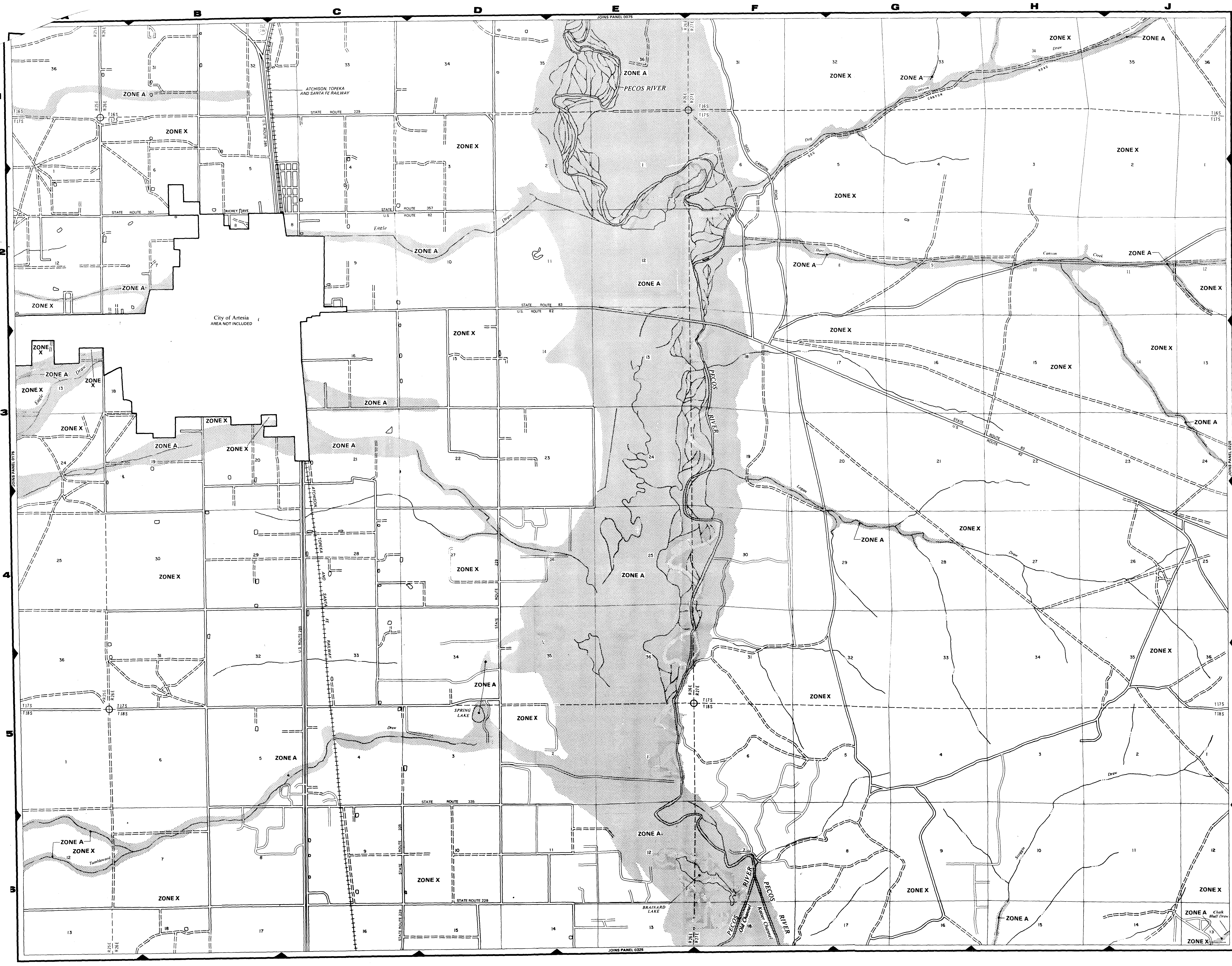
GW - 28

WORK PLANS



LEGEND

▨ SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding; velocities also determined.
ZONE A99	To be protected from 100-year flood by Federal flood protection system under construction; no base flood elevations determined.
ZONE V	Coastal flood with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood with velocity hazard (wave action); base flood elevations determined.

▨ OTHER FLOOD AREAS

ZONE X	Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.

☐ OTHER AREAS

ZONE X	Areas determined to be outside 500-year floodplain.
ZONE D	Areas in which flood hazards are undetermined.

———————	Floodplain Boundary
— — — —	Floodway Boundary
- ——— ——— -	Zone D Boundary
▨	Boundary Dividing Special Flood Hazard Zones.
~~ 513 ~~~	Base Flood Elevation Line: Elevation in Feet*
⟨D⟩——⟨D⟩	Cross Section Line
(EL 987)	Base Flood Elevation in Feet Where Uniform Within Zone*
RM 7×	Elevation Reference Mark
•M1.5	River Mile

*Referenced to the National Geodetic Vertical Datum of 1929

NOTES

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas. The community map repository should be consulted for possible updated flood hazard information prior to use of this map for property purchase or construction purposes.

Coastal base flood elevations apply only landward of 0.0 NGVD, and include the effects of wave action; these elevations may also differ significantly from those developed by the National Weather Service for hurricane evacuation planning.

Areas of special flood hazard (100-year flood) include Zones A, AE, AH, AO, A99, V, and VE.

Certain areas not in Special Flood Hazard Areas may be protected by flood control structures.

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the Federal Emergency Management Agency.

Floodway widths in some areas may be too narrow to show to scale. Floodway widths are provided in the Flood Insurance Study Report.

Elevation reference marks are described in the Flood Insurance Study Report.

For adjoining map panels see separately printed Map Index.

MAP REPOSITORY
Eddy County Courthouse, Carlsbad, New Mexico 88221 1139 (Maps available for reference only, not for distribution).

INITIAL IDENTIFICATION:
FEBRUARY 7, 1978

FLOOD HAZARD BOUNDARY MAP REVISIONS:
NONE

FLOOD INSURANCE RATE MAP EFFECTIVE:
FEBRUARY 6, 1991

FLOOD INSURANCE RATE MAP REVISIONS:

Refer to the Flood Insurance Rate Map Effective date shown on this map to determine when actuarial rates apply to structures in the zones where elevations or depths have been established.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at (800) 638-6620.

APPROXIMATE SCALE
2000 0 2000 FEET

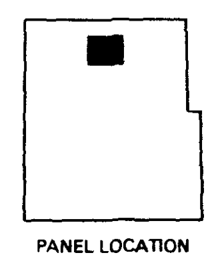
Master

NATIONAL FLOOD INSURANCE PROGRAM
C71

FIRM
FLOOD INSURANCE RATE MAP

EDDY COUNTY, NEW MEXICO
UNINCORPORATED AREAS

PANEL 200 OF 1125
(SEE MAP INDEX FOR PANELS NOT PRINTED)


PANEL LOCATION

COMMUNITY-PANEL NUMBER
350120 0200 B

EFFECTIVE DATE:
FEBRUARY 6, 1991

Figure 3-1 Flood Hazard Map
Pecos River, Artesia Area

Federal Emergency Management Agency

EVAPORATION POND 1 CORRECTIVE MEASURES STUDY WORKPLAN
(2nd Revision)

NAVAJO REFINERY
ARTESIA, NEW MEXICO

Topical Report RSI-0635

RECEIVED
SEP 13 1995
Environmental Bureau
Oil Conservation Division

prepared for

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

August 1995

R/S RE/SPEC INC.
RESEARCH SPECIALISTS

TELEPHONE
(505) 748-3311

EASYLINK
62905278

Navajo **REFINING COMPANY**

501 EAST MAIN STREET • P. O. BOX 159
ARTESIA, NEW MEXICO 88211-0159

FAX
(505) 746-6410 ACCTG
(505) 746-6155 EXEC
(505) 748-9077 ENGR
(505) 746-4438 P / L

August 31, 1995

Mr. William K. Honker, P.E.
Chief, RCRA Permits Branch
U.S. Environmental Protection Agency, Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202

RE: Transmittal of the revised Corrective Measures Study Workplan, Pond 1, Navajo Refinery, Artesia, New Mexico, August 1995

Dear Mr. Honker:

Please find enclosed a revised and expanded Corrective Measures Study (CMS) Workplan for the above-referenced solid waste management unit. The original workplan was submitted to EPA in August, 1994 with a revision submitted on December 15, 1994. The current version of the workplan has been extensively rewritten in response to EPA comments transmitted to Navajo correspondence dated January 25 and April 13, 1995.

The December 1994 revision presented the results of an environmental risk assessment (RA) using the premise of a residential exposure scenario which evaluated human health risk posed by direct oral ingestion of contaminated soil and groundwater. The December report also presented documentary evidence that demonstrates the very small potential that the site and immediate downgradient area would ever be used for residential habitation due to the ready availability of other land, the naturally poor quality of the native groundwater which requires treatment prior to human consumption and the relatively frequent inundation of the flood plain alluvium.

EPA's review of the December CMS solicited additional clarification on a number of points presented in the report and requested additional risk assessment of soils and groundwater based upon human health impacts from direct exposure to soils by workers who may visit the site on a temporary basis, and to ecological receptors (i.e. cattle, small mammals, birds) who may visit or forage at the site and inhale or ingest soil or plant material. EPA also requested an RA be performed for indirect effects due to food-chain concentration by persons consuming cattle which may have grazed on plants at the site, or by raptors or predators consuming small animals. Finally, EPA requested that impacts on livestock from drinking groundwater with elevated levels of toxic constituents be determined, and required that the potential impact of groundwater seepage to the Pecos River be evaluated.

In response, to EPA's requests, Navajo has conducted risk assessments, reviews and evaluations as a follow-up to our December 1994 CMS using conservative assumptions (i.e. elevated levels of toxic constituents, long exposure duration, etc.) as prescribed in various EPA guidance documents. Without exception, the results of these latter exercises demonstrate the absence of any unacceptable risk to human health through direct and indirect exposure pathways. Similarly, the reviews demonstrate the absence of an ecologically significant risk to animal life, including mammals, birds or fish, from conditions as they exist today without any further remediation or restorative action by Navajo.

On the basis of new information and findings ensuing from the additional evaluations prompted by EPA review comments of the December 1994 CMS, Navajo is proposing to limit future corrective actions to the indefinite control of the site property. Future land use will be restricted through retention of ownership, deed restrictions and access site controls. This will ensure the human residential scenario evaluated in the RA cannot occur, and allow the monitoring of soils and/or groundwater on an as-needed basis for continued demonstration of low exposure conditions.

Navajo remains prepared to enter into discussions and dialogue with the EPA on the types and frequencies of monitoring to be undertaken at the site once the currently active ponds are closed through separate agreements. In the meantime, should you have any questions, please do not hesitate to contact me or David Griffin, Manager of Environmental Affairs for Water and Waste at (505)748-3311.

Sincerely,

Phillip L. Youngblood
Director of Environmental Affairs

PLY/sj

Enclosure

ATTACHMENT 1

RESPONSE TO JANUARY 1995 EPA REGION 6 COMMENTS ON THE DECEMBER 1994 REVISED EVAPORATION POND 1 CMS WORKPLAN, NAVAJO REFINERY, ARTESIA, NEW MEXICO

COMMENT:

Page 24; Table 3-5: ***What are the units of measure for the semivolatile compounds, is it 150 ug/kg or mg/kg?***

RESPONSE:

The concentration units for all organic constituents presented in Table 3-5, which includes both volatile and semivolatile organic constituents, are mg/kg, as indicated in the title of the table.

COMMENT:

Page 33; 3rd paragraph: ***Please give further justification why 10,000 ppm TPH is a reasonable remediation goal for Pond 1. NMED guidelines for TPH cleanup is 1,000 ppm, the New Mexico UST program is 100 ppm and NMOCD guidelines are 100 to 1,000 ppm. NMED has approved a 1,000 ppm TPH level for contamination at Holloman AFB.***

RESPONSE:

As a result of additional risk assessment requirements required by two rounds of EPA review comments and a June 2, 1995 meeting at EPA Region 6 headquarters in Dallas Texas, the current revised version of the CMS Workplan includes risk evaluations that consider a variety of direct and indirect environmental exposure pathways for both human and non-human receptors. Consequent to those evaluations, Navajo believes that sufficient information has been developed to demonstrate that environmental contaminants in Pond 1 soils and groundwater are not likely to pose a substantial risk to any of the modeled contaminants receptors. Therefore, Navajo now proposes to permit the site to naturally revegetate so that it may be potentially available to be used as rangeland for livestock production, according to the agricultural land use scenario now included under Section 3.6 of the current version of the CMS Workplan. However, in the interest of providing further insight into the nature of hydrocarbon contaminants present in site soils, the following paragraphs have been included regarding the relative appropriateness of TPH cleanup criteria for Pond 1 soils.

It is technically inappropriate to apply the cited NMED and NMOCD regulations and guidelines to the Navajo Evaporation Ponds for several reasons. The residual hydrocarbon contaminants in Pond 1 primarily consist of high molecular weight molecules exhibiting extremely low solubility characteristics. Despite the fact that these hydrocarbons have been accumulating in the unit for over 50 years, under continuously saturated soil conditions where they were also continuously subjected to several feet of overlying hydraulic head, they have failed to migrate significantly beyond the uppermost portion of the soil profile, even where present at concentrations in excess of 10 percent oil and grease (approximately 100,000 mg/kg TPH). These facts alone are sufficient to demonstrate the extreme lack of mobility of these materials through the soil profile, even under highly favorable leaching conditions. The hydrocarbon materials contained in Pond 1 now reside in a permanently de-watered unit subject to a semi-arid climate in which the soil moisture regime consistently exhibits an extreme annual water deficit (in excess of 50 inches per year), and their present and future potential to leach to underlying groundwater is now greatly diminished.

The above-referenced New Mexico agency guidance TPH remediation standards were established with the sole intent to eliminate the potential leaching of mobile hydrocarbon contaminants from the soil profile to ground or surface waters. The guidance standards are extremely broad in scope, are intended to provide a conservative margin of environmental safety over a broad range of potential site conditions, and consider a far broader spectrum of hydrocarbon materials than those contained in Pond 1 soils. In contrast, there is ample evidence to indicate that contaminants in Pond 1 soils pose relatively minimal potential to leach to groundwater. Considering that a large database has been assembled to characterize the environmental setting and contaminant characteristics of Pond 1, reliance upon extremely broad, generic default standards designed for non-RCRA environmental programs is neither appropriate nor warranted.

For reference purposes, each of the agency guidance policies are discussed in the Addendum provided at the conclusion these comments.

COMMENT:

Page 34; Proposed Alternate Concentration Limits for Groundwater: ***A cleanup determination by EPA on the groundwater media must include contamination from all ponds. Therefore, a determination on ACL's will not be made at this point. However, the risk assessment information is still necessary.***

RESPONSE:

This comment requires no response.

COMMENT:

Page 38; last paragraph: ***How deep will the soils in the central area of Pond 1 be excavated for treatment?***

RESPONSE:

As discussed above, further corrective actions are no longer proposed for the site.

COMMENT:

Page 38; 2nd paragraph: ***How will Navajo ensure that surface soils with higher metal concentrations will be placed back in their original stratigraphic order after treatment?***

RESPONSE:

As discussed above, further corrective actions are no longer proposed for the site.

COMMENT:

Page 38; 4th paragraph: ***EPA questions whether Navajo's bioremediation cleanup goals can be met in two years without supplemental moisture added periodically? Please explain how bioremediation will be successful without irrigation of soils?***

RESPONSE:

As discussed above, further corrective actions are no longer proposed for the site. However, the general issue of the relative importance of natural bioremediation rates for site soils is worthy of consideration. Navajo acknowledges that there is considerable uncertainty associated with the rate at which hydrocarbon materials will biodegrade at Pond 1. However, there is no reason to believe that a slower rate of remediation occurring at the unit will result in detrimental environmental effects. The revised CMS Workplan has compiled and presented sound documentation and analyses to demonstrate that Pond 1 soils do not pose a significant health to human health and the environment prior to total biodegradation of organic soil contaminants.

COMMENT:

Page 39; last paragraph: ***Please clarify whether the final vegetative cover is grass and trees, or only trees?***

RESPONSE:

As a result of the extensive risk analyses conducted to evaluate environmental contaminants at the unit, Navajo now proposes to allow the site to naturally revegetate. When revegetated, the vegetative cover will consist of grasses, forbs and some interspersed saltcedar trees

COMMENT:

Page 40; ***1st paragraph: Navajo mentions that preliminary soil verification will be performed to determine whether the soils have been treated. Does this mean that every sample tested must meet the remediation goal?***

RESPONSE:

As discussed above, further corrective actions are no longer proposed for the site.

COMMENT:

Page 40; 3rd paragraph: ***Navajo needs to provide a schematic of the soil sampling for Pond 1 in the revised CMS plan. In addition, how deep will each soil sample be taken?***

RESPONSE:

As discussed above, further corrective actions are no longer proposed for the site.

COMMENT:

Page 41; Post-Remediated Revegetation Strategy: ***Please address the following questions pertaining to the salt cedars in the revised CMS Workplan:***

1. ***The effect the salt cedar trees would have on the groundwater as far as an increase in salt concentrations in the groundwater;***
2. ***Accumulation of metals in the tree itself;***
3. ***Ability of tree to intake and process the pollutants of concern; and***
4. ***Effect of the tree roots as a potential pathway for contaminants to move downward.***

RESPONSE:

The saltcedar revegetation plan previously proposed in the revised August 1994 submittal of the CMS Workplan was explicitly intended to preclude potential exposure of ecological receptors to site soil contaminants. However, at the time of the June 2, 1995 meeting at EPA Region 6 headquarters, EPA personnel indicated that Pond 1 soil conditions should meet acceptable ecological risk criteria, regardless of the potential for a saltcedar revegetation strategy, to prevent exposure to such ecological receptors. Consequently, Navajo concluded, and EPA agreed, that the saltcedar revegetation plan served no reasonable purpose, and was dropped from further consideration.

COMMENT:

Page 41; Post-Remediated Revegetation Strategy: ***Navajo needs to include some requirements for the monitoring and maintenance of the levee around Pond 1 to keep floodwaters out of the unit.***

RESPONSE:

As discussed in the accompanying Attachment 2, the response to EPA's April, 1995, comments, the Navajo levee system is engineered to withstand a 100-year flood event from the Pecos River. Furthermore, because Pond 1 is now dewatered and no longer subject to potential influence of internal wave action and lateral seepage, the long-term stability of the levee system is thereby further enhanced. For these reasons, the Pond 1 levee is expected to remain structurally sound and capable of excluding flood water for many years to come. However, Navajo understands that post-closure monitoring will be required until some as yet undetermined future date. Therefore, as discussed in Section 4 of the revised CMS report, Navajo proposes to routinely inspect the levee system at the time of routine post-closure monitoring events.

COMMENT:

Page 45; 1st paragraph: ***EPA will specify during the corrective measures implementation phase what information must be submitted during the remediation of Pond 1. This will occur after the remedy selection process has been completed.***

RESPONSE:

Based on the available information and risk analyses, Navajo does not believe that further monitoring of Pond 1 soils is warranted.

COMMENT:

Page 46; Interim Groundwater Monitoring: ***EPA may require interim groundwater monitoring requirements during Pond 1 remediation.***

RESPONSE:

Navajo anticipates that a required groundwater monitoring program will be best addressed in the context of the Evaporation Pond system taken as a whole, and expects to enter into a dialog with EPA on the type, frequency, and duration of monitoring to be required.

ADDENDUM TO THE NAVAJO RESPONSE TO JANUARY 1995 EPA REGION 6 COMMENTS ON THE DECEMBER 1994 REVISED EVAPORATION POND 1 CMS WORKPLAN

REMARKS IN RESPONSE TO EPA COMMENTS ON THE APPLICABILITY OF USE OF TPH AS A REMEDIATION GOAL

NMOCD Guidelines

TPH remediation goals recommended by NMOCD for soils contaminated by oil field products or wastes are contained in two documents, Guidelines for Remediation of Leaks, Spills, and Releases, and Unlined Surface Impoundment Closure Guidelines. The recommended TPH remediation levels are set forth in these documents at Part IV A(2)(b) and II A(2)(b), respectively. Under both sets of guidelines, the recommended TPH remediation levels range from 100 to 5,000 ppm.

The NMOCD remediation guidelines were promulgated to address RCRA-exempt products and wastes generated during crude oil and natural gas exploration and production (E&P) activities. The regulated wastes are highly variable in character, and include materials such as waste crude oil, produced waters from crude oil and natural gas production, various liquid hydrocarbon fractions separated at the production area, tank bottoms and impoundment sludges.

As is the case for the NMED UST standards discussed below, the TPH remediation goals specified under the NMOCD guidelines are designed to limit the leaching potential of generic (E&P) hydrocarbon contaminants to underlying groundwater and adjacent surface waters. For both sets of NMOCD guidelines, the maximum allowable TPH remediation levels specified in the guidance are established solely on the basis of surface and groundwater considerations that consist of: Depth to groundwater; distance to groundwater extraction and utilization areas; and distance to surface water bodies. Thus, the NMOCD TPH guidelines represent generic standards established solely on the basis of hydrocarbon leaching potential considerations which necessarily encompassed a broad range of potential hydrocarbon materials occurring under an even broader set of potential site settings. As such, the NMOCD guidelines must be highly conservative in character.

The guidelines explicitly reserve NMOCD the latitude to waive remedial goals when "an evaluation of risk may be performed and provided to OCD for approval showing that the remaining contaminants will not pose a threat to present or foreseeable beneficial use of fresh water, public health and the environment." Through the RFI and CMS processes, Pond 1 has been extensively characterized in terms of the nature of existing contaminants, local environmental setting, and potential environmental hazards. It is both feasible and appropriate to establish an optimized, site-specific remediation standard for the hydrocarbon contaminated soils at Pond 1. None of the guidance and recommendations contained in the cited NMOCD documents are in conflict with this position.

NMED UST Guidelines

In terms of the residual hydrocarbon materials currently contained in Pond 1 soils, the most comparable soil treatment standard permitted by the NMED UST program is set forth at section 1209D(3)(b) of the NMED Underground Storage Tank Regulations (EIB/USTR-12). This section specifies a final soil remediation standard of 100 ppm TPH for soils contaminated by diesel fuel, motor oil, heating oil, kerosene, jet aviation fuel, or other heavy petroleum products.

As is the case for the NMOCD guidance criteria, the soil remediation standards promulgated under the UST regulations program were established solely on the basis of the potential for leaching of the regulated hydrocarbon products to groundwater. This conclusion is readily surmised from the fact that, in the UST regulations: remedial action criteria for soils consistently take into account depth to groundwater and groundwater quality; with the exception of a 10 mg/kg soil maximum for benzene (which represents the theoretical maximum soil concentration that would not yield a TCLP leachate concentration in exceedance of the TC rule limit for that constant), maximum allowable soil concentrations are not specified for any hydrocarbon constituent. Thus, it is clear that the 100 ppm TPH remediation standard specified at 1209D(3)(b) lacks a direct health-based rationale, but is instead intended to represent a conservative standard protecting underlying groundwater from a hydrocarbon release originating in overlying soils.

Due to the comprehensive nature of the regulations, it is clear that the stringency of the specified TPH concentration standard was necessarily determined by those petroleum product(s) listed at 1209D(3)(b) that possess the highest potential mobility when released to a generic subsurface soil environment. The petroleum products included at 1209D(3)(b) are highly variable in character. The average carbon number (number of carbon atoms per molecule) for the listed products ranges from approximately C11 to C13 (kerosene and jet fuels), to greater than C25 (heavy-end petroleum products). It is a well-documented fact that, with increasing carbon number, hydrocarbon viscosity and affinity to sorb to soil matrices also increases, while overall volatility and water solubility decrease.

For the petroleum products listed at 1209D(3)(b), jet fuels possess the lowest average carbon number (C11 to C13) and the highest concentrations of potentially mobile organic constituents. For example, representative chemical characterizations are available for the military-specified JP-4 and JP-5 jet fuels. A representative JP-4 mixture typically contains 2,200 ppm total xylenes and 5,700 ppm naphthalene. JP-5 typically contains 5,000 ppm benzene, 13,300 ppm toluene, 3,700 ppm ethylbenzene, and 23,200 ppm total xylenes (Riser-Roberts, 1992. Thus, when expressed on a weight basis, a JP-5 mixture can contain as much as 4 to 5 percent total BTEX constituents.

It is apparent that the 100 ppm TPH remediation standard established under the UST program for hydrocarbon contaminated soils was designed to take into account factors such as a potentially high BTEX concentration and correspondingly high mobility potential for those constituents. The hydrocarbon materials contained in Pond 1 soils possess very little resemblance to the residual organic constituents expected to be found in soils contaminated by petroleum products such as those described above, and for which the remediation goals set forth at section 1209D(3)(b) of the NMED Underground Storage Tank Regulations are applicable.

The NMED UST regulations constitute a set of generic standards intended to be safely applied to all possible site circumstances and environmental settings across the entire state of New

Mexico. Because these regulations and standards endeavor to be comprehensive for all possible site circumstances, they are necessarily highly conservative in character. Meanwhile, under the framework of the RCRA RFI and CMS programs, considerable time, expense, and energy have been devoted to developing an extensive site-specific environmental characterization of Pond 1. Reliance upon a stringent default cleanup standard intended for hydrocarbon contaminants bearing little similarity to those currently present at the unit is not warranted on the basis of the numerous technical facts and considerations described herein. Based on site-specific information and sound principles of environmental science, it is both feasible and appropriate to establish an optimized, site-specific remediation standard for the hydrocarbon contaminated soils at Pond 1.

NMED Guidelines

For purposes of clarification, the review comment citing an NMED guideline for a 1,000 mg/kg TPH remediation standard presumably refers to the TPH remediation standard approved by NMED for a site (or sites) located at Holloman Air Force Base. Navajo has no information concerning circumstances surrounding the 1,000 ppm TPH remediation standard, and is therefore unable either to assess either the technical appropriateness of the approved remediation goal either for the site in question or its relevance to Pond 1.

ATTACHMENT 2

RESPONSE TO APRIL 1995 EPA REGION 6 RISK ASSESSMENT COMMENTS ON THE DECEMBER 1994 REVISED EVAPORATION POND 1 CMS WORKPLAN, NAVAJO REFINERY, ARTESIA, NEW MEXICO

GENERAL COMMENT: *Below are the specific comments pertaining primarily to the risk assessment portion of the CMS. In addition to those comments, EPA would like to re-emphasize the following comments:*

1. *All risk assessment calculations and assumptions are to be included in the revised plan;*
2. *Navajo must include a preliminary ecological risk assessment in the revised CMS plan; and*
3. *Navajo must include an agricultural scenario for the assessment that includes a groundwater-animal-human pathway.*

RESPONSE:

1. The CMS has been revised to include the calculations and assumptions used in the human health assessment, which are presented as Appendix H of the revised CMS Workplan.
2. An assessment of potential ecological risks has been included in the revised CMS as Section 3.5.
3. Discussion of the specified scenario is presented in Section 3.6.2 of the revised CMS Workplan.

Page 5; Section 2.1.2, Groundwater: *Semi-volatiles were reported to be non-detect against practical quantitation levels in the range of 0.025 to 0.030 mg/l. This PQL range is 2-1/2 to 3 times the required practical quantitation limit listed in SW-846 method 8270. Please clarify whether this quantification limit is the norm or an exception in each groundwater sampling event and explain why the PQL is higher than it should be. In order for Navajo to conduct a complete risk assessment in groundwater, semivolatile data used in the assessment must meet the proper PQLs; otherwise elevated PQL levels must be used for each semivolatile constituent.*

RESPONSE:

As discussed during an April 6, 1995 telephone conference between Brian Sullivan and David Boyer of RE/SPEC Inc. (on behalf of Navajo) and Rich Mayer and Maria Martinez of EPA Region 6, and reiterated during the June 2, 1995 meeting at EPA region 6 headquarters between EPA and Navajo personnel, the EPA review comment does not represent an accurate interpretation of the purpose of OSWER-specified laboratory analytical practical quantitation limits (PQLs). The relevant section of SW-846 Method 8270 (SW-846 Method 8270, Table 2, p. 8270-7 states that: "PQLs are highly matrix-dependent. The PQLs listed herein are provided for guidance and may not always be achievable."

The latter part of this review comment concerns the selection of appropriate constituent concentrations in groundwater for purposes of estimating environmental risks to human health under a residential exposure scenario. During the aforementioned June 2 meeting, EPA personnel concurred with Navajo that risk management issues related to potential residential land use at the site were no longer considered to be relevant, so that further modification or elaboration of the previously submitted baseline human health risk assessment presented in Section 3-4 of the CMS Workplan was not necessary.

