic compounds commonly found in oily wastes. The results of the analyses and detection limits are shown in Table 3-5.

Table 3-4. Groundwater Indicator Measurements at the Time of Field Sampling, Three-Mile Ditch, Navajo Refinery, RFI Phase III

Well sample identification	Laboratory number	Date sampled	Time sampled	pH	Conductivity (μmhos/cm at 25°C)	Temperature (°C)
MW-20	0694G02058	11/03/94	0955	7	9,600	NM
MW-8	0694G02055	11/04/94	1104	7	6,300	NM
MW-21	0694G02057	11/04/94	1138	7	6,300	NM
MW-9	0694G02056	11/04/94	1228	NM	6,550	NM
MW-16	0694G02079	11/05/94	0915	NM	5,300	NM
MW-1	0694G02080	11/05/94	1035	7.5	16,500	NM
MW-15	0694G02111	11/09/94	0856	6.5	4,100	17
MW-46	0694G02159	11/11/94	0810	7	4,600	17
MW-45	0694G02160	11/11/94	0856	7	7,400	18
MW-30	0694G02161	11/11/94	1038	7	7,000	16.8
MW-29	0695G00137	01/12/95	1030	6.5	6,100	17.7
MW-15	0695G00138	01/12/95	1445	6.5	3,100	18.9
MW-28	0695G00139	01/15/95	0950	7	4,400	17.9
MW-27	0695G00149	01/15/95	1045	7	3,100	18.4
MW-26	0695G00150	01/15/95	1205	7	8,200	17.9
MW-25	0695G00189	01/18/95	0850	7	17,000	15.8
MW-28	0695G00602	02/23/95	1655	6.5	4,600	NM
MW-15	0695G00607	02/24/95	1600	7	3,300	NM
MW-15	0695G00977	06/27/95	1630	7	4,500	23

Notes:
pH measured using paper pH strips
NM - not measured

Table 3-5. Summary of TMD RFI Phase III Groundwater Volatile/Semivolatile Sample Analyses

		Volatile Organics (mg/L)						Semi-volatile Organics[a]
Sample ID	Date	Benzene	Toluene	Ethyl-benzene	Xylenes (total)	Methyl ethyl ketone	Carbon Disulfide	
MW-1	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
MW-8	4-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-9	4-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-15	9-Nov-94	0.015	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-15[b]	12-Jan-95	0.013	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS
MW-15[c]	24-Feb-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS
MW-15[c]	27-Jun-95	< 0.005	< 0.005	< 0.005	< 0.005	NS	NS	NS
MW-16	5-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-20	4-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-21	4-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-25	18-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-25 dup[d]	18-Jan-95	< 0.001	< 0.001	< 0.001	< 0.002	< 0.005	< 0.005	< 0.0032
MW-26	15-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-27	15-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-28	15-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-29	12-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-30	11-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.020
MW-45	11-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.020
MW-46	11-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010

Notes: All analyses by Inter-Mountain Laboratories, College Station, Texas, unless otherwise noted; NS - Not Sampled

[a] All semivolatile constituents that were evaluated were less than the reported detection limits presented in the table.

[b] Re-sample obtained during second phase of RFI Phase III field work.

[c] Sample obtained during follow-up sampling subsequent to formal RFI Phase III field work.

[d] Sample analyzed by Assaigai Analytical Laboratories, Albuquerque, NM.

Federal Secondary MCL Standards (mg/L): benzene, 0.005; ethylbenzene, 0.7; toluene, 1.0; xylenes, 10.0.

New Mexico WQCC Groundwater Standards (mg/L): benzene, 0.01; ethylbenzene, 0.75; toluene, 0.75; xylenes, 0.62.

Analyses for the above target compounds detected organics in just one well, MW-15, which is located immediately upgradient from the entrance to inactive Pond 1. In this well, benzene was detected at a level of 0.015 mg/L in the sampling on November 9, 1994, and again at 0.013 mg/L when resampled on January 12, 1995. However, the split sample taken on November 9 by PRC, EPA's on-site contractor, and subsequent resamplings by Navajo on February 24, and June 27, 1995, did not detect benzene at the practical quantitation limit (PQL) of 0.005 mg/L. The November 9 and January 14 detections of benzene by Inter-Mountain Laboratories of College Station, Texas, were not accompanied by the detection of other common BTEX constituents. Because benzene commonly is detected together with the other BTEX compounds in waste petroleum constituents, or, alternatively, has been removed while the others remain, its presence by itself is suspect. The absence of benzene or any BTEX constituent in the PRC split sample and February Navajo resampling lead to the conclusion that its detection was a false positive by the laboratory and the compound is not present in the groundwater at that location.

The results of the PRC split sample analyses for TMD monitor wells do not show any volatile or semivolatile organic constituents except for various phthalate compounds in the some semivolatile samples. Based on previous work and published literature, phthalates in this environment are considered laboratory artifacts and not a constituent of the groundwater.

3.2.4.3.2 Metals

Metals analyses for total and dissolved arsenic, chromium, lead, and nickel are presented in Table 3-6 together with EPA and New Mexico water-quality standards. The EPA maximum contaminant level (MCL) for lead is an action level requiring treatment at the tap if exceeded in drinking water. In New Mexico, nickel is an irrigation standard, not a human health standard. Because New Mexico groundwater protection regulations require that measurements be made on a dissolved (vs. total) sample, all samples were filtered in the field using a 0.45-micron dedicated filter, as described in Section 3.2.3.2, “Sample Collection.”

The results for TMD groundwater sampling show an exceedance of the federal or state standards for total arsenic in MW-9 (0.068 mg/L) and in one sample from MW-28 (0.120 mg/L). Dissolved arsenic from both wells was not detected at the PQL of 0.005 mg/L. The sample from MW-9 was increased over the value found during the Phase II sampling, but a similar increase was noted in total chromium. As documented in that study, the stainless steel casing has significantly deteriorated over time, leading to the displacement of very turbid water during the purging process. MW-28 was a new well completed in January which was sampled three days after initial development. Total metals results for all four metal constituents were elevated in this well, although dissolved metals were not detected at the respective detection levels. MW-28 was resampled five weeks later and purged using a low-flow peristaltic pump to minimize introduction of turbidity. Tubing used in the purging was set to remove water in the well from within two feet of the static water level, which is the zone sampled using a bailer. Total metals analysis of this sample did not result in any detections.

Table 3-6. Results of groundwater metals analyses, Three-Mile Ditch, Navajo Refinery, RFI Phase III, 1995.

Sample ID	Date Sampled	Total Dissolved Solids (180°C)	Total Arsenic (mg/L)	Total Chromium (mg/L)	Total Lead (mg/L)	Total Nickel (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Chromium (mg/L)	Dissolved Lead (mg/L)	Dissolved Nickel (mg/L)
MW-1	05-Nov-94	10,200	0.013	**0.184**	<0.01	0.08	<0.005	<0.02	<0.1	<0.05
MW-8	04-Nov-94	5,730	0.029	**8.320**	<0.01	**1.45**	<0.005	**0.060**	<0.01	**0.50**
MW-9	04-Nov-94	6,160	**0.068**	**24.520**	<0.01	**4.96**	<0.005	0.030	<0.01	**4.11**
MW-15	09-Nov-94	3,660	0.028	<0.02	<0.01	0.02	0.008	<0.02	<0.01	0.02
MW-16	05-Nov-94	4,080	<0.005	<0.02	<0.01	0.02	<0.005	<0.02	<0.01	0.02
MW-20	04-Nov-94	8,630	0.008	<0.005	<0.01	0.03	0.007	0.020	<0.01	<0.01
MW-21	04-Nov-94	5,690	0.007	<0.005	<0.01	0.04	<0.005	<0.02	<0.01	<0.01
MW-25	18-Jan-95	11,600	<0.005	0.020	<0.01	<0.05	<0.005	0.006	<0.01	<0.05
MW-26	15-Jan-95	7,830	0.013	0.024	<0.01	<0.05	<0.005	<0.005	<0.01	<0.05
MW-26 (Lab Dup.)	15-Jan-95	7,830	0.014	0.021	<0.01	<0.05	<0.005	<0.005	<0.01	<0.05
MW-27	15-Jan-95	2,650	0.006	0.017	<0.01	<0.05	<0.005	<0.005	<0.01	<0.05
MW-28	15-Jan-95	3,930	**0.120**	**0.278**	**0.07**	**0.11**	<0.005	<0.005	<0.01	<0.05
MW-28	23-Feb-95	- -	<0.005	<0.005	<0.01	<0.05	- -	- -	- -	- -
MW-29	12-Jan-95	5,650	0.008	0.025	<0.01	<0.05	<0.005	<0.005	<0.01	<0.05
MW-30	11-Nov-94	4,890	0.020	<0.005	<0.01	0.02	0.018	<0.02	<0.01	0.02
MW-45	11-Nov-94	6,590	0.022	0.035	**0.10**	<0.01	<0.005	<0.02	<0.01	<0.01
MW-45 (Field Dup. 4)	11-Nov-94	- -	0.018	0.040	**0.07**	<0.01	<0.005	<0.02	<0.01	0.02
MW-45 (L Dp.of FD 4)	11-Nov-94	- -	0.018	0.040	**0.08**	<0.01	<0.005	<0.02	<0.01	0.01
MW-46	11-Nov-94	3,880	<0.005	<0.005	0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-46 (Lab Dup.)	11-Nov-94	3,920	<0.005	<0.005	0.01	<0.01	<0.005	<0.02	<0.01	<0.01

Notes: Water Quality Standards (mg/L):
EPA MCL: As, 0.05; Cr, 0.1; Pb, Action level=0.015; Ni, 0.1
NM WQCC Groundwater: As, 0.10; Cr, 0.05; Pb, 0.05; Ni, 0.2
Bold: Excedance of listed standard

Lead was not detected in any of the wells along TMD except in MW-28 (0.07 mg/L), as discussed above, and in MW-45. In MW-45, total lead at an average of 0.08 mg/L for three analyses (sample, field duplicate, and laboratory duplicate) was slightly elevated above the Phase II value of 0.05 mg/L. Again, no lead was detected in the dissolved samples. The total lead concentration observed in MW-45 is approximately 23 times less than the value of 1.83 mg/L reported from the Phase I investigation.

As observed in the Phase II investigation, both chromium and nickel are elevated in several of the wells along TMD, with chromium levels in three wells ranging from 0.184 to 24.52 mg/L, and nickel levels significantly elevated in two of the wells. The three wells with elevated levels of chromium or nickel were constructed of stainless-steel casing, and the high values for the two metals are related to degradation of the well casing material in the saline environment rather than actual groundwater concentrations of chromium and nickel. PVC-cased wells installed intermediate between two of these wells during the Phase II study had uniformly low values of both constituents.

3.2.4.3.3 Water Chemistry

The laboratory analytical data for the inorganic water quality constituents and indicator constituents for groundwater in the vicinity of TMD are shown in Table 3-7. In addition to the major constituents, the minor constituent fluoride, measured and calculated values of TDS, cation-anion totals, and percent difference are shown in the table. The latter three values provide a rapid check of the completeness and accuracy of the water analysis. For good-quality, low-TDS water, a percent difference of one to two percent is easily obtained. For wastewater and high-TDS water that can cause analytical instrument interference, a five percent difference may be acceptable.

Although discussion and interpretation of these results are presented in Section 3.2.5.2.3, the water quality of the NSSZ along TMD exceeded federal and state secondary standards for chloride, fluoride, sulfate, and TDS at all locations sampled except chloride at MW-27. Secondary drinking water standards are applied for constituents that generally impart aesthetic impacts such as taste or odor or increase salt concentrations in the water. They also may cause minor stomach irritation (sulfates), mottling of teeth (fluorides), or staining of clothes and fixtures (iron and manganese).

TDS, especially, is a good indicator of potability for humans and animals. TDS for the November 1994 and January 1995 sampling events ranged from 3,880 to 8,630 mg/L in the upper portion of TMD (MW-30 to MW-29) and from 2,650 to 11,600 mg/L in the lower portion (MW-28 to MW-15). The average TDS of upper and lower sections was 5,903 and 6,280 mg/L, respectively. The overall average for all ditch wells was 6,080 mg/L. A follow-up sample collected at MW-15 in February 1995 measured 2,200 mg/L TDS.

Table 3-7. Results of Water Chemistry Analyses, Three-Mile Ditch, RFI Phase III Navajo Refinery, 1995.

Sample ID	MW-1	MW-8	MW-9	MW-15	MW-15	MW-15 (Lab Dup.)	MW-15	MW-16	MW-20
Date Sampled	05-Nov-94	04-Nov-94	04-Nov-94	09-Nov-94	24-Feb-95	24-Feb-95	27-Jun-95	05-Nov-94	04-Nov-94
Lab pH (SU)	7.7	7.2	6.8	7.5	7.6	7.6	7.7	7.4	7.4
Lab EC (umhos/cm)	14,500	5,880	6,380	4,860	2,880	2,880	4,580	4,600	8,220
Total Dissolved Solids (180°C)	10,200	5,730	6,160	3,660	2,200	2,200	3,400	4,080	8,630
Calcium (mg/L)	862	556	637	372	263	262	357	570	499
Magnesium (mg/L)	459	480	488	113	79	77	102	238	932
Potassium (mg/L)	8	3	5	8	4	4	4	14	2
Sodium (mg/L)	2,130	358	416	519	332	329	568	424	456
Bicarbonate (mg/L)	472	400	293	175	124	125	154	379	451
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	3,590	524	621	743	443	451	798	704	628
Sulfate (mg/L)	2,800	3,020	3,250	1,470	943	917	1,280	1,920	4,800
Fluoride (mg/L)	1.2	2.2	2.0	1.2	1.1	1.1	0.8	2.3	3.2
Cations (meq/L)	173.42	82.89	90.16	50.65	34.17	33.82	51.03	66.83	121.48
Anions (meq/L)	167.46	84.28	89.94	54.37	34.17	33.86	51.61	66.03	125.11
Balance (% Diff.)	1.75	-0.83	0.12	-3.54	0.00	-0.06	-0.57	0.60	-1.47

See final page of table for applicable federal and state standards.

Table 3-7. Results of Water Chemistry Analyses, Three-Mile Ditch, RFI Phase III Navajo Refinery, 1995. (continued)

Sample ID	MW-21	MW-25	MW-26	MW-26 (Lab Dup.)	MW-27	MW-28	MW-29	MW-30
Date Sampled	04-Nov-94	18-Jan-95	15-Jan-95	15-Jan-95	15-Jan-95	15-Jan-95	14-Jan-95	11-Nov-94
Lab pH (SU)	7.3	7.0	7.8	7.8	7.3	7.8	7.4	7.7
Lab EC (umhos/cm)	5,800	17,100	8,900	8,900	3,250	4,660	6,410	6,080
Total Dissolved Solids (180°C)	5,690	11,600	7,830	7,830	2,650	3,930	5,650	4,890
Calcium (mg/L)	589	664	488	494	470	512	537	467
Magnesium (mg/L)	480	436	661	666	95	245	438	285
Potassium (mg/L)	2	7	7	7	10	6	5	3
Sodium (mg/L)	321	2,560	804	812	194	319	477	568
Bicarbonate (mg/L)	368	202	317	317	258	313	373	450
Carbonate (mg/L)	0	0	0	0	0	0	0	0
Chloride (mg/L)	466	4,010	1,020	1,020	179	328	484	756
Sulfate (mg/L)	2,990	2,670	3,740	3,740	1,460	2,180	3,000	2,090
Fluoride (mg/L)	2.1	1.1	2.3	2.3	1.2	1.9	1.8	1.5
Cations (meq/L)	82.92	180.51	113.90	114.96	39.97	59.73	83.73	71.55
Anions (meq/L)	81.35	172.05	111.65	111.75	39.70	59.75	82.12	72.26
Balance (% Diff.)	0.96	2.40	1.00	1.42	0.34	0.00	0.97	-0.49

See final page of table for applicable federal and state standards.

Table 3-7. Results of Water Chemistry Analyses, Three-Mile Ditch, RFI Phase III Navajo Refinery, 1995.
(concluded)

Sample ID	MW-45	MW-46	MW-46 (Lab Dup.)	Pecos River	Pecos River	Effluent, 02-93	Effluent (NMOCD)
Date Sampled	11-Nov-94	11-Nov-94	11-Nov-94	11-Nov-94	1-Mar-91	11-Feb-93	26-Jul-89
Lab pH (SU)	6.9	7.1	7.1	7.9	8.3	8.3	- -
Lab EC (umhos/cm)	7,450	4,410	4,410	6,630	10,500	9,300	- -
Total Dissolved Solids (180°C)	6,590	3,880	3,920	4,580	6,620(s)	7,348	2,915(s)
Calcium (mg/L)	865	641	652	555	470	21	95
Magnesium (mg/L)	447	247	252	178	240	55	71
Potassium (mg/L)	14	14	14	6	12	22	9
Sodium (mg/L)	463	205	206	696	1,600	1,290	656
Bicarbonate (mg/L)	303	401	400	191	176	1,011	788
Carbonate (mg/L)	0	0	0	0	0	0	0
Chloride (mg/L)	939	369	371	1,300	2,300	1,920	577
Sulfate (mg/L)	3,110	2,020	2,010	1,510	1,900	1,034	860
Fluoride (mg/L)	2.1	2.4	2.4	0.7	1.5	151	- -
Cations (meq/L)	100.45	61.60	62.59	73	- -	62	- -
Anions (meq/L)	96.21	59.10	58.92	71	- -	92	- -
Balance (% Diff.)	2.16	2.07	3.02	1	- -	-19	- -

Federal Secondary MCL Standards (mg/L): TDS, 500; chloride, 250; sulfate, 250; fluoride, 2.
New Mexico WQCC Groundwater Standards (mg/L): TDS, 1,000; chloride, 250; sulfate, 600; fluoride, 1.6.
Federal MCL for fluoride: 4 mg/L.

The Piper water quality diagrams graphically demonstrate that the effluent sources have had no obvious impact on the water chemistry of groundwater adjacent to the ditch. The effluent sources plot separately from the monitor wells and river water on both diagrams. The diagrams and results of the organic and metal analyses presented previously continue to support the conclusion of the Phase II study that show that any current groundwater impacts of past ditch use are at most minimal.

The shallow groundwater in the vicinity of the ditch, as shown in Table 3-7, has high, naturally-occurring TDS concentrations that make it unusable except for occasional stock use. Not withstanding the lack of current use, there is no evidence to support widespread contamination of the groundwater as a result of past ditch use and no evidence that existing sediments are contributing or will contribute to groundwater degradation in the ditch area.

3.2.6 Future Groundwater Monitoring

The ditch monitor wells are proposed to be sampled annually for a five-year period beginning in the winter of 1995-96. Water level and total depth in each well will be measured prior to purging, and electrical conductivity, temperature and pH measured during the purging operation. To avoid obtaining turbid samples, purging will be conducted at discharge rates that will not exceed two liters per minute. Samples will be analyzed for the same constituent listing of volatiles, semi-volatiles, metals, and water chemistry parameters as was performed during this Phase III investigation. A summary report will be submitted to EPA by April 1 of each year. At the end of the five-year period it is proposed to discontinue ditch monitor well sampling unless a review and evaluation of the monitoring results indicates that selected monitoring should be continued.

4.4.2.1 Vertical Flow Gradients

Depth-to-water measurements in the eleven paired monitor wells were made from November 5 to 10, 1994 and again in February and June 1995. Between the November and February measurement sets, an additional three monitor wells were drilled to provide water level and water quality measurements of the deep alluvial zone to approximately 70 feet. Newly installed and existing paired wells were surveyed in February 1995 to determine new casing elevations and confirm previously surveyed readings.

The Phase II and III installation of a total of eleven sets of nested monitor wells enabled determination of the existence of positive or negative vertical gradients at a particular well location. Water-level elevations were first calculated by subtracting the depth-to-water readings from the surveyed top-of-casing elevations. Differences in vertical potentiometric levels are determined by comparing water-level elevations in the shallow "A" wells and the deeper "B" and "C" wells.

Water level elevation readings in the nested monitor wells have been taken since February 1993. The water level elevations and results of the comparison of the elevations in the adjacent wells are shown in Table 4-2. A positive difference indicates upward vertical movement in the aquifer in the immediate vicinity of the well. Upward vertical movement is seen at eight of the eleven well locations. Well locations indicating downward groundwater movement are at MW-2, OCD-2, and OCD-7. All three locations are directly adjacent to active sections of the evaporation ponds and intercept the groundwater mound created by the pond.

The direction and magnitude of the well readings are generally consistent over time. A discrepancy was seen in the data from OCD-2 for February 1993 which may have been caused by an error in one of the depth-to-water readings for these wells on those dates. Except for June 1995 water levels, the other readings show little difference between measurement dates. Both positive and negative gradient values are higher in June then were observed in the preceding months; the reasons for the larger numbers are undetermined. Although absolute values are higher, these readings are consistent with earlier trends and do not indicate that gradient reversals are occurring.

4.4.2.2 Aquifer Test Data Analysis

A series of tests were conducted on February 4, 1995, to determine the *in situ* hydraulic conductivity of the aquifer opposite the three newly drilled deep wells in the vicinity of the Navajo Refinery evaporation ponds. The wells, MW-4C, MW-5C, and OCD-7C, were tested using a procedure known as a "slug test" where a tool of known volume was quickly inserted in the well and the subsequent displacement and time for recovery of water levels were registered on a data recorder. The equipment and methodology used in conducting the test was described in Section 4.3. This section describes the procedures used in analyzing the data and compares the results to earlier hydraulic conductivity testing performed in the vicinity of the evaporation ponds.

Table 4-2. Well and Water-Level Elevations at Monitor Wells Near Navajo Evaporation Ponds, 1993-1995

Well I.D.	Top of Casing Elevation (ft.)	2/09/93 D-T-W (ft.)	2/09/93 Water Level Elevation (ft.)	11/13/93 D-T-W (ft.)	11/13/93 Water Level Elevation (ft.)	11/94 D-T-W (ft.)	11/94 Water Level Elevation (ft.)	02/95 D-T-W (ft.)	02/95 Water Level Elevation (ft.)	06/95 D-T-W (ft.)	06/95 Water Level Elevation (ft.)
MW-2A	3309.80	8.32	3301.48	10.01	3299.79	9.59	3300.21	9.35	3300.45	6.45	3303.35
MW-2B	3309.29	9.36	3299.93	10.94	3298.35	10.57	3298.72	10.09	3299.20	8.85	3300.44
Difference:			**-1.55**		**-1.44**		**-1.49**		**-1.25**		**-2.91**
MW-4A	3309.57	--	--	--	--	--	--	11.27	3298.30	10.06	3299.51
MW-4C	3309.09	--	--	--	--	--	--	10.50	3298.59	9.25	3299.84
Difference:									**0.29**		**0.33**
MW-5A	3305.87	7.64	3298.23	8.45	3297.42	8.90	3296.97	8.46	3297.41	7.87	3298.00
MW-5B	3305.94	7.22	3298.72	8.06	3297.88	8.49	3297.45	8.04	3297.90	7.07	3298.87
Difference:			**0.49**		**0.46**		**0.48**		**0.49**		**0.87**
MW-5A	3305.87	--	--	--	--	--	--	8.46	3297.41	7.87	3298.00
MW-5C	3306.23	--	--	--	--	--	--	8.19	3298.04	7.20	3299.03
Difference:									**0.63**		**1.03**
MW-6A	3310.67	11.01	3299.66	12.56	3298.11	12.19	3298.48	11.75	3298.92	10.85	3299.82
MW-6B	3310.59	10.86	3299.73	12.41	3298.18	12.05	3298.54	11.59	3299.00	10.59	3300.00
Difference:			**0.07**		**0.07**		**0.06**		**0.08**		**0.18**
MW-7A	3304.73	6.52	3298.21	7.22	3297.51	7.64	3297.09	7.20	3297.53	5.60	3299.13
MW-7B	3306.30	7.72	3298.58	8.41	3297.89	8.85	3297.45	8.42	3297.88	6.80	3299.50
Difference:			**0.37**		**0.38**		**0.36**		**0.35**		**0.37**

Notes:	DTW - Depth to Water
Difference:	Value shown is "B" or "C" elevation minus "A" elevation; positve number is upward gradient, negative is downward gradient.

Table 4-2. Well and Water-Level Elevations at Monitor Wells Near Navajo Evaporation Ponds, 1993-1995 (concluded)

Well I.D.	Top of Casing Elevation (ft.)	2/09/93 D-T-W (ft.)	2/09/93 Water Level Elevation (ft.)	11/13/93 D-T-W (ft.)	11/13/93 Water Level Elevation (ft.)	11/94 D-T-W (ft.)	11/94 Water Level Elevation (ft.)	02/95 D-T-W (ft.)	02/95 Water Level Elevation (ft.)	06/95 D-T-W (ft.)	06/95 Water Level Elevation (ft.)
MW-11A	3307.46	8.81	3298.65	9.07	3298.39	9.29	3298.17	9.00	3298.47	6.34	3301.12
MW-11B	3307.55	8.76	3298.79	9.04	3298.51	9.22	3298.33	8.93	3298.63	6.20	3301.35
Difference:			**0.14**		**0.12**		**0.16**		**0.16**		**0.23**
MW-18A	3305.36	9.53	3295.83	10.68	3294.68	10.35	3295.01	9.81	3295.55	7.83	3297.53
MW-18B	3305.58	9.46	3296.12	10.62	3294.96	10.29	3295.29	9.71	3295.87	7.53	3298.05
Difference:			**0.29**		**0.28**		**0.28**		**0.32**		**0.52**
MW-22A	3304.14	6.75	3297.39	7.65	3296.49	8.06	3296.08	7.52	3296.62	6.50	3297.64
MW-22B	3304.77	6.61	3298.16	7.51	3297.26	7.91	3296.86	7.37	3297.40	6.27	3298.50
Difference:			**0.77**		**0.77**		**0.78**		**0.78**		**0.86**
OCD-2A	3310.99	11.23	3299.76	12.26	3298.73	11.77	3299.22	11.53	3299.46	8.89	3302.10
OCD-2B	3309.90	10.07	3299.83	11.51	3298.39	11.13	3298.77	10.70	3299.20	9.14	3300.76
Difference:			**0.07**		**-0.34**		**-0.45**		**-0.26**		**-1.34**
OCD-7AR	3307.05	7.89	3299.16	8.33	3298.72	8.69	3298.36	8.46	3298.59	5.38	3301.67
OCD-7B	3307.15	8.21	3298.94	8.80	3298.35	9.10	3298.05	8.72	3298.43	6.01	3301.14
Difference:			**-0.22**		**-0.37**		**-0.31**		**-0.16**		**-0.53**
OCD-7AR	3307.05	--	--	--	--	--	--	8.46	3298.59	5.38	3301.67
OCD-7C	3306.92	--	--	--	--	--	--	8.58	3298.34	6.66	3300.26
Difference:									**-0.25**		**-1.41**
OCD-8A	3306.66	8.33	3298.33	8.93	3297.73	9.32	3297.34	9.17	3297.49	8.04	3298.62
OCD-8B	3306.08	7.66	3298.42	8.32	3297.76	8.69	3297.39	8.27	3297.81	6.43	3299.65
Difference:			**0.09**		**0.03**		**0.05**		**0.32**		**1.03**

Notes: DTW - Depth to Water
Difference: Value shown is "B" or "C" elevation minus "A" elevation; positve number is upward gradient, negative is downward gradient.

Depending on aquifer properties, slug test results are evaluated using one of two procedures. Water in confined (artesian) aquifers is analyzed using a procedure developed by H. Cooper and others in 1967 (Cooper, et al, 1967). Although possessing upward vertical gradients, alluvial groundwater in the vicinity of the evaporation ponds was observed to be shallow, at depths generally less than ten feet, and unconfined. Procedures were developed by H. Bouwer and R.C. Rice (Bouwer and Rice, 1976; Bouwer, 1989) for analysis of slug test data from unconfined aquifers. Because of its simplicity, the Bouwer and Rice slug test method is a frequently used tool in groundwater studies and its use was appropriate for evaluation of information collected during the current investigation.

The Bouwer and Rice equation and test parameters used in calculating the hydraulic conductivities are presented in Appendix C. Appendix C also includes graphs of the test data. Displacement and time data collected during the two tests conducted at each well are graphically displayed on a semi-logarithmic plot with displacement plotted on the vertical logarithmic axis and time plotted on the horizontal axis. For the straight line portion of each graph, two points are chosen for inclusion in the equation and resultant hydraulic conductivity (K) calculated. The resultant values are shown on each graphical plot and summarized in Table 4-3 below.

Table 4-3. Results of Slug-Test Evaluation, Evaporation Pond Area, RFI Phase III, 1995

Well	Screened Interval (ft)	Test	Hydraulic Conductivity (ft/min)	Hydraulic Conductivity (ft/day)	Transmissivity[a] (ft^2/day)	Seepage Velocity (ft/yr)
MW-4C	9.5	Slug-in	0.00187	2.69	25.6	4.9
MW-4C	9.5	Slug-out	0.00186	2.68	25.4	4.9
MW-5C	9.5	Slug-in	0.00867	12.5	118.6	22.8
MW-5C	9.5	Slug-out	0.00925	13.3	126.3	24.3
OCD-7C	9.5	Slug-in	0.00806	11.6	110.3	21.2
OCD-7C	9.5	Slug-out	0.00882	12.7	120.7	23.2

Notes:

[a] Transmissivity shown is the product of hydraulic conductivity and screened aquifer interval

The slug test equations require use of aquifer thickness as a parameter for calculation of hydraulic conductivity. The depth to the base of the alluvial system in the vicinity of the ponds has not been determined, and an arbitrary depth of 100 feet was selected for use in the calculations. This depth was used in calculating hydraulic conductivities in the Phase I investigation which makes the results of these tests directly comparable with the earlier findings. A sensitivity analysis that compared use of thicknesses of 100 and 200 feet in the calculation showed only a slight decrease in values of hydraulic conductivity when using a thickness of 200 feet. On the other hand, equating the saturated thickness of water in the wells (approximately 64 feet) with aquifer thickness increased hydraulic conductivities approximately 20 percent. Because hydraulic conductivity values between wells in alluvial environments commonly differ by one order of magnitude or more, an exact aquifer thickness is not necessary to evaluate the results. Therefore, use of the thickness value of 100 feet selected for the earlier tests was continued in these calculations.

The seepage velocity of the groundwater system can be determined from the hydraulic conductivity, hydraulic gradient, and effective porosity of the aquifer. The hydraulic gradient is typically measured from a groundwater contour map or a potentiometric surface map. The groundwater-flow gradient of 0.001 foot/foot calculated in the Phase II investigation for the area south of the evaporation ponds was used in the calculation of seepage velocity. The effective porosity can be estimated from the intrinsic porosity of the aquifer. Although the intrinsic porosity is the actual pore volume of the aquifer matrix, it is usually not representative of the actual porosity that governs the flow of water through the matrix because of the influence of isolated pore spaces, grain angularity, and other factors. The effective porosity of the aquifer is a corrected porosity that more closely represents true flow conditions. Effective porosity can be several orders of magnitude lower than the intrinsic porosity in consolidated aquifers, but the effective porosity of an unconfined alluvial aquifer is typically 10 to 100 percent of the intrinsic porosity (Fetter, 1988), which is usually 25 percent to 30 percent in alluvial sediments. In the absence of site-specific porosity data, the effective porosity was assumed to be 20 percent, which is representative of porosities found in this lithologic environment. Thus, the seepage velocity of the groundwater system south of the evaporation ponds was calculated using an effective porosity of 20 percent according to the following equation:

$$v = \mathbf{Ki/n_e}$$

where:

$K =$ hydraulic conductivity (ft/yr),
$v =$ seepage velocity (ft/yr),
$i =$ hydraulic gradient (ft/ft), and
$n_e =$ effective porosity (unitless)

To compare the slug test results from the current investigation with those of earlier studies, hydraulic conductivity and transmissivity were converted to units of feet per day and square feet per day, respectively. The results of the tests are of the same magnitude as the results of earlier slug tests shown in Table 4-4. The deeper wells generally have higher hydraulic conductivities than those found in the shallow wells, but values from both sets of tests were within approximately one order of magnitude. Since hydraulic conductivities in alluvial environments can commonly deviate over several orders of magnitude, the slug test results show a generally homogeneous aquifer setting.

Because a slug test is conducted using only a small volume of water and the resultant impacts on the aquifer last for only a short period of time, the information obtained using a slug test is limited to the immediate vicinity of the borehole. Aquifer pumping tests conducted for 24 hours or longer and using one or more observation wells are commonly utilized to obtain a data that is more regional in nature. Several such tests were conducted in the past in the vicinity of the ponds and the results were discussed in the Phase II report.

Table 4-4. Summary of Previous Evaporation Pond Aquifer Test Data

Well	Screened interval (ft)	Test Number or Description	Test Conducted by[a]	Hydraulic conductivity (ft/day)	Transmissivity[b] (ft^2/day)	Seepage velocity (ft/yr)
MW-4	10	1, Slug	Mariah	10.08	100.8	18.4
MW-4	10	2, Slug	Mariah	7.25	72.5	13.3
MW-6A	10	1, Slug	Mariah	26.87	268.7	49.2
MW-6A	10	2, Slug	Mariah	3.97	39.7	7.27
MW-7A	10	1, Slug	Mariah	2.67	26.7	4.89
MW-7A	10	2, Slug	Mariah	1.09	10.9	2.00
MW-18B (pumped well)	9.5	Pumping	KWBES	2.29	21.7	4.18
MW-18B (pumped well)	9.5	Recovery	KWBES	0.70	6.7	1.29
MW-18T (observation well)	9.5	Pumping	KWBES	27.67	263.4	50.6
MW-18T (observation well)	9.5	Recovery	KWBES	29.95	284.0	54.7
OCD-3	18.5	1, Slug	Mariah	1.98	36.6	3.63
OCD-3	18.5	2, Slug	Mariah	2.30	42.5	4.19
EPA-1	10	1, Slug	Mariah	2.63	26.3	4.83
EPA-1	10	2, Slug	Mariah	1.98	19.8	3.63
Temp. well (vicinity Pond 1)	25	- -	Geoscience	33.42	834.2	60.9

Notes:

[a] Tests conducted by Mariah Associates, K.W. Brown Environmental Services, Geoscience Consultants

[b] Calculated from the test data as the product of hydraulic conductivity and the length of the screened interval except for MW-18 and Geoscience tests.