Page 6; Interim Corrective Measures: ***Navajo has been performing bioremediation activities at pond 1 since the fall of 1989. Please provide all soil monitoring data taken during this time so that EPA can review the effectiveness of the project to date.***

RESPONSE:

The existing soil sample data base, which includes analytical data generated from the RFI Phase II and a follow-up November, 1993 sampling event are presented at Appendix A and B of the revised CMS Workplan.

Page 7; 3.2, Comparison of Pond 1 Soil Sampling Data to 40 CFR Part 503 Standards: ***The comparison of 40 CFR Part 503 Standards to hazardous waste risk assessment guidance is not appropriate for this facility. Part 503 of the Clean Water Act governs sewage sludge from a Publicly Owned Treatment Plant (POTW) or for treatment facilities that deal exclusively with domestic sludge. Neither of these two characteristics apply to this particular facility. Part 503 sewage sludge regulations do not address organic constituents in their risk assessment procedures based on the assumption that any organic pollutants have either been banned, have restricted use in the United States have low percent of detection or limits are not expected to be exceeded in the sludge. Furthermore, Part 503 risk assessment procedures are not appropriate since it does not address direct ingestion of sludge either through inhalation or oral ingestion. Part 503 only addresses ingestion of sludge through ingestion of soil impacted by sludge mixed with soil not directly through the ingestion of sludge.***

RESPONSE:

Navajo maintains that the rationale and scientific foundation of the Part 503 risk comparison originally presented in the Pond 1 CMS Workplan is technically appropriate. The inclusion of the Part 503 comparison included in the Pond 1 CMS Workplan was intended to characterize postremediation site conditions in terms of various potential environmental risk posed by Pond 1 soils to human and non-human receptors, as estimated on the basis of an agricultural land use scenario. The use of the Part 503 soil criteria is considered to be highly appropriate and relevant for comparison with soil conditions at Pond 1.

The review comment stating that the Part 503 risk assessments did not address direct ingestion of metal bearing sludges is incorrect. In establishing metal loading limits for land-applied sludge regulated under the Part 503 Rule, EPA assessed environmental risks posed by several environmental pathways based on direct ingestion or inhalation of metal-containing sludges. For other pathways, environmental risks were modeled on the basis of the behavior of metal pollutants accumulated on an area of land, and then back-calculated from the total pollutant limits in a given area of land to derive a permissible sludge pollutant concentration. These factual observations regarding the risk assessment modeling conducting by EPA in the development of the Part 503 Rules are not disputable.

The reviewer states that the Part 503 regulations did not address organic pollutants in their risk assessment procedures. This statement is incorrect. While the final Part 503 regulations did not establish criteria for organic constituents in land-applied sewage sludge, considerable risk assessment modeling was conducted as part of the technical support effort conducted in development of the regulations to evaluate organic constituents. While the CMS did not attempt to use Part 503 risk assessment information in the comparison presented in the CMS Workplan, technical information for various environmental parameters (plant and animal uptake response slopes, human dietary consumption values, etc.) presented in the Part 503 risk modeling have subsequently been employed as appropriate for the additional risk assessment sections (ecological, food chain pathways) that have been added to the current revision of the CMS Workplan.

The general applicability of the Part 503 sludge rule is further confirmed by the fact that EPA has subsequently proposed to adopt major portions of the technical methods developed for the Part 503 program for use in the federal CERCLA program (Technical Background Document for Soil Screening Guidance, December 1994, EPA/540/R-94/106). Furthermore, since the Part 503 comparison was originally presented in the August 1994 and revised December 1994 CMS Workplans, the American Petroleum Institute (API) has subsequently published a report presenting metals criteria for land management of exploration and production (E&P) wastes. The metal criteria cited in the report (Metals Criteria for Land Management of E&P Wastes: Technical Support Document of API Recommended Guidance Values, Publication 4600, January 1995) were adopted directly from the Part 503 regulations.

Page 9; Table 3-1: ***In trying to evaluate the values on Table 3-1, it appears that the average concentration for the inorganic constituents was utilized for the calculation of the risk-based limits. The appropriateness of the average concentration being used to calculate the risk-based limits is questioned due to the wide variation of the reported concentrations in the soils for the inorganic constituents. It is necessary to address the variation of the data. If combining all data can be justified, then perhaps a better estimate of the exposure concentrations would be a calculated 95 percent upper confidence limit or use the highest concentration detected for each constituent.***

RESPONSE:

This comment pertains to the human health environmental risk assessment originally presented in the December 1994 revised Pond 1 CMS Workplan. During the previously mentioned meeting at Region 6 headquarters in Dallas, Texas on June 2, 1995, an agreement was reached between representatives of EPA and Navajo that the consideration of potential environmental risks posed by Pond 1 soils on the basis of a residential land use scenario were not relevant to site management issues. Furthermore, as also stated explicitly by the Navajo representative during the meeting, Navajo intends to impose deed restrictions on property usage to prohibit future residential land use at the Evaporation Ponds. Thus, both Navajo and EPA agree that further elaboration of the human health baseline risk assessment previously presented in the December 1994 Pond 1 CMS Workplan is not required.

However, for purposes of completeness and documentation, the human health risk assessment based on the originally residential land use scenario continues to be presented as Section 3.4 of the current August 1995 submittal of the revised Pond 1 CMS Workplan.

Page 13; Section 3.3.1, Potential for Future Industrial Use: ***EPA will require that industrial use be deed restricted. If in the future, Navajo decides to use the pond property for industrial use, EPA will require Navajo to submit an industrial risk assessment. EPA must approve the industrial risk assessment before Navajo can use the property for industrial operations.***

RESPONSE:

Navajo is fully prepared to develop appropriate and legal deed restrictions pertaining to future land use for the property at which Pond 1 is located. Navajo foresees that deed restrictions on property usage will include prohibitions on activities involving all potential land use which might reasonably be anticipated to result in human exposure beyond the probable exposure levels specified under the agricultural scenario presented at Section 3.6 of the current revised CMS Workplan, which involves agricultural activities related to livestock management.

Page 13-20; Section 3.3.2, Groundwater Suitability for Human Consumption: ***It is important to understand that the risk assessment should address potential beneficial uses. Additionally, the impacts of groundwater contributions to surface water i.e., Pecos River should be addressed in the risk assessment. Furthermore, potential ecological impacts by groundwater contributions to surface water need to be addressed as well.***

Page 2 of the transmittal letter accompanying the document states that the site is located in the 100-year flood plain of the Pecos River and is subject to recurring inundation from Pecos River flooding events. Thirty flooding events in the last thirty years have been documented. However, on Page 17 the report states that the ponds themselves are protected by dikes from inundation by the 100-year flood with the surrounding agricultural land not having any such protection. It is important to accurately characterize the site and its surroundings in order to

determine whether the assumptions made during the course of developing the exposure scenarios and specific routes of exposure are accurate.

References and/or documentation on saltcedar trees utilized for remediation/attenuation of contamination should be submitted to support their decisions. Additionally, phytotoxic effects by some of the contaminants present at the site on the vegetation i.e., grasslands and saltcedar trees should be addressed. Since phytotoxic effects are characterized by low yield and stunted growth, the facility should address how they intend to address these impacts on the vegetation they are depending on for the attenuation of the contamination at the site.

Calculations for the human health risk assessment should be included in the report in order to verify accuracy of final results. Potential ecological impacts should also be addressed in an preliminary ecological risk assessment e.g., endangered species.

RESPONSE:

The list of items included under this comment are addressed individually in the following sections.

It is important to understand that the risk assessment should address potential beneficial uses. Additionally, the impacts of groundwater contributions to surface water i.e., Pecos River should be addressed in the risk assessment.

An evaluation of potential impacts of groundwater contributions to the Pecos River have been addressed at Section 3.7 of the revised August 1995 CMS Workplan.

Furthermore, potential ecological impacts by groundwater contributions to surface water need to be addressed as well.

The discussion concerning the groundwater contributions to the Pecos River presented in Section 3.7 demonstrates that potential contributions of groundwater-borne waste constituents to the river will not exceed State of New Mexico Stream Water Quality Standards, as discussed in that section. Therefore, it has been concluded that significant ecological perturbations within the aquatic environment of the river can not be reasonably anticipated.

Page 20; Section 3.4, Human Health Risk Assessment for Pond 1 Soils and Groundwater: *Flooding of the area was mentioned in the summary pages of the report. Potential contaminant contributions through surface runoff to surface water or groundwater should be addressed in the risk assessment.*

RESPONSE:

This issue was addressed during the June 2, 1995 meeting at EPA Region 6 headquarters. The evaporation pond berm system was originally designed to maintain sufficient freeboard to avoid overtopping of wind-generated waves. The berms are engineered structures whose design required the approval of a certified professional engineer. Berm design specifications were driven by internal containment requirements that incidentally represent a margin of over specification to withstand waters produced by a 100-year flood event from the adjacent river. Therefore, potential contaminant migration pathways involving surface runoff from the unit do not constitute a relevant consideration.

Page 23; Section 3.4.1, Data Collection and Evaluation: ***It is recommended that lead be addressed in the human health risk assessment. The IEUBK model, although conservative, may yield results that can support the facility's decision not to further address the lead present at the site. The document should also be corrected for the statement on paragraph four that reads, EPA's integrated uptake model (IUBK)...to establish a permissible soil lead concentration of 500 mg/kg." This statement contains several errors, namely, the name of the lead model, the actual application of the lead concentration and the actual value of the concentration. The name of the lead model is Integrated Exposure Uptake Biokinetic Model (IEUBK), the application of the suggested lead concentration is a residential screening level NOT a permissible level and the current value is 400 ppm (OSWER Directive # 9355.4-12, dated July 14, 1994). Additionally, the above mentioned directive also states that even where the soil lead concentrations are less than 400 ppm and where special circumstances such as agricultural or areas of ecological risk, shallow aquifers etc., these issues be addressed in the risk assessment.***

The document states that there was a limited amount of data in the data sets utilized for the risk assessment. The risk assessment should include the number of samples taken as well as the calculations used to derive the numbers reported. A final determination of the accuracy of the estimated potential risk cannot be conducted until this information has been evaluated.

For Tables 3-5 (page 24) and 3-7 (page 28), the listed detection limits are above the required detection limit by OSW of 0.6 mg/kg (Method 8270A). In order to proceed with the evaluation of risk, the detection limit would need to be used [as the] concentration for that chemical i.e., the concentration for benzo(a)pyrene would be 300 mg/kg.

The list of items included under this comment are addressed individually in the following sections.

It is recommended that lead be addressed in the human health risk assessment. The IEUBK model, although conservative, may yield results that can support the facility's decision not to further address the lead present at the site.

As discussed above, the human health environmental baseline risk assessment previously developed under the assumption of a residential land use scenario has been determined to be no longer relevant to the technical deliberations associated with site management issues. However, for purposes of documentation and completeness, the baseline human health residential risk assessment discussion at Section 3.4.1 has been revised to include potential risks posed by lead in Pond 1 soils relative to the applicable lead criteria developed on the basis of the IEUBK model.

The document should also be corrected for the statement on paragraph four that reads, EPA's integrated uptake model (IUBK)...to establish a permissible soil lead concentration of 500 mg/kg." This statement contains several errors, namely, the name of the lead model, the actual application of the lead concentration and the actual value of the concentration. The name of the lead model is Integrated Exposure Uptake Biokinetic Model (IEUBK), the application of the suggested lead concentration is a residential screening level NOT a permissible level and the current value is 400 ppm (OSWER Directive # 9355.4-12, dated July 14, 1994).

As stated above, the baseline human health residential risk assessment has been revised to include a discussion of potential risks posed by lead in Pond 1 soils relative to the applicable lead criteria developed on the basis of the IEUBK model, and to indicate that the current residential soil standard for lead is now 400 mg/kg, as specified by the cited OSWER directive. Regarding the appropriate acronym for EPA's lead human exposure model, the Integrated Exposure Uptake Biokinetic model is variously referred to as the IUBK or IEUBK within the agency. The text has been revised to conform to the preference of the reviewer.

Additionally, the above mentioned directive also states that even where the soil lead concentrations are less than 400 ppm and where special circumstances such as agricultural or areas of ecological risk, shallow aquifers etc., these issues be addressed in the risk assessment.

The EPA-sponsored Land Application Technical Review Committee has previously noted that body burdens of animals fed up to 10 percent of their diet as sewage sludge did not change until the lead concentrations in the sewage sludge exceeded 300 mg/kg. Subsequently, this concentration value was established as the limiting lead concentration criteria for the Part 503 regulations. The average soil lead concentration reported for the Pond 1 soils used in the evaluation is approximately 177 mg/kg. No scenario can be foreseen in which the presumed agricultural land use (livestock production) could result in a lead ingestion rate approaching the specified 300 mg/kg lead criteria.

However, environmental fate and transport issues related to lead in Pond 1 soil have been extensively evaluated in the current CMS Workplan revision in the ecological risk analysis presented at Section 3.5. The relevancy of the findings regarding potential food chain risks posed by soil lead contamination under a livestock production scenario are discussed in Sections 3.6.2.2 and 3.6.2.3, respectively.

Regarding the potential for lead to migrate to groundwater, Navajo believes that a review of the RFI Phase II analytical data for Pond 1 soils, which includes total lead concentration data, lead concentration trends with increasing soil depth, and TCLP analyses, aptly demonstrate the extremely minimal potential for the mobilization of lead constituents in Pond 1 soils. Further, the extensive body of groundwater monitoring data provides further evidence to indicate that significant and widespread lead contamination of the shallow aquifer underlying the unit is not indicated. Therefore, Navajo is confident that the existing data is sufficient to demonstrate that lead constituents in Pond 1 soils pose little potential threat to the underlying shallow aquifer.

The document states that there was a limited amount of data in the data sets utilized for the risk assessment. The risk assessment should include the number of samples taken as well as the calculations used to derive the numbers reported. A final determination of the accuracy of the estimated potential risk cannot be conducted until this information has been evaluated.

The RFI Phase II soil sample locations and groundwater monitoring wells from which analytical data was obtained for use in the baseline risk assessment, as well as all analytical data for those same sampling locations are presented in their entirety in Tables 3-4 through 3-6 of the CMS Workplan, and the text associated with those tables has been revised to indicate this fact. These sampling locations are those which were originally specified by EPA in their Review Comments for the August 1994 CMS Workplan for inclusion in the human health-based risk assessment. The text of the residential baseline risk assessment has also been revised to explicitly identify the sample locations and total sample numbers presented in Tables 3-4 through 3-6.

For tables 3-5 (page 24) and 3-7 (page 28), the listed detection limits are above the required detection limit by OSW of 0.6 mg/kg (Method 8270A). In order to proceed with the evaluation of risk, the detection limit would need to be used [as the] concentration for that chemical i.e., the concentration for benzo(a)pyrene would be 300 mg/kg.

As discussed above, EPA and Navajo agree that estimation of potential human health risks posed by Pond 1 soils under the assumptions of a residential land use scenario will require no further evaluation during the course of the RCRA Corrective Action Program process.

However, Navajo is compelled to address the underlying concern that apparently provoked this review comment. It is reasonable to assume that a number of semivolatile constituents are present in Pond 1 soils at concentrations below the relatively elevated detection previously obtained for Pond 1 soil samples. But on the basis of fundamental knowledge of the characteristics of the waste stream formerly received by Pond 1, it is highly unlikely that semivolatile organic constituents are present in Pond 1 soils at such concentrated proportions.

For purposes of the human risk assessment presented in the December 1994 Pond 1 CMS Workplan, the assumed presence in Pond 1 soils of semivolatile constituents at concentrations representing one-half the previously obtained average detection limit values (150 mg/kg) is believed to represent a highly conservative assumption. In this regard, the analytical results for surface soil sample EP-TR-003-01 are of potential relevance. For this sample, a detection limit of 6.0 mg/kg was achieved for most of the Method 8270 semivolatile constituents. However, among the 66 constituents analyzed, only a single detection (phenanthrene, 8.0 mg/kg) was reported. The reported oil and grease concentration for this sample was seven percent (see RFI Phase II Report for Three-Mile ditch and Evaporation Ponds, Volume III). Therefore, elevated hydrocarbon content in Pond 1 soils, which has resulted in elevated PQLs due to matrix interference, doe not necessarily imply a corresponding abundance of semivolatile organic constituents. Further, no physical or chemical mechanisms can reasonably be postulated that would account for a radically dissimilar ratio of semivolatile constituents to total hydrocarbons for other Pond 1 soil samples.

Therefore, in consideration of basic knowledge of refinery operations and waste stream characteristics and the available analytical evidence, there is no rational basis to anticipate that many semivolatile constituents are present in Pond 1 soils (however infrequently) at the concentration proposed by the (300 mg/kg) for use in the residential scenario risk assessment. However, for several subsequent risk analysis components presented in the revised CMS Workplan (Sections 3.6.1, 3.6.2.3), the average semivolatile organic detection limit of 300 mg/kg has been adopted as a default soil concentration estimate for purposes of the exposure analyses.

Page 25: ***Since the detection limits for the semivolatile organics were deemed too high, the appropriateness of utilizing only half of the detection limit is questionable. Typically the value equaling to half the detection limit is used when the detection limit is acceptable. However, in this case it would be more appropriate to used the "high" detection limit value. It is important to understand that this is not the manner in which exposure concentrations should be calculated, however, it is the best approach in light of the high detection limits.***

See response to previous comment.

Section 3.4.2; Risk Assessment for Pond 1 Soils: ***It is not clear what is meant by a residential occupation scenario. Different exposure scenarios were used for calculating potential risk to systemic toxicants versus carcinogenic constituents. That is, children exposure factors were utilized for the systemic toxicant, whereas, adult exposure factors were utilized for the carcinogenic constituents. This approach although conservative does not result in any benefit to adequately address potential risk at the site since the assumptions made during the calculation of risk are discounted in the discussion on page 27. This discussion further discounts the value of the risk calculations based on data with high detection limits.***

RESPONSE:

As discussed above, EPA and Navajo understand that estimation of potential human health risks posed by Pond 1 soils under the assumptions of a residential land use scenario will require no further evaluation during the course of the RCRA Corrective Action Program process.

Section 3.4.3; Risk Assessment for Pond 1 Groundwater: ***Groundwater quality should be addressed on potential uses. The risk assessment was based on an residential exposure scenario. The conclusions discounted the applicability of that exposure scenario but does not offer an alternative. However, the residential scenario came up with unacceptable risks.***

Additionally, the revised risk assessment needs to address the effects of animals drinking the contaminated water and the potential exposure via bioaccumulation and uptake through the food chain i.e., ingestion of potentially contaminated animal food products by humans.

It has been reported throughout the RFI process that there are a number of tentatively identified compounds (TICs) in many of the groundwater samples taken around the ponds. Special analytical services (SAS) may be warranted to identify and reliably quantify the risk assessment. This becomes vital especially when there are multiple TICs present. In either case, TICs should be discussed in the risk assessment. This approach is discussed in RAGS (see Sections 5.6.1 and 5.6.2 of RAGS Part A).

The various comments are addressed individually in the following paragraphs.

Groundwater quality should be addressed on potential uses. The risk assessment was based on an residential exposure scenario. The conclusions discounted the applicability of that exposure scenario but does not offer an alternative. However, the residential scenario came up with unacceptable risks.

This comment appears to acknowledge that a residential exposure scenario is not appropriate for risk evaluation at the unit. Navajo has addressed non-residential use of water in Section 3.6.2.1 where potential consumption by livestock is discussed with arsenic considered the constituent of greatest concern. However, groundwater downgradient from Pond 1 currently meets NM Water Quality Control Commission standard for arsenic in groundwater and is better than the non-domestic numerical standards shown in Table 3-14.

Additionally, the revised risk assessment needs to address the effects of animals drinking the contaminated water and the potential exposure via bioaccumulation and uptake through the food chain i.e., ingestion of potentially contaminated animal food products by humans.

In response the current CMS Workplan has been revised to include analysis and discussion of potential food-chain risks posed by site contaminants via groundwater and soils are discussed in Sections 3.6.2.1 through 3.6.2.3.

It has been reported throughout the RFI process that there are a number of tentatively identified compounds (TICs) in many of the groundwater samples taken around the ponds. Special analytical services (SAS) may be warranted to identify and reliably quantify the risk assessment. This becomes vital especially when there are multiple TICs present. In either case, TICs should be discussed in the risk assessment. This approach is discussed in RAGS (see Sections 5.6.1 and 5.6.2 of RAGS Part A).

Discussion of the potential significance of TICs in regards to potential environmental risks are discussed in Section 3.6.2.1 of the current revised version of the CMS Workplan.

EVAPORATION POND 1
CORRECTIVE MEASURES STUDY
WORKPLAN
(2nd Revision)

prepared for

Navajo Refining Company
Artesia, New Mexico

by

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

August 1995

David G. Boyer
David G. Boyer
Project Manager

Brian P. Sullivan
Brian P. Sullivan
Assistant Project Manager

Table of Contents

Table of Contents
(Continued)

Page

List of Tables

List of Figures

List of Appendices

EXECUTIVE SUMMARY

Navajo Refining Company (Navajo) operates a petroleum refinery located in Artesia, New Mexico (EPA I.D. No. NMD 048918817). Under the technical framework of the RCRA Corrective Action Program, a RCRA Facility Investigation (RFI) was required for an inactive facility wastewater evaporation pond known as Pond 1. Pond 1 received a refinery oily wastewater stream for approximately 50 years prior to becoming inactive in 1987.

Subsequent to the completion of the RFI investigation, this document presents the findings of a revised Corrective Measures Study (CMS) Workplan prepared for Pond 1. The original Pond 1 CMS Workplan was submitted to EPA Region 6 in August, 1994. Subsequent to additional EPA review comments, a revised CMS Workplan was resubmitted to the agency in December 1994. The revised December 1994 CMS Workplan presented new information estimating potential environmental risks posed to human health by site contaminants, and a more detailed characterization of the site setting as it relates to the feasibility of alternative future land usages. On the basis of the new information presented in the revised December Workplan, EPA requested that Navajo conduct a number of additional environmental risk analyses which were intended to examine Navajo's assertion that residual site contaminants posed minimal risk to human health and the environment.

Previous submittals of the CMS Workplan presented environmental risk analyses based on agricultural and residential land use scenarios. Potential environmental risks posed by persistent metal contaminants in Pond 1 soils were compared using environmental pathway fate and transport models developed in support of EPA's municipal sludge land application rules. The EPA risk analyses assumed a prevailing agricultural land use scenario, and are considered by Navajo to constitute and appropriate basis of comparison for the metal contaminants in Pond 1 soils. An environmental baseline human health risk analysis was also conducted on the basis of standard EPA default assumptions for a residential exposure scenario.

The comparison of soil metals concentrations to the risk-based Part 503 metals criteria suggested that Pond 1 metal concentrations would pose minimal environmental risks based on a reasonable assumption that the Pond 1 property would revert to rangeland agricultural usage at a future date. The human health risk analysis conducted for the unit, which was established on the basis of a number of highly conservative assumptions, yielded a risk estimate that exceeded existing federal standards for permissible risk. However, several lines of evidence were also presented to indicate that the probability that the site will be used for human residential occupancy at a future date is extremely low.

In response to the findings of the completed risk evaluations and Navajo's contention that the site posed minimal risk under the single most reasonably anticipated land use (open range for livestock), EPA required that Navajo conduct an assemblage of additional risk analyses focusing on ecological systems and those environmental pathways that could be of significance under the most probable agricultural land use scenario. As summarized below, the results of the required additional environmental analyses presented in this revised CMS Workplan provide further documentation to demonstrate the relatively low level of environmental risks posed by site contaminants:

- A fundamental ecological risk assessment was developed according to a two-tiered food chain model in which a prey species experiencing considerable on-site exposure was subsequently consumed by a societally-valued bird of prey. Based on the available soils data and the future likelihood of greatly diminished organic constituent concentrations, arsenic and lead were identified as constituents of ecological concern. A series of reasonable exposure assumptions, which included 100 percent bioavailability, a bioaccumulation factor of 1.0 and several other conservative EPA default values, showed no significant indication of potential risk to the secondary receptor (bird of prey) was indicated.
- Estimation of human health risks posed by soil contaminants to a postulated ranch worker visiting the site on a regular basis yielded an acceptable level of risk, despite the fact that extremely conservative default soil concentration values were assumed for semivolatile organic constituents. Exposure to semivolatile constituents at assumed soil concentration levels which were set at the average soil sample analytical detection of 300 mg/kg yielded an overall incremental carcinogenic risk estimate of 7.53×10^{-5}. Approximately 95 percent of the cumulative risk was contributed by a single semivolatile constituent, benzo(a)pyrene. It is considered to be highly improbable that actual benzo(a)pyrene concentration levels in Pond 1 soils approach the assumed default concentration used in the risk estimation.
- A quantitative estimate of indirect risks to human health via food chain pathways involving human consumption of livestock which have previously been exposed to site groundwater was not undertaken. For EPA-designated inorganic hazardous constituents, recent groundwater sample data from wells downgradient of Pond 1 indicate that reported concentrations of these constituents do not exceed applicable State of New Mexico water quality standards for groundwater purposes (including livestock watering). Benzene, with a low bioaccumulation potential and relatively minimal concentrations in groundwater samples, was not identified as a constituent of concern for this food chain exposure pathway. For the various unidentified organic compounds reported in groundwater samples, no information exists regarding the identity of these compounds. If identified, it is probable that little information is available regarding their potential toxicological characteristics or bioaccumulative potential in livestock. However, no livestock watering wells are downgradient of the unit, and due to the documented poor background quality of the shallow groundwater and the nearby Pecos River, new livestock watering wells are considered unlikely. Further, livestock has been exposed to petroleum hydrocarbons with documented adverse effects much higher than the unidentified hydrocarbon levels seen in groundwater in the vicinity of the unit. Based on the above discussion, Navajo does not believe that further evaluation of this issue is justified.
- A direct quantitative risk estimate was conducted for the food chain pathway involving soils-plants-livestock to humans. On the basis of the existing soils database for the unit and the results of the previously described ecological risk assessment, inorganic and volatile organic constituents were eliminated as potential constituents of concern. Potential risks posed by semivolatile constituents were modeled on the assumption that benzo(a)pyrene, was the most potent carcinogen amongst the semivolatile constituents. In addition, numerous additional conservative factors were incorporated into the risk estimation methodology. On the basis of plausible assumptions regarding the extent and duration of exposure to postulated livestock receptors, and specifying a stringent 1×10^{-6}

acceptable risk level for humans, it was determined that the soil concentration for benzo(a)pyrene which would be required to exceed the permissible human carcinogenic risk level was approximately 6,450 mg/kg. This analysis provides a singular demonstration to indicate that the overall level of exposure to livestock receptors to all site contaminants in Pond 1 soils is so minimal as to be of negligible concern for the evaluated food chain pathway.

- A direct quantitative risk estimate was also conducted for the food chain pathway involving soils-livestock to humans, and which also incorporated most of the highly conservative default assumptions assumed above for the soil-plant-livestock-human food chain analysis. Results of the exposure analysis yielded a carcinogenic risk level of 3.4×10^{-6}, which even under the series of compounding conservatisms employed in the estimate, remains well within acceptable risk limits. Again, the minimal potential for exposure to livestock receptors was strongly indicated.
- An evaluation of potential risks to the environment resulting from seepage of contaminated groundwater to the Pecos River was also undertaken. Arsenic was identified as the sole constituent of concern for this pathway, based on existing concentrations in groundwater samples and its potential persistence in the environment. Hydrogeologic modeling of arsenic transport from groundwater to river incorporated numerous conservative assumptions, the most significant of which has arsenic concentrations remaining constant and non-attenuated with transport from zones of known contamination to areas of seepage into the river. Minimum river flow rate was represented by a low-flow volume expected to occur only once every three years. The modeling indicates that resultant total arsenic concentrations under low-flow river conditions would be approximately 0.006 mg/l, with a range of 0.003 to 0.025 mg/l. Under the conservative assumptions employed in the model, the best estimate and range value predictions for arsenic concentration in Pecos River waters are all significantly less than any existing water quality standards based on protective criteria for fish, livestock and humans.

The Navajo Evaporation Pond system is situated in a remote setting in which the nature of the surrounding landscape, which is best characterized as a desert grassland, results in a more dispersed distribution of vegetation and wildlife relative to other habitats. Based on these considerations alone, Navajo has maintained that the site posed little real risk to human health and the environment, and the diverse assemblage of risk analyses presented in this revised CMS provides additional evidence in support of this assertion. Pond 1 has now been the subject of a series of extensive environmental investigations and risk analyses, and no evidence can be found to indicate that contaminants within and released from the unit pose a meaningful threat of harm to human health and the environment. Consequently, no compelling reason has been identified to undertake further corrective actions at the unit.