The aquifer tests using observation wells resulted in seepage velocities which are from two to three times to an order of magnitude greater than seepage velocities determined using the slug test method. Given the limitations of the slug test methodology discussed above, these differences are not considered significant in evaluating the overall ability of the aquifer to transmit water. The Phase II study showed that the seepage velocities determined using the aquifer test results matched well with the available field information. This included data generated by that investigation, such as the subsurface soil gas survey, and earlier groundwater studies. The current results continue to show that the new deep wells generally exhibit good hydraulic conductivity which, together with the upward vertical gradients, will assist in natural groundwater quality improvement as the ponds are closed and preexisting groundwater conditions are reestablished.

4.4.3 Groundwater Quality

Results of the RFI Phase III groundwater sampling of the monitor wells and a windmill used for stock watering are presented in this section, with the data included in Appendix D. Pecos River water quality data is tabulated in Section 5. Field parameters of pH, conductivity, and temperature were measured at each monitor well sampled. As described in the protocol in Section 3.2.3.2, "Sample Collection," sampling was performed after these field parameters had stabilized during pumping. Final readings taken for samples from the monitor wells are shown in Table 4-5.

4.4.3.1 Results of Organics Analyses

Table 4-6 is a summary table showing sampling results for volatile and semi-volatile organic compounds in monitor wells in the vicinity of the ponds. Sampling of the existing and new monitor wells installed in the vicinity of the evaporation ponds for volatile organic compounds detected target compounds in several wells south (downgradient) of inactive Ponds 1 and 2. Volatiles were detected and confirmed during one or more Phase III samplings in wells MW-3, 4A, 5A, and 6A. All detected compounds in the pond wells are at concentrations less than 0.050 mg/L. As will be discussed in Section 4.5, the shallow groundwater in the vicinity of the ponds is naturally unsuitable for human consumption, but drinking-water standards for the detected compounds are presented in the table for comparison purposes where they have been established.

Benzene at concentrations between 0.009 and 0.015 mg/L was detected during one or more Phase III samplings in wells MW-4A, MW-4C, MW-5C, and MW-15. Detections in MW-4C and MW-5C were not confirmed in split-samples by EPA's contractor PRC. Also, in the vicinity of the ponds, benzene was detected but not confirmed in sampling of TMD well MW-15 as discussed in Section 3.2.4.2. The MCL for benzene set by the EPA under the Safe Drinking Water Act is 0.005 mg/L. In New Mexico, the state Water Quality Control Commission (WQCC) health standard for benzene in groundwater is 0.010 mg/L.

Toluene was found at low levels just above the detection level of 0.005 mg/L in MW-4A and MW-5C. The detection in MW-5C was not confirmed by additional sampling nor in the EPA-PRC split sample. A level of 0.034 mg/L was detected in MW-5A during the June sampling, but analysis was performed using SW-846 Method 8020 (versus 8240) which sometimes can produce false positive results due to matrix interference. The MCL for toluene is 1.0 mg/L, whereas the New Mexico health standard in groundwater is 0.750 mg/L. The proposed EPA secondary, aesthetic standard for toluene is 0.040 mg/L.

Table 4-5. Groundwater Indicator Measurements at the Time of Field Sampling, Evaporation Pond Area, Navajo Refinery, RFI Phase III

Well sample identification	Laboratory number	Date sampled	Time sampled	pH	Conductivity (µmhos/cm at 25°C)	Temperature (°C)
MW-2A	0694G02081	11/05/94	1218	7.5	13,000	NM
MW-2B	0694G02083	11/05/94	1245	7	3,950	NM
OCD-1	0694G02074	11/05/94	1350	7.5	15,000	NM
OCD-2B	0694G02075	11/05/94	1512	7	15,000	NM
OCD-2A	0694G02077	11/05/94	1733	7.5	17,000	NM
OCD-3	0694G02076	11/05/94	1625	7	20,500	NM
OCD-4	0694G02086	11/06/94	0825	7.5	20,500	NM
OCD-5	0694G02087	11/06/94	0920	7.5	20,000	NM
OCD-6	0694G02088	11/06/94	1005	7.5	15,000	NM
MW-11B	0694G02089	11/06/94	1055	6.7	23,000	NM
MW-11A	0694G02090	11/06/94	1120	7	32,000	NM
OCD-8B	0694G02091	11/06/94	1225	6.7	8,450	NM
OCD-8A	0694G02092	11/06/94	1240	7.5	11,400	NM
MW-7A	0694G02099	11/06/94	1540	7	15,000	NM
MW-7B	0694G02100	11/06/94	1555	7	7,650	NM
OCD-7B	0694G02103	11/06/94	1515	7.5	7,000	19
OCD-7AR	0694G02104	11/06/94	1645	7	13,000	18
MW-5B	0694G02094	11/08/94	0920	7	9,950	15.8
MW-5A	0694G02095	11/08/94	1010	7.5	19,500	18
MW-3	0694G02096	11/08/94	1145	7.5	6,150	NM
MW-6B	0694G02107	11/08/94	1555	6.5	5,050	17.3
MW-6A	0694G02110	11/08/94	1635	7	5,300	19.5
MW-15	0694G02111	11/09/94	0856	6.5	4,100	17
Pond Windmill	0694G02112	11/09/94	0954	6.5	6,600	NM
MW-10	0694G02113	11/09/94	1047	6	6,150	16
MW-22B	0694G02128	11/09/94	1351	6.5	6,300	16
MW-22A	0694G02129	11/09/94	1422	6.5	7,100	17.5
MW-18B	0694G02130	11/09/94	1635	6	5,300	16
MW-18A	0694G02131	11/09/94	1650	NM	26,000	17.5
MW-19	0694G02153	11/10/94	1014	7	7,000	17
MW-23	0694G02154	11/10/94	1135	7	20,000	15.5
MW-14	0694G02155	11/10/94	1322	7	19,000	17
MW-4A	0694G02156	11/10/94	1552	7	7,900	NM

Notes:

pH measured using paper pH strips
NM - not measured

Table 4-5. Groundwater Indicator Measurements at the Time of Field Sampling, Evaporation Pond Area, Navajo Refinery, RFI Phase III (concluded)

Well sample identification	Laboratory number	Date sampled	Time sampled	pH	Conductivity (µmhos/cm at 25°C)	Temperature (°C)
MW-6A	0695G00139	01/14/95	1630	6.5	4,600	18.9
MW-6B	0695G00151	01/15/95	1420	7	4,400	19.3
MW-5B	0695G00152	01/15/95	1500	7	9,200	17.9
MW-7B	0695G00153	01/15/95	1720	7	7,600	18.8
MW-4C	0695G00191	01/20/95	1330	7.5	6,100	18.0
MW-5C	0695G00193	01/20/95	1605	7.5	4,300	11.0
OCD-7C	0695G00198	01/20/95	1010	7	7,600	18.8
OCD-7C	0695G00603	02/24/95	1255	7.5	11,500	NM
OCD-7AR	0695G00604	02/24/95	1315	7.5	10,400	NM
MW-5C	0695G00605	02/24/95	1435	7	4,200	NM
MW-5A	0695G00606	02/24/95	1505	7	18,500	NM
MW-4C	0695G00608	02/24/95	1710	7	5,000	NM
MW-4A	0695G00609	02/24/95	1740	7	7,350	NM
MW-5C	0695G00954	06-21-95	1115	7	4,300	22
MW-5B	0695G00955	06-21-95	1410	7	9,000	24
MW-5A	0695G00956	06-21-95	1440	7	16,000	23
MW-3	0695G00957	06-21-95	1520	7	6,400	25
MW-6A	0695G00958	06-22-95	1000	NM	4,200	22
MW-2A	0695G00959	06-22-95	1045	7	14,000	24
OCD-1	0695G00960	06-22-95	1115	7	11,000	23
OCD-2A	0695G00961	06-22-95	1155	7	14,000	23
OCD-3	0695G00962	06-22-95	1235	7	18,000	23.5
OCD-5	0695G00963	06-22-95	1515	7	17,000	23.5
OCD-7AR	0695G00974	06-26-95	1530	7	10,000	22
OCD-7C	0695G00975	06-26-95	1610	8	10,600	21
MW-10	0695G00976	06-26-95	1745	7	5,800	22
MW-15	0695G00977	06-27-95	1630	7	4,500	23
MW-4A	0695G00981	06-28-95	1030	7	7,200	23
MW-4C	0695G00982	06-28-95	1120	7	5,100	23
Pipe Effluent	0695G00983	06-28-95	1340	7	2,600	30
MW-22A	0695G00984	06-28-95	1535	7	6,300	23
MW-7A	0695G00985	06-28-95	1650	8	11,500	23

Notes:

pH measured using paper pH strips
NM - Not measured

Table 4-6. Summary of Navajo Evaporation Ponds groundwater volatile/semivolatile sample analyses, RFI Phase III, 1995

		Volatile Organics (mg/l)						
Sample ID	Date	Benzene	Toluene	Ethyl-benzene	Xylenes (total)	Methyl ethyl ketone	Carbon Disulfide	Semi-volatile Organics (mg/l)[a]
MW-1	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
MW-2A	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
MW-2B	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
MW-2B (dup)	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
MW-3	5-Nov-94	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.40
MW-3[e]	21-Jun-95	<0.017	<0.017	0.018	0.030	NS	NS	NS
MW-4A	10-Nov-94	0.013	0.006	0.015	0.028	<0.005	<0.005	<0.010
MW-4A (dup)	10-Nov-94	0.014	0.006	0.016	0.032	<0.005	<0.005	<0.010
MW-4A[e]	28-Jun-95	0.015	0.008	0.019	0.036	0.012	<0.005	a
MW-4C[c]	20-Jan-95	0.013	<0.005	<0.005	0.006	<0.005	<0.005	<0.020
MW-4C[b]	20-Jan-95	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.020
MW-4C[e]	24-Feb-95	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NS
MW-4C[e]	28-Jun-95	0.015	<0.005	<0.005	<0.005	<0.020	<0.005	NS
MW-5A	8-Nov-94	<0.005	<0.005	<0.005	0.021	<0.005	<0.005	<0.020
MW-5A (dup)	8-Nov-94	<0.005	<0.005	<0.005	0.020	<0.005	<0.005	<0.40
MW-5A[e]	21-Jun-95	<0.005	0.034	0.006	0.050	NS	NS	NS
MW-5B	8-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
MW-5B[d]	15-Jan-95	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NS
MW-5C[c]	20-Jan-95	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NS
MW-5C[b]	20-Jan-95	0.009	0.005	<0.005	<0.005	<0.005	<0.005	<0.010
MW-5C[e]	24-Feb-95	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NS
MW-5C[e]	21-Jun-95	<0.001	<0.001	<0.001	<0.001	NS	NS	NS
MW-6A	8-Nov-94	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.010
MW-6A[d]	14-Jan-95	<0.005	<0.005	0.006	0.010	<0.005	<0.005	<0.010
MW-6A[e]	22-Jun-95	<0.005	<0.005	0.006	0.011	NS	NS	a
MW-6B	8-Nov-94	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.010
MW-6B[d]	15-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	<0.010
MW-7A	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-7A[e]	28-Jun-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.020	< 0.005	NS
MW-7B	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-10	9-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.10
MW-11A	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-11B	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-14	10-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.040
MW-15	9-Nov-94	0.015	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-15[d]	12-Jan-95	0.013	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS
MW-15[e]	24-Feb-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS
MW-15[e]	27-Jun-95	< 0.005	< 0.005	< 0.005	< 0.005	NS	NS	NS

Notes found on final page of table

Table 4-6. Summary of Navajo Evaporation Ponds groundwater volatile/semivolatile sample analyses, RFI Phase III, 1995 (concluded)

Sample ID	Date	Volatile Organics (mg/l)						Semi-volatile Organics (mg/l) [a]
		Benzene	Toluene	Ethyl-benzene	Xylenes (total)	Methyl ethyl ketone	Carbon Disulfide	
MW-18A	9-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-18B	9-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
MW-19	10-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.020
MW-22A	9-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.050
MW-22B	9-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.050
MW-23	10-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
OCD-1	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-1 [e]	22-Jun-95	<0.005	<0.005	<0.005	<0.005	NS	NS	NS
OCD-2A	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-2B	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-3	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-3 [e]	22-Jun-95	<0.001	<0.001	<0.001	<0.001	NS	NS	NS
OCD-4	6-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-5	6-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-5 [e]	22-Jun-95	<0.005	<0.005	<0.005	<0.005	NS	NS	NS
OCD-6	6-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-7AR	7-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
OCD-7AR [e]	26-Jun-95	< 0.005	< 0.005	< 0.005	< 0.005	NS	NS	NS
OCD-7B	7-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
OCD-7C [c]	21-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS
OCD-7C [b]	21-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
OCD-7C dup [b]	21-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
OCD-7C dup [f]	21-Jan-95	< 0.001	< 0.001	< 0.001	< 0.002	< 0.005	< 0.005	< 0.003
OCD-8A	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
OCD-8B	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
Pond Windmill	9-Nov-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
Pond Windmill [e]	20-Jan-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS
Pond 3	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NS
Pipe Effluent [e]	28-Jun-95	0.047	0.077	0.032	0.275	0.161	0.006	a

Notes:

[a] All semivolatile constituents evaluated were less than the reported detection limits presented in the table or appendix data sheets; NS - Not Sampled.

[b] Sample obtained by standard bailing method.

[c] Sample obtained through submersible pump as described in text.

[d] Re-sample obtained during second phase of RFI Phase III field work.

[e] Sample obtained during follow-up sampling subsequent to formal RFI Phase III field work.

[f] Sample analyzed by Assagai Laboratories, Albuquerque.

Federal MCL Standards (mg/L): benzene, 0.005; toluene, 1.0; ethylbenzene, 0.70; xylenes, 10.0

New Mexico WQCC Groundwater Standards (mg/L): benzene, 0.75; toluene, 0.01; ethylbenzene, 0.75; xylenes, 0.62.

Ethylbenzene was detected in wells MW-3, MW-4A and MW-6A at concentrations between 0.006 and 0.018 mg/L. The MCL for ethylbenzene is 0.700 mg/L, whereas the WQCC health standard for ethylbenzene in groundwater is 0.750 mg/L. EPA has proposed an MCL of 0.030 mg/L as a recommended aesthetic standard.

Xylenes were detected during one or more Phase III samplings at MW-3, MW-4A, MW-4C, MW-5A, and MW-6A at concentrations between 0.006 and 0.050 mg/L. The MW-4C detection was not confirmed in subsequent samplings. The drinking-water MCL for total xylenes is 10 mg/L, with a proposed MCL of 0.020 mg/L as a recommended aesthetic standard. In New Mexico, the WQCC health standard for total xylenes in groundwater is 0.62 mg/L.

Methyl ethyl ketone was detected at 0.012 mg/L in MW-4A, but carbon disulfide was not detected during Phase III sampling. In the Phase II study, these two compounds were found only in MW-6B.

No semivolatile constituent detections were found in the Phase III samples above detection levels which were generally 0.010 mg/L. At some sample locations, dilution of the sample was necessary to allow enough to be available for internal QC testing. The sample analyses were limited only to polycyclic aromatic hydrocarbons, but results from samples split with PRC showed phthalates in several PRC samples. As discussed in previous study report, phthalates are common laboratory contaminants and unlikely to be found in groundwater.

The pond windmill is close to the inactive evaporation pond inlet and south of TMD. However, it did not show evidence of volatile or semivolatile organic contamination in two samplings in November and January. Although south of the ponds, the windmill is located off-gradient from all but the uppermost end of Pond 1.

4.4.3.2 Results of Metals Analyses

Seventy samples were collected for metals analysis from 37 groundwater locations and two surface water sources in the vicinity of the evaporation ponds. One sample was obtained from the effluent pipe and two samples were obtained from the active ponds. The difference between the number of samples and locations represents samples that were field or laboratory duplicates or locations that were resampled. Metals analyses for total and dissolved arsenic, chromium, lead, and nickel are presented in Table 4-7 together with EPA drinking water and New Mexico groundwater quality standards. The EPA MCL for lead is an action level requiring treatment at the tap if exceeded in drinking water. In New Mexico nickel is an irrigation standard, not a human-health standard. The other standards shown are human-health standards in water. Because New Mexico groundwater protection regulations require measurements be made on a dissolved (versus total) sample basis, November 1994 and January 1995 samples were filtered in the field using a 0.45-micron dedicated filter, as described in 3.2.3.2, "Sample Collection." Metals samples not filtered included surface water samples from the evaporation ponds, groundwater from "pump" samples at wells MW-4C, MW-5C, and OCD-7C, and follow-up samples collected at monitor wells for verification purposes.