In order to eliminate the potential for environmental risks posed by unit contamination under inappropriate land use scenarios, Navajo proposes to establish legal deed restrictions to ensure that land use at the site will be limited to the agricultural purpose (livestock grazing) for which it is best suited. Navajo also understands that some level of additional groundwater monitoring will be required during the unit closure and post-closure processes, and will work with EPA to develop an appropriate groundwater monitoring program.

1.0 INTRODUCTION

Navajo Refining Company (Navajo) operates a petroleum refinery located in Artesia, New Mexico (EPA I.D. No. NMD 048918817). The facility is regulated under the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984. At the time that the U.S. Environmental Protection Agency (EPA) conducted a preliminary review (PR) of the facility, certain facility areas were identified as solid waste management units. Among these were:

- An unlined waste water conveyance unit known as Three-Mile Ditch (TMD) operated from the 1930s to 1987; and
- The facility evaporation pond system.

The evaporation pond system consists of now inactive surface impoundment's known as Evaporation Pond 1 and Evaporation Pond 2, which formerly received waste water conveyed by the ditch, and a series of interconnected active evaporation ponds, which currently receive facility waste water conveyed via an underground pipeline. A site plan for the facility evaporation ponds system is presented as Figure 1-1.

Under the technical framework of the RCRA Corrective Action Program, EPA determined that a RCRA Facility Investigation (RFI) was required for these two facility units to characterize the nature and extent of releases of hazardous constituents. As a result, TMD and the evaporation ponds were the subject of RFI Phase I and Phase II investigations completed in 1990 and 1993, respectively.

As stated in May 19, 1994 correspondence from EPA to Navajo, EPA required that an RFI Phase III investigation be executed for TMD and the active evaporation ponds, together with the preparation of a Corrective Measures Workplan for Evaporation Pond 1. The RFI Phase III investigation was conducted in the winter of 1994-1995 and the RFI report was submitted to EPA in April 1995. The original version of the Corrective Measures Study (CMS) Workplan was submitted to EPA on August 20, 1994. EPA comments, dated October 7, 1994, required the preparation of additional sections, including risk assessment for soils and groundwater. The revised CMS was submitted to EPA on December 15, 1994. EPA subsequently responded to the December, 1994 submittal with two additional sets of review comments dated January 26, 1995 and April 13, 1995. The revised December 1994 CMS report included new information regarding environmental risk assessment and land use issues. Consequently, preliminary EPA review comments for the revised December 1994 CMS were largely focused on those same issues.

On June 2, 1995, representatives of Navajo Refining and RE/SPEC Inc. met with EPA personnel at EPA Region 6 headquarters in Dallas for the purpose of discussing risk assessment and risk management issues related to the ongoing development of a final CMS document for Pond 1. Based upon those discussions, it is Navajo's understanding that EPA and Navajo are in substantive agreement on a number of items as discussed below.

Human Residential Exposure Scenario Risk Assessment

The human health risk assessment presented in the revised December, 1994 CMS document was conducted under standard exposure assumptions employed under a residential land use scenario, and yielded an overall potential risk estimate that exceeded permissible federal environmental risk standards. However, under current land use patterns in the vicinity of the Evaporation Ponds, environmental risks to human health posed by contaminants in Pond 1 soils and groundwater in the vicinity of the unit are highly minimal. Furthermore, when taken as a whole, factors which include local demographic trends, the remote nature of the site, background water quality, the controlled nature of site access, and physical features of the site setting related to its location within the 100-year flood plain of the Pecos River, strongly indicate that future human occupancy of the site is highly improbable. Navajo is also expressly committing to the establishment of legal limitations on future site usages at Pond 1 (as well as the remaining units of the Evaporation Pond system) by appropriate property deed restrictions.

Based on these considerations, additional adjustments or elaboration of the current human health risk presented in the revised December, 1994 CMS document, which assumed a standard residential land use exposure scenario, are no longer deemed relevant to risk management at the site. No further modification or elaboration of the existing residential exposure assessment is required, but for purposes of complete documentation, the residential risk assessment will remain as part of the CMS, along with the additional inclusion of all calculations and assumptions (Appendix H), as requested by EPA in their April 13, 1995 CMS review comments.

Additional Human Health Risk Concerns

At the time of the June 2, 1995 discussions in Dallas between EPA and Navajo personnel, EPA adhered to the further assessment requirement, stated in their April 13, 1995 review comments for the revised December, 1994 CMS, that the document be revised to include consideration of an indirect human exposure pathway involving food chain transfer of environmental contaminants extending from groundwater to livestock to humans. In addition, the EPA risk assessment specialist in attendance also stipulated that human health risks also be evaluated according to a direct human exposure scenario in which an agricultural worker enters the Pond 1 area to tend grazing livestock. The current submittal of the CMS document has been modified to include the requested additional human health environmental risk evaluations.

Ecological Risk Assessment

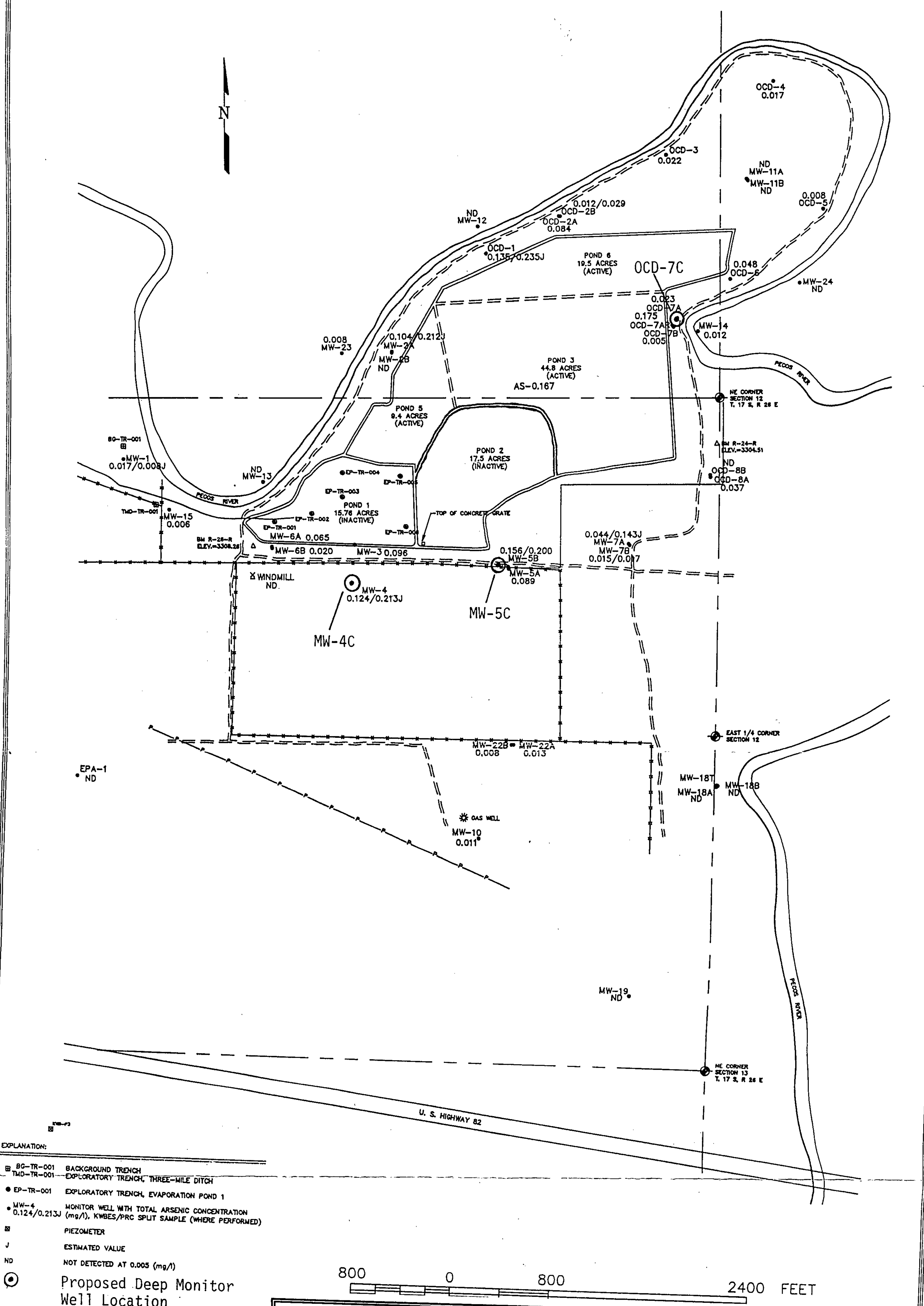
EPA personnel attending the June 2, 1995 meeting were resolute in their desire (initially communicated to Navajo in the review comments for the revised December, 1994 CMS Workplan) that Navajo conduct a preliminary assessment intended to address potential ecological impacts resulting from environmental contaminants present in Pond 1 soils, as well as assessing potential impacts of contaminated groundwater received by the Pecos River. The current CMS document has been revised to include the aforementioned evaluations of potential ecological risks. At the time of the meeting, Navajo noted that the post-closure revegetation plan proposed for the unit in the revised December, 1994 CMS was in large part formulated to ensure the elimination of unquantified potential future ecological risks. Consequently, with the conducting of an ecological risk assessment, EPA and Navajo agreed that the proposed revegetation strategy, which involved the establishment of a dense stand of saltcedar within the confines of Pond 1, was no longer required.

The development of an appropriate Corrective Measures approach for environmental contaminants at Pond 1 has been an evolutionary process. In the original August, 1994 submittal of the CMS Workplan, Navajo stated that "the potential for short and long-term risk to human health subsequent to direct exposure to unit soils is negligible," and further reasoned that corrective measures were necessary only to the extent necessary to establish a vegetative cover at the site. In response, EPA requested substantiation of Navajo's position of the limited nature of environmental risks posed to human health, with the result that the focus of the revised December, 1994 CMS Workplan shifted to encompass a more detailed evaluation of environmental human health risks posed by soil and groundwater contaminants.

As a result of the more detailed risk analyses presented in the revised December, 1994 CMS Workplan, EPA and Navajo are in general agreement that environmental risk management for the unit is closely linked to that form of land usage to which the unit and surrounding properties will in all likelihood ever be subjected (i.e., livestock grazing).

With the fulfillment of the additional human and ecological risk assessment analyses required by EPA, as communicated to Navajo in their April 13, 1995 review comments and at the time of the June 2, 1995 meeting at EPA Region 6 headquarters in Dallas, Navajo now believes that a sufficient degree of effort has been devoted to site risk analyses to demonstrate the minimal environmental risks posed by environmental contaminants at the site. Therefore, it is the judgment of Navajo that management of environmental risks at the unit should not entail further corrective actions beyond the interim actions already completed. Rather, risk management will depend upon institutional controls in the form of property deed restrictions intended to ensure that future site usage will not result in human exposure to residual site contaminants at levels which would potentially incur an unacceptable level of environmental risk.

The CMS Workplan is organized into four sections. Section 1 summarizes the unit's regulatory history and introduces the CMS. Section 2 describes the status of environmental conditions and interim corrective measures being conducted at the unit, and provides updated groundwater information not available at the time of the previous December, 1994 submittal of the CMS Workplan. Section 3 presents environmental risk analyses that consider various exposure pathways to human and non human receptors, identifies appropriate corrective measures objectives arrived at on the basis of the potential environmental risk, and identifies the appropriate corrective measures alternative designed to obtain the stated objectives. Section 4 presents the risk management strategy intended to ensure human health under future land use scenarios, short and long-term monitoring requirements for unit groundwater, proposed content and scheduling of routine unit inspections and maintenance, and proposed community relations activities.



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 2/9: JAQUESS & ASSOCIATES.

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

NOTE: KWBES ARSENIC CONCENTRATION SHOWN IS THE VERIFICATION ANALYSIS OR AVERAGE OF TWO VERIFICATION ANALYSES; IF NO VERIFICATION ANALYSIS WAS PERFORMED, VALUE SHOWN IS ORIGINAL CONCENTRATION.

RE/SPEC INC.
RESEARCH / SPECIALISTS

Navajo Evaporation Ponds Site Plan

prepared for:
Navajo

PROJECT: 318/2.1	
LOCATION: NAVAJO REFINERY, ARTESIA, NM	
APPR:	DATE: 11/23/93
DRAWN BY:	SCALE AS SHOWN
DATE: 4/27/93	FIGURE: 1-1

Figure 1-1 Navajo Evaporation Ponds Site Plan

2.0 SITE CONDITIONS AND INTERIM CORRECTIVE MEASURES

The following sections update and summarize the existing information and data for Pond 1 soils and groundwater underlying and adjacent to the unit (Section 2.1), and a description of previous and current interim corrective actions activities conducted at the unit.

2.1 Soil and Groundwater Conditions

Detailed discussions of climate, soils, geology and groundwater in the vicinity of the refining process areas, TMD, and the facility evaporation ponds were presented in the November, 1993 RFI Phase II report and summarized in the July, 1994 RFI Phase III workplan. An updated summary discussion of Pond 1 soil and groundwater information presented in the cited reports is provided in the following sections.

2.1.1 Soils

Pond 1 soils were evaluated for hydrocarbon content and hazardous constituents during the course of the units' Phase II RFI (KWBES, 1993). As part of the Phase II investigation, soil samples were obtained at various depths from five trackhoe-excavated trenches located within the unit, as well as from an additional surface grab sample obtained by the trackhoe from an area of unconsolidated sludges near the periphery of the unit.

The Phase II analytical data for the Pond 1 soils is summarized in Appendix A of this document. The data indicated that organic and inorganic contaminants were most heavily concentrated in the upper soils of the unit above a depth of 3 ft. The average percent oil and grease concentration reported in soil samples obtained at a one-foot sample depth was 10.4 % (Appendix A, Table 1). Oil and grease concentrations decreased markedly at sample intervals below the one-foot depth. At the three-foot sample interval, the average oil and grease concentration declined to 0.41%, with the average being skewed upwards by two samples collected at the trench locations completed proximal to the ditch influent point, which exhibited relatively elevated oil and grease concentrations (approximately 1%). At successive soil sample depth intervals below 3 ft., oil and grease concentrations became attenuated with depth (Appendix A, Table 1).

Supplementary soil sampling intended to further characterize soil TPH concentrations were also conducted at the unit in November, 1993. Sampling locations and analytical data for the November, 1993 soil sampling event are presented in Appendix B. The laboratory analytical data from that sample event yielded average TPH values of 4,100 mg/kg, roughly equivalent to an oil and grease concentration of 4.1%.

The RFI Phase II analytical results for inorganic metal constituents in Pond 1 soils indicated that elevated metal concentrations were limited to the upper portion of the soil profile within a few feet of the surface, with arsenic, chromium and lead being identified as potential metals of concern (Appendix A, Table 2). The apparent fixation of these three constituents in the upper soil profile was further confirmed by the results of TCLP testing, which failed to yield any TC exceedances.

Until late spring of 1995, Pond 1 was subject to interim corrective measures actions (see Section 2.2) conducted to remediate surface soils. As a result of those previous interim actions, the unit does not currently provide vegetative cover for wildlife, and neither supports or attracts vegetation-dependent populations of above-ground or subterranean vertebrate or invertebrate fauna. Consequently, there is little risk that contaminants contained in unit soils are entering the food chain or otherwise exerting a deleterious impact on the surrounding ecosystem (ecological risk considerations are presented in Section 3).

The potential risk for further contamination to groundwater underlying the unit is considered to be minimal. Although evidence of past hydrocarbons releases beneath the base of the unit have been documented, it is not indicative of the potential for residual hydrocarbons remaining within the soil profile of Pond 1 to be released from the unit. During active use, the pond contained wastewater fluids to a depth of 5-7 feet, which provided a significant hydraulic head for subsurface seepage. Also, the historical rate of hydrocarbon constituent releases from the unit was likely far higher in earlier decades due to lower rates of fractionation efficiency in the refining process. In all likelihood, inefficiencies in early period refinery processes resulted in a larger proportion of low-molecular weight hydrocarbons in the historical waste stream relative to later years of unit operation.

However, perhaps of much greater significance is the tangible physical evidence provided by the very persistence of the accumulated hydrocarbon materials within the unit. The bulk of the residual hydrocarbon constituents existing in Pond 1 soils are predominantly concentrated in the upper portion of the soil profile (Appendix A). Despite the fact that the hydrocarbon materials have been accumulating in the unit for over 50 years under continuously saturated soil, they failed to solubilize and migrate in significant quantities beyond the uppermost portion of the soil profile, even where present at concentrations in excess of 10 percent oil and grease (approximately 100,000 mg/kg TPH). These facts alone are sufficient to demonstrate the low mobility potential of these materials through the soil profile, even under highly favorable leaching conditions which formerly prevailed at the unit during its operational life.

The origin of the hydrocarbon waste constituents resulting from oil refining processes, together with their demonstrated lack of mobility in the upper profile of Pond 1 indicate that the residual contaminants consist primarily of high-molecular weight, low solubility constituents. In order to evaluate the chemical characteristics of these materials, a representative soil sample was obtained from the unit at a 0.5-foot sample depth and subjected to more detailed analysis. The laboratory report for the analysis is presented in Appendix C.

The soil sample was fractionated on the basis of diesel and crude range organic. Carbon numbers for molecules contained within those two hydrocarbon classes range from C-10 to C-18 and C-18 to C-44, respectively. The total TPH concentration was estimated to be 11,000 mg/kg, of which 22 percent (2,400 mg/kg) fell within the diesel range fraction (C-10 to C-18). Therefore, by subtraction, the remaining crude-range TPH concentration comprised approximately 78 percent (approximately 8,600 mg/kg) of the total 11,000 mg/kg.

A second analytical quantification conducted solely for crude oil range hydrocarbons yielded a TPH concentration of 10,000 mg/kg. The crude range analysis also characterized the distribution of hydrocarbon materials over a range of C-18 to C-44 (Table 2-1). According to that fractional characterization, nearly 70 percent of the total hydrocarbons within the crude range fraction fell within a size range from C-24 to C-44 (Table 2-1).

Table 2-1 Size Fractionation of Crude Range Hydrocarbons Extracted from Pond 1 Soils.

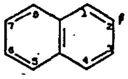
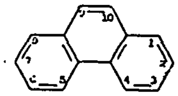
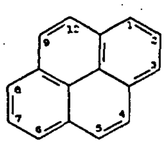
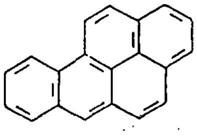
Size Fraction	Percentage
C-18	9
C-20	11
C-22	12
C-24	16
C-26	13
C-28	15
C-30	11
C-32	10
C-34-36	2
C-40	1
C-44	0.2

The crude range analysis also provides indirect information regarding the distribution of hydrocarbons within the diesel range fraction. On the basis of two analyses, the total hydrocarbon concentration falling within the crude oil fraction ranged between 8,600 to 10,000 mg/kg. As shown in Table 2-1, approximately 9 percent of the total crude oil fraction consisted of hydrocarbons in the C-18 hydrocarbon range. Therefore, the C-18 fraction of the crude oil range organics comprised approximately 774 to 900 mg/kg of the total crude range hydrocarbons.

Based on the observations that diesel range organics in the soil sample were quantified at 2,400 mg/kg (Appendix C), and that the proportion of sample hydrocarbons within the C-18 range was approximately 774 to 900 mg/kg, then the data indicates that between 32 to 37 percent of all diesel range hydrocarbons occur at the uppermost end of the diesel range. Since years of exposure to leaching and weathering can not be expected to have resulted in a bimodal distribution of molecular size classes for the hydrocarbons in unit soils, the analytical data would appear to indicate that diesel range hydrocarbons are skewed towards the upper end of that range and, like the heavier crude range hydrocarbons that dominated the sample, exhibit relatively low solubility characteristics.

The analytical results described above are highly consistent with observations regarding the placement of hydrocarbon contaminants within the soil profile. As a general rule for hydrocarbon compounds, relative mobility in a soil environment decreases as carbon number increases. However, as reflected in water solubility characteristics, the relationship between carbon number and constituent mobility is significantly nonlinear. Table 2-2 presents a summary of the water solubility characteristics for a series of alkane and aromatic hydrocarbons within a range between C-5 to C-20. As shown in Table 2-2, a three-fold increase in carbon number from pentane to tetradecane is associated with nearly a 60,000-fold decrease in water solubility. For aromatic hydrocarbons, trends of differential solubility with increasing hydrocarbon number are even more pronounced within the range of evaluated hydrocarbons. A slightly greater than three-fold increase in carbon number between benzene (C-6) and benzo(a)pyrene(C-20) is associated with a 445,000-fold decrease in water solubility. In consideration of the apparent nature of the residual hydrocarbons within the unit and the nature of the site setting, the residual hydrocarbons are not expected to pose significant risks to further impact the quality of groundwater downgradient of the unit.

Table 2-2 Relationship Between Carbon Number and Water Solubility for Select Hydrocarbon Constituents

CONSTITUENT	CARBON #	CHEMICAL STRUCTURE	H_2O SOLUBILITY (mg/1)	H_2O SOLUBILITY RATIO (pentane:alkane)
n-ALKANES				
pentane	5	C-C-C-C-C	38.5	1
heptane	7	C-C-C-C-C-C-C	2.9	13.3
decane	19	C-C-C-C-C-C-C-C-C-C	0.052	740
dodecane	12	C-C-C-C-C-C-C-C-C-C-C-C	0.0034	11,323
teradecane	20	C-C-C-C-C-C-C-C-C-C...C_{20}	0.00065	59,230
				H_2O SOLUBILITY RATIO (benzene:aromatic)
AROMATICS				
benzene	6		1780	1
naphthalene	10		31.7	56.2
phenanthrene	14		1.29	1380
pyrene	16		0.135	131,852
benzo(a)pyrene	20		0.004	445,000

(1) hydrocarbon solubility and partitioning data obtained from Mackay and Shiu (1992)

The RFI Phase II data also demonstrates that metal constituents are primarily immobilized in the upper few feet of the soil surface in Pond 1, and the very low leaching potential of these soils is further demonstrated by the failure of unit soil samples to yield TC exceedances for any metal constituents under even the most extreme of leaching conditions.

In conclusion, with the inactivation and dewatering of Pond 1 in 1987, the residual waste constituents contained in Pond 1 now reside in a permanently de-watered unit subject to a semi-arid climate in which the soil moisture regime consistently exhibits an extreme annual water deficit (in excess of 50 inches per year). Consequently, the potential for leaching of hazardous organic constituents to groundwater has been drastically reduced.

2.1.2 Groundwater

Groundwater monitoring in the vicinity of the evaporation ponds using monitoring wells constructed to RCRA specifications has been performed since 1986. Prior to that time several shallow wells were used to monitor for state required constituents. Constituent concentrations for organics, metals, and water chemistry inorganics were presented in the RFI Phase II and Phase III reports. Copies of these data are reproduced as Appendix D, Table D-1 through D-4 (Phase II); and Appendix E, Tables E-1 through E-3 (Phase III). Groundwater analyses for the most recent sampling event in June, 1995 can be found in Appendix F. A summary of the 1994 and 1995 data is shown in Table 2-3 and a discussion of the more important recent findings is provided below.

Five monitor wells have been installed in the vicinity of Pond 1 at locations either downgradient or slightly off-gradient from the direction of groundwater flow. Three are shallow wells tapping the upper 10 ft. of saturated sediments. One boring (MW-6B) is an intermediate depth well screened 30 to 40 ft. into the saturated zone at an approximate depth between 40 and 50 ft. beneath the surface. The remaining well (MW-4C) was installed during the RFI Phase III investigation and is screened 50 to 60 ft. into the saturated zone at a depth from 60 to 70 ft.

In the vicinity of the evaporation ponds, levels of volatile organic constituents slightly elevated above detection limits are found mainly south and downgradient of Pond 1. Monitor wells MW-3, 4A, 4C, and 6A had detectable levels of benzene, toluene, ethylbenzene, and xylene (BTEX) volatiles in one or more samples, but benzene was the only constituent where samples exceeded the EPA MCL health based standard of 0.005 mg/l (ppm). The maximum benzene concentration in 1994-95 was 0.015 mg/L, down from 0.021 mg/L in MW-4A in 1993. Other than BTEX, the only other volatile organic detected in the analyses was 2-butanone in one well (MW-4A). No identifiable semi-volatiles were detected in monitor wells surrounding Pond 1. Semi-volatile practical quantitation levels ranged from 0.010 to 0.020 mg/L except for MW-3 which had a semi-volatile detection level of 0.40 mg/L (Appendix F, Table F-1).

Table 2-3 Summary of 1994-1995 Water Quality Results for Monitor Wells in the Vicinity of Pond 1

Sample ID	Date	Benzene (mg/L)	Toluene (mg/L)	Ethyl-benzene (mg/L)	Total Xylenes (mg/L)	Total Arsenic (mg/L)	Total Chromium (mg/L)	Total Lead (mg/L)	Total Nickel (mg/L)	TDS (mg/L)	Comment
MW-3	11/08/94	<0.005	<0.005	<0.005	<0.006	0.045	0.040	<0.01	0.04	5,970	
MW-3	6/21/95	<0.017	<0.017	0.018	0.030	0.031	0.006	<0.01	<0.05	5,250	Low-flow purge
MW-4A	11/10/94	0.013	0.006	0.015	0.028	0.156	0.090	0.07	0.13	5,410	
MW-4A (dupl)	11/10/94	0.014	0.006	0.016	0.032	0.143	0.063	0.06	0.07	5,600	
MW-4A	2/24/95	- -	- -	- -	- -	0.051	<0.005	<0.01	<0.05	- -	Low-flow purge
MW-4A	6/28/95	0.015	0.008	0.019	0.036	0.061	0.006	<0.01	<0.05	5,750	Low-flow purge, MEK @ 0.012 mg/L
MW-4C	1/20/95	0.013	<0.005	<0.005	<0.006	0.067	0.009	<0.01	<0.05	3,840	Sample from submersible pump
MW-4C	1/20/95	0.010	<0.005	<0.005	<0.005	0.070	0.019	<0.01	<0.05	3,830	Sample from standard bailer, PRC BTEX values ND @ 0.005
MW-4C	2/24/95	<0.005	<0.005	<0.005	<0.005	0.061	<0.005	<0.01	<0.05	- -	Sample from bailer after low-flow purge
MW-4C	6/28/95	0.015	<0.005	<0.005	<0.005	0.065	0.006	<0.01	<0.05	3,970	Low-flow purge
MW-6A	11/08/94	<0.025	<0.025	<0.025	<0.025	0.085	0.062	0.02	0.07	3,650	
MW-6A	1/14/95	<0.005	<0.005	0.006	0.010	- -	- -	- -	- -	- -	
MW-6A	6/22/95	<0.005	<0.005	0.0059	0.011	0.034	0.015	<0.01	<0.05	3,340	Low-flow purge
MW-6B	11/08/94	<0.025	<0.025	<0.025	<0.025	0.011	<0.02	<0.01	<0.01	3,190	
MW-6B	1/15/95	<0.005	<0.005	<0.005	<0.005	- -	- -	- -	- -	- -	

Notes:

Semi-volatiles not detected at 0.010 mg/L for MW-4A, -6A and -6; not detected at 0.020 mg/L for MW-4C; not detected at 0.040 mg/L for MW-3.

Federal MCL : Benzene, 0.005 mg/L; toluene 1.0 mg/L; ethylbenzene, 0.70 mg/L; xylenes, 10.0 mg/L; arsenic, 0.05 mg/L, chromium, 0.10 mg/L; lead, 0.015 mg/L(action level), nickel, 0.10 mg/L; TDS, 500 mg/L.

NM Water Quality Control Commission Groundwater: Benzene, 0.010 mg/L; toluene, 0.75; ethylbenzene, 0.75; xylenes, 0.62 mg/L; dissolved arsenic, 0.10 mg/L, dissolved chromium, 0.05 mg/L; dissolved lead, 0.05 mg/L, dissloved nickel, 0.20 mg/L; TDS, 1,000 mg/L.

Well MW-4C, installed during January, 1995, had detections of benzene at levels from 0.005 to 0.015 mg/L; however, these detections were sporadic and not necessarily repeatable in split samples or subsequent follow-up samplings. Additionally, the other BTEX constituents were not present in the samples. It is possible these detections are laboratory carryover from other samples, or artifacts remaining from the drilling of the wells. Even though surface casing was used during drilling, some material may have been moved downwards during drilling of the surface casing and remains close to well bore and sandpack. In any event these detections do not greatly exceed the EPA MCL of 0.005 mg/L and occur in naturally poor quality water. As discussed later in this report, the water is non-potable for domestic consumption without extensive treatment that would remove benzene and other water contaminants.