Table 4-7. Results of Groundwater Metals Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995

Sample ID	Date Sampled	TDS (mg/L @ 180°C)	Total Arsenic (mg/L)	Total Chromium (mg/L)	Total Lead (mg/L)	Total Nickel (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Chromium (mg/L)	Dissolved Lead (mg/L)	Dissolved Nickel (mg/L)
MW-1	05-Nov-94	10,200	0.013	0.184	<0.01	0.08	<0.005	<0.02	<0.1	<0.05
MW-2A	05-Nov-94	7,620	0.156	0.020	<0.01	0.03	0.208	<0.02	<0.1	0.02
MW-2A (LabDp.)	05-Nov-94	7,670	0.158	0.030	<0.01	0.03	0.259	<0.02	<0.1	0.03
MW-2A	22-Jun-95		0.023	0.012	<0.01	<0.05				
MW-2B	05-Nov-94	2,490	<0.005	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-2B (FldDp.1)	05-Nov-94	2,610	<0.005	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-3	05-Nov-94	5,970	0.045	0.040	<0.01	0.04	0.029	0.020	0.11	<0.05
MW-3	21-Jun-95	5,250	0.031	0.006	<0.01	<0.05				
MW-3 (Lab Dp.)	21-Jun-95	5,360	0.031	0.007	<0.01	<0.05				
MW-4A	10-Nov-94	5,410	0.156	0.090	0.07	0.13	0.076	<0.02	<0.1	<0.05
MW-4A (FldDp.3)	10-Nov-94	5,600	0.143	0.063	0.06	0.07	0.083	<0.02	<0.01	<0.01
MW-4A	24-Feb-95		0.051	<0.005	<0.01	<0.05				
MW-4A	28-Jun-95	5,750	0.061	0.006	<0.01	<0.05				
MW-4C Bail	20-Jan-95	3,830	0.070	0.019	<0.01	<0.05	0.063	0.011	<0.01	<0.05
MW-4C Pump	20-Jan-95	3,840	0.067	0.009	<0.01	<0.05				
MW-4C	24-Feb-95		0.061	<0.005	<0.01	<0.05				
MW-4C	28-Jun-95	3,970	0.065	0.006	<0.01	<0.05				
MW-5A	08-Nov-94	14,600	0.127	0.084	0.02	0.15	0.132	<0.02	<0.1	0.05
MW-5A (FldDp.2)	08-Nov-94	14,700	0.129	0.056	0.01	0.11	0.122	<0.02	<0.01	0.04
MW-5A	24-Feb-95		0.092	<0.005	<0.01	<0.05				
MW-5A	21-Jun-95	13,100	0.099	<0.005	<0.01	<0.05				
MW-5B	08-Nov-94	6,570	0.213	<0.02	<0.01	<0.01	0.178	<0.02	<0.01	<0.01
MW-5B	21-Jun-95	7,100	0.087	<0.005	<0.01	<0.05				
MW-5C Bail	20-Jan-95	3,750	0.204	0.526	0.28	0.35	0.013	<0.005	<0.01	<0.05
MW-5C Pump	20-Jan-95	3,430	0.022	0.031	<0.01	<0.05				
MW-5C	24-Feb-95		0.008	<0.005	<0.01	<0.05				
MW-5C	21-Jun-95	3,499	<0.005	<0.005	<0.01	<0.05				

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Table 4-7. Results of Groundwater Metals Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	Date Sampled	TDS (mg/L @ 180°C)	Total Arsenic (mg/L)	Total Chromium (mg/L)	Total Lead (mg/L)	Total Nickel (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Chromium (mg/L)	Dissolved Lead (mg/L)	Dissolved Nickel (mg/L)
MW-6A	08-Nov-94	3,650	0.085	0.062	0.02	0.07	0.017	<0.02	<0.01	0.01
MW-6A	22-Jun-95	3,340	0.034	0.015	<0.01	<0.05				
MW-6B	08-Nov-94	3,190	0.011	<0.02	<0.01	<0.01	0.006	<0.02	<0.01	<0.01
MW 7A	06-Nov-94	10,200	0.097	0.040	0.02	0.03	0.039	<0.02	<0.01	<0.01
MW 7A	28-Jun-95	8,960	0.022	<0.005	<0.01	<0.05				
MW 7A (Lab Dp.)	28-Jun-95	8,960	0.021	<0.005	<0.01	<0.05				
MW 7B	06-Nov-94	5,600	0.011	<0.02	<0.01	<0.01	0.007	<0.02	<0.01	<0.01
MW-10	09-Nov-94	4,420	0.035	0.107	0.09	0.18	0.006	<0.02	<0.01	<0.01
MW-10	26-Jun-95		0.009	0.007	<0.01	<0.05				
MW-10 (Lab Dp.)	26-Jun-95		0.008	0.007	<0.01	<0.05				
MW-11A	06-Nov-94	19,200	0.013	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-11A (LabDp.)	06-Nov-94	19,200	0.012	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-11B	06-Nov-94	13,600	0.013	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-14	10-Nov-94	12,600	0.087	<0.005	<0.01	<0.01	0.040	<0.02	<0.01	<0.01
MW-15	09-Nov-94	3,660	0.028	<0.02	<0.01	0.02	0.008	<0.02	<0.01	0.02
MW-18A	09-Nov-94	17,700	<0.005	<0.005	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-18B	09-Nov-94	3,670	<0.005	<0.005	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-19	10-Nov-94	5,360	0.015	<0.005	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-22A	09-Nov-94	4,740	0.075	<0.005	<0.01	<0.01	0.021	<0.02	<0.01	<0.01
MW-22A	28-Jun-95	4,740	0.028	<0.005	<0.01	<0.05				
MW-22B	09-Nov-94	4,480	<0.005	<0.005	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-23	10-Nov-94	15,600	0.034	<0.005	<0.01	<0.01	0.015	<0.02	<0.01	<0.01
OCD-1	05-Nov-94	8,970	0.103	0.024	0.02	0.07	0.072	<0.02	<0.01	0.04
OCD-1	22-Jun-95	8,660	0.051	<0.005	<0.01	<0.05				
OCD-2A	15-Nov-94	11,000	0.048	0.077	0.03	0.08	0.041	<0.02	<0.1	<0.01
OCD-2A	22-Jun-95		0.020	<0.005	<0.01	<0.05				
OCD-2B	05-Nov-94	4,070	0.006	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01

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Table 4-7. Results of Groundwater Metals Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (concluded)

Sample ID	Date Sampled	TDS (mg/L @ 180°C)	Total Arsenic (mg/L)	Total Chromium (mg/L)	Total Lead (mg/L)	Total Nickel (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Chromium (mg/L)	Dissolved Lead (mg/L)	Dissolved Nickel (mg/L)
OCD-3	05-Nov-94	12,200	0.028	0.043	0.02	0.04	<0.005	<0.02	<0.01	<0.01
OCD-3	22-Jun-95	13,500	<0.005	<0.005	0.02	<0.05				
OCD-4	06-Nov-94	12,400	0.024	0.028	0.02	<0.01	0.005	<0.02	<0.1	<0.01
OCD-5	06-Nov-94	12,100	0.041	0.030	0.02	0.02	0.008	<0.02	<0.01	<0.01
OCD-5	22-Jun-95	12,500	<0.005	<0.005	0.01	<0.05				
OCD-6	06-Nov-94	9,500	0.039	0.040	0.03	0.04	0.053	<0.02	<0.1	0.01
OCD-7AR	07-Nov-94	8,320	0.149	<0.02	<0.01	0.03	0.150	<0.02	<0.01	0.02
OCD-7AR (LabDp)	07-Nov-94	8,340	0.164	<0.02	<0.01	0.04	0.159	<0.02	<0.01	0.02
OCD-7AR	24-Feb-95	8,590	0.030	0.007	<0.01	<0.05				
OCD-7AR	26-Jun-95	8,100	0.159	0.009	<0.01	<0.05				
OCD-7B	07-Nov-94	5,190	<0.005	<0.02	<0.01	<0.01	<0.005	<0.02	<0.1	<0.01
OCD-7C Bail	21-Jan-95	5,280	0.111	0.598	0.33	0.53	0.015	0.005	<0.01	<0.05
OCD-7C Pump	21-Jan-95	8,730	0.011	0.018	<0.01	<0.05				
OCD-7C	24-Feb-95	8,680	0.011	<0.005	<0.01	<0.05				
OCD-7C	26-Jun-95	8,900	0.012	0.007	<0.01	<0.05				
OCD-8A	06-Nov-94	9,560	0.022	0.058	0.02	0.11	0.019	<0.02	<0.1	<0.05
OCD-8B	06-Nov-94	5,550	<0.005	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
Pond Windmill	09-Nov-94	4,260	0.017	<0.02	0.02	<0.01	<0.005	<0.02	<0.01	<0.01
Pond Windmill	20-Jan-95	4,450	<0.005	<0.02	<0.01	0.06				
Pnd.Wind (LabDp)	20-Jan-95	4,500	<0.005	<0.02	<0.01	<0.05				
Pipe Effluent	28-Jun-95	1,760	0.082	0.009	<0.01	<0.05				
Pond 3	06-Nov-94	8,220	0.497	<0.02	<0.01	0.03				
Pond 5	06-Nov-94	4,630	0.298	<0.02	<0.01	<0.01				

Notes:

TDS - Total Dissolved Solids

Water Quality Standards (mg/L):

EPA MCL: As, 0.05; Cr, 0.1; Pb, Action level 0.015; Ni, 0.1

NM WQCC Groundwater: As, 0.10; Cr, 0.05; Pb, 0.05; Ni, 0.2

Arsenic analyses by SW-846 Method 7061, except MW-2A 11/94 sample by by method 6010A

The analyses for total arsenic samples collected in the evaporation pond area showed exceedances of the EPA MCL of 0.05 mg/L for total arsenic at 13 of 37 groundwater sample locations. However, for wells where multiple samples were collected not all samples exceeded the federal MCL. Figure 4-1 is a map showing values of total arsenic in the evaporation pond area. The value shown for total arsenic is the most recent verification or follow-up sample presented in Table 4-7.

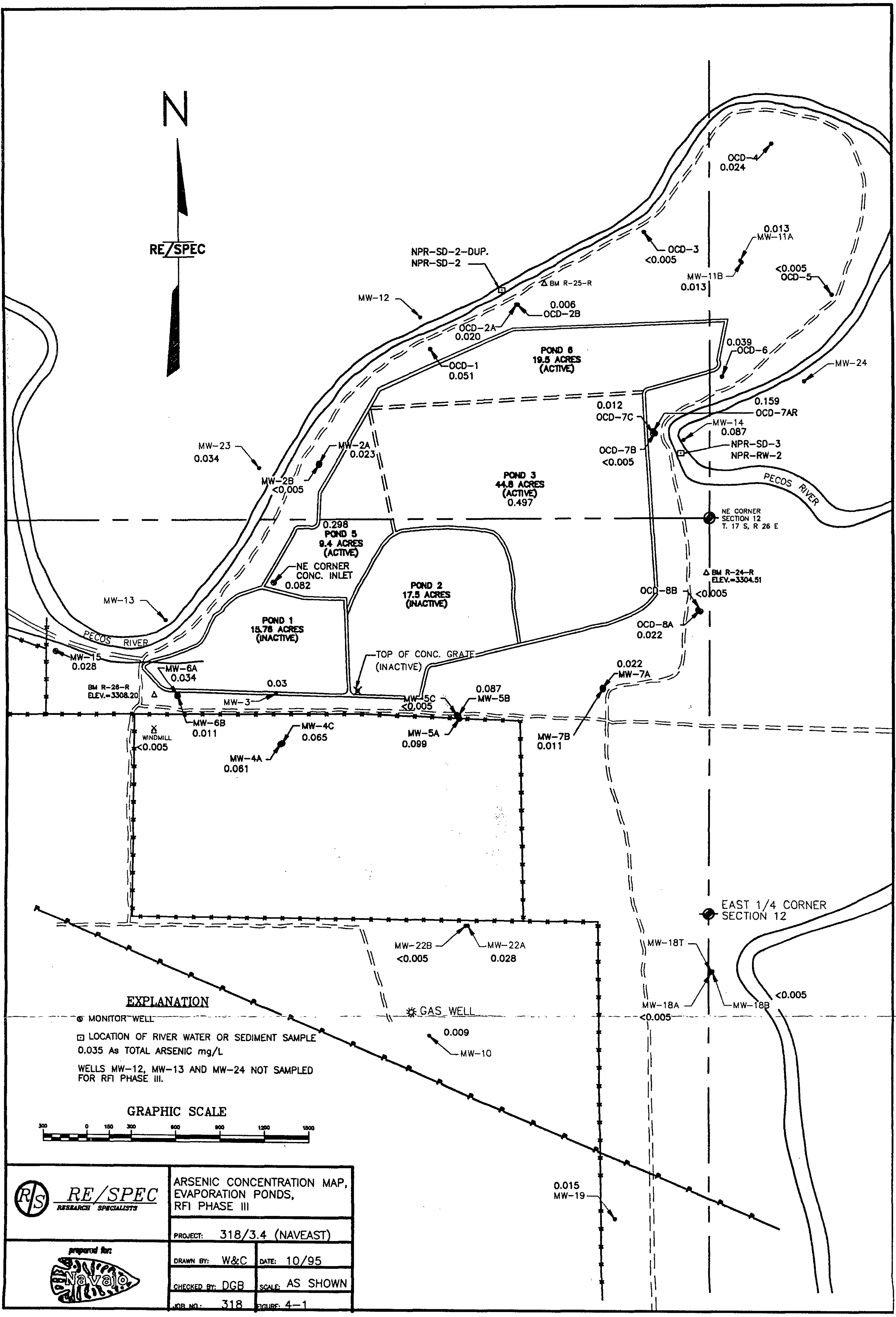
The New Mexico groundwater standard of 0.10 mg/L is exceeded at four locations (MW-2A, 5A, 5B, and OCD-7AR) in the dissolved samples. Analyses for dissolved arsenic generally showed reductions in the metal from the non-filtered sample. However, the degree of change from the total arsenic value ranged from non-detection to values greater than the total arsenic value. The wide range of values is believed due to two factors: dissolved arsenic actually in solution (e.g., at MW-5A), and turbid samples containing arsenic that moves into solution when the sample is digested (e.g., MW-5C, bailed sample). Some results may be a combination of these postulated effects. Further discussion of arsenic results is presented in Section 4.5.2.2.

Total chromium exceeded the EPA MCL of 0.1 mg/L in four wells. Two of these were new deep wells (MW-5C and OCD-7C) where turbidity was still a problem due to incomplete development before sampling. Of the other two wells, MW-1 was documented to have a deteriorated casing which can impart chromium particles to a sample bailer under turbid conditions. The final well, MW-10, did not exhibit elevated levels of chromium in the Phase II study. However, because of the distance from the ponds and the fact that both chromium and nickel were found to be elevated during this sampling, it is possible that the detections are from the well casing. Since downhole well construction details are unknown, this cannot be verified. Follow-up sampling in June 1995 found chromium in MW-10 at a concentration just above the detection level which is an order of magnitude less than the November 1994 results. Dissolved chromium did not exceed the NM WQCC standard of 0.05 mg/L in any of the wells sampled.

Total lead exceeded the EPA action level 0.015 mg/L at several wells in the vicinity of the pond. The most significant exceedances were at new wells MW-5C and OCD-7C, where sample turbidity was high. One sample from the pond windmill had a slightly elevated value of 0.02 mg/L, but analysis of the PRC split-sample did not detect lead at 0.01 mg/L. The MW-3 sample found dissolved lead at 0.11 mg/L, but this is believed to be a reporting error based on the total lead value of <0.01 mg/L. Otherwise, lead was not detected in dissolved samples.

MCL exceedances for total nickel were observed in samples collected at wells MW-4A, MW-5A, MW-5C, MW-10, OCD-7C, and OCD-8A. Significant levels of nickel were found only in new wells MW-5C and OCD-7C, which were observed to have high levels of turbidity. Subsequent resampling of all wells except OCD-8A did not result in nickel detections. Dissolved nickel concentrations did not exceed federal MCL or NM groundwater standards.

Laboratory analytical results for total metals in the evaporation pond samples did not detect any metals exceeding federal or state standards except for arsenic. Arsenic in Ponds 3 and 5 was detected at 0.497 mg/L and 0.298 mg/L, respectively. Both values exceed federal and state water standards and are likely contributing to elevated arsenic values in monitor wells completed in the shallow groundwater around the periphery of the ponds.



EXPLANATION

- ⊕ MONITOR WELL
- ⊡ LOCATION OF RIVER WATER OR SEDIMENT SAMPLE
- 0.035 As TOTAL ARSENIC mg/L

WELLS MW-12, MW-13 AND MW-24 NOT SAMPLED FOR RFI PHASE III.