Based on results obtained during the Phase I RFI, water samples were taken during the Phase II and Phase III studies for analysis of arsenic, chromium, lead and nickel. Some samples obtained during the 1994 -95 sampling were exceedingly turbid due to abundant clay zones. Arsenic, total chromium, lead and nickel values were elevated in some samples. Low-flow purging at rates less than two liters per minute was performed at four of the five wells in February and June, 1995; MW-6B did not have elevated levels of metal constituents and was not resampled. Analysis of the latter samples did not confirm the elevated levels of total chromium, lead and/or nickel found in the November, 1994 and January, 1995 RFI Phase III monitoring (Table 2-3). However, total arsenic levels in wells MW-4A and MW-4C continued to exceed the EPA MCL of 0.05 mg/L but were lower than the New Mexico ground water quality standard of 0.1 mg/L.

Although arsenic levels in the current wastewater ponds are elevated due to concentration by evaporation, this may not always have been the situation in the past. During the time Pond 1 was in use, it acted mainly as a settling pond with water continuing onward to the other ponds. Prior to more advanced treatment beginning in 1987, arsenic concentrations may have been more dilute due to the relatively large water volumes flowing prior to recent water conservation efforts that have allowed closure of Ponds 1 and 2. In addition to direct contribution from Pond 1, it is likely that some insoluble arsenic in the alluvium, either naturally occurring or possibly resulting from agricultural activities, is being mobilized due to the effects of the reducing environment caused by high biological and chemical oxygen demand from organics in the shallow subsurface. One recent discussion of arsenic in the groundwater environment discusses naturally occurring levels of insoluble ferric hydroxide that can release significant amounts of soluble arsenic to groundwater in excess of 0.05 mg/L under reduced conditions (Vance, 1995). If this mechanism is causing elevated arsenic levels, replacement of the oxygen-deficient water with fresher water from the river or from deeper zones should naturally reduce these high concentrations.

The analytical results of water quality sampling of the monitor wells must be evaluated in the overall context of groundwater quality in the vicinity of the ponds. As documented by U.S. Geological Survey (USGS) studies and reported in the RFI Phase II report, the area immediately adjacent to the Pecos River serves as a regional zone of groundwater discharge. Groundwater in an area from the river west to the Sacramento Mountains migrates eastward and discharges upwards into the river and shallow alluvium adjacent to the river channel. This effect was observed and documented during the Phase II and III RFI work. Upward vertical gradients have been continuously recorded in paired monitor wells away from the immediate area of the active ponds. Water levels in deeper monitor wells in the vicinity of Pond 1 are greater than in the shallow wells. In June, 1995 differences ranged from 0.18 ft. for the MW-6A,-6B pair to 0.33 ft. for MW-4A,-4C pair. The continued presence of the upward gradient ensures that water quality impacts due to previous releases from Pond 1 will be limited to the shallow zones where they are currently observed.

As deeper water migrates upward, water quality markedly deteriorates due to the combined effect of near-surface evaporation of water and transpiration by phreatophytic salt cedar entrenched along the river channel. Total dissolved solids (TDS) of the river as measured during the Phase II study exceed 5,100 mg/L and the USGS has documented values greater than 10,000 mg/L at their Artesia gauging station. During the Phase II RFI, water quality measurements from four monitor wells adjacent to the river and upgradient from the ponds, including three wells on the opposite side of the river from the ponds, resulted in an average TDS exceeding 10,000 mg/L. Groundwater in the alluvium a short distance to the west is of slightly better quality. The average of the TDS of the evaporation pond windmill and the EPA-1 monitor well on the western edge of the shallow alluvium is greater than 4,200 mg/L. However, even this water greatly exceeds the EPA recommended drinking water standard of 500 mg/L. The quality of water for human consumption is further discussed in Section 3.3.2.2.

The exceedingly poor natural water quality in the alluvium immediately adjacent to the river and ponds prevents it from being used as a drinking water source for humans, and only marginally for livestock. The Phase II study documented that groundwater movement downgradient from the ponds is southeastward and the final discharge zone is a marshy area overgrown with salt cedar near the U.S. Highway 82 crossing of the Pecos River.

2.2 Interim Corrective Measures

Between approximately Fall 1989 and Spring 1995, Navajo conducted interim corrective actions to facilitate complete access to all portions of the unit and to enhance in situ biodegradation of the hydrocarbon-contaminated soils. In order to desiccate and solidify heavy waste solid deposits located around the periphery of the unit, initial activities employed a trackhoe to undertake bulk turning and mixing of waste solids and soils across the entire unit. From Summer 1990 through Spring 1995, Pond 1 surface soils were tractor-disced at a frequency of approximately once a month, with the precise timing of tillage events dependent on the availability of sufficient soil moisture to minimize wind-induced soil erosion.

3.0 ESTABLISHMENT OF CORRECTIVE MEASURES OBJECTIVES AND SELECTION OF CORRECTIVE MEASURES ALTERNATIVE

Appropriate corrective measures objectives are established on the basis of potential risks posed to human health and the environment. Therefore, discussion of corrective measures objectives and risk management issues is preceded by the following sections, which provide evaluation and discussion of the overall risk posed by present and future environmental conditions at Pond 1 and its vicinity.

Section 3.1 presents an overview of general risk-related considerations associated with the site. Section 3.2 details a comparison of potential environmental risks posed by metal contaminants in Pond 1 soils relative to extensive environmental fate and transport modeling concerning those same metal constituents that was previously conducted by EPA under the auspices of the Clean Water Act Part 503 Program.. Section 3.3 provides a qualitative evaluation of the relative probabilities that future site land usages might come to pass. Section 3.4 presents the results of a baseline human health risk assessment conducted on the premise of a standard residential land use scenario, and Section 3.5 presents the results of a basic ecological risk assessment designed in congruence with the overall potential for significant ecological risks posed by the site. Section 3.6 details an additional evaluation of potential human health risks conducted on the premise of a credible agricultural exposure scenario, and considers potential for indirect human exposure via an indirect food-chain pathway entailing exposure of livestock subject to subsequent human consumption. Section 3.7 evaluates seepage from the active pools to the river and evaluates potential impact on the river water quality. Section 3.8 discusses corrective measures alternatives.

3.1 General Risk-Related Considerations

Pursuant to EPA guidance, facility specific objectives are to be proposed to the administrative authority for corrective action. These objectives are based on public health and environmental criteria, information gathered during the RFI, EPA guidance, and the requirements of any applicable Federal statutes and regulations.

The available soil analytical data for Pond 1 indicates that unit soils contain hydrocarbon contaminants including trace concentrations of VOA constituents, SVOA constituents, as well as levels of several metal constituents elevated significantly greater than background concentration values. While existing concentrations for some contaminants might be construed as posing a potential risk to human health under relatively high exposure scenarios, several factors serve to minimize potential environmental risk. The location of the unit (approximately three miles east of the city of Artesia in an area dedicated to open rangeland) is remote from areas of human occupation or intensive activity. Access to the unit is controlled by fences and locked gates, and by the adjacent physical barrier of the Pecos River. Further, the private property adjacent to State Highway 82, which must be entered to approach the unit, is kept under routine surveillance by local law enforcement agencies.

As reported in the Phase II RFI (and summarized in Section 2.1.2), impacts of any hazardous constituent releases from Pond 1 on groundwater having a current or potential use by humans, livestock, or for agricultural purposes are believed to be either minimal or non-existent. This is due to the naturally occurring poor water quality documented in the area and the hydrogeologic conditions at the location of the ponds.

3.2 Comparison of Pond 1 Soil Sampling Data to 40 CFR Part 503 Standards

Since organic hydrocarbon constituents present in Pond 1 soils will ultimately be degraded to simple non-hazardous carbon molecules, long-term environmental concerns associated with unit soils have previously been associated with the persistence of elevated concentrations of arsenic, chromium, and lead. Although nickel and zinc were previously identified as potential constituents of concern in Pond 1 soils (as evidenced by EPA Region 6 requirements to include those in the baseline risk assessment presented in Section 3.3), it is anticipated that the assessment discussions presented below will demonstrate that, with a high degree of confidence, nickel and zinc may be eliminated as constituents of concern in Pond 1 soils.

Because Pond 1 is situated in a relatively remote agricultural setting, an appropriate assessment of overall environmental risk posed by elevated metal constituents would entail a comparison of unit soils to risk-based standards developed for an agricultural/forest setting. A reliable comparative source to assist in defining risk-based limits for soils occurring in an agricultural setting is found in the EPA document entitled *Technical Support Document for Land Application of Sewage Sludge* (Eastern Research, 1992). The technical support document was developed to provide justification for the promulgation of the final rule regulating the beneficial land application of municipal sewage sludge (40 CFR Part 503) under the authority of the Clean Water Act.

The EPA technical support effort entailed a comprehensive review of existing scientific data concerning the environmental effects of ten metal constituents. The data was assessed, summarized, and used to model or estimate the concentration-related risk levels posed by the constituents in the context of 14 agricultural and non-agricultural environmental exposure pathways. Risk-based pollutant limits were established for each constituent of concern at the level of the lowest risk-based number for any of the evaluated pathways.

In order to model the effects of the metal constituents in sewage sludge applications to land, EPA defined assumed values for soil mass and depth of sludge incorporation in order to obtain concentration-based exposure values (see Section 5.1.2.5.3 of the Technical Support Document). For the five Pond 1 metal constituents of concern, Table 3-1 presents the Part 503 risk-based pollutant limits and most limiting pathway that were used to establish each limit value. Employing the assumptions for depth of sludge incorporation and total soil mass specified by EPA in the Part 503 technical support document, Table 3-1 also presents calculated concentration-based soil values used by EPA in the establishment of the risk-based sludge application limits for these constituents. The derivation of the concentration-based soil limits is presented in Appendix G.

Table 3-1 **Comparison of Part 503 Risk-Based Pollutant Limits, Limiting Pathways, and Derived Concentration-Based Limits with Pond 1 Soil Metal Concentrations**

Constituent	Range/Average for Pond 1 soils (mg/kg)(1)	Primary Limiting Exposure Pathway and Risk-Based Limit	Derived Concentration Limit - Primary Exposure Pathway	Secondary Limiting Exposure Pathway and Risk-Based Limit	Derived Concentration Limit - Secondary Exposure Pathway
Arsenic	1.6-39.9 / 23.5	sludge to child via oral ingestion 41 kg/ha (2)	41 mg/kg	sludge to groundwater to human via drinking 1,200 mg/kg (3)	600 mg/kg
Chromium	32-1,011 / 386	phytotoxicity 3,000 kg/ha (3)	1,500 mg/kg	sludge to groundwater to human via drinking 12,000 mg/kg (3)	6,000 mg/kg
Lead	9-389 / 112	sludge to child via oral ingestion 300 kg/mg (2)	300 mg/kg	sludge to soil to animal 1,200 kg/ha (2)	1,200 mg/kg
Nickel	12-37/ 22.5	phytotoxicity 420 kg/ha (3)	210 mg/kg	sludge to child via oral ingestion 820 kg/ha (2)	820 mg/kg
Zinc	40-434 / 198	phytotoxicity 2,800 kg/ha (3)	1,400 mg/kg	sludge to soil to plant to human via home garden 3,600 kg/ha (3)	1,800 mg/kg

Notes:
(1) RFI Phase II soils data for 1 foot sample depth.
(2) Kg constituent per 1x10^{-6} kg dry weight sludge, as specified in U.S. EPA Part 503 Techical Support Document, p. 6-2.
(3) Kg constituent per 2x10^{-6} kg soil, as specified in U.S. EPA Part 503 Techical Support Document, p. 5-19.

It is acknowledged that the contaminant profile for Pond 1 soils exhibits significant differences from the sludge application scenario employed by EPA for its development of the Part 503 soil standards. For instance, Part 503 rules assume an approximate 6-inch soil mixing depth for incorporated sludges. In contrast, RFI Phase II data for Pond 1 soils indicate that elevated metal concentrations in surface soils may extend from the surface to 1 to 3 ft. This distinction is most relevant for the Part 503 phytotoxicity exposure pathway, which assumes that metal constituents are primarily limited to the upper soil surface in a specified zone of incorporation. However, as discussed below, for Pond 1 metal constituents of concern for which phytotoxic effects constitute the most limiting exposure pathway, the concentrations of those constituents reported in Pond 1 soils are significantly lower than the derivable Part 503 pollutant limits to the extent that potential phytotoxicity effects are not indicated.

In terms of the Pond 1 soil metal constituents of concern, the most limiting Part 503 exposure pathways for chromium, nickel and zinc are based on phytotoxic effects. The Part 503 risk assessment conducted for this pathway may be sensitive to variations in total contaminant depth in soils, since at least some of the technical data used to establish concentration limits for these constituents were based on field-test data for surface-applied sludge that was presumably not incorporated into deeper soil horizons. It is known that a major metal toxicity avoidance mechanism for plants involves the establishment of adequate root mass extending below metal-contaminated surface soils. Therefore, the Part 503 cumulative metal limits are likely to be less applicable for those situations in which elevated metals of concern extend to greater depths (e.g., deeper than six inches below the soil surface). However, as described below, when the Part 503 phytotoxicity pathway limits for chromium, nickel and zinc are converted to soil concentration-based values, the average concentrations of these metals in Pond 1 soils are many times lower than the permissible Part 503 application limits.

For the remaining Pond 1 metal constituents (arsenic and lead), the most limiting Part 503 exposure pathway is based on direct oral ingestion of contaminated sludge materials rather than sludge-incorporated soils, so that the Part 503 risk assessment conducted for this exposure pathway is independent of the depth to which soils have been impacted and is directly comparable with Pond 1 soils. In conclusion, the comparison of Pond 1 soils with the Part 503 sludge standards described below is considered to be generally valid and appropriate.

As shown in Table 3-1, the average soil concentration values obtained for arsenic, chromium, lead, nickel and zinc during the Pond 1 RFI Phase II are all below the derived Part 503 soil concentration limits for those constituents. A single Pond 1 soil sample obtained during the Phase II RFI from the one-foot sample depth yielded a concentration value in excess of the Part 503 limit for lead. However, the overall average concentration value for lead in Pond 1 soils was well below the Part 503 limit (Table 3-1).

The second most-limiting pathway for arsenic under the Part 503 rules is based on human ingestion of contaminated groundwater obtained from a well located immediately at the unit boundary. Based on a 6-in. sludge incorporation interval in surface soils, EPA has determined that an arsenic loading limit no greater than 1200 kg/ha is necessary to protect a generic shallow groundwater source underlying agricultural soils subjected to sludge applications. This represents a derived soil concentration value (600 mg/kg) approximately 25 times greater than the average concentration obtained for arsenic in surface soils at Pond 1.

The risk-based limit for this pathway established by EPA employed extremely conservative assumptions regarding the environmental setting: soil texture in both the vadose zone and underlying saturated zone was assumed to consist of pure sand; and the water table under a site to which sewage sludge was applied was not greater than 1 meter from the treated surface.

For lead, the second most-limiting exposure pathway under the Part 503 rules is based on livestock consumption of sludge adhering to forage crops and/or sludge on the soil surface. For the conservative assumptions used by EPA in developing a risk-based limit for this pathway, EPA has determined that a limit of 1,200 mg/kg is appropriate for lead. As was the case for the child sludge ingestion exposure pathway for lead, criteria for the livestock consumption pathway are independent of the depth to which the lead contaminant extends into the soil profile. Therefore, the comparison of Pond 1 soils with the Part 503 standards for these two most limiting lead exposure pathways is directly comparable and valid.

The average concentration of chromium in Pond 1 soils (386 mg/kg) is nearly four times less than the soil concentration-based phytotoxicity limit derived from the cumulative chromium loading limit established under the Part 503 regulations (1,500 mg/kg). No Pond 1 soil sample concentrations exceeded the derived Part 503 limit. The second most limiting exposure pathway for chromium under the Part 503 regulations is based on human ingestion of contaminated groundwater obtained from a well located immediately at the unit boundary. The risk-based limit for that pathway is equivalent to a total soil concentration of 6,000 mg/kg, which again was based on conservative assumptions of a sandy, saturated vadose zone, and a one-meter depth to groundwater.

The average concentration of nickel in Pond 1 soils (22.5 mg/kg) is more than nine times less than the derived soil concentration-based limit for the most limiting exposure pathway (210 mg/kg), based on plant phytotoxicity effects. The maximum nickel value obtained for Pond 1 soils (37 mg/kg) is also well below the derived Part 503 phytotoxicity pathway limit for this constituent. The second most limiting exposure pathway for nickel under the Part 503 regulations yields a derived concentration-based limit of 820 mg/kg, based on direct oral ingestion.

The average concentration of zinc in Pond 1 soils (197 mg/kg) is more than seven times lower than the derived concentration-based soil limit for the Part 503 rule (1,400 mg/kg) (also based on phytotoxic effects). Furthermore, even the maximum zinc concentration value obtained from Pond 1 soils during the RFI Phase II investigation (434 mg/kg) is more than three times less than the Part 503 phytotoxicity pathway limit. The second most limiting exposure pathway for zinc under the Part 503 regulations yields a derived concentration-based limit of 1,800 mg/kg, based on human consumption of vegetables grown in a sludge-amended home garden.

On the basis of the comparisons of Pond 1 soil metal concentrations with the specified criteria set forth under the 40 CFR Part 503 rules for allowable cumulative soil loading limits for metal constituents, none of the Pond 1 metals of concern can be construed as posing a threat to human health and the environment. In particular, this analysis indicates that Pond 1 soil concentrations for nickel and zinc are sufficiently low to eliminate these constituents from all future soil monitoring activities at the unit. In the case of nickel, Pond 1 soil concentrations are elevated approximately two to three times above local background levels. However, the average Pond 1 nickel soil concentration indicated by the RFI data (is only slightly above the nationwide average of 20 mg/kg for nickel concentration in surface soils (U.S. Geologic Survey, 1971). The average and maximum nickel soil concentrations reported for Pond 1 soils are well below established Part 503 standards specifying concentration exceedances that would constitute grounds for environmental concern in a general agricultural land use setting, and are many times less than relatively stringent residential health-based standards for this constituent that are widely employed by EPA for risk-based screening (U.S. EPA, 1993a).

In contrast, reported maximum zinc values in Pond 1 soils represent concentrations which may be as high as twenty times above background levels. However, as was the case for nickel in Pond 1 soils, average and maximum zinc concentrations reported for Pond 1 soils are well below derivable Part 503 standards, and are also many times less than EPA residential health-based standards used for risk-based screening (U.S. EPA, 1993a). Furthermore, zinc is not identified as a human carcinogen, and, as indicated by the Part 503 standards, its human noncarcinogenic toxicity is very low. In fact, zinc is an essential human nutrient. Based on a toddler's Recommended Daily Allowance (RDA) of 10 mg zinc (National Academy of Science, 1989), a standard soil ingestion rate of 200 mg/day for a 16 kg infant, and conservatively assuming chronic exposure to the maximum reported zinc concentration in Pond 1 soils (434 mg/kg), daily consumption of Pond 1 soils would supply only about 13% of the zinc RDA for an exposed toddler. In conclusion, there is no evidence to suggest that zinc concentration levels in Pond 1 soils pose a threat to human health and the environment.

In development of the Part 503 standards, environmental fate of soil-applied metal constituents and consequent risk to human health and the environment posed by those constituents were conservatively assessed on the basis of sites situated in an agricultural/forest setting, and it is recognized that these rules were not formulated to generically address conditions associated with RCRA SWMUs. However, EPA's risk modeling (particularly in regard to indirect human exposure pathways and risks to non-human receptors) considered fate and transport of metals in a <u>soil</u> environment, from which acceptable sludge loading limits were back-calculated. This is a statement of fact that is not disputable. Further, the Navajo evaporation ponds are situated in an environmental setting that, in terms of physical features, surrounding land usage and proximity to potentially exposed populations, is distinctly agricultural.

The Part 503 standards are designed to serve as sound environmental guidelines applicable across a broad spectrum of environmental settings in the United States. As such, the development of the Part 503 standards has taken into account information obtained from exhaustive reviews of the scientific literature. In addition, numerous conservative assumptions are incorporated into the risk evaluation for the generic agricultural/forest setting, such as the presence of a coarse sandy soil exhibiting a low bulk density, a one-meter depth to groundwater, exposure to the most sensitive receptors (e.g., children, most sensitive crop species). For these reasons, the EPA Part 503 standards constitute a conservative basis of comparison that is generally valid for the assessment of potential environmental risks posed by the inorganic waste constituents contained in Pond 1 surface soils, as well as for metal contaminated soils in general (Sullivan, 1995).

3.3 Assessment of Potential For Future Site Usage

As discussed above, the most comprehensive guidance currently available to EPA indicates that the Pond 1 soils pose no apparent threat to the surrounding environment, or to human health on the basis of reasonable exposure scenarios. Notwithstanding the level of contaminant concentrations in the soil, a key component of establishing the overall human health risk posed by environmental contamination is consideration of the potential for exposure to the various contaminated environmental media. In this regard, it is essential to evaluate the potential future land usage of the Navajo Evaporation Ponds system and adjoining properties.

3.3.1 Potential for Future Industrial Use

The property where Pond 1 is located is dedicated to a specific industrial purpose. In a larger context, the selection of that particular site location can be considered to have arisen as a result of: the history of oil exploration and production in the region; the random nature of human business dealings; and, most directly, the unique geography of the local Artesia area. As such, the use of the subject property for an industrial function represents a highly unique event. For this reason alone, it must be considered extremely improbable that this particular location will again be utilized as an industrial site. As discussed below, there are also other, more compelling reasons associated with the physical setting of the site which greatly reduce the possibility that an alternative industrial use for the site will occur. Subsequent to discontinuation of operations and final closure of the pond system, there is no reasonable likelihood that future land usages at the property could result in significant human exposure via activities associated with industrial occupation.

3.3.2 Potential for Future Residential Use

In a residential land use scenario, potential exposure to environmental contaminants of concern associated with former operations at Pond 1 would occur primarily from direct exposure to contaminated soils and consumption of contaminated groundwater. However, due to factors described in the following sections, it is considered highly improbable that human exposure to contaminants at ingestion rates even remotely approaching those currently established for residential exposure scenarios will ever occur.

3.3.2.1 Local Demographics

The Navajo evaporation pond system is located several miles east of the city of Artesia. The population of the city of Artesia reached its current historical peak over thirty years ago around the time of the 1960 U.S. Population Census when the town recorded an official population of 12,000 inhabitants. Population trends since that time, as characterized by subsequent U.S. Census Bureau surveys, are as follows: 1970 - 10,315; 1980 - 10,385; 1990 - 10,610. It is evident that for the past 20 years, the city of Artesia has exhibited a relatively stable population base. While demographic data for the U.S. as a whole indicates significant population growth, no signifying demographic or economic trends or events have been identified to suggest that Artesia and surrounding areas either are, or will soon be, subject to rapid population expansion that would in turn generate social and economic pressures for the subject property to be converted to residential land use.

3.3.2.2 Groundwater Suitability for Human Consumption

As was demonstrated by the Phase I and Phase II RFI studies, groundwater unimpacted by the ponds is non-potable. For example, TDS for several off-gradient wells (EPA-1, Pond Windmill, and MW-24 east of the river) range from 3,570 to 11,600 mg/l (Table 3-2). Two downgradient wells believed unimpacted by pond seepage (MW-18A and MW-19) have TDS concentrations of 5,720 and 12,600 mg/l, respectively. These naturally occurring high-salt concentrations make groundwater unacceptable for human consumption without significant and costly treatment such as distillation and reverse osmosis.

Table 3-2 Major Constituent Ion Concentrations in Naturally Occurring Groundwater in the Vicinity of the Navajo Refinery Evaporation Ponds

Well ID	Sample Date	TDS (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Sulfate (mg/l)
EPA-1	10/90	3,570	N/A	N/A	950	1,220
	11/92	3,750	176	480	989	1,420
Pond Windmill	11/29	4,740	180	872	1,190	1,780
	11/94	4,260	165	697	1,130	1,440
MW-18A	11/92	12,600	664	2,420	3,930	3,950
	11/94	17,700	956	3,980	5,790	4,880
MW-19	11/92	5,720	226	718	1,370	1,950
	11/94	5,360	216	661	1,170	2,020
MW-24	11/92	11,600	240	2,500	4,170	2,910
Pecos River	11/92	5,110	186	733	1,470	1,660
	11/94	4,610	164	696	1,280	1,460

Water Quality Standards and Notes:

1. TDS: 500 mg/l (SMCL), 1,000 mg/l (NMWQCC)
2. Magnesium: 100 mg/l @ 5 liter/day (USAMRDC), 150 mg/l (WHO)
3. Sodium: 20 mg/l (DWEL), 100 mg/l (NAS)
4. Chloride: 250 mg/l (SMCL, NMWQCC), 600 mg/l (USAMRDC)
5. Sulfate: 250 mg/l (SMCL), 300 mg/l @ 5 liter/day (USAMRDC), 500 mg/l (proposed PMCL) 600 mg/l (NMWQCC), 630 mg/l (LOAEL)
6. Abbreviations: DWEL - EPA Drinking Water Equivalent Level; LOAEL - EPA Lowest Observable Adverse Effects Level; N/A - No analysis; NAS - National Academy of Sciences; NMWQCC - New Mexico Water Quality Control Commission; PMCL - EPA proposed Primary Maximum Contaminant Level, SMCL - EPA Secondary Maximum Contaminant Level; TDS - Total Dissolved Solids; USAMRDC - U.S. Army Medical Research and Development Command; WHO - World Health Organization.
7. Table data is from Navajo Phase I, Phase II and Phase III RFI Reports

Several constituents naturally occurring in groundwater in the vicinity of the evaporation ponds contribute to the unsuitability of untreated water for domestic consumption. Additionally, the total of these dissolved constituents, or TDS, produce adverse health effects by contributing to dehydration of body tissues either directly through osmotic effects after ingestion, or by refusal of individuals to drink the water because of the salty taste. The effects of the individual constituents and total salt concentrations on human health are discussed individually below.

Magnesium

Reported magnesium concentrations in background-quality groundwater in the vicinity of the Navajo Evaporation Ponds range from 176 to 664 mg/l. Health effects of elevated concentrations of magnesium include catharsis and voluntary and involuntary dehydration. In clinical medicine, a dose of 480 mg is recommended to induce laxative effects (USAMRDC, 1988). Above 100 mg/l, there is increasing susceptibility to dehydration due to increasing laxative effects with water intake. Also, voluntary dehydration may occur as a result of rejection of water due to taste. Although the World Health Organization's recommended limit is 150 mg/l, magnesium at concentrations less than that value impart astringent taste that make water less palatable (NAS, 1977a).

Sodium

Reported sodium concentrations in background-quality groundwater in the vicinity of the Navajo Evaporation Ponds range from 480 to 2,500 mg/l. Excessive sodium intake is linked to the development of hypertension. However, sodium in water usually provides only a small portion of sodium found in the diet. Commonly, for taste reasons, sodium is added to foods during processing, in home cooking, and at the table. Habitual intake bears no relationship to physiological need, but can be detrimental to individuals susceptible to hypertension through genetics, hormones, diet, or stress. An estimated 15 to 20 percent of the healthy American population is at risk of developing hypertension while about 3 percent is on a sodium restricted diet. A small portion of the population is on a severely restrictive diet that limits sodium content in water to 20 mg/l (NAS, 1977a). A more important limitation on use of sodium rich water is its impact on potability due to taste when, combined with the anions chloride and sulfate, elevated levels lead to rejection due to taste or possible dehydration due to internal osmotic effects of salt fluids on the human body.

Chloride

Reported chloride concentrations in background-quality groundwater in the vicinity of the Navajo Evaporation Ponds range from 950 to 4,170 mg/l. The major impacts of ingestion of high chloride water are its laxative effects and hypertension at higher concentrations, voluntary dehydration resulting from rejection of water due to taste, and involuntary dehydration resulting from loss of body fluids due to the process of osmoregulation in the digestive tract. At increasing concentrations above 600 mg/l, a greater proportion of the population is likely to refuse to drink the water because of taste. At concentrations above 1,200 mg/l, the water was judged so objectionable that it would be rejected leading to voluntary dehydration (USAMRDC, 1988). Laxative effects and osmoregulation effects are reported to occur at concentration levels three to four times higher than concentrations which lead to voluntary dehydration. Hypertension effects have been reported when sodium is the cation ion in solution with chloride.

Sulfate

Reported sulfate concentrations in background-quality groundwater in the vicinity of the Navajo Evaporation Ponds range from 1,010 to 3,950 mg/l. Elevated concentrations of sulfate, in combination with either sodium or magnesium, lead to increased laxative effects in water which may be used for drinking. Medical studies report that a 15-gram dose of Epsom salt ($MgSO_4 \bullet 7H_2O$) or Glauber's salt ($NaSO_4 \bullet 10H_2O$) will produce a cathartic response within three hours or less. A single five-gram dose of Epsom salt or Glauber's salt was reported to produce a significant laxative effect (USAMRDC, 1988). The latter level of Epsom or Glauber's salt (i.e., 1,950- or 1,450-mg dose of sulfate, respectively) are equivalent to the ingestion of two liters of water per day with sulfate concentrations ranging from about 700 to 1,000 mg/l. By comparison, the minimum concentration of sulfate in groundwater in the vicinity of the ponds is about 1,200 to 1,400 mg/l in EPA-1. More recently, in soliciting comments relating to a proposed maximum concentration limit goal (MCLG) for sulfate, EPA reported a concentration of 630 mg/l as the lowest observable adverse effect level in humans, in this case infant diarrhea (55 FR 30383, July 25, 1990). EPA has subsequently proposed a primary Maximum Contaminant Level for sulfates in drinking water of 500 mg/l (FR 59:65578, 12/20/94).

Total Dissolved Solids

Collectively, the sum of the individual salt constituents dissolved in water is referred to as total dissolved solids (TDS). Reported TDS concentrations in background-quality groundwater in the vicinity of the Navajo Evaporation Ponds range from 3,570 to 12,600 mg/l. Various authors have categorized waters above 1,000 mg/l as either brackish or saline. Davis and DeWiest (1966) categorize waters between 1,000 and 10,000 mg/l as brackish. Hem (1992) classifies water between 3,000 and 10,000 mg/l as moderately saline. Either classification is appropriate for the naturally occurring water found in the vicinity of the evaporation ponds.

The health impact of individual cations and anions has been presented above. Health risks due to elevated concentrations of TDS similarly occur in two general categories: the risk of dehydration caused by refusal to drink water and the possibility of laxative effects. Although some populations can tolerate TDS levels exceeding 2,000 mg/l if acclimated, one study estimates that 18 percent of the population will reject water as objectionable due to taste at that concentration. Although increasingly higher percentages of the population reject water with TDS above 2,000 mg/l due to taste, dehydration due to laxative effects becomes an increasing concern. At a concentration of 3,600 to 3,800 mg/l TDS, well EPA-1 (which represents the lowest reported TDS value among the background groundwater wells) contains sufficient sulfate and other ion concentrations to cause laxative effects which could lead to dehydration due to loss of body fluids.

To summarize, the concentration of natural salts in the groundwater in the vicinity of the evaporation ponds are above all current acceptable standards. At a minimum, this renders the water non-potable due to taste. Additionally, the untreated water contains elevated levels of naturally occurring constituents that can lead to serious health effects such as dehydration which results from the loss of bodily fluids as a result of laxative action of the water. Because the water is non-potable, extensive treatment would need to be performed by a potential user to remove elevated levels of salts prior to human consumption. Such point-of-use treatment would also act to remove any contaminants introduced into the groundwater by the evaporation ponds.

3.3.2.3 Site Suitability for Residential Habitation

The land area adjacent to and downgradient from the evaporation ponds, including inactive Pond 1, is subject to relatively frequent flooding by the Pecos River. Though the ponds themselves are protected by dikes from inundation by the 100-year flood, surrounding agricultural grazing land has no such protection. The Pecos River is deeply incised in a meander channel in the vicinity of the ponds and is somewhat restricted from changes in direction during flood events by thick growths of saltcedar along each bank. When the river floods, it overtops the restrictive channel in the vicinity of the northwest corner of Pond 1 and flows southerly via overland flow and exits the area via large box culverts beneath U.S. Highway 82 (Figure 1-1).

The Federal Emergency Management Agency (FEMA) has published flood insurance maps for much of the United States to use in administrating the National Flood Insurance Program. Among other features, the maps show areas of special flood hazards including the area subject to an 100-year flood. The maps, together with a review of other related information, should be used prior to purchase of property or construction. Map 350120 0200B (Eddy County, unincorporated areas) effective February, 1991, shows the Navajo evaporation ponds to be within an area inundated by at least an 100-year flood. The map shows the pond system lying in the approximate center of the 100-year flood zone (Figure 3-1), with the western boundary of the zone lying approximately 4,000 ft. west of Pond 1.

Additional information was obtained from U.S. government records to determine the frequency of flooding in the immediate proximity of the ponds. From 1905 through the present, the U.S. Geological Survey (USGS) has maintained a water discharge gauge at the Highway 82 crossing of the Pecos River (Station 08396500). This location is approximately 6,000 ft. southeast of Pond 1. The station documents flow and water quality for a 15,300 square-mile drainage area. Yearly water discharge records list average daily flow, and maximum and minimum flow for the year together with water level elevations (gage heights). The published data (Cruz et al., 1994) also includes dates, discharge and elevations of base floods above 2,000 cubic ft. per second (cfs) for each water year (October 1 to September 30).

In 1981 the gage was moved upstream 250 ft. and the stage-discharge relationship recalculated by the USGS. For the CMS, information in published records and received from the agency's Carlsbad office were used to evaluate at what elevation and flow the river overtopped its incised channel. River stage was graphically plotted versus discharge. An abrupt change in slope was noted at a river stage of about 11.1 to 11.2 ft. and at a flow of approximately 2,000 cfs (Figure 3-2). This change in slope is interpreted as the height at which the river overtops the channel and water moves via overland flow over a much broader area. The graph shows that the 2,000 cfs value, chosen by the USGS after evaluation of earlier flood events, continues to be a valid lower limit above which flooding occurs in the vicinity of the evaporation ponds.

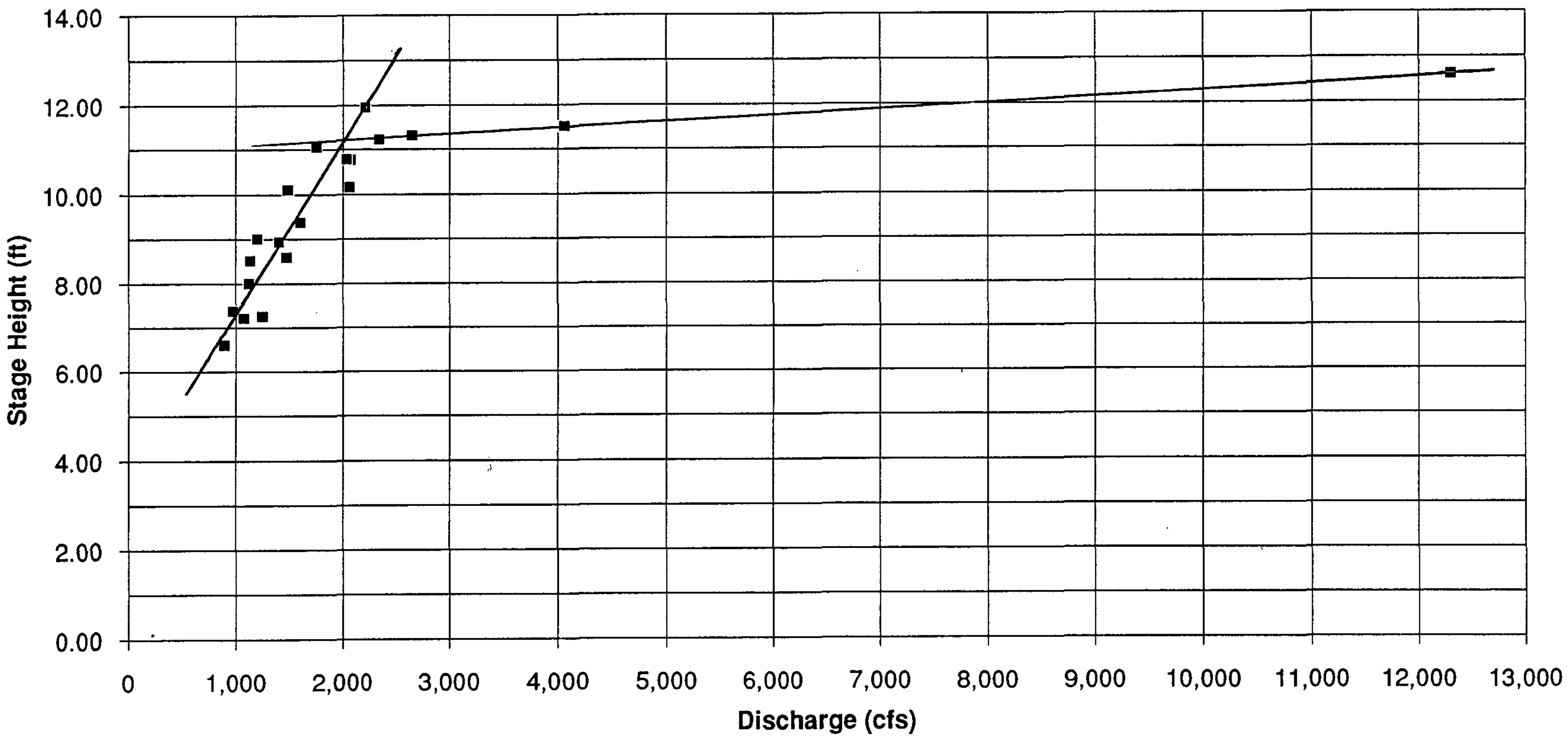


Figure 3-2. Stage-Discharge Relationship, 1981-1993

Records for water years 1964 through 1993 were researched and examined to determine the frequency and severity of flooding along this reach of the river. Records for earlier years provide historical perspective, but upstream dams have been constructed for flood control. The most recent major project completed was the Two Rivers Reservoir on tributary arroyos southwest of Roswell in July of 1963. Table 3-3 provides information on yearly maximum discharge and floods greater than 2,000 cfs at the Artesia gage for water years subsequent to completion of the Two Rivers Reservoir.

Figure 3-3 is a table showing maximum annual river discharge at the station and floods discharging greater than 2,000 cfs. During the 30-year time period under discussion, 30 flood events with a peak discharge greater than 2,000 cfs were recorded at the gauging station. During the past ten years, five events greater than 2,000 cfs were recorded. Even with increased flood control construction on river tributaries, the June 1986 flood at 12,300 cfs was the largest flood in the period of record researched for this report.

In summary, the historical hydrologic evidence demonstrates that the area downgradient from the evaporation ponds is prone to frequent and significant flooding even subsequent to flood control measures. No further flood control efforts are known to be planned in the vicinity of the ponds. No residential housing (including farm and ranch structures) are currently located downgradient from the ponds. Because of the documented frequent flooding potential, it is extremely unlikely that any residential housing will be constructed, and no domestic use of the groundwater will occur, irrespective of its natural quality. Therefore, there is no potential future human exposure to any water contaminants that may be present in groundwater due to seepage from Navajo's evaporation pond, and no risk to human population by this exposure pathway.

3.3.3 Potential for Future Agricultural Use

The Navajo evaporation pond system and surrounding property is situated inside a large west-to-south running bend of the Pecos River and is contained within the boundaries of the 100-year flood plain. Soils in this area are too saline for commercial-scale agricultural crop production and quality irrigation water is unavailable. Furthermore, the area is prone to periods of frequent and prolonged inundation from river overflow, which would severely disrupt any form of agricultural crop production (Section 3.3.2.3). Due to these factors, the property surrounding the Navajo ponds is utilized exclusively as open rangeland for livestock grazing, and open rangeland represents the only feasible usage of the Pond 1 site at a future time.

3.4 Human Health Risk Assessment for Pond 1 Soils and Groundwater

For this CMS plan, EPA has required that a human health risk assessment (RA) be conducted for organic and inorganic constituents contained in Pond 1 soils and groundwater. Specifically, an RA based on a residential exposure scenario involving human ingestion of contaminated surface soils, using RFI Phase II trench soil sample data obtained from the 0-1 ft. sample interval at four trenches (EP-TR-01, 02, 03, and 06) has been specified by the agency.

Table 3-3 Maximum Discharge Records and Floods Greater Than 2,000 Cubic Feet Per Second (cfs), Artesia Gage, Water Years 1964 - 1993

Water Year	Discharge (cfs)	Gage Height (ft)	Date	USGS Comment
1964	5,200	6.80	14-Jun-64	Flow bypassed gage
1965	4,700	12.34	30-Jul-65	Flow bypassed gage
1966	2,200	8.94	20-Jun-66	
1966	7,000	12.42	24-Aug-66	Flow bypassed gage
1967	2,300	9.48	30-May-67	
1967	2,060	8.80	17-Aug-67	
1968	4,000	12.30	7-Jul-68	
1969	3,360	12.26	12-Sep-69	
1969	3,580	12.31	19-Sep-69	
1970	2,050	- -	26-Jul-70	
1970	3,050	11.93	18-Sep-70	
1971	1,690	8.57	13-Aug-71	
1972	2,780	11.11	21-Jul-72	
1972	3,100	11.82	30-Aug-72	
1972	2,300	10.38	3-Sep-72	
1972	3,800	12.25	10-Sep-72	
1972	2,290	10.90	14-Sep-72	
1972	2,260	10.85	16-Sep-72	
1973	2,060	9.62	18-May-73	
1974	6,500	12.40	24-Sep-74	Flow bypassed gage
1974	4,300	- -	24-Oct-74	Flow bypassed gage
1976	4,300	12.20	24-Oct-75	Flow bypassed gage
1976	931	6.54	5-Aug-76	
1977	2,380	11.34	1-Sep-77	
1978	2,930	11.85	29-Jun-78	
1979	1,180	7.57	14-Jun-79	
1980	1,670	9.00	12-Sep-80	
1981	1,080	7.21	13-Aug-81	
1982	2,070	10.15	15-Sep-82	
1983	895	6.59	16-May-83	
1984	2,080	10.76	4-Nov-83	
1984	2,220	11.94	13-Aug-84	
1985	1,480	8.59	19-Jun-85	
1986	12,300	12.61	27-Jun-86	
1987	1,210	9.00	25-May-87	
1988	1,130	7.99	24-Sep-88	
1989	1,140	8.51	14-May-89	
1990	975	7.38	17-Aug-90	
1991	2,347	11.22	17-Jul-91	
1991	4,060	11.50	18-Jul-91	
1991	2,040	10.77	16-Aug-91	
1992	1,250	7.26	2-Jun-92	
1993	1,490	10.10	22-Jul-93	

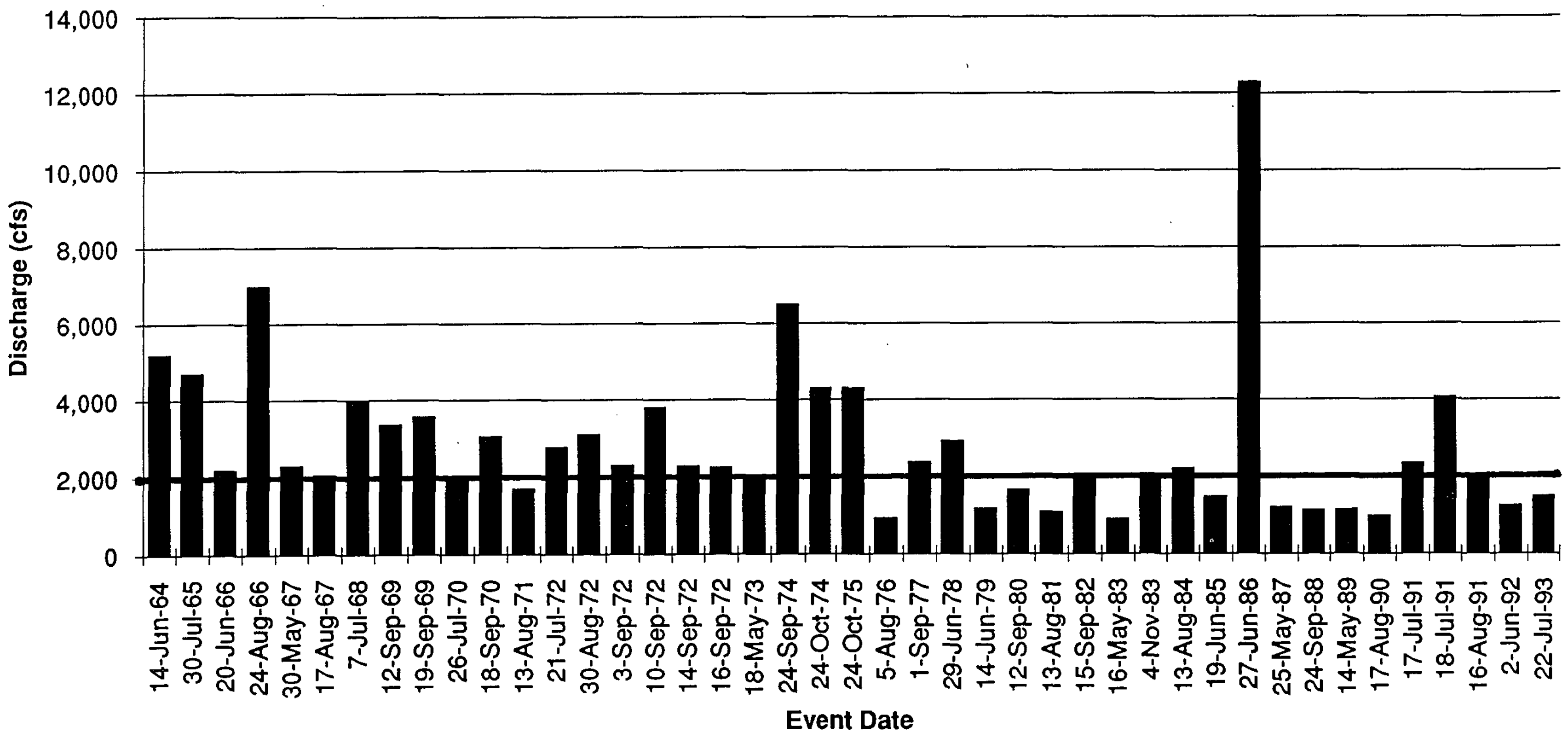


Figure 3-3 Maximum Annual Discharge and Floods Greater than 2000 Cubic Feet Per Second, Artesia Gage, Water Years 1964-1993

The baseline RA described in the following sections has been conducted in general accordance with the guidance and methods described in the document entitled *Risk Assessment Guidance for Superfund: Vol. I, Human Health Evaluation Manual (Part A)* (EPA, 1989a).

3.4.1 Data Collection and Evaluation

Data reviewed for use in the RA for Pond 1 soils was obtained from the *RCRA Facility Investigation TMD and Evaporation Ponds, Phase II, (Revised)* report (KWBES, 1993). Data reviewed for use in the RA for groundwater in the vicinity of the unit came from the *RFI Phase I Report (Second Submittal)*, Mariah Associates, Inc., December, 1990 as well as the Phase II report.

Pond 1 soil analytical data for inorganic and organic constituents obtained from the from the RFI Phase II and employed in the RA is presented in Tables 3-4 and 3-5, respectively. Four of the five inorganic constituents of concern (arsenic, chromium, nickel, and zinc), were included in the RA evaluation. For volatile organic constituents, only those constituents detected at one or more of the designated soil sample location intervals were included for evaluation.

Potential human health risks posed by lead contaminants in Pond 1 soils were not quantified in the RA, since EPA currently considers it inappropriate to develop numerical estimates for either the RfD or oral slope factor parameters for this constituent. However, potential environmental risk posed by lead in Pond 1 soils was discussed in detail in Section 3.2, and the maximum soil concentration value for lead in Pond 1 soil samples obtained from the 0-1 ft. interval for the four sample locations of interest was 389 mg/kg, and the average value was 177 mg/kg. EPA's integrated exposure uptake model (IEUBK) defines a human blood lead concentration level not to exceed 10 ug/deciliter and a 95th-percentile population distribution to protect the most sensitive exposed individuals. Based on that criteria and standard exposure assumptions, the IEUBK establishes a permissible soil lead concentration of 400 mg/kg. Since the maximum observed lead concentration in Pond 1 soils is less than that value, and since average soil concentrations are significantly less than that value, the exclusion of lead from the current RA is not considered to be crucial to the evaluation.

Table 3-4 Summary of Pond 1 Soil Sampling Data for Total Metals (mg/kg)

Location	Arsenic	Chromium	Lead	Nickel	Zinc
EP-1	26.1	74	389	21	54
EP-2	38.6	1011	93	37	303
EP-3	22.6	633	73	14	434
EP-6	39.9	235	153	37	161

Table 3-5 Summary of Pond-1 Soil Sampling Data for Organic Constituents (mg/kg)

Constituent	Sample Location				
	EP-TR-01	EP-TR-02	EP-TR-03	EP-TR-06	
Volatile Organics(1)					**Maximum Value:**
Acetone	0.387	<0.391	<0.061	<0.263	0.387
Benzene	0.030	<0.196	<0.031	<0.132	0.030
Ethylbenzene	0.443	0.590	0.101	<0.132	0.590
Methylene chloride	<0.028	<0.196	0.076	<0.132	0.076
Toluene	0.622	0.376	0.114	0.147	0.622
Xylenes (total)	2.050	1.570	0.264	<0.132	2.050
Semivolatile Organics(2)					half - average(3)
Benzo(g,h,i)perylene	<80	<890	<6.0	<220	150
Benzo(a)pyrene	<80	<890	<6.0	<220	150
Chrysene	<80	<890	<6.0	<220	150
Dibenzofuran	<80	<890	<6.0	<220	150
2,4-Dimethylphenol	<80	<890	<6.0	<220	150
Fluorene	<80	<890	<6.0	<220	150
Naphthalene	<80	<890	<6.0	<220	150
2-Methylnaphthalene	<80	<890	<6.0	<220	150
Phenanthrene	<80	<890	8.0	<220	150
Pyrene	<80	<890	<6.0	<220	150

Notes:

(1) Only constituents detected in one or more samples are reported.

(2) Includes all constituents detected at any depth for total semivolatile and TCLP-semivolatile analyses.

(3) Average of 1/2 detection limit values.

Based on EPA specifications for data to be used in the assessment, environmental monitoring data for four soil samples and four groundwater groundwater samples were used in the RA. Due to the limited size of the data set, calculation of a 95% Upper Confidence Level for the arithmetic average of sample constituent concentrations was not appropriate. Considering the limited nature of the data set and the general inability to derive valid statistics for use in the RA, it was decided that the maximum values obtained for each inorganic and organic constituent would be used for the RA.

Assessment of semivolatile constituents was hampered by an absence of appropriate data. For the most part, semivolatile data presented in the final RFI Phase II report had sample detection limits which were too high to determine whether those constituents were present at levels of potential concern. In their review of the original submittal of the Pond 1 CMS Workplan, EPA requested that the analytical results for split samples obtained by EPA contractors during the RFI Phase II field activities be used in the soils RA. However, it was subsequently discovered that split samples were not obtained for the locations of interest at the 0-1 foot sample interval. To address this shortcoming, it was decided to devise a conservative worst-case approach. For the sample locations of interest, all hazardous semivolatile constituents reported at any sample interval were compiled, including those reported in both total semivolatile analyses and TCLP-semivolatile analyses. For each constituent, the average value of one-half the reported detection limit was calculated for use in the RA.

Groundwater data for monitor wells selected by EPA for inclusion in the RA are presented in Table 3-6. Sample concentration data from the RFI Phase I and Phase II for the four metals of concern, and for all volatile and semivolatile constituents for which detection events were reported are summarized in Table 3-6. RFI Phase III results, presented in Table 2-3, reported constituent concentration values that are lower than the earlier results, especially for metals.

The sample analytical data used in the RA was obtained during the course of the Pond 1 RFI Phase I and Phase II. The data in question was collected under the auspices of the RFI quality assurance/quality control program, and has previously been reviewed by EPA. Therefore, the quality and reliability of the data is presumed to be acceptable for purposes of the RA.

Toxicity data used in the RA was obtained primarily from the Integrated Risk Information System (IRIS), an on-line EPA database carried on the National Library of Medicine on-line database system. The data obtained from IRIS at the time of the RA was current as of December, 1994.

Data obtained from IRIS consisted of reference dose (RfD) and oral slope factor data for the various constituents. For several constituents, information was lacking on these parameters on IRIS, and secondary sources of information were used to fill the information gaps as necessary. When alternate information sources were employed (e.g., Health Effects Summary Table, other EPA documents), the source of the information is cited in the summary tables. All calculations used in execution of the risk assessment are presented in Appendix H.

3.4.2 Risk Assessment for Pond 1 Soils

For purposes of the RA, EPA has stipulated that potential human health risks posed by Pond 1 soils be assessed on the basis of an oral ingestion exposure pathway under a residential occupation scenario. Calculation of the residential ingestion of soil contaminants was accomplished according to the residential soil ingestion equation presented in Exhibit 6-14 of the EPA Human Health Evaluation Manual, Part A (EPA, 1989a). Standard default exposure assumptions typically employed in a residential exposure assessment were used in the current RA. For the evaluation of non-carcinogenic of soil-borne constituents, the following assumptions were employed:

- exposed individual is a child, age 1-5 years;
- body weight is 16 kg;
- fraction of soil ingested from the contaminated source is 100 percent; and
- ingestion rate of contaminated soil is 200 mg per day.

In addition, the product of the exposure frequency times duration were set to be equivalent to the averaging time, so that these terms canceled, and the oral ingestion exposure term was expressed in mg contaminant /kg body weight/day.

Table 3-6 RFI Phase I and Phase II Groundwater Contaminant Concentrations(1)

	RFI PHASE I(1)			RFI PHASE II(1)				EPA MCL(4)
Well ID:	**MW-3**	**MW-4**	**MW-6**	**MW-3**	**MW-4**	**MW-6A**	**MW-6B**	
Constituent (2)								
Arsenic	0.11	0.22	0.056	0.078	0.080	0.065	0.021	0.05
Chromium	0.01	0.02	0.01	0.03	<0.02	0.05	<0.02	0.1
Lead	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	0.015(5)
Nickel	0.01	0.07	<0.01	0.12	<0.11	0.11	<0.01	0.1
Benzene	0.041	ND(3)	ND	0.017	0.021	<0.005	0.009	0.005
Ethylbenzene	ND	0.032	0.011	0.016	0.019	0.007	<0.005	0.7
Toluene	ND	ND	0.013	0.021	0.009	0.006	0.006	1.0
Xylene	ND	0.023	0.019	0.025	0.032	0.014	<0.005	10
2-hexanone	0.014	ND	0.023	<0.005	<0.005	<0.005	<0.005	--
2-butanone	ND	ND	ND	<0.010	<0.010	<0.005	0.048	--
carbon disulfide	ND	ND	ND	<0.005	<0.005	<0.005	0.117	--
bis(2-chloro isopropyl) ether	ND	ND	0.022	<0.030	<0.050	<0.010	<0.010	--

Notes:
(1) RFI Phase III results are shown in Table 2-3.
(2) All constituent concentrations are milligrams per liter (mg/l).
(3) ND - Not Detected; detection limits not available for RFI Phase I groundwater data.
(4) Maximum Contaminant Level.
(5) Action level for domestic water at the tap.

For the soil contaminant non-carcinogenic health effects segment of the RA, maximum soil concentration values for the various constituents, calculated soil ingestion rates, reference doses for the various constituents, and the resulting hazard quotients and the cumulative hazard index are presented in Table 3-7.

For the evaluation of lifetime carcinogenic effects, the following standard assumptions were employed:

- exposed individual is an adult;
- body weight is 70 kg;
- fraction of soil ingested from the contaminated source is 100 percent; and
- ingestion rate of contaminated soil is 100 mg per day.

Table 3-7 Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Non-Carcinogenic Health Effects for Pond 1 Soils

Constituent	Maximum Concentration (mg/kg)	Calculated Soil Intake (mg/kg/day)(1)	Reference Dose (mg/kg/day)(2)	Calculated Hazard Quotient
Arsenic	39.9	4.99E-04	3.00E-04	1.66E+00
Chromium	1011	1.26E-02	1.00E+00	1.26E-02
Nickel	37	4.63E-04	2.00E-02	2.32E-02
Zinc	434	5.43E-03	3.00E-01	1.81E-02
Acetone	0.387	4.84E-06	1.00E-01	4.84E-05
Benzene	0.03	3.75E-07	NA	NA
Ethylbenzene	0.59	7.38E-07	1.00E-01	7.38E-05
Methylene chloride	0.076	9.50E-07	6.00E-02	1.58E-05
Toluene	0.622	7.78E-06	2.00E-01	3.89E-05
Xylenes	2.05	2.56E-05	2.00E+00	1.28E-05
Benzo(g,h,i) perylene	150(3)	1.88E-03	NA	NA
Benzo(a)pyrene	150(3)	1.88E-03	NA	NA
Chrysene	150(3)	1.88E-03	NA	NA
Dibenzofuran	150(3)	1.88E-03	NA	NA
2,4-Dimethylphenol	150(3)	1.88E-03	2.00E-02	9.40E-02
Fluorene	150(3)	1.88E-03	4.00E-02	4.70E-02
Naphthalene (4)	150(3)	1.88E-03	4.00E-02	4.70E-02
2-Methylnaphthalene	150(3)	1.88E-03	NA	NA
Phenanthrene (5)	150(3)	1.88E-03	2.90E-02	6.48E-02
Pyrene	150(3)	1.88E-03	3.00E-02	6.27E-02
Hazard Index				**2.03E+00**

Notes:

(1) Assumptions: 200 mg soil intake/day; 16 kg body weight (ingestion by child)
(2) Based on 12/94 Integrated Risk Information System (IRIS) data.
(3) Based on average of one-half of constituent detection limits.
(4) RfD data obtained from HEAST.
(5) RfD data obtained from Region 3 risk-based screening guidance (EPA, 1993).
NA = Not Available.