GRAPHIC SCALE

RE/SPEC
RESEARCH SPECIALISTS

ARSENIC CONCENTRATION MAP,
EVAPORATION PONDS,
RFI PHASE III

prepared for:
Navajo

PROJECT: 318/3.4 (NAVEAST)

DRAWN BY: W&C DATE: 10/95

CHECKED BY: DGB SCALE: AS SHOWN

JOB NO.: 318 FIGURE: 4-1

4.4.3.3 Water Chemistry Results

The laboratory analytical data for the inorganic water quality constituents and indicator constituents for groundwater in the vicinity of the evaporation pond are shown in Table 4-8. In addition to the major constituents, the minor constituent fluoride, measured TDS, cation-anion totals, and percent difference are shown. The latter three values provide a rapid check of completeness and accuracy of the water analysis. For good-quality, low-TDS water, a percent difference of one to two percent is easily obtained. For wastewater and high-TDS water that can cause analytical instrument interference, a five percent difference is acceptable. Although discussion and interpretation of these results are presented in Section 4.5.2.3 , the water quality of the alluvial zone exceeded federal and state secondary (aesthetic) standards for chloride, sulfate, and TDS at all locations sampled. The EPA MCL for fluoride of four mg/L was exceeded at wells MW-2A, MW-7A, OCD-1, and OCD-7AR. An additional six wells had concentrations above the aesthetic concentration of two mg/L, but less than the MCL.

4.5 Discussion

4.5.1 Groundwater Occurrence and Movement

4.5.1.1 Groundwater Hydrogeology

Extensive discussion of the geology and hydrologic characteristics of the shallow alluvial materials in the vicinity of the ponds was provided in the Phase II report. The most notable feature of the sediments to a depth of approximately 70 feet is the coarse-grained nature of the material with fine- to medium-grained sands being predominant with some gravel zones. Thin interbedded clay zones are present in the upper 20 feet and thicker zones up to two feet were occasionally observed. However, most clay zones are several inches to about six inches thick and appear to be discontinuous. The general uniformity of the sediments allows fairly complete mixing of groundwater in the upper subsurface and also facilitates the transport of constituents.

The drilling of shallow and deep paired wells allowed measurement of vertical gradients. Four separate sets of measurements continue to demonstrate that upward movement of water occurs in the vicinity of the ponds except directly adjacent to the active ponds where groundwater mounding counteracts upward flow. The magnitudes of the gradient values have been consistent over the past two years. If regional water withdrawals for irrigation have an impact on the gradients, values measured in early November, shortly after conclusion of the growing season in October, should be lower than February values. Examination of the data for wells away from the ponds shows no obvious seasonal variations.

Table 4-8. Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995

Sample ID	MW-1	MW-2A	MW-2A (Lab Dup.)	MW-2B	MW-2B (Field Dup. 1)	MW-3	MW-3	MW-3 (Lab Dup.)	MW-4A	MW-4A (Field Dup. 3)	MW-4A	MW-4C (Bail)	MW-4C (Pump)
Date Sampled	11-05-94	11-05-94	11-05-94	11-05-94	11-05-94	11-05-94	06-21-95	06-21-95	11-10-94	11-10-94	06-28-95	01-20-95	01-20-95
Lab pH (SU)	7.7	7.1	7.1	7.5	7.4	7.1	7.2	7.2	7.4	7.1	7.3	7.3	7.8
Lab EC(umhos/cm)	14,500	10,600	10,600	3,310	3,330	7,500	6,660	6,660	7,480	7,690	7,520	5,510	5,420
TDS (180°C)	10,200	7,620	7,670	2,490	2,610	5,970	5,250	5,360	5,410	5,600	5,750	3,830	3,840
Calcium (mg/L)	862	542	541	379	359	608	499	476	495	502	472	351	336
Magnesium (mg/L)	459	91	90	133	120	204	148	141	139	156	157	150	153
Potassium (mg/L)	8	10	10	4	3	7	10	10	3	5	2	2	2
Sodium (mg/L)	2,130	2,100	2,110	295	280	983	935	994	1,230	1,240	1,250	626	622
Bicarbonate (mg/L)	472	701	706	199	198	357	387	387	311	605	301	278	276
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	3,590	1,910	1,910	868	738	1,120	1,090	1,090	1,310	1,390	1,630	784	777
Sulfate (mg/L)	2,800	2,610	2,570	746	746	2,290	2,060	2,050	2,370	1,900	1,820	1,370	1,320
Fluoride (mg/L)	1.2	14.3	14.3	1.1	1.0	2.6	3.0	3.0	1.9	1.7	1.9	1.2	1.1
Cations (meq/L)	173.42	126.27	126.23	42.78	40.05	90.06	78.04	78.84	89.76	91.99	91.03	57.13	56.48
Anions (meq/L)	167.46	119.53	118.83	43.28	39.59	85.16	79.93	79.76	91.21	88.58	88.90	55.18	53.90
Balance (% Diff.)	1.75	2.74	3.02	-0.58	0.58	2.80	-1.20	-0.58	-0.80	1.89	1.18	1.74	2.34

Note: See last page of table for applicable federal and state standards.

Table 4-8. Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	MW-4C	MW-5A	MW-5A (Field Dup.2)	MW-5A	MW-5B	MW-5B	MW-5C (Ball)	MW-5C (Pump)	MW-5C	MW-6A	MW-6A	MW-6B	MW-7A
Date Sampled	06-28-95	11-08-94	11-08-94	06-21-95	11-08-94	06-21-95	01-20-95	01-20-95	06-21-95	11-08-94	06-22-95	11-08-94	11-06-94
Lab pH (SU)	7.1	7.0	7.3	7.2	7.3	7.0	7.4	7.4	7.2	7.5	7.6	7.8	7.7
Lab EC(umhos/cm)	5,100	17,500	17,100	15,400	8,750	9,050	4,820	4,570	4,200	4,720	4,280	4,390	12,900
TDS (180°C)	3,970	14,600	14,700	13,100	6,570	7,110	3,750	3,430	3,490	3,650	3,340	3,190	10,200
Calcium (mg/L)	355	536	567	546	543	530	503	480	474	390	274	362	409
Magnesium (mg/L)	153	587	546	575	168	178	126	126	119	94	84	81	336
Potassium (mg/L)	2	8	3	7	7	7	6	4	4	2	1	6	7
Sodium (mg/L)	645	3,370	3,120	2,990	1,020	1,490	428	388	404	512	632	520	2,520
Bicarbonate (mg/L)	284	475	473	467	371	374	212	224	218	175	181	32	349
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	1,010	3,320	3,310	3,050	1,720	1,770	515	540	609	727	647	803	2,450
Sulfate (mg/L)	1,300	5,350	5,400	5,100	1,170	2,470	1,660	1,450	1,460	1,400	1,290	1,180	3,380
Fluoride (mg/L)	1.3	2.9	2.4	2.9	1.4	1.4	1.2	1.0	1.1	2.2	2.8	0.6	7.1
Cations (meq/L)	58.41	221.80	208.98	204.70	85.64	105.97	54.24	51.30	51.12	49.52	48.10	47.51	157.89
Anions (meq/L)	60.28	212.88	213.62	199.76	79.02	107.58	52.62	49.12	51.15	52.61	48.07	47.70	145.15
Balance (% Diff.)	-1.58	2.05	-1.10	1.22	4.02	-0.75	1.52	2.17	-0.03	-3.03	0.03	-0.20	4.20

Note: See last page of table for applicable federal and state standards.

Table 4-8. Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	MW-7A	MW-7A (Lab Dup.)	MW-7B	MW-7B	MW-10	MW-11A	MW-11A (Lab Dup.)	MW-11B	MW-14	MW-15	MW-15	MW-15 (Lab Dup.)	MW-15
Date Sampled	06-28-95	06-28-95	11-06-94	01-15-95	11-09-94	11-06-94	11-06-94	11-06-94	11-10-94	11-09-94	02-24-95	02-24-95	06-27-95
Lab pH (SU)	7.2	7.2	7.6	7.4	7.6	7.1	7.1	7.2	7.2	7.5	7.6	7.6	7.7
Lab EC(umhos/cm)	12,000	12,000	7,190	9,110	5,960	27,800	27,800	19,600	16,800	4,860	2,880	2,880	4,580
TDS (180°C)	8,960	8,960	5,600	6,620	4,420	19,200	19,200	13,600	12,600	3,660	2,200	2,200	3,400
Calcium (mg/L)	383	383	512	543	395	1,065	1,106	842	733	372	263	262	357
Magnesium (mg/L)	330	331	190	238	83	442	441	187	469	113	79	77	102
Potassium (mg/L)	6	5	8	8	4	23	24	38	10	8	4	4	4
Sodium (mg/L)	2,290	2,280	895	1,200	937	4,920	4,800	3,640	2,960	519	332	329	568
Bicarbonate (mg/L)	350	350	255	287	279	407	409	134	1,344	175	124	125	154
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	2,500	2,540	1,230	1,460	993	9,260	9,030	5,890	3,680	743	443	451	798
Sulfate (mg/L)	3,410	3,400	2,160	2,550	1,570	1,770	1,760	1,840	3,760	1,470	943	917	1,280
Fluoride (mg/L)	1.5	1.6	1.1	1.3	1.0	0.8	0.8	0.8	0.8	1.2	1.1	1.1	0.8
Cations (meq/L)	146.03	145.74	80.31	98.99	67.39	303.94	301.02	216.80	204.15	50.65	34.17	33.82	51.03
Anions (meq/L)	147.17	147.95	83.89	98.89	65.30	304.72	297.85	206.57	204.14	54.37	34.17	33.86	51.61
Balance (% Diff.)	-0.39	-0.75	-2.18	0.05	1.58	-0.13	0.53	2.42	0.00	-3.54	0.00	-0.06	-0.57

Note: See last page of table for applicable federal and state standards.

Table 4-8. Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	MW-18A	MW-18B	MW-19	MW-22A	MW-22A	MW-22B	MW-23	OCD-1	OCD-1	OCD-2A	OCD-2B	OCD-3	OCD-3
Date Sampled	11-09-94	11-09-94	11-10-94	11-09-94	06-28-95	11-09-94	11-10-94	11-05-94	06-22-95	11-15-94	11-05-94	11-05-94	06-22-95
Lab pH (SU)	7.3	7.2	7.5	7.6	7.4	7.6	7.1	7.2	7.4	7.1	7.6	7.2	7.7
Lab EC(umhos/cm)	23,000	4,680	6,990	6,760	6,450	6,040	21,500	11,700	11,200	14,400	5,190	17,500	17,800
TDS (180°C)	17,700	3,670	5,360	4,740	4,740	4,480	15,600	8,970	8,660	11,000	4,070	12,200	13,500
Calcium (mg/L)	731	576	720	374	328	409	1,033	601	558	581	692	1,025	975
Magnesium (mg/L)	956	163	216	99	88	145	504	142	127	238	46	274	285
Potassium (mg/L)	51	4	11	6	3	35	15	7	8	11	12	27	39
Sodium (mg/L)	3,980	326	661	1,170	1,140	875	3,800	2,170	2,150	2,830	480	2,750	2,990
Bicarbonate (mg/L)	400	185	255	201	199	199	695	756	721	615	46	300	291
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	5,790	635	1,170	1,170	1,370	910	5,560	2,200	2,150	2,800	828	5,680	5,290
Sulfate (mg/L)	4,880	1,590	2,020	1,660	1,510	1,820	3,800	2,940	2,880	3,510	1,630	2,000	2,460
Fluoride (mg/L)	2.3	1.0	0.9	1.1	1.2	0.8	0.8	6.0	7.7	1.2	0.4	0.8	1.0
Cations (meq/L)	289.45	56.45	82.74	77.98	73.14	71.30	258.87	136.37	132.01	171.87	59.51	193.96	202.95
Anions (meq/L)	271.29	54.12	79.19	70.85	73.28	66.86	247.30	135.68	132.28	162.31	58.08	206.73	205.15
Balance (% Diff.)	3.24	2.11	2.19	4.79	-0.10	3.21	2.29	0.25	-0.10	2.86	1.22	-3.19	-0.54

Note: See last page of table for applicable federal and state standards.

Table 4-8. Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	OCD-4	OCD-5	OCD-5	OCD-6	OCD-7AR	OCD-7AR (Lab Dp.)	OCD-7AR	OCD-7AR	OCD-7B	OCD-7C	OCD-7C (Bail)	OCD-7C (Pump)	OCD-7C
Date Sampled	11-06-94	11-06-94	06-22-95	11-06-94	11-07-94	11-07-94	02-24-95	06-26-95	11-07-94	02-24-95	01-21-95	01-21-95	06-26-95
Lab pH (SU)	7.2	7.4	7.7	7.7	7.2	7.2	7.3	7.4	7.6	7.0	7.3	7.1	7.2
Lab EC(umhos/cm)	18,000	16,800	16,900	12,800	10,800	10,800	10,100	10,700	6,880	10,400	7,140	12,100	11,500
TDS (180°C)	12,400	12,100	12,500	9,500	8,320	8,340	8,590	8,110	5,190	8,680	5,280	8,730	8,900
Calcium (mg/L)	795	744	757	527	575	575	571	593	715	650	620	643	646
Magnesium (mg/L)	248	230	223	164	173	173	225	135	105	217	134	216	225
Potassium (mg/L)	62	36	40	13	8	7	3	11	13	11	14	11	11
Sodium (mg/L)	3,270	3,040	3,180	2,590	1,960	1,970	1,850	1,860	824	1,880	789	1,900	2,000
Bicarbonate (mg/L)	234	287	231	754	642	641	706	598	118	525	320	456	461
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	4,820	4,520	4,700	2,210	2,000	2,020	1,930	1,990	1,120	2,250	1,000	2,160	2,450
Sulfate (mg/L)	2,690	2,620	2,760	3,510	2,920	2,920	2,950	2,800	2,060	3,110	2,040	2,860	2,860
Fluoride (mg/L)	1.0	1.0	1.1	3.7	5.1	4.9	1.1	7.6	1.2	1.2	1.7	1.0	1.2
Cations (meq/L)	203.82	189.34	195.55	152.96	128.26	128.64	127.44	121.88	80.49	132.35	76.65	132.97	137.99
Anions (meq/L)	195.77	186.81	193.85	147.83	127.66	128.39	127.47	124.15	76.52	136.71	76.03	127.93	136.14
Balance (% Diff.)	2.01	0.67	0.44	1.71	0.23	0.10	-0.01	-0.92	2.53	-1.62	0.41	1.93	0.67

Note: See last page of table for applicable federal and state standards.

Table 4-8. Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (concluded)

Sample ID	OCD-8A	OCD-8B		Pond Windmill	Pond Windmill	Pond Windmill (Lab dp.)		Pond 3	Pond 5	Pipe Effluent		NPR-RW-1	NPR-RW-2
Date Sampled	11-06-94	11-06-94		11-09-94	01-20-95	01-20-95		11-06-94	11-06-94	06-28-95		11-11-94	11-11-94
Lab pH (SU)	7.4	7.6		7.6	7.6	7.6		7.2	7.1	7.2		7.9	7.8
Lab EC(umhos/cm)	12,200	7,460		5,870	6,610	6,610		12,600	8,030	2,430		6,630	6,680
TDS (180°C)	9,560	5,550		4,260	4,450	4,500		8,220	4,630	1,760		4,580	4,610
Calcium (mg/L)	634	822		330	298	301		38	33	77		555	547
Magnesium (mg/L)	345	190		165	173	175		86	61	80		178	164
Potassium (mg/L)	9	6		3	4	6		86	51	18		6	7
Sodium (mg/L)	2,140	588		697	841	847		2,670	1,260	298		696	696
Bicarbonate (mg/L)	497	164		176	144	143		251	315	326		191	188
Carbonate (mg/L)	0	0		0	0	0		0	0	0		0	0
Chloride (mg/L)	2,340	1,740		1,130	1,070	1,120		2,300	1,370	307		1,300	1,280
Sulfate (mg/L)	3,480	1,780		1,440	1,550	1,570		2,720	958	493		1,510	1,460
Fluoride (mg/L)	2.7	0.8		0.9	1.0	1.0		158.4	126.8	36.6		0.7	0.7
Cations (meq/L)	153.36	82.39		60.46	65.79	66.40		127.19	62.92	23.83		72.76	71.24
Anions (meq/L)	146.46	88.81		64.67	64.75	66.61		125.45	63.78	24.26		71.24	69.49
Balance (% Diff.)	2.30	-3.75		-3.36	0.80	-0.16		0.69	-0.68	-0.89		1.06	1.24

Notes:

Federal Secondary MCL Standards (mg/L): TDS, 500; chloride, 250; sulfate, 250; fluoride, 2.

New Mexico WQCC Groundwater Standards (mg/L): TDS, 1,000; chloride, 250; sulfate, 600; fluoride, 1.6.

Federal MCL for fluoride: 4 mg/L.