Again, the product of the exposure frequency times duration were set to be equivalent to the averaging time, so that these terms canceled, and the oral ingestion exposure term was expressed in mg contaminant /kg body weight/day.

For the lifetime cancer risk portion of the RA, maximum soil concentration values for the various constituents, calculated soil ingestion rates, oral slope factors for the various constituents, and the resulting individual and cumulative cancer risks are presented in Table 3-8.

EPA typically considers a hazard index greater than 1 to be indicative of potentially unacceptable risk, while the results of the acute human health risk assessment for Pond 1 soils presented in Table 3-7 reveal an overall hazard index calculation of 2.03. However, there is ample reason to consider the derived hazard index to be an overestimate of the overall non-carcinogenic risk posed by Pond 1 soils. First, in the absence of a sufficient soil sample database from which to draw an estimate, maximum soil concentrations for each constituent were employed in the evaluation. More than 80 percent of the total contribution to the hazard index resulted from the hazard quotient of 1.66 obtained for arsenic. However, should the average arsenic value for Pond 1 soils actually be similar to the overall average for the six Pond 1 surface samples obtained during the RFI Phase II (25 mg/kg) the overall contribution of arsenic to the hazard index is reduced by nearly 40 percent. Furthermore, there is no evidence to support the extremely conservative concentration values assumed for the semivolatile constituents. The conservatively assumed maximum concentrations for these constituents contributed approximately 16 percent of the total hazard index.

Finally, while the residential exposure assumptions used in the non-carcinogenic evaluation (based on child exposure) were mandated by EPA, there is abundant reason to doubt that such an exposure scenario could ever occur at the site, as was discussed in preceding sections of this document If the exposure assumptions are modified to a more reasonable adult exposure scenario, using an ingestion rate of 100 mg/kg soil/day and a 70 kg adult body weight, the overall hazard index is reduced to a value of 0.232, which is nearly one tenth of the current value of 2.03, and also less than one-fourth of a hazard index value of 1.0.

For the carcinogenic risk assessment summarized in Table 3-8, an overall cumulative cancer risk of 1.7×10^{-3} was calculated. Again, the derived value is very likely to be a gross overestimate. Two semivolatile constituents, benzo(g,h,i)perylene and benzo(a)pyrene, contribute approximately 94 percent of the total estimated cumulative carcinogenic risk posed by the Pond 1 soils. There is no evidence to believe that these assumed values provide a realistic estimate of the true soil concentration values for these constituents. The assumed soil concentration for arsenic (39.9 mg/kg), which essentially contributes the remainder of the cancer risk, falls within an acceptable risk range of 10^{-4} to 10^{-6}, particularly when the extremely minimal potential for residential occupation of the site is taken into account.

Table 3-8 Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Lifetime Cancer Risks for Pond 1 Soils

Constituent	Maximum Concentration (mg/kg)	Calculated Soil Intake (mg/kg/day)(1)	Oral Slope Factor (mg/kg/day)(2)	Calculated Cancer Risk
Arsenic	39.9	5.70E-05	1.75	9.98E-05
Chromium	1011	1.43E-04	NA	NA
Nickel	37	5.29E-05	NA	NA
Zinc	434	6.20E-04	NA	NA
Acetone	0.387	5.53E-07	NA	NA
Benzene	0.03	4.29E-08	2.90E-02	1.24E-09
Ethylbenzene	0.59	8.43E-07	NA	NA
Methylene chloride	0.076	1.09E-07	7.50E-03	8.18E-10
Toluene	0.622	8.89E-07	NA	NA
Xylenes	2.05	2.93E-06	NA	NA
Benzo(g,h,i)perylene (3)	150(4)	2.14E-04	1.55E-01	3.32E-05
Benzo(a)pyrene	150(4)	2.14E-04	7.30E+00	1.56E-03
Chrysene	150(4)	2.14E-04	NA	NA
Dibenzofuran	150(4)	2.14E-04	NA	NA
2,4-Dimethylphenol	150(4)	2.14E-04	NA	NA
Fluorene	150(4)	2.14E-04	NA	NA
Naphthalene	150(4)	2.14E-04	NA	NA
2-Methylnaphthalene	150(4)	2.14E-04	NA	NA
Phenanthrene	150(4)	2.14E-04	NA	NA
Pyrene	150(4)	2.14E-04	NA	NA
Total Cancer Risk				**1.70E-03**

Notes:

(1) Assumptions: 100 mg soil intake/day; 70 kg body weight (ingestion by adults).

(2) Based on 12/94 Integrated Risk Information System (IRIS) data.

(3) Oral slope factor data obtained from Region 3 risk-based screening guidance (EPA, 1993).

(4) Based on average of one-half of constituent detection limits.

3.4.3 Risk Assessment for Pond 1 Groundwater

For the Pond 1 groundwater RA, EPA also stipulated that potential human health risks posed by groundwater in the vicinity of the unit be assessed on the basis of an oral ingestion exposure pathway under a residential occupation scenario. Calculation of the residential ingestion of groundwater contaminants was determined according to the residential groundwater ingestion equation presented in Exhibit 6-11 of the EPA Human Health Evaluation Manual, Part A (EPA, 1989a). Again, standard default exposure assumptions typically employed in a residential exposure assessment were used in the current RA. For the evaluation of both non-carcinogenic and carcinogenic effects, the following assumptions were employed:

- exposed individual is an adult;
- body weight is 70 kg; and
- ingestion rate of contaminated groundwater is 1.4 liters/day.

As was the case for the soils assessment, the product of the exposure frequency times duration were set to be equivalent to the averaging time, so that these terms canceled, and the oral ingestion exposure term was expressed in mg contaminant /kg body weight/day.

Results of the assessment of non-carcinogenic effects of groundwater-ingestion are summarized in Table 3-9. The estimated hazard index for residential ingestion of groundwater was 14.8, with arsenic contributing 99 percent of the total. Since arsenic has been reported in site monitoring well samples at concentrations exceeding the arsenic MCL, it is reasonable to expect that a hazard index greater than 1.0 would be obtained. Similarly, while arsenic and benzene both contributed to the calculated cancer risk of 7.72×10^{-3} (Table 3-10), the total cancer risk was dominated by the estimated effects of arsenic.

Although the non-carcinogenic and carcinogenic risk parameter calculations described above might appear to indicate significant potential risk, scarce significance should be attached to these findings. More recent sampling utilizing low-flow purge techniques has significantly reduced turbidity and associated metals concentration. Also, preceding sections of this document have provided ample demonstration that human occupation of land overlying the groundwater in the vicinity of Pond 1 will not occur, and that, even if such occupation were to occur, the natural quality of the groundwater causes it to be grossly unsuitable for human consumption. Indeed, in providing guidance for characterizing the potential for human exposure to environmental contaminants, EPA has explicitly recognized that "an assumption of future residential land use may not be justifiable if the probability that the site will support residential land use in the future is exceedingly small" (EPA, 1989a).

Table 3-9 Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Non-Carcinogenic Risks for Exposure to Pond 1 Groundwater

Constituent	Maximum Concentration (mg/l)	Calculated Groundwater Intake (mg/kg/day)(1)	Oral Reference Dose (2)	Hazard Quotient
Arsenic	0.22	4.40E-03	3.00E-04	1.47E+01
Chromium	0.05	1.00E-03	1.00E+00	1.00E-03
Nickel	0.12	2.40E-03	2.00E-02	1.20E-01
Benzene	0.041	8.00E-04	NA	NA
Ethylbenzene	0.032	6.00E-04	1.00E-01	6.00E-03
Toluene	0.021	4.00E-04	2.00E-01	2.00E-03
Xylene	0.032	6.40E-04	2.00E+00	3.20E-04
2-Hexanone	0.023	2.80E-04	NA	NA
2-Butanone	0.048	9.60E-04	6.00E-01	1.60E-03
Carbon disulfide	0.117	2.34E-03	1.00E-01	2.34E-02
Bis(2-chloro isopropyl)ether	0.022	4.40E-04	4.00E-02	1.10E-02
Hazard Index				**1.48E+01**

Notes:

(1) Assumptions: 1.4 liter intake/day; 70 kg adult body weight.

(2) Based on 12/94 Integrated Risk Information System (IRIS) data.

Table 3-10 Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Carcinogenic Effects for Exposure to Pond 1 Groundwater

Constituent	Maximum Concentration (mg/l)	Calculated Groundwater Intake (mg/kg/day)(1)	Oral Slope Factor (mg/kg/day)(2)	Calculated Cancer Risk
Arsenic	0.22	4.40E-03	1.75E+00	7.70E-03
Chromium	0.05	1.00E-03	NA	NA
Nickel	0.12	2.40E-03	NA	NA
Benzene	0.041	8.00E-04	2.90E-02	2.32E-05
Ethylbenzene	0.032	6.00E-04	NA	NA
Toluene	0.021	4.00E-04	NA	NA
Xylene	0.032	6.40E-04	NA	NA
2-Hexanone	0.023	2.80E-04	NA	NA
2-Butanone	0.048	9.60E-04	NA	NA
Carbon disulfide	0.117	2.34E-03	NA	NA
Bis(2-chloro isopropyl) ether	0.022	4.40E-04	NA	NA
				7.72E-03

Notes:

(1) Assumptions: 1.4 liter intake/day; 70 kg adult body weight.

(2) Based on 12/94 Integrated Risk Information System (IRIS) data.

3.5 Characterization of Potential Ecological Effects

Subsequent to discussions with personnel at EPA Region 6, Navajo has been required to conduct an ecological assessment of potential environmental risks in the vicinity of Pond 1. Specifically, EPA has requested that potential impacts of soil contaminants to nonhuman terrestrial receptors also be evaluated and discussed in this revised CMS.

In response, the following sections describe the general considerations and assumptions, methodology and findings of the ecological assessment. Due to the potentially limitless breadth and complexity of ecological risk assessments, it was necessary to circumscribe a reasonable level of appropriate effort for the current assessment. Further, it is Navajo's understanding that there is general agreement with EPA that neither the scale and magnitude of environmental contamination associated with the unit, nor the environmental setting in which the unit is situated, are likely to result in profound or widespread environmental impacts. Therefore, no attempt has been made to evaluate potential ecosystem impacts at every possible level of biological organization or scale. Instead, the scope of the assessment has been designed to provide sufficient information to demonstrate that, from both biological and societal perspectives, no significant and meaningful ecological impact has or can be expected to occur at a future date as a result of environmental conditions at the unit.

The limited ecological assessment presented in the following sections is based on general guidelines contained in the report "Framework for Ecological Risk Assessment" (EPA, 1992a) and various other guidance and technical documents. Section 3.5.1 discusses the ecological problem formulation. Problem formulation establishes the goals, breadth and focus of the assessment, and identifies major factors to be considered in light of regulatory requirements and societal values (EPA, 1994a). Section 3.5.2 presents the conceptual model of ecological components involved in the flow of contaminants through a model food chain, and 3.5.3 presents conservative estimates of environmental exposure to chemical stressors of selected ecological receptors, and the extent to which such exposures may potentially result in a deleterious ecological impact. The results and conclusions of the risk characterization are summarized in Section 3.5.4. A summary of the risk assessment results is presented in Section 3.5.5.

3.5.1 Problem Formulation

The two primary components of problem formulation are the selection of endpoints and the development of a conceptual model that describes the potential risks to the problem-specific ecological endpoints. The designation of appropriate ecological endpoints must in turn take into account the overarching concept of ecological significance. Determination of ecological significance depends on the following general factors (EPA, 1994a):

- whether a detected or projected change in the ecological system or its individual components is important to the structure, function or health of the system; and
- whether such a change is of sufficient type, intensity, extent, or duration to be important to society.

Although the societal decision may not be explicit, societal assignment of a use for a given landscape and its accompanying ecosystem is highly determinative for defining ecological significance, (EPA, 1994a). From a conceptual perspective, ecological systems exist along a continuum ranging from natural systems exhibiting characteristics essentially unchanged from their original prehuman history condition, to systems in which a very large proportion of the biological components are either directly or indirectly impacted by human activities. Societal valuation of natural systems and assignment of ecological significance to human impacts is not necessarily correlated to an ecosystems position on the natural continuum. Judgmental criteria used to assign ecological significance include factors such as:

- ecological change impacting the economic productivity and/or long-term sustainability of a natural resource (i.e. fisheries, forests, farmland);
- ecological change exerting indirect impacts on human society and economies (i.e. a wetlands that functions as a flood control system during peak precipitation events); and
- effects which directly or indirectly impact nominally noncommercial (aesthetic) properties (i.e. rare habitat, exceptional diversity, scenic beauty, historical significance, etc.)

The Navajo Evaporation Pond network is situated in the Pecos Valley physiographic region of the Great Plains province (Thelin and Pike, 1991). The landscape surrounding the site is dominated by patchy shrubs and grasses. Adjacent to the Pecos River, large tracts of exotic saltcedar also occur. Terrestrial vegetation characteristic of the Pecos Valley is most often classified as a desert grassland ecotone, although alternative terms have also been used (shrub-steppe, desert plains grassland, desert shrub grassland, etc.). Plant ecologists presume that climax desert grasslands existed in prehistoric times either within or at the borders of the Chihuahuan Desert. However, intensive overgrazing of the once prevalent and more economically productive plains-mesa grassland ecotone is believed to have created vast new areas of successional-disturbance desert grassland (Dick-Peddie, 1993). Contemporary plant ecologists are generally unable to discern successional desert grassland from the original terrestrial range of climax desert grassland (Dick-Peddie, 1993).

Within the framework of ecological significance described above, an evaluation of the landscape encompassing Pond 1 makes it apparent that the site and its surroundings have not been or likely will be subject to significant ecological effects resulting from soil-borne contaminants (the issue of potential ecological effects of unit contaminants transferred to receptors via the groundwater pathway is discussed in section 3.7). In terms of relevant spatial scale, the total land area impacted by Pond 1 constitutes a relatively small absolute area (15.7 acres) and represents a very small fraction of the surrounding desert grassland landscape. Furthermore, as discussed in Section 3.3.1, environmental impacts resulting from the operations at the Navajo Evaporation Ponds represent a unique industrial occurrence in the Pecos Valley. Environmental contaminants at the site do not constitute a contributory component of any generalized or widespread trend in the Pecos Valley region which would potentially suggest a significant cumulative impact upon the environment.

Without question, the most prevalent land use in this area is open livestock rangeland. This activity represents the most widespread, socially-sanctioned land use in the region. In direct terms of forage productivity, environmental contaminants present at Pond 1 have no impact upon the economic productivity or sustainability of the surrounding landscape dedicated to rangeland usage. In terms of alternative “nonuse” aesthetic, recreational or educational values, the site and surrounding landscape possess no outstanding features which would confer upon them any societal value of this type.

In conclusion, as viewed from biological, economical and societal perspectives, no compelling evidence exists to indicate that any critical ecological significance should be conferred upon the ecological landscape surrounding Pond 1.

3.5.1.1 Endpoint Selection

Given the extensive, relatively non-fragmented nature of the prevailing rangeland habitat surrounding the site, it is concluded that large-scale ecological effects on the surrounding landscape can not reasonably be anticipated as a result of environmental conditions at Pond 1. Consequently, any potential ecological effects would be expected to have an impact at the level of the individual organism, rather than at the higher organizational levels of species population or community. Ecological effects, if any, can be expected to occur primarily at the level of a localized spatial scale (e.g. within and immediately adjacent to the unit). The potential ecological significance of such a localized small-scale effect would be highly minimal, since receptor organisms would, in all likelihood, be members of populations exhibiting large and widespread populations. Macrofauna possessing the highest likelihood to experience significant and sustained exposure to residual site contaminants, include small herbivorous species possessing limited home ranges and foraging territories, such as rodents and rabbits.

Localized impacts on individual organisms belonging to widespread terrestrial species does not constitute grounds for ecological significance under the ecological setting in the vicinity of the ponds, which are already subject to significant and ongoing impacts from human activity in the form of livestock grazing. However, it is true that significant societal value is extended to individual members of rare species that have been designated as threatened or endangered. Due to the fact that the landscape surrounding Pond 1 is devoted primarily to livestock grazing, the probability that rare or endangered species possessing unique habitat requirements will be present at the site on a constant or frequent basis is greatly diminished. However, potential exposure of individuals belonging to certain endangered species can not be entirely ruled out. In particular, raptors such as hawks and eagles typically utilize extremely large hunting ranges, such that visitation of the site on an infrequent basis is conceivable.

Based on the considerations delineated above, it was determined that the estimation of ecological risk was most appropriately focused on assessing the potential impact of site contaminants on individual members of endangered species that might sporadically visit the site. In adopting this ecological model, the following assumptions were established:

- potential exposure of individual members of endangered raptorial species to soil contaminants at the site occurs via a relatively direct food chain pathway in which the raptor preys upon an individual residing and/or feeding on-site;
- raptor predation of such a resident prey would occur at a frequency rate sufficiently low as to permit the simplifying assumption that any such predation can be considered to be a one-time event for any particular individual bird.

3.5.1.2 Stressor Selection

Environmental contaminants documented at Pond 1 include various metals and volatile and semivolatile organic compounds. The available data indicate that volatile constituents are present only sporadically and at relatively low (e.g. ug/kg) concentrations (KWBES, 1993). Their infrequent occurrence and low concentrations indicate that volatile organic constituents do not pose a significant ecological risk in the context of the site environmental setting. In addition, the trace concentrations of volatile constituents will diminish even further over time as they are subject to natural biodegradative processes. Based on these considerations, volatile organic constituents were not considered further in the ecological risk assessment.

Various semivolatile organic constituents have been reported in surface soils in the mg/kg concentration range (KWBES, 1993). However, environmental data for this class of contaminants in the soil medium is limited due to pervasive analytical interference in environmental soil samples resulting from the oily matrix of the hydrocarbon wastes. However, sufficient data exists to indicate that semivolatile organic constituents do not occur at concentrations that could be construed to indicate significant ecological impacts. A review of the Integrated Risk Information System (IRIS) database reveals that, for those semivolatile organic constituents reported in Pond 1 soils during the RFI Phase II (and for which human reference dose standards have been established) lowest observed adverse affect levels (LOAEL) for experimental animals have been documented to occur at exposure levels typically in excess of several hundred milligrams of constituent per kilogram body weight. As is most often the case for regulated environmental contaminants, stringent human exposure standards are primarily derived by extrapolation from high-dosage animal experiments to establish exposure levels which would theoretically yield very small incremental cancer probabilities for humans.

Research conducted for this assessment included searches of the general scientific literature and an EPA database dedicated to ecotoxicological effects information for terrestrial wildlife (TERRETOX). That search failed to yield any information regarding ecotoxicological effects (including bioaccumulation factors) for any of the Pond 1 semivolatile organic constituents of concern. However, there is little reason to believe that semivolatile organic constituents have high bioaccumulative potential in terrestrial food chains. As common combustion products generated by large-scale phenomena such as forest fires, volcanic eruptions and burning of fossil fuels, semivolatile organic constituents are ubiquitous global pollutants. While other globally-distributed pollutants that are well represented in the TERRETOX database (i.e. organochlorine pesticides, mercury, PCB's, and dioxins) are well documented to possess significant bioaccumulative potential (Travis and Hester, 1991), no scientific literature was identified that suggested that semivolatile constituents pose comparable bioaccumulation potentials for terrestrial ecosystems.

The existing analytical database, together with general knowledge of the chemical characteristics of the former waste stream received by Pond 1, are sufficient to indicate that individual semivolatile organic constituents do not occur in Pond 1 soils at levels which would exert a significant impact on the surrounding terrestrial ecosystem. Therefore, in view of the probable low toxicity of these constituents (relative to existing concentrations in Pond 1 soils), the relatively low level of ecological sensitivity exhibited by the surrounding environment, and the fact that semivolatile organic constituents in Pond 1 soils will continue to diminish over time, semivolatile constituents also were excluded from further analysis in the assessment.

Three inorganic constituents (arsenic, chromium, and lead) have been identified as potential constituents of concern in Pond 1 soils. A preliminary review of the potential of these constituents resulted in the exclusion of chromium from further consideration as a potential ecological stressor at Pond 1. This conclusion was based primarily on ecological exposure pathway modeling previously conducted by EPA as technical support for the development of the Clean Water Act Part 503 Municipal Sludge Disposal regulations (Eastern Research Group, 1992). EPA's own analysis was conducted in the context of an agricultural setting in which ecological sensitivity was considered noncritical, and in which numerous conservative assumptions were adopted. Environmental exposure pathways for which assessments were conducted in that technical support effort and which are considered to be particularly relevant to the current ecological risk assessment include:

- soil to plant to animal
- soil to animal
- soil to soil biota to soil biota predator

The results of the analyses indicated that land-applied chromium posed minimal risks to modeled terrestrial receptors at concentration exposure levels similar to, or even greatly exceeding those occurring in Pond 1 soils. Under residential land use scenario assumptions yielding the most stringent soil concentration limits for chromium based on permissible human exposure limits, a permissible soil concentration of 78,000 mg/kg (chromium as Cr^{3+}) has been established (EPA, 1995). Based on these considerations, chromium was not considered further in the ecological risk assessment.

During the previously cited ecological exposure pathway modeling conducted by EPA for the Clean Water Act Part 503 program, either arsenic, lead, or both, were considered relevant to the exposure pathways listed above. Both arsenic and lead are persistent environmental contaminants in Pond 1 soils. Consequently, arsenic and lead were identified as the potential ecological stressors of interest.

3.5.2 Ecological Exposure Model

The assumptions and methodologies used to develop an estimate of significant ecological risk resulting from exposure of terrestrial receptors to potential ecological stressors in the form of arsenic and lead contaminants at Pond 1 are presented herein. The conceptual model consists of a two-tiered food chain in which the first tier considers potential exposure of a target prey species (jackrabbit) ingesting soil contaminants via one direct pathway (soil to receptor) and one indirect pathway (soil to plant to receptor). Second tier evaluation considers potential impact at a higher trophic level in which a generic raptor species feeds upon the tier one-modeled prey species. Exposure assumptions and calculations for the receptors at the two trophic levels are detailed in the following sections.

3.5.3 Exposure Analysis

The following parameters are necessary to establish exposure of the Tier 1 model prey species to environmental contaminants of interest:

- food ingestion rate
- soil ingestion rate
- contaminant concentration in ingested foods
- contaminant concentration in ingested soils

Methods and assumptions used to derive values for those parameters are detailed in the following sections.

3.5.3.1 Derivation of Food and Soil Intake Values

An estimate of the ingestion rate of soil-borne contaminants via the postulated direct and indirect exposure pathways requires the derivation of an approximate daily rate of food ingestion (FI). Information providing a basis for arriving at an estimated ingestion rate for the target prey species is presented in the document entitled *Wildlife Exposure Factors Handbook,* Vol. 1 (EPA, 1993b), and Nagy (1987) as cited therein.

Food ingestion (FI) rates for animal species vary according to numerous factors, such as body size, metabolic rate, composition of the diet, reproductive status, ambient temperature, etc. In general, FI values for a given animal species can be derived by establishing the animal metabolic rate and dividing that value by the metabolizable energy in its food (Nagy, 1987). However, site specific data for types and relative proportions of ingested food materials for jackrabbit (or any other rabbit species) either in southeastern New Mexico, or in a desert grassland environment in general, were not identified.

Nagy (1987) developed general allometric equations for FI rates as a function of body weight for birds, mammals and lizards using estimated metabolic rates and general dietary composition (the equations are presented in the *Wildlife Exposure Factors Handbook,* Section 3.1.2). For placental mammals, the general equation for herbivores is:

$$FI\ (g\text{-}dry\ wt/day) = 0.577 \times g\text{-}body\ wt^{0.727}$$

An estimation of jackrabbit body weight was obtained from the Biota Information System of New Mexico (BISON) electronic database, which is maintained by the State of New Mexico Department of Game and Fish. In the absence of specific data for New Mexico, data for the species as it occurs in southern Arizona was considered to be reasonably equivalent. According to the information presented in BISON for southern Arizona jackrabbit, average adult body weight is 2,300 grams (the relevant information excerpted from BISON is reproduced as Appendix I of this report). At any given time, approximately 75% of rabbit populations consists of non-adult individuals. Based on these considerations, a default jackrabbit body weight value of 2,000 grams was selected for use in the assessment.

Based on the general FI equation for herbivorous placental mammals derived by Nagy, and the selected average adult body weight of 2,000 g, the daily FI estimated equation rate was calculated as:

$$FI\ (g\text{-}dry\ wt/day) = 0.577 \times 2{,}000^{0.727} = 145\ g$$

The New Mexico Game and Fish Department BISON database reports that captive jackrabbits in southern Arizona (animal size not reported) consumed approximately one-quarter pound (approximately 113 g) alfalfa and rolled oats per day (although the moisture content of the feed was not reported). In addition, BISON also reports that the forage consumption potential of 148 jackrabbits is equivalent to that of one cow. Assuming a standard cattle body weight of 401 kg and a daily consumption rate of approximately 14.5 kg dry weight (U.S. Bureau of Land Management, undated circular), the cited rabbit-cow consumption equivalency estimate translates to a per rabbit forage consumption potential of only 98 g dry weight/day. Consequently, the calculated FI value would appear to be a conservative estimate.

Data to quantify soil ingestion rates for various animal species is largely lacking at this time. However, Lepus californicus is among the few species for which a soil ingestion rate value has been obtained. Based on the findings of Arthur and Gates (1988), it has been estimated that jackrabbits incidentally ingest soil materials (expressed on a dry weight basis) at a rate equivalent to 6.3 percent of their diet. Thus:

$$145\ g\text{-}dry\ wt\ FI/day \times .063 = 9.1\ g\text{-}dry\ wt\ soil/day$$

3.5.3.2 Selection of Soil Contaminant Concentration Values

Overall, average values for arsenic and lead obtained from the seven samples collected from the 0-1 ft. sample interval depth (Appendix A) were 23.5 and 112 mg/kg, respectively. In addition to consideration of average soil concentrations for these constituents, maximum soil concentration values obtained for any soil sample collected at Pond 1 were also considered in the development of the exposure estimate. Highest reported concentration values for arsenic and lead in Pond 1 soil samples were 39.9 and 389 mg/kg, respectively. These maximum soil concentration values were both reported for soil samples collected at a one-foot sample collection depth. Maximum soil concentration values for arsenic and lead exceeded overall average concentration values for those constituents by factors of approximately 1.7 and 3.5, respectively.

3.5.3.3 Estimation of Plant Tissue Metal Concentration Values

As described above, the indirect exposure pathway considered in the ecological risk modeling involves contaminant uptake by vegetation that is subsequently consumed by the model prey species. It was therefore necessary to model the transfer of arsenic and lead contaminants from soil to plants, for which EPA-accepted algorithms are available. Information sources for the assumptions, formulas and most of the required input values are presented in the document entitled, *Technical Support Document for Land Application of Sewage Sludge* (Eastern Research Group, 1992). It should be stressed that the methodologies and various parameter values presented in that document were used in part to form the basis for a major nationwide environmental regulatory program. Due to their general applicability to metal-contaminated soils, they have subsequently been adapted in part for the CERCLA program (see Appendix A of the Technical Background Document for Soil Screening Guidance - Review Draft, EPA, 1994b).

Basic Algorithm

The basic method for estimating potential plant uptake of a metal contaminant from the soil takes the general form:

$$C_{plant} = C_{soil} \times UC$$

where,

C_{plant} = plant metal concentration (ug metal/g dry wt plant tissue)
C_{soil} = soil metal concentration (ug metal/g soil)
UC = plant uptake concentration slope factor (ug metal/g dry wt plant tissue)(ug metal/g soil)$^{-1}$

Empirical parameter values for C_{soil} are readily obtained from the analytical data for Pond 1 soils generated during the RFI Phase II. As discussed above, average and maximum soil concentration values for arsenic and lead are included for consideration in the modeling.

Plant UC values for arsenic and lead are dependent upon the types of vegetation for which estimates are desired. Estimated values for UC are available for a variety of general categories of consumable vegetation (Eastern Research Group, 1992), and their use for risk analysis at CERCLA sites has also been proposed by EPA (1994b). However, since UC values vary with vegetation type, it is necessary to establish vegetation consumption patterns for the Tier 1 model prey species.

In the absence of available data for jackrabbit dietary composition in southeastern New Mexico, information presented in the BISON database for southern Arizona was reviewed. The information indicated that grass, mesquite and cactus were the predominant components in the jackrabbit diet, with no detectable evidence of consumption of tubers, roots and bark. Mesquite is known to occur infrequently in the general area of the ponds, but is not found at the Navajo Evaporation Ponds property. No species of cactus have been observed to occur in the vicinity of Pond 1 or the surrounding properties. Therefore, for purposes of this assessment, it is assumed that grass and forb species would constitute the bulk of ingested vegetation for the modeled prey species. In this regard, it is relevant to note that the BISON database reports that jackrabbit in southern Arizona are documented to compete directly with livestock for available rangeland forage.

Based on the considerations discussed above, a generic UC value for livestock forage was deemed to be most appropriate for use in the assessment. On the basis of an exhaustive literature survey, EPA has established default UC values of 0.03 for arsenic and 0.002 for lead (see Eastern Research Group, 1992, p. 5-181, Table 5.2.6-3).

Using the parameter values defined above for soil metal concentrations and plant UC, the following plant tissue metals concentration values are obtained:

forage arsenic concentration

minimum =(23.5 ug As/g soil) (0.03 ug As/g dry wt plant tissue)(ug metal/g soil)$^{-1}$*= 0.71 ug As /g dry wt plant tissue*

maximum = (39.9 ug As/g soil) (0.03 ug As/g dry wt plant tissue)(ug metal/g soil)$^{-1}$ *= 1.12 ug As /g dry wt plant tissue, and*

forage lead concentration

minimum = (112 ug Pb/g soil) (0.002 ug Pb/g dry wt plant tissue)(ug metal/g soil)$^{-1}$*= 0.22 ug Pb /g dry wt plant tissue.*

maximum = (389 ug Pb/g soil) (0.002 ug Pb/g dry wt plant tissue)(ug metal/g soil)$^{-1}$*= 0.78 ug Pb /g dry wt plant tissue.*

For both metals background plant tissue concentrations were also determined in the same manner as described above. Parameter values for soil arsenic and lead concentrations used in the assessment are summarized in Table 3-11.

Table 3-11 Summary of Soil and Plant-Related Parameter Values Used in the Tier 1 Ecological Risk Modeling.

	Location			
	Soil background As (1)	**Soil background Pb (1)**	**Pond 1-As (min/max)**	**Pond 1-Pb (min/max)**
Parameter				
Soil concentration (ug metal /g soil)	3	11	23.5/39.9	112/389
Plant Uptake Slope (UC) (ug metal /g dry wt plant tissue) (ug metal/g soil)$^{-1}$ (2)	0.03	0.002	0.03	0.002
Calculated plant tissue metal concentration (ug metal/g dry wt plant tissue)	0.09	0.022	0.71/1.20	0.22/0.78

Notes:

(1) based on nationwide averages (Eastern Research Group, 1992)

(2) based on default values derived from compiled scientific literature (Eastern Research Group, 1992)

3.5.3.4 Exposure Estimate for Tier 1 Prey Species

Development of an exposure estimate for the Tier 1 model prey species required an estimate of the relative proportion of food resources which would be obtained by the modeled Tier 1 jackrabbit from within the physical confines of Pond 1. Again, the new Mexico Game and Fish Department BISON database was used to obtain a default estimate for this parameter, which was designated as the Fraction of Food and Soil Ingested at the site (F_{FSI}). Information presented on the BISON database for jackrabbit in southern Arizona indicated that daily movements of 1-2 miles per day were common, with some individuals known to make round trips as great as 10 miles in a day. Estimates of jackrabbit home range size reported from various states included average range sizes of 16.2 ha (Kansas and Idaho-habitat not characterized), 20.2 ha (California-habitat not characterized) and 30 ha (Colorado-shortgrass prairie). Based on the presumption that the desert grassland habitat characteristic of the landscape surrounding Pond 1 will possess a jackrabbit carrying capacity no greater or less than a Colorado short grass prairie habitat, and incorporating a reasonable margin of conservatism, a default home range area value of 20 ha was selected for use in the exposure estimate.

The total surface area of Pond 1 is approximately 6.4 ha (15.7 acres). Based on an assumed home range area of 20 ha and a Pond 1 area of 6.4 ha, a value for the parameter F_{FSI} is estimated as:

$$F_{FSI} = 6.4 \text{ ha (Pond 1)} / 20 \text{ ha (assumed home range area)} = 0.32$$

Based on the required parameter values, the relevant exposure calculations for the Tier 1 model prey species were executed for each metal according to the following general equation:

$$\text{ug metal ingested/kg-BW} =$$

$$[(FI \times \text{ug metal/g dry wt plant tissue-Pond 1}) + (SI \times \text{ug metal/g soil-Pond 1})] (0.32)(BW)^{-1}$$

$$+$$

$$[(FI \times \text{ug metal/g dry wt plant tissue-background}) + (SI \times \text{ug metal/g soil-background})] (0.68)(BW)^{-1}$$

where

BW is animal default body weight (default value =2 kg)

FI is food ingested (default value = 145g dry wt plant tissue/day)

SI is soil ingested (default value = 9.1 g soil/day),

0.32 is the fraction of ingested food and soil obtained at Pond 1, and

0.68 is the fraction of ingested food and soil obtained from background areas adjacent to Pond 1

Input of soil and plant tissue-specific values for arsenic and lead to the equation yield the following exposure range estimates:

Estimated daily exposure range of the Tier 1 model prey species to arsenic: 129 to 199 ug As/day

Estimated daily exposure range of the Tier 1 model prey species to lead: 405 to 1,239 ug Pb/day

3.5.4 Tier 1 Risk Evaluation

Under the assumptions of the exposure estimation methodology presented in Section 3.5.3.4, the exposure estimates do not indicate that the model prey species would be significantly affected by exposure to the designated ecological stressors of concern. Quantified ingestion values for arsenic and lead ranged from 129 to 199 ug and 405 to 1,239 ug, respectively. The potential significance of the derived exposure estimates is discussed in the following sections.

3.5.4.1 Risk Analysis of Tier 1 Receptor Exposure to Arsenic

From the perspective of applicable human exposure standards for arsenic, the calculated jackrabbit exposure rate would appear to be highly excessive. However, for a variety of reasons, human exposure standards do not lend themselves to useful comparisons with animal receptors, particularly in the context of the current postulated exposure scenario.

Human tolerance levels for arsenic are based on conservatively established potential for an incremental cancer incidence ranging from 1 x 10^{-4} to 10^{-6} for exposed populations. The maximum permissible human exposure level for arsenic via a soil ingestion pathway under the most limiting assumptions of a residential land use scenario (EPA, 1995) translates to a soil ingestion limit of approximately 0.042 ug/day. The life expectancy for most wild animals does not extend significantly beyond their reproductive years - a fact that is particularly true for prolific-breeding prey species such as rabbits. Therefore, potential low probability cancer risks have no relevancy for such nonhuman species.

Current EPA standards for arsenic are based on a documented case study in which the populations of several Taiwanese villages were chronically exposed to arsenic as arsenite (As^{3+}) in drinking water (IRIS database). Arsenite ingestion rates for case-study population in Taiwan (in which high mortality rates due to arsenic exposure were not observed and in which physiological effects in individuals under age 20 were limited primarily to noncancerous skin lesions) were approximately 2,130 ug/day (IRIS database). However, arsenic toxicity is related to the molecular form in which it occurs. Arsenite is significantly more water soluble and bioavailable than other common forms of arsenic. In a typical, pH-neutral, oxidized soil environment, the most prevalent form of arsenic is arsenate (As^{5+}) (O' Neil, 1995, Woolson, 1977). Arsenic also exists in a wide variety of natural arsenorganic forms, of which various methylated forms are most common.

Oral dosages required to attain rat LD_{50}s for sodium arsenite, sodium methyl arsenate, and sodium dimethyl aresenate, determined by the National Institute for Occupational Safety and Health (NIOSH), and as reported by Hamasaki et al., (1995) on a mg per kg body weight basis are: 41 mg/kg, 790 mg/kg, and 2,600 mg/kg, respectively. As the LD_{50} data indicates, methylated arsenic compounds are significantly less toxic than inorganic arsenic. In mammalian systems, ingested methylated arsenic absorbed through the gastrointestinal tract exhibits low toxicity and is readily excreted through the urinary system (Adams, et al., 1994). Ingested and absorbed inorganic arsenic (As^{3+} and As^{5+}) are transported to the liver, where As^{5+} is also reduced to As^{3+}. It subsequently undergoes methylation in the liver and is also excreted via the urinary system. The EPA Science Advisory Board has stated that "at dose levels below 200 to 250 ug As^{3+}/ person/day there is a possible detoxification mechanism (methylation) that may substantially reduce cancer risk from the levels EPA has calculated" (EPA, 1989b).

Finally the issue of bioavailability is also highly relevant to the current exposure assessment. In a study in which dogs ingested quantities of soils possessing high arsenic concentrations (average dosage approximately 561 ug/kg body weight) it was demonstrated that only about eight percent of the ingested arsenic was absorbed from the gastrointestinal tract (Groen et al., 1994).

Assuming a 2,000 g body weight for the model jackrabbit receptor in this assessment, a daily arsenic dosage ranging from 142 to 219 ug/kg body weight is obtained (129 to 199 ug As/0.909 kg body wt). In preparation for this report, little available literature was identified regarding the evaluation of long-term arsenic exposure effects on nonhuman receptors. The National Academy of Sciences (NAS, 1980) has established a maximum dietary tolerance criteria for arsenic for domestic animals, with limitations being established on the basis of the species exhibiting greatest sensitivity. The dietary limit for arsenic recommended by NAS is 50 ug As /dry weight g diet.

The above-cited NAS arsenic criteria translates to a large daily arsenic dosage for domestic animals. For example, a 401-kg cow consumes approximately 7.3 kg forage (dry weight) per day (U.S.Bureau of Land Management, undated circular). Applying the 50 ug As/g diet criteria to this animal results in a daily arsenic dosage of 910 ug/kg body weight - a value which considerably exceeds the 219 ug/kg arsenic dosage derivable from the upper-end estimate for daily arsenic intake for the hypothetical jackrabbit receptor. In fact, if the NAS criteria is extended to the jackrabbit model under the body weight and food ingestion rate assumptions used for this evaluation, application of the criteria results in a daily arsenic intake such that:

(50 ug / dry weight g diet) x (145 g diet/day) = 7,250 ug As / day

This value exceed the upper bound arsenic exposure estimate (199 ug As/day) derived in this exposure estimate by a factor of 36.

In consideration of the information provided above, it is concluded that it is possible, if not probable, that the arsenic exposure rates estimated for the receptor model will not result in significant physiological effects. The further significance of these findings upon the ensuing Tier 2 ecological evaluation is discussed in Section 3.5.4.3.

3.5.4.2 Risk Analysis of Tier 1 Receptor Exposure to Lead

The maximum permissible human exposure for lead via a soil ingestion pathway is currently about 46 ug/day, as calculated under standard EPA default assumptions for child exposure under a residential land use scenario (EPA, 1995) and standard assumptions regarding the bioavailability of lead used in EPA's Integrated Environmental Uptake Biokinetic (IEUBK) model. In addition, the U.S. Food and Drug Administration has previously established a goal of less than 100 ug/day as the total lead intake by children 1-5 years of age (ASTDR, 1990). At levels of exposure just above these intake standards, exposed children may experience subtle neurological effects related to intellectual and behavioral functions, with higher exposure levels resulting in more pronounced deleterious physiological effects.

Lead toxicosis was produced in chicks by dietary supplementation of lead acetate at concentrations of 3,300 to 6,700 parts per million lead (as lead acetate) (Simpson, et al., 1976). Manifested symptoms included weight loss, loss of appetite and kidney necrosis. A study conducted by Haschek et al., (1979) suggested that on the basis of frequency of histopathologic lesions, soil lead concentrations of 2,500 mg/kg were possibly too high to sustain a healthy rodent population. Beyer et al. (1990) reported that earthworm-consuming birds tolerated approximately 150 ug lead/g dry wt diet.

NAS (1980) has also established a maximum dietary tolerance criteria for lead for domestic animals, with limitations being established on the basis of the species exhibiting greatest sensitivity. The dietary limit for lead recommended by NAS is 30 ug As /dry weight g diet. Based on the assumptions of the current exposure assessment for the model jackrabbit receptor (145 g dry wt diet and total daily lead intake concentrations ranging from 405 to 1,239 ug) the estimated daily lead dietary intake ranges from approximately 2.8 to 8.5 ug/g diet. These estimated lead ingestion rates are both well below the NAS dietary criteria for domestic animals.

Based on the results of the ecological exposure modeling for lead and the available scientific literature, no evidence has been found to suggest that the Tier 1 model prey species receptor would likely experience any profound physiological effects resulting from the estimated lead exposure. It is possible that more subtle effects (behavioral, reproductive, etc.) might be incurred from the postulated level of exposure to lead. However, in view of the fact that any potential exposure effects will be limited to those few individual animals residing in the immediate vicinity of the site, no meaningful ecological significance can be attributed to such subtle effects. The implications of these findings are discussed in the ensuing Tier 2 ecological evaluation presented in Section 3.5.4.3.

3.5.4.3 Tier 2 Risk Evaluation

This section discusses the significance and implications of the Tier 1 ecological assessment as it relates to the Tier 2 ecological component of the model food chain. The Tier 2 model receptor is represented by a societally-valued, idealized raptor that feeds upon the Tier 1 model prey species previously subject to long-term exposure to the selected stressors.

Due to the relatively small area of environmental contamination represented by Pond 1 relative to the very large and uniform habitat surrounding the unit, the scarcity of threatened or endangered raptor species in the Pecos Valley, and the extremely large hunting territories utilized by such raptors, potential ecological risk at the Tier 2 level is most appropriately considered at the level of an individual bird subject to secondary exposure (via predation) during a singular exposure event.

For purposes of this evaluation, it has been assumed that the idealized raptor model possesses a body weight of 3,000g. An estimation of FI for those bird species which include non-passerine and non-seabird types (which would therefore include raptors) is provided by Nagy (1987). Utilization of the equation in conjunction with the assumed 3,000 g body weight yields the following FI value:

$$FI\ (g\text{-}dry\ wt/day) = 0.301 \times 3{,}000\ g\ body\ wt^{0.751} = 123\ g\ dry\ wt\ diet\ /day$$

Evaluation of potential impacts of the selected ecological stressors (arsenic and lead) upon the Tier 2 receptor are discussed in the following sections.

3.5.4.3.1 Tier 2 Risk Evaluation - Arsenic

The Tier 1 exposure estimate (Section 3.5.4.1) yielded a daily exposure arsenic dosage ranging from 129 to 199 ug per day. A search of the scientific literature failed to yield any specific information on arsenic regarding either its bioaccumulation potential in food chains or exposure levels which might be deleterious to raptors. However, as discussed at length in Section 3.5.4.1, a review of the scientific literature does not indicate that arsenic exposure levels modeled for the Tier 1 prey species would result in significant arsenic body burdens relative to those occurring as background animal tissue levels, since arsenic is widely recognized as not being highly bioaccumulative and is generally excreted quickly from animal systems.

In order to assess a worst case scenario the following assumptions are made with regards to the modeled Tier 1 prey species and the Tier 2 predator:

- the bioavailability of ingested arsenic is 100%;
- arsenic is assigned a bioaccumulation factor (BAF) of 1; and
- the 3 kg raptor ingests the 0.9 kg jackrabbit in it's entirety.

The first assumption is considered to be highly conservative. From the Tier 1 analysis, a majority of the ingested arsenic (approximately 67 percent) is derived from soil ingestion. Although arsenic contaminants have not been characterized in terms of molecular speciation in Pond 1 soils, the demonstrated lack of arsenic mobility in those soils (as demonstrated by TCLP analyses) indicates that arsenic primarily exists in the form of relatively insoluble arsenate oxides of iron, magnesium, carbonate, etc. Arsenic bioavailability studies in humans and animals have primarily considered gastrointestinal tract uptake of arsenite or arsenate delivered as a solution, and bioavailability of inorganic arsenic form administered solutions is typically greater than 90 percent (Charbonneau, et al., 1978, Ishinishi, et al., 1986, Johnson and Farmer, 1991). However, in a study in which dogs ingested quantities of high arsenic-containing soils (average dosage approximately 561 ug/kg body weight) it was demonstrated that only about eight percent of the ingested arsenic was absorbed from the gastrointestinal tract (Groen, et al., 1994).

The second assumption is also considered to be highly conservative. There is in fact no evidence to indicate that arsenic possesses a significant bioaccumulative potential in terrestrial organisms. For instance, an analysis of (nonmedicated) animal feed conducted by Anderson (1983) showed and average arsenic content of 400 ug/kg. This estimated arsenic concentration in animal feed is consistent with a very large body of literature concerning background arsenic concentrations in plant tissues (see NAS, 1977b for extensive literature summary). However, with the possible exception of turkey, animal meat products rarely exhibit arsenic concentrations greater than 50 ug/kg (Adams, et al., 1994). In conclusion, the scientific literature indicates that arsenic exhibits a low bioaccumulation potential in animal systems. Therefore, an arsenic BAF of 1 is considered to be highly conservative as applied to terrestrial organisms.

Finally, the third assumption is considered to be reasonably appropriate. The selected FI value for the idealized 3 kg raptor is 123 g dry wt food/day. Assuming a 90% water content, a 2,000 g jackrabbit would yield 200 g of potential food on a dry wt basis, much of which would consist of fur, bone and other indigestible material. Therefore, it would not appear unrealistic to presume that the hypothetical prey animal could provide the raptor with a sufficient mass of digestible tissue to achieve the designated daily FI value.

Based on the assumptions delineated above, the postulated jackrabbit would possess a total body burden of arsenic equivalent to the mass ingested on a daily basis (which ranges from 129 to 199 ug As / day). If a further conservative factor is included by assuming that the entire hypothetical prey body burden of arsenic is consumed in 123 g of digestible tissue by the raptor, the arsenic dosage received by the raptor as a one-time dose would range from 1.1 to 1.6 ug As/g diet. Based on the available literature, the estimated one-time dosage of arsenic imparted to the modeled raptor would not appear to constitute grounds for significant concern. In fact, the available literature indicates the modeled raptor would possibly receive a much greater arsenic by preying upon domestic turkey birds, which reportedly possess arsenic concentrations in excess of 50 ug/g (Adams, et al., 1994).

Finally, it is also relevant to note the findings of an EPA-approved ecological risk assessment conducted for the Rocky Mountain Arsenal complex in Denver, Colorado (EPA, 1993c). In that assessment, arsenic was identified as a major widespread contaminant across the 27 square-mile facility. Based upon bioaccumulation factors for plants, mammals, and a resident bald eagle population, an acceptable arsenic soil concentration criteria of 52 mg/kg was considered to be sufficient to protect ecological systems and the local bald eagle population. By comparison, the average arsenic concentration in Pond 1 soils (23.5 mg/kg) constitutes less than one-half of the soil concentration standard established for the Arsenal, and the total land area of Pond 1 is approximately 15.7 acres, which is in marked contrast to the far larger areas of arsenic contamination identified within the confines of the 27 square-mile Rocky Mountain Arsenal facility (EPA, 1993c).

3.5.4.3.2 Tier 2 Risk Evaluation - Lead

The Tier 1 exposure assessment yielded an daily exposure dosage estimate for lead ranging from 405 to 1,239 ug As / day (Section 3.4.2). As is the case for arsenic, the scientific literature provides little information regarding the overall bioaccumulative potential for lead. Lead is known to accumulate in human tissue to some extent, particularly in bone tissue. For purposes of modeling a soil to soil biota to soil predator environmental exposure pathway involving lead-contaminated soil, EPA (Eastern Research Group, 1992) has previously selected a default BAF of 0.45 for the case of earthworms ingesting lead-contaminated soils. However, the default BAF was acknowledged by the agency to be highly conservative, since the scientific literature indicated no significant bioaccumulation of lead in earthworm tissues. Instead the default BAF represented the proportion of soil materials relative to total body weight which were contained in the digestive tract of earthworms at any given time. Large dosages of lead acetate (6,700 ppm as a dietary supplement) fed to chicks resulted in concentrations of lead in liver tissue as high as 82.5 ppm (Simpson, et al., 1976). Although it is unlikely that such elevated lead levels would occur in most other body tissues, if the liver content of the exposed chicks is assumed to be representative, a conservative BAF factor of approximately 0.01 can be derived.

As is the case for arsenic, the bioavailability of lead is also highly dependent upon the molecular species in which it occurs. The EPA IEUBK model assumes a default bioavailability of 30 percent for lead derived from ingested soils. Based on the demonstrated lack of mobility of lead in Pond 1 soils (as demonstrated by TCLP analyses) it is considered probable that the bioavailability of lead in Pond 1 soils does not exceed (and could possibly be significantly less than) the assumed standard 30 percent value used for the IEUBK model. Recently, EPA adjusted cleanup goals at a Superfund site from 400 ppm to 1,100 ppm on the basis of pig ingestion tests that demonstrated that lead absorption ranged from 16 to 19 percent instead of the standard 30 percent absorption assumed for the IEUBK model (Superfund Week, 1995).

However, for purposes of this assessment, the default assumptions used to estimate indirect raptor exposure to arsenic via predation on the Tier 1 jackrabbit model are also hereby conservatively assumed (100 percent lead bioavailability, BAF of 1, complete consumption of prey tissues).

Based on the conservative default assumptions described above, the modeled jackrabbit receptor would possess a total body burden of lead equivalent to the quantity of lead it ingests on a daily basis (ranging from 405 to 1,239 ug As). Again assuming that the entire lead burden of the jackrabbit is consumed in the estimated 123 g of raptor diet, the dosage delivered to the raptor in a one-time feeding event will range from 3.3 to 10.1 ug Pb/g diet. EPA has stated that no scientific literature exists to support a lead exposure limit for terrestrial receptors lower than 150 ug/g diet (Eastern Research Group, 1992, p. 5-237). Based on the available literature the estimated food chain exposure of lead contaminants imparted to the modeled raptor does not appear to constitute grounds for concern.

3.5.5 Ecological Risk Assessment Summary

An ecological risk assessment was conducted in order to assess potential for ecologically significant risks posed by contaminants present in surface soils at Pond 1. In general, the ecological landscape surrounding Pond 1 does not possess characteristics which would cause it to be considered a sensitive or highly valuable terrestrial environment. On the basis of a preliminary evaluation of the potential for ecologically significant impacts resulting from site environmental conditions, a simplified, two-tiered food chain model was conceived in order to evaluate potential ecological risks, which evaluated potential exposure to two identified ecological stressors, arsenic and lead.

The results of the Tier 1 exposure assessment and analysis indicate that:

- In terms of direct exposure of a modeled animal receptor to the selected ecological stressors, no evidence exists to indicate that significant physiological effects (including significant increased risk of premature mortality) would result from the estimated exposure levels; and

- Regardless of the nature of any potential deleterious ecological impacts, the ecological significance of any such impact is negligible due to the minimal spatial scale of the impacted area relative to surrounding habitat features.

The results of the Tier 2 exposure assessment and analysis indicate that:

- Even when an entire series of modifying conservative factors are included in the evaluation, the results of the Tier 2 exposure assessment indicate that minimal ecological risks would be posed to a raptor species exposed to site contaminants via the relatively direct food chain pathway which extends from a primary exposed prey to a secondary exposed predator.

It is recognized that considerable uncertainty is inherent in the undertaking of assessments of ecological risk. However, an effort was made to incorporate conservative factors into the assessment wherever feasible in order to compensate for those uncertainties.

It is also recognized that this assessment did not endeavor to assess all conceivably observable/and or measurable potential ecological impacts that might occur as a result of environmental contaminants in Pond 1 soils. However, the ecological assessment presented herein has been designed to be commensurate with the overall degree of ecological sensitivity and significance inherent in the surrounding landscape, as assessed by societal standards of worth as reflected by various biological, economic and aesthetic considerations. As such, it is considered to be reasonable and appropriate.

3.6 Human Health Environmental Risk Under an Agricultural Scenario

Subsequent to the submittal of the revised December, 1994 CMS Workplan for Pond 1, Navajo has been required to include several additional risk evaluation components in the CMS environmental risk assessment. Specifically, the April 13, 1995 EPA review comments for the revised December, 1994 CMS Workplan required the evaluation of a food-chain risk evaluation which considered a groundwater-animal-human pathway. Also at the June 2, 1995 meeting at Region 6 headquarters in Dallas, the attending EPA risk specialist also stipulated that the next revision of the CMS workplan include a human health risk evaluation based on direct exposure to Pond 1 soils under an assumed agricultural land use scenario.

In conducting the required risk evaluations, Navajo has also opted to consider two additional potential sources of environmental risks associated with Pond 1 soils. The two risk components involve the consideration of food chain effects for a soils-animal-human pathway and a soils-plant to animal to human pathway. With the inclusion of these two additional risk assessment components, Navajo believes that all potential environmental exposure pathways relevant to the environmental setting of the site have been considered for Pond 1 soil contaminants.

The human health risk assessment for direct exposure to contaminated soils according to an agricultural land use scenario is presented in Section 3.6.1. The food chain risk assessment considering a groundwater- animal- human pathway is presented in Section 3.6.2.1, and the assessments for the soils-plant-animal-human and soils-animal-human pathways are presented in Sections 3.6.2.2 and 3.6.2.3, respectively.

3.6.1 Human Health Risk Assessment - Direct Exposure

As a result of discussions held on June 2, 1995 between representatives of EPA and Navajo at EPA Region 6 headquarters, Navajo has been required to conduct a human health environmental risk assessment on the basis of an agricultural land use scenario. Specifically, the exposure assessment is required to be in accordance with risk contaminant exposure assumptions and methodologies previously used in the development of an environmental baseline risk assessment for Navajo Evaporation Pond units 2, 3, 5, and 6. The latter risk assessment was conducted as a requirement for the RCRA closure plan for those units, and is presented in the Evaporation Ponds Closure Plan submitted to EPA Region 6 in March, 1995 (ENSR, 1995).

3.6.1.1 Exposure Scenario Assumptions

Under the specified agricultural land use scenario, agricultural activities in the form of livestock production are presumed to occur at the site. The maximum exposed individual is a rancher or ranch hand who periodically visits the site to feed and water livestock, check gates and fences, etc. In evaluating noncarcinogenic and carcinogenic effects, the following assumptions are made:

- the exposed individual is an adult with 70 kg body weight;
- exposure duration is 15 years;
- exposure frequency is 3 days /week, 52 weeks / year;
- the soil ingestion rate is 25 mg/day; and
- the averaging time is 15 years for noncarcinogens and 70 years for carcinogens.

In addition to exposure via a soil ingestion route, the agricultural risk assessment presented in the Evaporation Ponds Closure Plan also considered potential risks posed by soil contaminants via an inhalation exposure pathway. However, a preliminary review of the contaminants reported in Pond 1 soils revealed that potential inhalation risks were either insignificant (VOAs, arsenic) for those constituents for which inhalation toxicology data was available, or for the remaining constituents, no toxicological inhalation data was available (SVOAs and remaining metals).

VOA constituents are present in Pond 1 soils only at trace levels that pose no potential environmental risk via an inhalation exposure pathway.

Potential risks posed by arsenic via an inhalation pathway have previously been modeled by EPA under a residential exposure scenario (EPA, 1994b). The results of that prior risk modeling resulted in a risk-based soil limit of 380 mg/kg for arsenic. Maximum reported arsenic concentrations in Pond 1 soils are nearly two orders of magnitude less than the risk-based standard for arsenic developed under the more stringent exposure considerations of the aforementioned residential exposure. Therefore, it is concluded that risks posed by arsenic contaminants contained in Pond 1 soils via an inhalation exposure pathway are also negligible.

3.6.1.2 Exposure Estimates

Soil contaminant concentrations for metal and VOA constituents that were used in the exposure estimates are the same as those presented in Table 3-7.

For the human health risk assessment conducted under the assumptions of a residential land use scenario (Section 3.4), SVOA concentrations used in the exposure estimate were assumed to be equal to 150 mg/kg - a value equal to one-half of the average detection limit for those constituents. Based on general knowledge of the waste stream formerly received by the unit, the assumed SVOA concentration for Pond 1 soils is expected to represent a highly conservative assumption. However, in view of uncertainty regarding the actual concentrations of SVOAs in Pond 1 soils, incorporation of a cautious degree of conservatism was deemed appropriate in the current risk estimate.

Navajo believes that the specified agricultural exposure scenario considered herein is more plausible than the residential exposure scenario modeled in Section 3.4. Therefore, in view of the greater likelihood that the agricultural exposure scenario could come to pass, it was decided to assume that SVOA constituents in Pond 1 soils were represented by the full average value of the detection limits (300 mg/kg). Selection of this assumed SVOA concentrations for Pond 1 soils results in the incorporation of a very high degree of conservatism in the agricultural exposure assessment.