The upward gradient observed during the Phase II and III studies is regional in nature. Upward discharge of water from the shallow aquifer along the Pecos River from the vicinity of Acme (north of Roswell) to about one mile south of the Highway 82 bridge has been documented by the USGS and the New Mexico State Engineer Office (Welder, 1983).

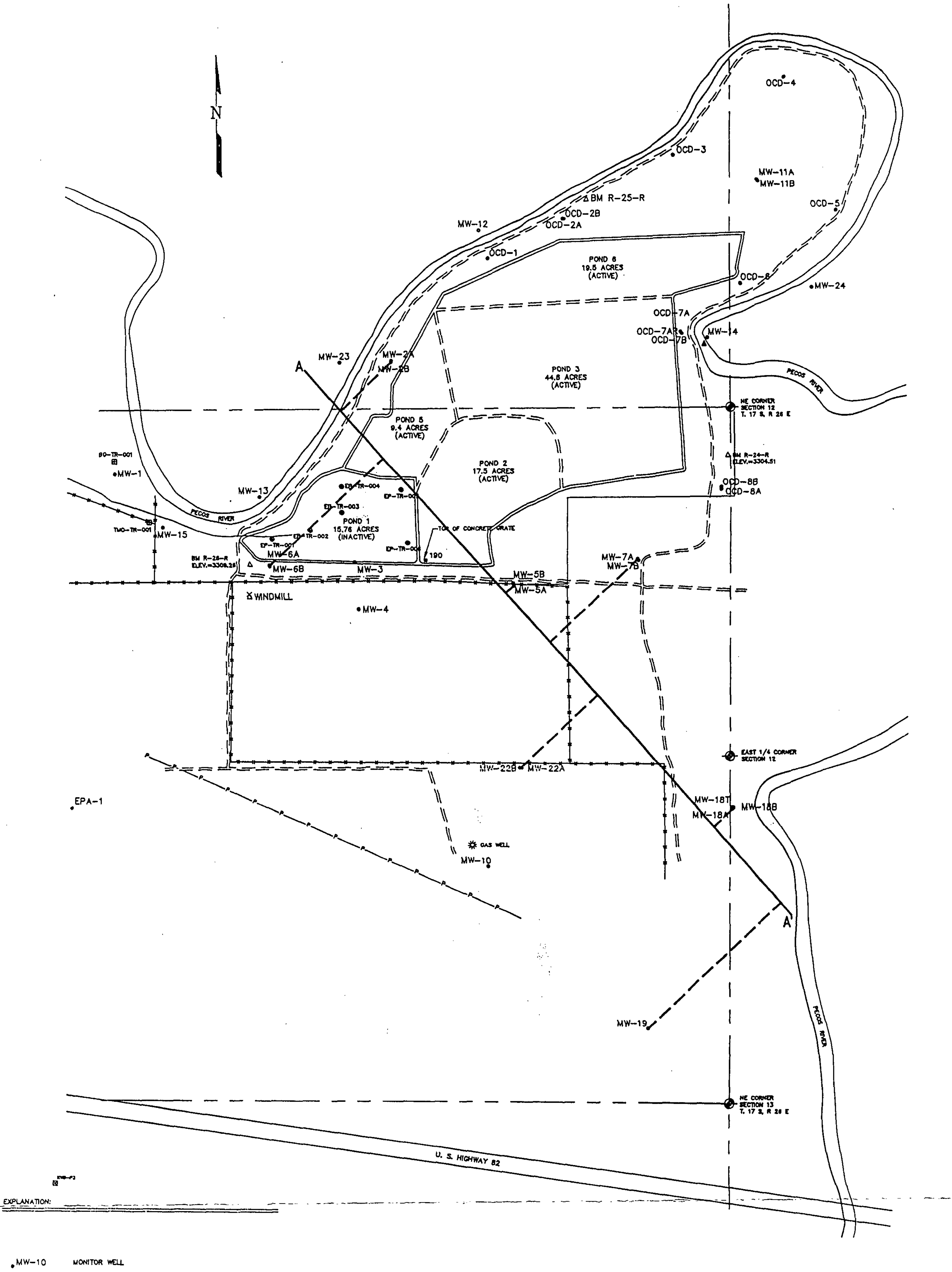
Groundwater mapping performed for the Phase II study showed groundwater flow to be generally southeasterly in the area south of Ponds 1 and 2, which until 1987 received effluent having minimal wastewater treatment. The discharge area for seepage water from these ponds is the vicinity of U.S. Highway 82 and the Pecos River, in an area populated with salt cedar, a phreatophyte that consumes large amounts of water in the summer months. Heavily vegetated areas of salt cedar in the vicinity of the highway extend at least several miles to the south. As water is consumed by the plant, the dissolved salts remain behind and contribute to the poor water quality of shallow groundwater and cause localized areas of salt-impacted soils. The negative impact of phreatophytes on groundwater in this reach of the Pecos River has been studied by both state and federal investigators (Mower et al., 1964). Water not consumed by vegetation has concentrated levels of natural salts. Water within several feet of the surface evaporates, leaving elevated salts in soils, or discharges into the Pecos River during low flow thus exacerbating river salt impacts.

4.5.1.2 Groundwater Modeling

Groundwater modeling of the flow system in the vicinity of the river was performed during the Phase II investigation to provide mathematical and visual interpretation of the hydraulic effects occurring as a result of the interaction of the ponds and the natural system. Sufficient information was available on vertical and horizontal gradients and hydraulic conductivities to allow use of a relatively simple and accepted groundwater model.

Because the hydrologic data measured during the current Phase III study has not significantly changed and supports information collected in the earlier investigation, no additional groundwater modeling was performed for this study. However, because current data support the earlier results, the model is briefly discussed in this report. Figures 4-2 and 4-3 show the location of the wells used in the model and the resultant particle flow lines. The latter figure illustrates a situation in which there is downward flow from the pond superimposed on a flow that is generally moving vertically upward. Thus, the flow is initially downward directly beneath the pond, and rises laterally in the downgradient direction. There is a surface upon which particles move neither upward or downward. Here, motion is lateral and follows the regional gradient away from the influence of the pond. Thus, a particle moves off the vertically static surface to a region in which flow is again upward.

From Figure 4-3, it is clear why, under the given conditions, lower zones remain uncontaminated despite local downward movement in upper zones significantly influenced by the ponds. For example, the lower zone in the vicinity of MW-2 remains largely uncontaminated because of the confined effect of the vertical and horizontal gradients and conductivity. The particle flow map also shows how flow will influence the movement of particles upward toward a discharge area southeast of the ponds.



•MW-10 MONITOR WELL

⊞ PIEZOMETER

800 0 800 2400 FEET

NOTE: MAP COMPILED FROM NAVAJO REFINERY AND USGS SPRING LAKE 7.5 MINUTE QUADRANGLE. WELL LOCATIONS AND ELEVATIONS FROM NAVAJO REFINERY CONTROL. WELL LOCATIONS SURVEYED 2/93, JAQUESS & ASSOCIATES.

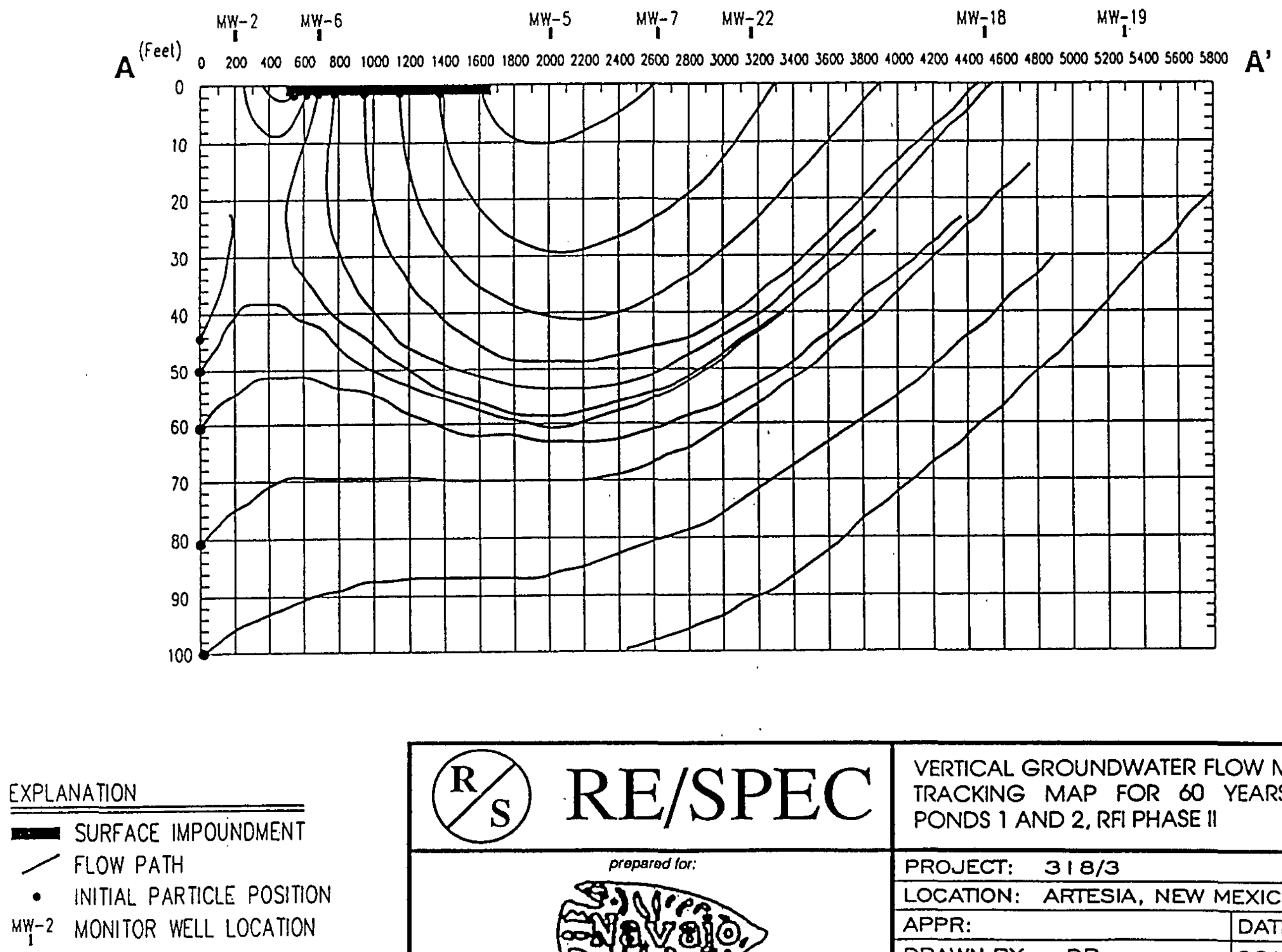
LOCATION T 17 S, R 26 E, NMPM, EDDY COUNTY, NM

RE/SPEC

prepared for:

CROSS SECTION LOCATION FOR VERTICAL GROUNDWATER FLOW MODEL, EVAPORATION POND AREA, RFI PHASE II

PROJECT: 318/3
LOCATION: ARTESIA, NEW MEXICO
APPR:
DATE: 4-28-95
DRAWN BY: DB
SCALE:
DATE:
FIGURE: 4-2



RE/SPEC

VERTICAL GROUNDWATER FLOW MODEL - PARTICLE TRACKING MAP FOR 60 YEARS, EVAPORATION PONDS 1 AND 2, RFI PHASE II

prepared for:

Navajo

PROJECT: 318/3	
LOCATION: ARTESIA, NEW MEXICO	
APPR:	DATE: 4-28-95
DRAWN BY: DB	SCALE:
DATE:	FIGURE: 4-3

The groundwater modeling results provide a graphical picture of the interaction of groundwater moving upward from the valley fill aquifer with water seepage from the evaporation pond. Although some zones appear to undergo little mixing, movement of water into and out of the cross section can not be seen because the model is two dimensional. Slight variations in actual vertical or horizontal gradients or hydraulic conductivity will cause particle movement to deviate from the paths shown. However the overall effect will cause groundwater to move upward toward the discharge zone, where it will be consumed through evaporation and transpiration.

With use of the map and available geologic, hydrologic, and chemical data, predictions regarding locations of future impact of the seepage water can be offered. For example, the model shows that not all flow paths have reached the surface discharge area even after 60 years. During the remaining time necessary for a particle to reach the surface, the model can show locations of intermediate zones subject to degradation as the contaminant front passes through the area. Therefore, the first detection of constituents in a monitor well should not immediately be a cause for concern if the location of the well is in the predicted path of the mobile contaminants. Such detection should be looked upon as verification of the utility of the program and its ability to accurately represent subsurface flow.

The results of these measurements, together with aquifer testing, contour mapping and the groundwater modeling performed in the Phase II study, provide sufficient scientific evidence to demonstrate that the hydrologic system in the vicinity of the evaporation ponds is discharging groundwater upward. That work also showed that groundwater in the general vicinity of Ponds 1 and 2 moves in a southeasterly direction toward the Pecos River crossing at U.S. Highway 82 and areas heavily vegetated with salt cedar located immediately adjacent to the highway.

4.5.2 Groundwater Quality

4.5.2.1 Organic Compounds

The results of testing for volatile organic compounds in the area of the evaporation ponds showed improvement from the sampling analyses conducted during RFI Phase II study. Table 4-9 compares the type and number of organic constituents detected in this investigation with those found during the 1993 Phase II investigation. Also, Table 4-9 includes results of split sampling by PRC.

The number of confirmed benzene detections are lower than reported during the 1993 Phase II study. In the current study, only MW-4A was confirmed to contain benzene and it exists at a lower concentration than found in earlier samplings. However, MW-4C had detectable levels of benzene in three of the five samples taken since monitor well installation in January 1995. In the 1993 study, water samples from four additional wells (MW-3, MW-5A, MW-6B, and OCD-7B) had detectable levels of benzene.

Table 4-9 Comparison of Volatile Organic Compound Detections, 1992-1995, Evaporation Pond Area, Navajo Refining Company, RFI Phase III, 1995

Sample ID	Date Sampled	Benzene (mg/L)	Toluene (mg/L)	Ethyl-benzene (mg/L)	Total Xylenes (mg/L)	MEK (mg/L)	Carbon Disulfide (mg/L)
Evap. Pond. 3	11/06/94 (11/20/92)	ND (0.043)	ND (0.061)	ND (0.016)	ND (0.045)	ND (<0.010)	ND (0.032)
MW-3	11/05/94 (11/12/92)	ND (0.017)	ND (0.021)	ND (0.016)	0.006 (0.025)	ND (<0.010)	ND (ND)
MW-3 PRC	11/05/94	ND	0.004	0.004	0.006	<0.010	ND
MW-3	06/21/95	<0.017	<0.017	0.018	0.030	NS	NS
MW-4A	11/10/94 (11/12/92)	0.013 (0.021)	0.006 (0.009)	0.015 (0.019)	0.028 (0.032)	ND (<0.010)	ND (ND)
MW-4A Field Dup.	11/10/94	0.014	0.006	0.016	0.032	ND	ND
MW-4A PRC	11/10/94	0.015	0.0067	0.017	0.028	<0.010	ND
MW-4A	06/28/95	0.015	0.008	0.019	0.036	0.012	<0.005
MW-4C Bail	01/20/95	0.010	ND	ND	ND	ND	ND
MW-4C Pump	01/20/95	0.013	ND	ND	0.006	ND	ND
MW-4C PRC	01/20/95	ND	ND	ND	ND	<0.010	ND
MW-4C	02/24/95	ND	ND	ND	ND	ND	ND
MW-4C	06/28/95	0.015	<0.005	<0.005	<0.005	<0.020	<0.005
MW-5A	11/08/94 (11/11/92)	ND (0.013)	ND (0.028)	ND (0.006)	0.021 (0.008)	ND (<0.010)	ND (ND)
MW-5A Field Dup.	11/08/94	ND	ND	ND	0.020	ND	ND
MW-5A PRC	11/08/94	ND	ND	ND	0.010	<0.010	ND
MW-5A	06/21/95	<0.005	0.034	0.006	0.050	NS	NS
MW-5C Bail	01/20/95	0.009	0.005	ND	ND	ND	ND
MW-5C Pump	01/20/95	ND	ND	ND	ND	ND	ND
MW-5C PRC	01/20/95	ND	ND	ND	ND	<0.010	ND
MW-5C	02/24/95	ND	ND	ND	ND	ND	ND
MW-5C	06/21/95	<0.001	<0.001	<0.001	<0.001	NS	NS

Notes:
MEK: Methyl ethyl ketone
ND: Not detected at a minimum detection level of 0.005 mg/L.
NS: Not sampled
EPA MCL: Benzene, 0.005 mg/L; toluene, 1.0 mg/L; ethylbenzene, 0.70 mg/L; xylenes, 10.0 mg/L.
NM WQCC: Benzene, 0.010 mg/L; toluene, 0.75 mg/L; ethylbenzene, 0.75 mg/L; xylenes, 0.62 mg/L.

Table 4-9 Comparison of Volatile Organic Compound Detections, 1992-1995, Evaporation Pond Area, Navajo Refining Company, RFI Phase III, 1995 (concluded)

Sample ID	Date Sampled	Benzene (mg/L)	Toluene (mg/L)	Ethyl-benzene (mg/L)	Total Xylenes (mg/L)	MEK (mg/L)	Carbon Disulfide (mg/L)
MW-6A	11/08/94 (11/12/92)	<0.025 (ND)	<0.025 (0.006)	<0.025 (0.007)	<0.025 (0.014)	<0.025 (<0.010)	<0.025 (ND)
MW-6A	01/14/95	ND	ND	0.006	0.010	ND	ND
MW-6A	06/22/95	<0.005	<0.005	0.006	0.011	NS	NS
MW-6B	11/08/94 (01/30/93)	<0.025 (0.009)	<0.025 (0.006)	<0.025 (ND)	<0.025 (ND)	<0.025 (0.048)	<0.025 (0.117)
MW-6B PRC	11/08/94	ND	ND	ND	ND	<0.010	ND
MW-6B	01/15/95	ND	ND	ND	ND	ND	ND
OCD-7B	11/07/94 (01/30/93)	ND (0.009)	ND (ND)	ND (ND)	ND (ND)	ND (<0.010)	ND (ND)
OCD-7B PRC	11/07/94	ND	ND	ND	ND	<0.010	ND

Notes:
MEK: Methyl ethyl ketone
ND: Not detected at a minimum detection level of 0.005 mg/L.
NS: Not sampled
EPA MCL: Benzene, 0.005 mg/L; toluene, 1.0 mg/L; ethylbenzene, 0.70 mg/L; xylenes, 10.0 mg/L.
NM WQCC: Benzene, 0.010 mg/L; toluene, 0.75 mg/L; ethylbenzene, 0.75 mg/L; xylenes, 0.62 mg/L.

In 1993, toluene was present in MW-3, MW-4A, MW-5A, MW-6A, and MW-6B; the current study detected and confirmed toluene only in MW-4A. Ethylbenzene continues to be detected in four wells (MW-3, MW-4A, MW-5A, and MW-6A), at levels up to 0.019 mg/L. Xylene was detected in wells MW-3, MW-4A, MW-5A, and MW-6A during both Phase II and Phase III samplings. Unlike the Phase II study, methyl ethyl ketone and carbon disulfide were not detected in MW-6B, but MEK was seen in MW-4A in the June 1995 sampling. In both studies, only benzene exceeds current federal or state standards. As in 1993, the extensive testing conducted for semivolatile organic compounds in groundwater in the area of the evaporation ponds did not result in any semivolatile detections.

4.5.2.2 Selected Metals

Several problems, separately or together, caused elevated concentrations of lead, chromium, and/or nickel in several of the wells sampled. This was especially true for new wells drilled and developed only several days before first being sampled, and for the older stainless steel wells. In some of newer wells, fine grained particles continued to produce light brown opaque water even though other water quality parameters, especially conductivity, had long since stabilized. It was not uncommon to pump over 100 gallons of water from the new wells to storage barrels in an attempt to remove turbidity. The older stainless steel wells also were difficult to purge. The submersible pump used in purging the more recent two-inch well installations could not be inserted inside the casing of the older wells. Use of a bailer was difficult due to frequent hang-up on the casing joints. Considerable fine material was dislodged from the casing walls and the shallow wells also were silty near the bottom.

These problems were most prevalent in stainless steel wells MW-1, MW-4A, MW-5A, and MW-6A, and to a lessor extent in the other steel wells. MW-10, whose construction details are unknown, had elevated chromium and nickel concentrations that mimicked the steel wells, but an elevated lead concentration could lead to an interpretation of turbidity in the sample. Water from new wells MW-5C and OCD-7C was clearly turbid and appeared dark brown in the bailer after purging. Because of time constraints, these new wells were sampled almost immediately after development and, based on observed turbidity, apparently needed additional development work. In an attempt to get a less turbid sample, a second sample for metals was collected through the submersible pump used for purging at MW-4C, MW-5C, and OCD-7C. Bailed samples at these wells were also field filtered which eliminated most detections except for arsenic.

Several wells experienced changes in chromium, lead, and nickel concentrations from sampling results reported in the Phase II report. PVC-cased well OCD-3, which had a total chromium concentration of 0.19 mg/L in the 1993 sampling, currently is not detected at the detection level of 0.005 mg/L. In 1993, total lead was found in OCD-3 at a concentration of 0.06 mg/L. Current sampling detected lead at 0.02 mg/L. Turbidity and/or high TDS concentrations may elevate levels of these metal constituents in OCD-3; current TDS for this well is 13,500 mg/L. As mentioned above, MW-10 had elevated levels of several constituents, including nickel. The November 1994 concentration for total nickel doubled from that reported in the 1993 investigation. Nickel was not detected in the filtered sample leading to the supposition that elevated levels are due to turbidity.

Based on elevated concentration levels of chromium, lead, and nickel found in several of the new wells in the November, 1994 and January 1995 testing, additional sampling events were performed in February and June 1995. Using low velocity pumps, the three new deep wells and wells at several other locations were purged at low flow rates of approximately one to two liters per minute with the intake hose set at approximately two to three feet beneath the water level surface. Although slow in removing large volumes of water, wells purged using this method did not exhibit significant turbidity.

Low-flow purging and resampling resulted in significant improvement in the water quality of these wells for these three metal constituents. Total lead, and nickel were not reported detected in the three new deep wells. Total chromium was found to be at, or just slightly above, the 0.005 mg/L detection level in wells MW-4C and OCD-7C. MW-10, resampled in June 1995, confirmed the hypothesis that elevated metals levels were a result of turbidity; lead and nickel were not detected, and levels of arsenic and chromium were only slightly above the 0.005 mg/L detection level for these constituents. Based on these results, all future purging for RCRA samplings should be performed using a low flow pump prior to sampling.

Sampling from wells purged at low flow rates, and field filtering did not always prevent arsenic concentrations at some wells from exceeding the federal MCL of 0.05 mg/L. However, some wells had dramatic reductions in concentrations after such purging. In February 1995, for example, concentrations were reduced to one-third of the original value in MW-4A (0.156 to 0.051 mg/L), to one-fifth in OCD-7AR (0.149 to 0.030 mg/L), and to less than 10 percent of original levels in MW-5C (0.204 to 0.008 mg/L) and OCD-7C(0.111 to 0.011 mg/L). The other two wells had only slight reductions in arsenic; the value for MW-4C (0.061 mg/L) was approximately the same concentration as found in the original filtered and unfiltered bailed samples. Similar reductions in arsenic concentrations were observed in the June 1995 sampling.

As previously mentioned, the wide range of arsenic values is believed due to two factors: dissolved arsenic actually in solution (e.g., at monitor wells MW-5A, and OCD-7A), and turbid samples containing arsenic that moves into solution when the sample is digested (e.g., MW-4A, MW-5C, and OCD-7C). Some results may be a combination of these postulated effects.

The minimal effect of filtration on some samples of arsenic can be interpreted as meaning that arsenic is present in colloidal form. Common dimensions for colloids are 0.001 to 0.200 microns; substances of that size will pass through the 0.45 micron filter used to collect a dissolved sample. Arsenic sulfide is one such example of a colloid. The charge on the sulfur ion in As_2S_3 is negative, indicating sulfur is a reduced species. Likewise, the chemical environment in the immediate vicinity of the ponds also is expected to be reduced because of the presence of organics in the subsurface. In such surroundings, the charge on a sulfur ion would likely be negative (-2) versus the positive charge (+6) commonly found in an oxidizing environment. Although arsenic speciation in the groundwater is unknown; it could very likely be colloidal in nature given the circumstances postulated above.

Table 4-10 is a compilation and comparison of all arsenic sample results collected from wells in the vicinity of ponds during the Phase II and III investigations. Arsenic problems due to turbidity mask actual groundwater concentrations and make comparison of concentration changes from 1993 to 1995 difficult. However, measurable and, in some instances, significant concentration increases are suspected in MW-5A, MW-11A, MW-14, MW-15, MW-19, MW-22A, MW-23, and OCD-4.. Lowered values are observed in MW-2A, MW-3, MW-4A, MW-5B, MW-6A, MW-6B, MW-7A, MW-7B, MW-10, OCD-1, OCD-2A, OCD-3, and OCD-7AR. Three of these latter wells are in close proximity to inactive Pond 1, indicating possible improved water quality as a result of pond closure.

As discussed elsewhere, groundwater in the immediate area of the ponds is essentially unusable owing to the high natural concentration of salts. Although there is some limited use of poor-quality water for livestock on the west side of the ponds, which is upgradient from the site, the combination of a groundwater discharge area and high natural concentrations of salts eliminate the possibility of the high arsenic levels impacting usable ground water supplies and potential receptors.

4.5.2.3 Water Chemistry

Inorganic water chemistry data were collected during the Phase II study to provide information regarding the impact of the pond chemistry on the local hydrologic environment. The installation of the deeper monitor wells allowed comparison of the deeper groundwater with that at shallow depths.

Analysis of Phase II groundwater samples from the monitor wells in the vicinity of the ponds indicated that the groundwater at some locations had been impacted by seepage discharge from the ponds. This information was reviewed and updated using data collected during the Phase III study to perform trend analysis and to evaluate whether inactivation of Pond 1 in 1987, and Pond 2 early in 1994, have resulted in measurable improvement in groundwater quality. Water quality is considered to have improved if high sodium chloride water present in the ponds is being replaced with water having calcium-magnesium sulfate properties more common to unimpacted alluvial sediments. The use of water chemistry techniques, in addition to evaluation of changes in organic and metal constituents, can be used to provide evidence supporting the concept of natural remediation of pollutants at the units.

Because complete information on the major water constituents was collected at the time of sampling for target compounds, an analysis of the types of water present could be performed that would be useful in interpretation of hydrologic conditions at the site. The Piper trilinear diagram (Hem, 1989) was the method of analysis chosen to represent the various types of water likely to be present in the area. A description of method and its use was provided in the discussion of water chemistry at TMD (Section 3.2.5.2.3) and will not be reviewed here.

Table 4-10. Comparison of Total Arsenic Values, 1993-1995, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995

Well ID	Sample ID	Date	TDS (mg/L @180°C)	As Mean Value[1] (mg/L)	PRC As Value[2] (mg/L)	Sample ID	Date	TDS (mg/L @180°C)	Total Arsenic[1] (mg/L)	PRC As Value[2] (mg/L)
MW-1	MW-01-01	10-Nov-92	11,200	0.022	0.008^{J}	MW-1	05-Nov-94	10,200	0.013	
MW-2A	MW-02A	10-Nov-92	11,300	0.102	0.212^{J}	MW-2A	05-Nov-94	7,620	0.156	
MW-2A						MW-2A(Lab Dup)	05-Nov-94	7,670	0.158	
MW-2A						MW-2A	22-Jun-95		0.023	
MW-2B	MW-02B	16-Dec-92	2,500	<0.005	< 0.003	MW-2B	05-Nov-94	2,490	<0.005	
MW-2B	MW-02B(LabDp.)	16-Dec-92	2,540	<0.005		MW-2B(Fld Dp.1)	05-Nov-94	2,610	<0.005	
MW-3	MW-03	12-Nov-92	5,310	0.087		MW-3	05-Nov-94	5,970	0.045	0.090
MW-3						MW-3 (PRC Dup)	05-Nov-94			0.100
MW-3						MW-3	21-Jun-95	5,250	0.031	
MW-3						MW-3A(Lab Dup)	21-Jun-95	5,360	0.031	
MW-4A	MW-04	12-Nov-92	5,360	0.096	0.213^{J}	MW-4A	10-Nov-94	5,410	0.156	0.241
MW-4A	MW-04 (L. Dup.)	12-Nov-92	5,360	0.085		MW-4A(Fld Dp.3)	10-Nov-94	5,600	0.143	
MW-4A						MW-4A	24-Feb-95		0.051	
MW-4A						MW-4A	28-Jun-95	5,750	0.061	
MW-4C						MW-4C Bail	20-Jan-95	3,830	0.070	0.140
MW-4C						MW-4C Bail	20-Jan-95			0.135
MW-4C						MW-4C Pump	20-Jan-95	3,840	0.067	
MW-4C						MW-4C	24-Feb-95		0.061	
MW-4C						MW-4C	28-Jun-95	3,970	0.065	
MW-5A	MW-05A	11-Nov-92	24,300	0.082		MW-5A	08-Nov-94	14,600	0.127	0.075
MW-5A	MW-05A (Fld D.)	11-Nov-92	24,400	0.077		MW-5A(Fld Dp.2)	08-Nov-94	14,700	0.129	
MW-5A						MW-5A	24-Feb-95		0.092	
MW-5A						MW-5A	21-Jun-95	13,100	0.099	
MW-5B	MW-05B	22-Jan-93	7,350	0.141	0.200	MW-5B	08-Nov-94	6,570	0.213	0.290
MW-5B						MW-5B	21-Jun-95	7,100	0.087	
MW-5C						MW-5C Bail	20-Jan-95	3,750	0.204	0.090
MW-5C						MW-5C Pump	20-Jan-95	3,430	0.022	
MW-5C						MW-5C	24-Feb-95		0.008	
MW-5C						MW-5C	21-Jun-95	3,499	<0.005	
MW-6A	MW-06A	12-Nov-92	3,540	0.065		MW-6A	08-Nov-94	3,650	0.085	
MW-6A						MW-6A	22-Jun-95	3,340	0.034	

Notes found on final page of table

Table 4-10. Comparison of Total Arsenic Values, 1993-1995, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Well ID	Sample ID	Date	TDS (mg/L @180°C)	As Mean Value[1] (mg/L)	PRC As Value[2] (mg/L)	Sample ID	Date	TDS (mg/L @180°C)	Total Arsenic[1] (mg/L)	PRC As Value[2] (mg/L)
MW-6B	MW-06B	30-Jan-93	3,800	0.021		MW-6B	08-Nov-94	3,190	0.011	0.011
MW-7A	MW-07A	11-Nov-92	11,500	0.038	0.143^{J}	MW 7A	06-Nov-94	10,200	0.097	
MW-7A						MW-7A	28-Jun-95	8,960	0.022	
MW-7A						MW-7A(Lab Dup.)	28-Jun-95	8,960	0.021	
MW-7B	MW-07B	21-Jan-93	9,220	0.014	0.017	MW 7B	06-Nov-94	5,600	0.011	
MW-10	MW-10	18-Nov-92	4,400	0.011		MW-10	09-Nov-94	4,420	0.035	0.048
MW-10						MW-10	26-Jun-95		0.009	
MW-10						MW-10 (Lab Dup.)	26-Jun-95		0.008	
MW-11A	MW-11A	12-Dec-92	16,100	<0.005		MW-11A	06-Nov-94	19,200	0.013	
MW-11A						MW-11A(LabDup)	06-Nov-94	19,200	0.012	
MW-11B	MW-11B	23-Jan-93	14,000	<0.005		MW-11B	06-Nov-94	13,600	0.013	
MW-14	MW-14	17-Dec-92	8,230	0.012		MW-14	10-Nov-94	12,600	0.087	0.212
MW-14	MW-14 (Fld D.)	17-Dec-92	7,890	0.010						
MW-15	MW-15	20-Jan-93	2,790	0.008	<0.003	MW-15	09-Nov-94	3,660	0.028	0.034
MW-18A	MW-18A	25-Jan-93	12,600	<0.005		MW-18A	09-Nov-94	17,700	<0.005	
MW-18B	MW-18B	11-Mar-93	3,710	<0.005		MW-18B	09-Nov-94	3,670	<0.005	
MW-18B	MW-18B (L.Dup.)	11-Mar-93	3,710	<0.005						
MW-19	MW-19	26-Jan-93	5,720	<0.005		MW-19	10-Nov-94	5,360	0.015	0.023
MW-22A	MW-22A	29-Jan-93	4,410	0.013		MW-22A	09-Nov-94	4,740	0.075	0.102
MW-22A	MW-22A (Fld D.)	29-Jan-93	4,400	0.014		MW-22A	28-Jun-95	4,740	0.028	
MW-22B	MW-22B	29-Jan-93	4,700	0.008		MW-22B	09-Nov-94	4,480	<0.005	
MW-22B	MW-22B (L Dup.)	29-Jan-93	4,720	0.008						
MW-23	MW-23	28-Jan-93	11,700	0.008		MW-23	10-Nov-94	15,600	0.034	0.060
MW-23	MW-23 (L Dup.)	28-Jan-93	11,700	0.007						
OCD-1	OCD-1	13-Nov-92	10,300	0.106	0.235^{J}	OCD-1	05-Nov-94	8,970	0.103	
OCD-1						OCD-1	22-Jun-95	8,660	0.051	
OCD-2A	OCD-2A	15-Nov-92	11,800	0.076		OCD-2A	15-Nov-94	11,000	0.048	
OCD-2A	OCD-2A (L. Dp.)	15-Nov-92	11,700	0.069		OCD-2A	22-Jun-95		0.020	
OCD-2B	OCD-2B	21-Jan-93	11,600	0.006	0.029	OCD-2B	05-Nov-94	4,070	0.006	

Notes found on final page of table

Table 4-10. Comparison of Total Arsenic Values, 1993-1995, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (concluded)

Well ID	Sample ID	Date	TDS (mg/L @180°C)	As Mean Value[1] (mg/L)	PRC As Value[2] (mg/L)	Sample ID	Date	TDS (mg/L @180°C)	Total Arsenic[1] (mg/L)	PRC As Value[2] (mg/L)
OCD-3	OCD-3	16-Nov-92	11,600	0.022		OCD-3	05-Nov-94	12,200	0.028	
OCD-3						OCD-3	22-Jun-95	13,500	<0.005	
OCD-4	OCD-4-1	16-Nov-92	13,100	0.016		OCD-4	06-Nov-94	12,400	0.024	
OCD-5	OCD-5	16-Nov-92	12,400	0.008		OCD-5	06-Nov-94	12,100	0.041	
OCD-5	OCD-5 (Fld. D.)	16-Nov-92	12,400	0.009		OCD-5	22-Jun-95	12,500	<0.005	
OCD-5	OCD-5(LD.of FD)	16-Nov-92	12,400	0.008						
OCD-6	OCD-6-1	16-Nov-92	10,900	0.042		OCD-6	06-Nov-94	9,500	0.039	
OCD-7AR	OCD-7AR	19-Jan-93	8,350	0.175		OCD-7AR	07-Nov-94	8,320	0.149	0.280
OCD-7AR						OCD-7AR(LabDp)	07-Nov-94	8,340	0.164	
OCD-7AR						OCD-7AR	24-Feb-95	8,590	0.030	
OCD-7AR						OCD-7AR	26-Jun-95	8,100	0.159	
OCD-7B	OCD-7B	30-Jan-93	5,060	<0.005		OCD-7B	07-Nov-94	5,190	<0.005	0.018
OCD-7C						OCD-7C Bail	21-Jan-95	5,280	0.111	0.100
OCD-7C						OCD-7C Bail[3]	21-Jan-95	5,620	<0.20	
OCD-7C						OCD-7C Pump	21-Jan-95	8,730	0.011	
OCD-7C						OCD-7C	24-Feb-95	8,680	0.011	
OCD-7C						OCD-7C	26-Jun-95	8,900	0.012	
OCD-8A	OCD-8A	17-Nov-92	9,670	0.035		OCD-8A	06-Nov-94	9,560	0.022	
OCD-8B	OCD-8B	23-Jan-93	5,400	<0.005		OCD-8B	06-Nov-94	5,550	<0.005	
OCD-8B	OCD-8B (Fld Dp.)	23-Jan-93	5,270	<0.005						
Windmill	Pond Windmill	17-Dec-92	4,740	<0.005		Pond Windmill	09-Nov-94	4,260	0.017	0.007
						Pond Windmill	20-Jan-95	4,450	<0.005	<0.005
						Pond Wind(LDup.)	20-Jan-95	4,500	<0.005	
Pipe						Pipe Effluent	28-Jun-95	1,760	0.082	
Pond 3	Pond 3 at OCD 7	16-Nov-92	7,080	0.167		Evap. Pond 3	6-Nov-94	8,220	0.497	
Pond 5						Evap. Pond 5	6-Nov-94	4,630	0.298	

Notes:

[1] Navajo samples for arsenic analyzed using EPA SW-846 method 7061; 1993 mean value is average of original and verification value(s), when performed

[2] PRC samples for arsenic analyzed using EPA SW-846 method 7060

[3] Sample split with Assaigai Analytical Laboratories, Albuquerque

J Estimated value

- OCD-7AR and OCD-7B are located within 50 feet of Pond 3 with OCD-7AR showing continued impact by pond salts during the 1993-1995 period (Figure 4-15). Water in OCD-7B has remained approximately the same composition although the chloride composition has increased. Water in new well OCD-7C is almost identical in composition to water in OCD-7AR, even though arsenic levels differ significantly. Because of the chemistry similarities, water from the OCD-7AR zone likely was transported downwards during drilling and associated well development. Based on the lack of arsenic seen in intermediate well OCD-7B, it can be predicted that OCD-7C will stabilize unless artificially created vertical pathways remain available for direct fluid transport.

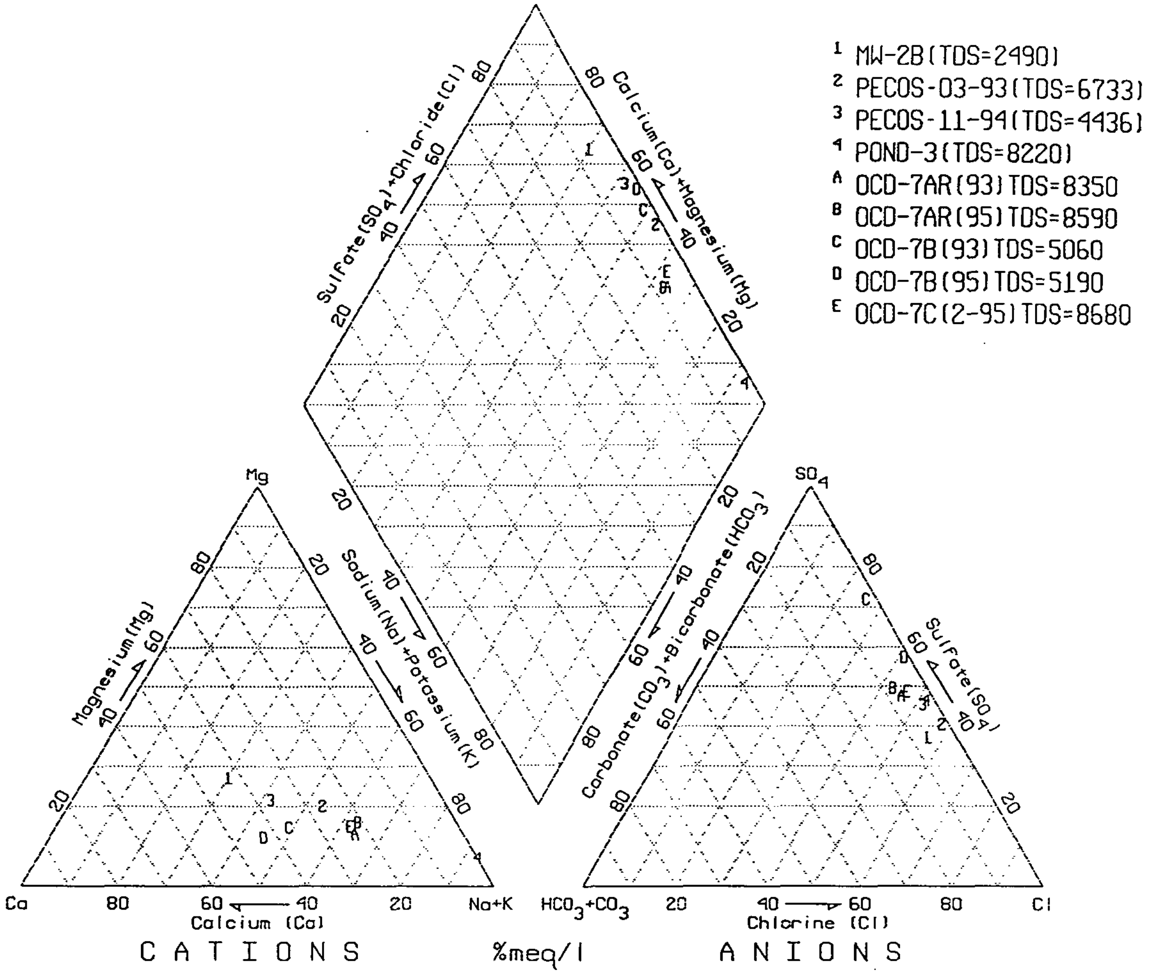
- OCD-8A appears slightly impacted by the pond, but OCD-8B does not (Figure 4-16). Although downgradient from the pond, no sign of any arsenic or other metal impact is seen in OCD-8B. The deep water has the characteristics seen in MW-2B and MW-18B. No significant changes in water quality were observed between 1993 and 1995.

The preceding information on water characteristics was derived from examination of the trilinear diagrams and used to verify the reasonableness of the groundwater flow model and examine changes in the water quality composition of the groundwater. Because the mathematical flow model is used to duplicate existing flow conditions, interpretation of the geochemical characteristics of the groundwater provides information that supports the predictions made by the model. Together they provide strong evidence that the impacts of past and continued use of the ponds will be limited to the area of the ponds and to the area of poor-quality groundwater that exists near the surface and downgradient of the site.

4.6 FUTURE GROUNDWATER MONITORING

Wells in the immediate proximity of the evaporation ponds are currently being sampled by Navajo on a schedule required by the NM Oil Conservation Division as a condition of approval of the Groundwater Discharge Plan in 1991. Wells are being sampled on a staggered schedule with adjacent wells alternately sampled in either the spring or fall months for selected water quality constituents regulated by the NM Water Quality Control Commission. Three wells (MW-3, 4A, and 5A) are sampled twice per year.

Beginning in the winter of 1995-96, Navajo proposes annual sampling of selected wells for hazardous constituents that could potentially occur based on the extensive RFI sampling conducted since 1990. The target monitor wells are proposed to be sampled annually during the active use of the ponds and for a five-year period thereafter. During the time the pond is in continued use, sampling for some wells will be staggered, with some wells sampled in Spring and others in Fall to allow coordination with the current Oil Conservation Division sampling program.



RE/SPEC

Trilinear mixing diagram, OCD-7A, -7B, -7C Pecos River, evaporation pond, RFI Phase III, April 1995

prepared for:

Navajo

PROJECT: 318/3

LOCATION: ARTESIA, NEW MEXICO

APPR:

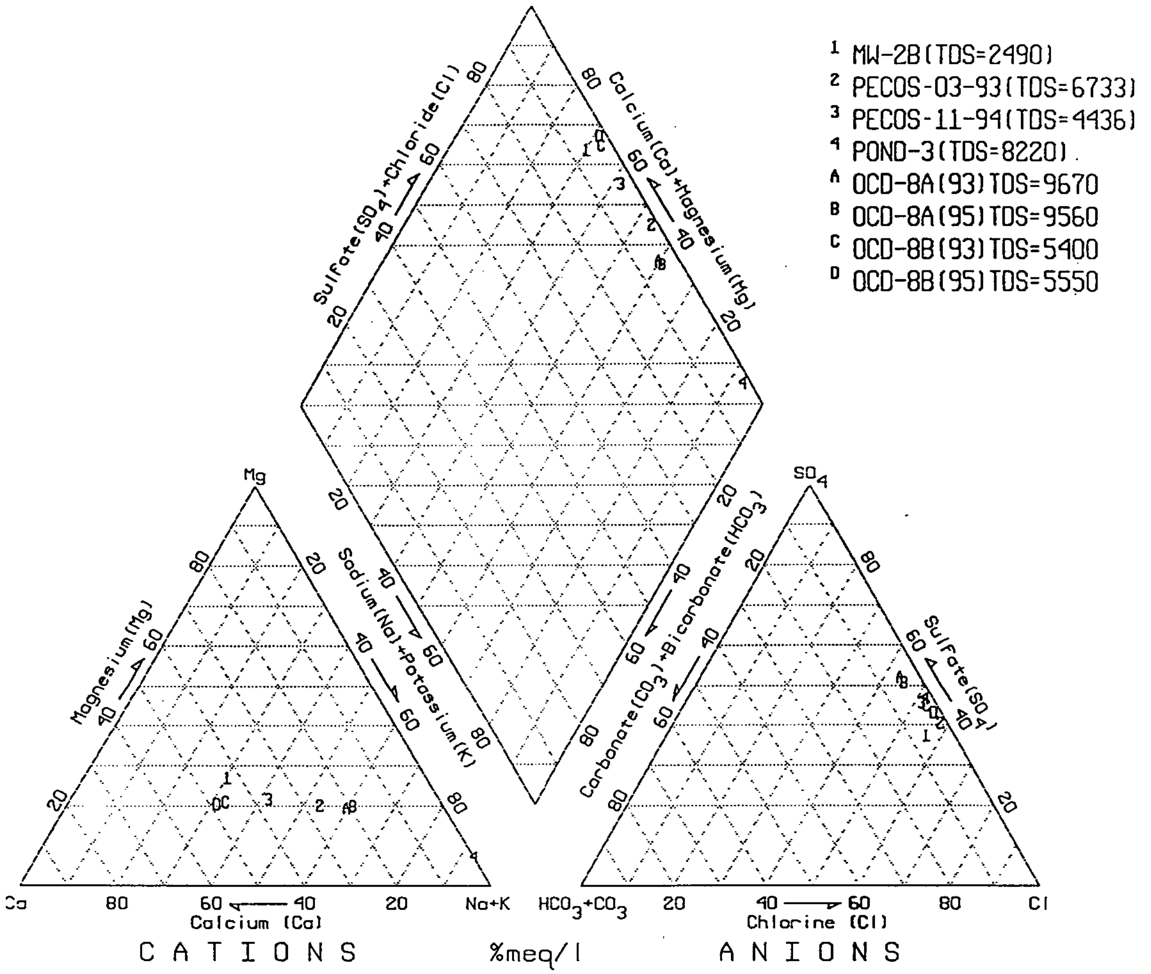
DATE: 4-28-95

DRAWN BY: DB

SCALE:

DATE:

FIGURE: 4-15



RE/SPEC

Trilinear mixing diagram, OCD-8A, -8B, Pecos River, evaporation pond, RFI Phase III, April 1995

prepared for:

Navajo

PROJECT: 318/3
LOCATION: ARTESIA, NEW MEXICO
APPR:
DATE: 4-28-95
DRAWN BY: DB
SCALE:
DATE:
FIGURE: 4-16

The following wells in the vicinity of the evaporation ponds are proposed for annual sampling:

MW Series: 1, 2A, 2B, 3, 4A, 4C, 5AR* ,5B, 5C, 6A, 6B, 7A, 7B, 14, 15, 22A and 22B.
OCD Series: 1, 2A, 2B, 3, 5, 6, 7AR, 7B, 7C, 8A and 8B.

Prior to purging, water level and total depth in each well will be measured, and electrical conductivity, temperature and pH will be measured during the purging operation. To avoid obtaining turbid samples, purging will be conducted at discharge rates that will not exceed two liters per minute.

Samples will be analyzed for the same constituent listing of volatiles, semi-volatiles, metals, and water chemistry parameters as was performed during this Phase III investigation. Based on the analytical results of past sampling events, semi-volatiles are proposed to be sampled only at wells MW-3, 4A, 4C, 5AR, 5B, 5C, 6A and 6B. These wells are downgradient from Pond 1 and the area of the entrance inlet to Pond 2, both of which received significant quantities of semi-volatile constituents prior to upgrading of the wastewater treatment plant in 1987. Also, based on past sampling results, it is not proposed to monitor wells OCD 3 and OCD 5 for volatile constituents. OCD 4 is not proposed for sampling because it was designed to monitor water quality of future pond expansion which no longer is scheduled to occur.

A summary report will be submitted to EPA by April 1 of each year. The summary report will include the sampling analytical results plus the quarterly water level measurements of the nested pond monitor wells which are completed at different depth intervals. At the end of the five-year period it is proposed to discontinue pond monitor well sampling and water level measurements, unless a review and evaluation of the monitoring results indicates that selected monitoring should be continued.

4.7 GROUNDWATER RISK ASSESSMENT

Risk assessments have been recently conducted at the evaporation ponds by RE/SPEC (1995) for inclusion in the Pond 1 Corrective Measures Study (CMS), and by ENSR (1995) as part of the closure plan for the other active evaporation ponds. A groundwater risk assessment was prepared for the CMS submitted in December, 1994 and included in the August 1995 revised CMS. The pertinent sections of the CMS are reproduced as Appendix G of this report.

The CMS presented the results of a groundwater risk assessment for a human residential scenario that utilized maximum concentration data from selected Pond 1 monitor wells collected during the Phase I and II RFI investigations. A review of RFI Phase III data for all monitor wells in the vicinity of the ponds does not show concentration levels exceeding data in the earlier reports, so the CMS risk assessment represents the worst-case analysis.

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* Monitor Well 5AR replaced well 5A at the same location in August 1995.

Of overwhelming significance, however, is the discussion in the CMS which demonstrates that, because of flood risks, residential use of property in the vicinity of the evaporation ponds will not occur. The CMS also documents that the naturally occurring groundwater in the vicinity of the ponds is unfit for human consumption without extensive treatment to remove salts which also would eliminate any hazardous constituents. In EPA Region 6 comments of April 1995 in response to earlier CMS submittals, EPA recognizes that the human residential scenario is inappropriate for the evaporation pond area and is allowing an agricultural-based use as the default risk scenario. Discussions of the latter scenario and various ingestion pathways are presented in the referenced RE/SPEC and ENSR documents.

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APPENDIX A

APPENDIX B

APPENDIX C