As was the case for the baseline human health residential risk assessment presented in Section 3.4, the agricultural risk assessment presented below was conducted in general accordance with the guidance and methods developed in the RAGS guidance document (EPA, 1989a). Sources of toxicological data used in the agricultural assessment were also the same as those employed in the baseline human health residential risk assessment, which includes IRIS, HEAST, and other EPA support documents (Section 3.4).

All calculations employed in the estimation of exposure to soil contaminants and the consequent risk levels are presented in (Appendix H). The results of the exposure estimates and ensuing noncarcinogenic and carcinogenic risks calculated on the basis of the exposures are presented in Tables 3-12 and 3-13, respectively.

For the constituents of concern presented in Table 3-12, hazard quotients calculated under the assumptions of the specified agricultural scenario all were two or more orders of magnitude below their respective health-based limits. The assessment does not indicate any potential noncarcinogenic health risks to the exposed individual under the modeled exposure scenario.

A cumulative cancer risk of 7.53×10^{-5} was calculated for human exposure under the specified agricultural land use scenario (Table 3-13). This value falls near the upper (10^{-4}) end of the acceptable range for carcinogenic risk. A number of factors related to the risk estimate suggest that the cumulative risk level associated with exposure to the modeled constituents provide no basis for significant health concerns.

Table 3-12 Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for Assessment of Non-Carcinogenic Human Health Effects For Pond 1 Soils Under the Assumptions of an Agricultural Land Use Scenario.

Constituent	Maximum Soil Concentration (mg/kg)(1)	Reference Dose (mg/kg/day)(2)	Calculated Hazard Quotient
arsenic	39.9	3.00E-04	2.0E-02
chromium	1011	1.00E+00	1.5E-04
nickel	37	2.00E-02	2.8E-04
zinc	434	3.00E-01	2.2E-04
acetone	0.387	1.00E-01	5.9E-07
benzene	0.03	NA	NA
ethylbenzene	0.59	1.00E-01	9.0E-07
methylene chloride	0.076	6.00E-02	1.9E-07
toluene	0.622	2.00E-01	4.7E-07
xylenes (total)	2.05	2.00E+00	1.6E-07
benzo(g,h,i)perylene	300 (3)	NA	NA
benzo(a)pyrene	300 (3)	NA	NA
chrysene	300 (3)	NA	NA
dibenzofuran	300 (3)	NA	NA
2,4-dimethylphenol	300 (3)	2.00E-02	2.3E-03
fluorene	300 (3)	4.00E-02	1.1E-03
naphthalene	300 (3)	4.00E-02	1.1E-03
2-methylnaphthalene	300 (3)	NA	NA
phenanthrene	300 (3)	2.90E-02	1.6E-03
pyrene	300 (3)	3.00E-02	1.5E-03

(1) Presented soil concentration is maximum value obtained at 0-1 ft interval (inorganics) or maximum value reported at any soil interval (organics).
(2) Based on 12/94 Integrated Risk Information System (IRIS) data.
(3) Based on average value of reported detection limits for soil samples at all sample intervals.
NA Not Available

Table 3-13 Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for Assessment of Carcinogenic Human Health Effects For Pond 1 Soils Under the Assumptions of an Agricultural Land Use Scenario.

Constituent	Maximum Soil Concentration (mg/kg) (1)	Oral Slope Factor (kg/mg/day)(2)	Calculated Cancer Risk
arsenic	39.9	1.75E+00	2.28E-06
chromium	1011	NA	NA
nickel	37	NA	NA
zinc	434	NA	NA
acetone	0.387	NA	NA
benzene	0.03	2.9E-02	2.84E-11
ethylbenzene	0.59	NA	NA
methylene chloride	0.076	7.5E-03	1.86E-11
toluene	0.622	NA	NA
xylenes (total)	2.05	NA	NA
benzo(g,h,i)perylene(3)	300 (4)	1.5E-01	1.47E-06
benzo(a)pyrene	300 (4)	7.3E+00	7.15E-05
chrysene	300 (4)	NA	NA
dibenzofuran	300 (4)	NA	NA
2,4-dimethylphenol	300 (4)	NA	2.3E-03
fluorene	300 (4)	NA	1.1E-03
naphthalene	300 (4)	NA	1.1E-03
2-methylnaphthalene	300 (4)	NA	NA
phenanthrene	300 (4)	NA	1.6E-03
pyrene	300 (4)	NA	1.5E-03
		Total Cumulative Risk	**7.53E-05**

(1) Presented soil concentration is maximum value obtained at 0-1 ft interval (inorganics) or maximum value reported any soil interval (organics).
(2) Based on 12/94 Integrated Risk Information System (IRIS) data.
(3) Oral Slope Factor data obtained from EPA Region 3 risk-based screening guidance (EPA, 1993).
(4) Based on average value of reported detection limits for soil samples at all sample intervals.
NA Not Available

Approximately 95 percent of the cumulative risk is incurred by a single constituent, benzo(a)pyrene. As discussed above, there is considerable likelihood that actual soil concentrations for this constituent in Pond 1 soils are much less than the selected default value of 300 mg/kg.

However, even at the derived cumulative cancer risk level, the nature of the specified agricultural scenario indicates little significant human health risk. Inherent in the exposure scenario design is the concept that a very limited number of individuals would ever potentially be exposed to soil contaminants at the site. In fact, the most probable land use scenario for the site is that no more than one or two individuals would be present on site on routine basis. Therefore, based on the extremely minimal number of exposed individuals, the overall aggregate risk is necessarily also very low.

The concept of aggregate risk is a valid point of consideration, and is one which is routinely considered by EPA in establishing acceptable risk boundaries. In essence the concept of aggregate risk may be summarized as follows: a 10^{-6} risk is far more likely to become actuated in a population of 10^6 individuals who are exposed to that risk than for a population of 10^1 individuals who are exposed to that same level of risk.

Within the conceptual bounds of aggregate risk, the agricultural exposure scenario presented in the current assessment represents the lower extreme of potential risk. In the current analysis, in which a conservatively estimated risk level of 7.53×10^{-5} has been obtained, and to which only a very few individuals will be potentially exposed, the probability that any individual member of the local population will actually experience a contaminant-induced cancer event is essentially nil.

3.6.2 Human Health Risk Assessment - Food Chain Exposure

The following sections consider potential exposure pathways via a cattle to human food chain. For much of the discussion that follows, reliable scientific data specific for the constituents of interest is lacking. However, it is possible to construct illustrative exposure estimates on the basis of default values and assumptions that can be demonstrated to be conservative in nature.

A primary consideration in the exposure analyses presented below is the potential livestock carrying capacity of the land in question. The standard parameter for estimation of rangeland carrying capacity for livestock is the animal unit month (AUM), which is the amount of feed necessary for the sustenance of one cow, one horse, five goats, or five sheep for a period of one month. The statewide average of acres per AUM for New Mexico is approximately 7.4 (U.S.BLM, undated circular). The typical range of acres per AUM for the BLM Roswell, New Mexico district (which includes those federal lands in the Artesia area) is 4 to 15 (Chuck Schmidt, U.S.BLM Roswell District, personal communication May, 1995). However, the river bend in which the Navajo Evaporation ponds is located is designated as salty bottomlands by BLM personnel, and required acres per AUM in such rangeland habitat can be as high as 32 acres per AUM (Chuck Schmidt, U.S.BLM Roswell District, personal communication May, 1995). Consequently, for the analyses that follow, it is conservatively assumed that the rangeland carrying capacity is near the upper bound of the average range carrying capacity for federal lands in the Roswell District (15 acres/AUM).

A second major assumption of the livestock exposure scenario is that cattle production is solely for market production, such that potential home farm consumption of livestock was not an exposure factor (the validity of this assumption was explicitly endorsed by EPA personnel during the June 2, 1995 meeting between representatives of EPA and Navajo).

As a result of the nature of the available forage and agricultural economic factors, livestock grazing in the landscape surrounding Pond 1 is relegated exclusively to cattle grazing. Therefore, it is also assumed that consumable livestock exposed to the site are represented only by beef cattle.

The food chain exposure assessments are presented in the following sections. Consideration of a groundwater-livestock-human exposure pathway is described in Section 3.6.2.1 and risk evaluation for the soils-animal-human and soil-plant-animal-human pathways are presented in Sections 3.6.2.2 and 3.6.2.3, respectively.

3.6.2.1 Human Exposure Via Groundwater to Livestock to Human

This section examines the issue of potential human exposure to groundwater contaminants via a groundwater-livestock-human exposure scenario. As discussed below, this scenario is more difficult to formulate than those involving soil contaminants. The food chain exposure assessments presented in this section involving soil contaminants readily lend themselves to a quantifiable risk estimate, since the a real extent of contaminated soils at which receptors could be potentially exposed is clearly defined, and since estimation of contaminant concentration is simplified by the fact that relevant soil contaminant data involves only that data limited to the upper point of the soil profile. Furthermore, potential exposure to livestock is also defined in part by the forage production potential of the delimited area of surface contamination, so that the potential exposure duration of livestock can also be reliably quantified.

While uncertainties related to variable contaminant characteristics in vertical and horizontal dimensions are issues that are routinely managed in groundwater risk assessments, the issue of exposure duration is far more problematic in the context of the food chain exposure assessment considered herein. Groundwater risk assessments targeting human exposure to contaminants are facilitated by a basic consideration - that the presence of a drinking water well implies ongoing human occupation according to a consistent and long-term exposure scenario.

In contrast, exposure to livestock at a water well requires additional amounts of site-specific information. For instance, the total land area in which a livestock watering well is located, together with the forage carrying capacity for livestock, can be directly relevant to the length of time livestock are permitted to remain on-site. In addition, the potential for supply of supplemental feed to livestock can be a factor of major importance. For the soils-related food chain exposure assessments presented in the following sections, presence of supplemental feed is not an issue, since livestock consumption of forage and incidental soils at contaminated areas is limited solely by the available forage quantity. Thus, upon exhaustion of available forage, exposure to contaminated soils and plants grown in contaminated soils is drastically diminished or eliminated, even though livestock may remain on-site subsisting on supplemental feed. In contrast, the duration of livestock exposure to environmental contaminants in a watering well may be extended indefinitely by supplemental feed supplies, regardless of the status of range conditions.

Although the issue of supplemental feed and its impact on exposure duration for potential livestock receptors are important issues, the following observations are also relevant to the current evaluation. First, the economics of livestock production dictate that utilization of available rangeland forage be maximized, and that the use of supplemental feed materials be minimized. Therefore, a scenario in which commercial livestock remain at a fixed location for an extended period that significantly exceeds the availability of adequate natural forage is not expected to be a common occurrence under the prevailing economic realities which prevail in southeastern New Mexico.

Despite the complicating factors discussed above, a series of extensive environmental investigations conducted at the ponds over the past 10 years has resulted in a reliable characterization of hazardous constituents in the shallow groundwater downgradient of the pond system. The available data is sufficient to permit a number of conclusions regarding potential environmental risk posed by environmental contaminants in the downgradient groundwater. Worst-case constituent concentration levels are summarized in Table 3-6 for those components of the monitoring well system situated downgradient of Pond 1, which includes wells MW-3, MW-4, MW-6A and 6B. (Well MW-4C was installed in January, 1995 and MW-4 was redesignated MW-4A at that time.)

Reported hazardous constituents in groundwater downgradient of Pond 1 consist primarily of inorganic and volatile organic constituents (Tables 2-3 and 3-6, this document and KWBES, 1992, Tables 25-27). Volatile organics are represented primarily by BTEX constituents, with a few other volatile constituents being sporadically detected. In terms of potential environmental risks, the occurrence of benzene in groundwater is most significant, since reported benzene concentrations in some groundwater monitoring well samples have exceeded human consumption MCL standards by a factor of approximately three to four.

Inorganic constituents of concern in downgradient groundwater include arsenic, chromium, lead, and nickel. Reported total arsenic concentrations have frequently exceeded the human MCL, with a maximum concentration of 0.22 mg/l. However, elevated arsenic concentrations are generally lower than the one-time maximum, and more recently exceed the MCL by a factor of less than two, if at all. Sporadic exceedances of established MCL limits for nickel and lead have also been documented in several downgradient wells (Tables 2.3 and 3.6). The most recent data for the impacted wells (generated from samples obtained by low-flow purging technique, as described in Section 2.1.2) suggest that elevated concentrations of constituents may be caused by excessive sample turbidity rather than the presence of dissolved metal species (Table 2.3). However, following low-flow purging, arsenic remains above MCL limits in some wells.

When compared to human MCL standards, the available monitoring data indicates that arsenic and benzene constitute the primary constituents of concern. The potential impact of these two constituents on the groundwater-livestock-human pathway is discussed below.

The current MCL for benzene has been established on the basis of its potential carcinogenic risks as assessed by documented cases of human exposure. However, carcinogenic risk estimates based on animal studies yield acceptable exposure levels approximately 5 times higher than those derived for humans (IRIS database). This observation indicates that, at the very least a lifetime exposure level no less than 0.025 mg/l would be associated with a 1×10^{-6} cancer risks for exposed animals. Thus, it can be presumed that if a legitimate LOAEL value was established for benzene, it would represent an exposure level significantly greater than the concentrations reported in Pond 1 groundwater monitoring wells.

No scientific literature was identified that assigned a bioaccumulation factor for benzene. Rather, the available literature indicates that essentially all absorbed benzene is eventually excreted in feces, urine, and respired air of mammalian receptors (Brainard and Beck, 1993). In consideration of the reported benzene concentrations in groundwater downgradient of the ponds, its apparent low bioaccumulation potential, and the probable short duration of exposure for livestock receptors, potential food chain risks posed by benzene are considered to be negligible.

As discussed in Section 3.5, arsenic also exhibits a relatively low bioaccumulation potential. While arsenic concentrations in downgradient wells exceeded the human MCL by a factor of four in one instance, the available information suggests no cause for concern relative to the environmental exposure pathway under consideration. State of New Mexico Standards for Interstate and Intrastate Streams (NMWQCC, 1995) specify that arsenic content of water designated for livestock watering must not exceed a concentration of 0.2 mg/l, which represents a limit that is currently not exceeded in wells downgradient of Pond 1. Additionally, the New Mexico groundwater standard of 0.1 mg/l has not been exceeded in recent low-flow samplings. Based on these considerations, current groundwater conditions do not appear to indicate the potential for a significant environmental risk resulting from arsenic via the groundwater-livestock-human exposure pathway.

A final issue to be considered concerns the reported occurrence of additional unidentified organic constituents in shallow groundwater. Samples obtained during the RFI Phase II from the three shallow groundwater monitoring wells downgradient of Pond 1 (MW-3, 4 and 6) indicated the presence of unknown volatile and semivolatile hydrocarbon constituents. Oily waste matrices, such as that occurring in the historical refinery wastewater stream, are expected to consist of complex hydrocarbon mixtures. Furthermore, upon their release and migration from the unit, the original components can be expected to undergo biodegradative transformations that create additional new compounds, so that original constituents coexist with their biodegradative reaction byproducts.

Unidentified hydrocarbon constituents were tentatively quantified in shallow groundwater samples obtained from monitoring wells MW-3, MW-4 and MW-6 at the time of the RFI Phase II groundwater investigation (KWBES, 1993), and the total quantity of unidentified organic compounds (volatiles plus semivolatiles) for MW-3, 4 and 6 was 4.0, 0.7, and 4.2 mg/l, respectively. However, since chromatogram release times for volatile and semivolatile runs share some overlap, the quantifications are overestimated to some degree.

Beyond this tentative quantification of various unidentified hydrocarbon compounds in groundwater samples obtained from wells MW-3, 4 and 6 (KWBES, 1993, Vol. 4), virtually no information is available regarding the unidentified constituents, and their potential toxicological and bioaccumulative qualities are unknown. However, it is possible to broadly characterize hydrocarbons in the shallow downgradient groundwater according to observed hydrogeologic conditions and general knowledge of microbiologic processes.

As a result of five decades of former unit operations, considerable quantities of hydrocarbon materials have accumulated in the shallow groundwater strata downgradient of the unit. Under such conditions, oxygen is soon exhausted by intense oxidative activity of aerobic microorganisms, and catabolism of hydrocarbon constituents must shift to alternative physiologic pathways. Observations made from borings during monitoring well installation suggest such anoxic conditions prevail within the shallow groundwater zones most heavily impacted by hydrocarbon releases. Under anoxic conditions, anaerobic and fermentative processes predominate, the byproducts of which include partially oxidized compounds containing functional chemical groups such as alkanoic acids, alkanols, and alkanones (Bertrand, et al., 1989).

From a general perspective, it is not considered likely that unidentified organic constituents present in the impacted shallow groundwater would result in significant short-term physiological effects on livestock at the concentration levels reported in groundwater samples. Herbivorous animals are physiologically adapted to process large quantities of complex organic materials. In the evolutionary war between plants and animals, animals have developed layers of inducible general defenses against potentially toxic chemicals synthesized by plants. Although it is often assumed that mammalian systems have evolved defenses against natural, but not synthetic chemicals, a preponderance of scientific evidence does not support that view (Gold et al., 1992). Furthermore, incidental ingestion of soils by herbivores exposes them to large quantities of complex organic mixtures contained in natural organic materials. Organic chemicals contained in natural soils include mono- and polynuclear aromatic compounds, cyclic alkanes, alkanols, alkanoic acids, organic cyanides, etc. (Dragun, 1988).

Herbivorous species have been documented to tolerate large dosages of hydrocarbon materials. Mixed-breed cattle have been documented to survive dosages of approximately 8 mg sweet crude oil per kg body weight delivered over a 2-week period (Rowe, et al., 1973), and sheep fed massive dosages of Bunker C fuel oil at a rate of 10 percent (by weight) diet mixed with hay over a 10 day period exhibited no ill effects (Macintyre, 1970). By comparison, assuming an average daily water intake rate of approximately 30 liters/day (Bud Wilson, U.S. BLM, personal communication, August, 1995) for a 400 kg cow, and assuming an average total hydrocarbon concentration of 4 mg/l, daily intake of largely unidentified hydrocarbons would be approximately 0.3 mg/kg body weight. However, these reports provide no information regarding the issue of potential bioaccumulation and food chain transfer of the uncharacterized groundwater hydrocarbon contaminants.

Regardless of what the scientific literature may suggest, Navajo does not endorse the intentional consumption of hydrocarbon-contaminated water by livestock. However, it is noted that no livestock watering wells in the vicinity of Pond 1 have been impacted by releases from the unit. In the 80 or 90 years in which the landscape has been utilized for rangeland agriculture, very few wells are known to have been installed in the vicinity of the unit, likely due to the direct proximity of the river. Additionally, shallow wells nearer the river are documented to have increasing levels of salt (Table 3-2). While cattle are less sensitive than humans to elevated dissolved salts, at levels greater than 5,000 mg/l, they become increasingly subject to the effects of heat stress and water loss, especially lactating animals (NAS, 1974). Moreover, physiological stress induced by consumption of saline water is further exacerbated when available forage possesses a relatively low water content (Faries, et al., 1990) as is likely often the case for rangeland located in the Pecos Valley.

Given the information presented above, Navajo believes that the evaluation of potential risks posed by livestock exposure to unidentified hydrocarbon contaminants in groundwater would represent a highly speculative and potentially contentious undertaking, and for which no compelling justification currently exists.

3.6.2.2 Human Exposure Via Soils to Plant to Livestock to Human

As presented in Section 3.5, ecological risk assessment exposure modeling was conducted for two inorganic constituents of concern (arsenic and lead) in Pond 1 soils. The results of that assessment, which modeled potential soil and plant-borne contaminant exposure for a small herbivore subsequently consumed by a bird of prey, did not indicate a significant potential for food chain transfer of the contaminants of concern. By simple extrapolation, it can also be demonstrated that potential food chain exposure risks via these pathways are negligible.

First, the Tier 1 prey species modeled in Section 3.5 was assumed to obtain approximately 32 percent of its food resources within the boundaries of Pond 1. In contrast, it is conservatively assumed that a revegetated Pond 1 consisting of 15.7 acres would support one head of livestock for slightly more than one month of the year (15.7 acres divided by 15 acres per AUM x 12 months/year = 1.05 months). Further, since cattle are most efficiently managed in groups that are not routinely contained in individual grazing allotments, it has also been conservatively assumed that at least 10 cattle would simultaneously be turned out to forage at the unit at any given time. As a result, the fraction of forage which could potentially be obtained from a single head of cattle from a revegetated Pond 1 is estimated to be approximately 0.8 percent (1/12 year /10 cattle = 0.0083).

Second, as described in Section 3.5, cattle eat less food proportional to their body weight on a daily basis (approximately 3.6 percent of their body weight for a typical cow as compared to approximately 6.3 percent of their body weight for the modeled jackrabbit). Based on these two scenario considerations, further assessment of inorganic constituents in the soils-livestock-human exposure was not considered to be warranted.

The results of the human health baseline environmental risk assessments conducted under residential and agricultural land use scenarios indicated that, under the conservative exposure assumptions, benzo(a)pyrene contributed the largest incremental risk to the overall carcinogenic risk estimate (Table 3-8). As a result, benzo(a)pyrene was identified as the organic constituent most relevant to modeling environmental risks via the soils-animal-human pathway. With the exception of a number of pesticide compounds (aldrin, dieldrin, etc.) few organic constituents exhibit oral potency slope factors as high as that attributed to benzo(a)pyrene. Benzo(a)pyrene is a frequent constituent in oily refinery sludges.

Food chain transfer of soil-borne benzo(a)pyrene via the soils-animal-human pathway was adapted from methodology previously developed by EPA (Eastern Research, 1992). In this instance, the risk estimation procedure assumes an acceptable level of risk and derives a soil-based concentration for the constituent of concern which would not exceed the specified risk level. Thus, in terms of the present evaluation, the risk assessment is comparative in nature (acceptable soil concentrations versus site-specific concentrations).

Establishment of acceptable soil concentration criteria for the pathway of interest is based upon the following series of equations:

$$RIA = (RL \times BW)(10^3) / q_h$$

where:

RIA = adjusted reference intake in humans (ug pollutant/day)
RL = acceptable risk level
BW = body weight, human (kg)
10^3 = conversion factor (ug/mg)
q_h = oral human cancer potency factor $(mg/kg/day)^{-1}$;

$$RF = RIA / (UA)(DA)(FA)(FC)$$

where:

RF = reference concentration of pollutant in human diet (ug / g diet dry weight)
UA = uptake response slope for pollutant in animal tissue (ug / g tissue dry wt)$(ug / g \text{ diet dry wt})^{-1}$
DA = daily dietary consumption of animal tissue food group (g tissue dry wt/day)
FA = fraction of food group assumed to be derived from animals ingesting forage on contaminated soils
FC = fraction of animal diet obtained from contaminated soils; and

$$RLC = RF/UC$$

where:

RLC = reference concentration of pollutant in soil (ug /g soil dry wt), and
UC = uptake response slope of pollutant in forage crop (ug / g forage dry wt) $(ug/g \text{ soil})^{-1}$

For the current assessment involving benzo(a)pyrene, the following default values were selected as input to the algorithms:

RIA = calculated value
RL = risk level = 1×10^6
BW = body weight = 70 kg
q_h = 7.3 $(mg/kg/day)^{-1}$
RF = calculated value
UA = 4.215 $(ug/g \text{ dry wt})^{-1}$
DA = 15.5 g dry wt/day
FA = 0.00274
FC = 0.0083
UC = 0.001 $(ug/g \text{ soil})^{-1}$

The risk level (RL) represents the acceptable incremental cancer risk level. Human body weight (BW) is the standard EPA default value. An animal uptake response value (UA) specific for benzo(a)pyrene was not identified. Therefore, as a conservative measure, the UA value for polychlorinated biphenyls (PCB's) (Eastern Research, 1992) was adopted as a default value. The daily dietary consumption of animal tissues (DA) involved the consumption of beef fat, in which lipophilic organic compounds preferentially accumulate. The default value for DA was set at 15.5 g/day, based on EPA selection criteria (Eastern Research, 1992). Although human ingestion of commercially marketed livestock products that had previously been subject to site exposure is most reasonably considered as a one-time event, it was conservatively assumed that ingestion of a site-exposed livestock product would recur on an annual basis, so that FA was the product of 1/365, or 0.00274. The fraction of the animal diet derived from forage obtained at the site was previously derived in an introductory paragraph to this section, and entails conservative assumptions that 10 head of livestock are on-site at a given time, and the livestock carrying capacity of the revegetated 15.7 acres of Pond 1 is 15 acres per AUM, so that a value of 0.0083 can be derived. The forage plant uptake response slope for organic contaminants is a conservative default parameter (Eastern Research, 1992).

Input of the selected values to the listed algorithms yields the following series of values:

$$\begin{aligned} RIA &= (1\times10^{-6} \times 70)(10^{3}) \,/\, 7.3 \\ &= 9.59 \times10^{-3} \end{aligned}$$

$$\begin{aligned} RF &= 9.59 \times10^{-3} \,/\, (4.215)(15.5)(0.00274)(0.0083) \\ &= 6.45 \end{aligned}$$

$$RLC = 6.45/0.001 = 6{,}450 \ mg/kg$$

The food chain exposure assessment methodology presented above indicates that, under the specified exposure scenario, a soil concentration limit of 6,450 mg/kg benzo(a)pyrene would be permissible to meet the specified 1 x 10^{-6} carcinogenic risk level. The greatly elevated soil concentration limit for benzo(a)pyrene derived in this exercise serves to illustrate the very minimal levels of potential contaminant exposure for both livestock and humans via this postulated pathway. Further, the estimate is also notable due to the incorporation of two highly conservative assumptions: the assignment of the UA value for PCB value as the default UA value for benzo(a)pyrene; and the inherent assumption that benzo(a)pyrene uptake by forage vegetation results in equal distribution of that constituent in plant roots and above-ground vegetation.

PCB's are globally-dispersed contaminants that are recognized to possess a very high bioaccumulative potential in mammalian systems. Average global exposure estimates for humans to PCB's is estimated at be 0.014 ug/kg body weight /day (Travis and Hester, 1991). In contrast, although human exposure to benzo(a)can pyrene be as high as that estimated for PCB's (or even much greater for cigarette smokers), benzo(a)pyrene has not been identified as having a significant bioaccumulation potential in humans (Menzie et al., 1992).

In regard to the uptake and distribution of benzo(a)pyrene in plants, the best available scientific data indicates that translocation of an organic constituent in plant systems is closely related to the log K_{OW} of the constituent. K_{OW} is the octanol-water partition coefficient which measures the ratio of constituent solubility in octanol to the solubility in water. Evaluation of the plant uptake and translocation characteristics of a broad spectrum of organic constituents indicates that the efficiency of root to shoot translocation peaks with a log K_{OW} of approximately 1.8, and constituents with K_{OW} values in excess of 5 are not expected to be present in above ground plant tissue if the organic compound is not abundant in the soil solution (Ryan et al., 1988, Paterson et al., 1990). Benzo(a)pyrene possesses a log K_{OW} of 6 (Ryan et al., 1988).

In view of the findings of the exposure estimate presented above, and the considerations regarding the conservative nature of the assumptions employed in the assessment, it is concluded that potential human risks posed by environmental contaminants in Pond 1 soils via the specified soil-plant-livestock-human food chain exposure pathway are negligible.

3.6.2.3 Human Exposure Via Soils to Livestock to Human

As discussed above, the ecological risk assessment presented in Section 3.5 was considered adequate to preclude further consideration of environmental risk for the selected inorganic constituents of concern (arsenic and lead) under the auspices of a soils-plant-livestock-human food chain pathway. A similar presumption can be made for the soils-livestock-human pathway considered in this section, based on the relatively diminished potential for on-site livestock to be exposed to Pond 1 soil contaminants relative to that which was estimated for the postulated jackrabbit receptor.

The soils exposure scenario for the on-site ecological receptor modeled in Section 3.5 (jackrabbit) utilized a 32 percent fraction value to define the proportion of incidentally ingested soils obtained from the Pond 1 site. However, as discussed in Section 3.6.2.2, as established under a sequence of relatively conservative assumptions, the fractional portion of incidentally ingested soils which could be obtained from the unit by livestock is expected to be approximately 0.83 percent.

Furthermore, the scientific literature appears to indicate that cattle ingest a lower proportion of incidental soil in their diet than that which has been estimated for jackrabbit. The default incidental soil ingestion rate for jackrabbit used in the ecological risk assessment (Section 3.5) was equivalent to 6.3 percent of their total diet (Arthur and Gates, 1988). Based on a technical review of the available scientific literature, EPA has estimated that cattle grazing upon sludge-amended soils consume approximately 1.5 percent sludge in their diet (Eastern Research, 1992). Assuming that the proportion of soil adhering to above-ground plant parts is roughly equivalent to exogeneously applied sludge, and assuming relative bulk densities of 2.5 g/cc for soil and 1.0 g/cc for sludge (Eastern Research, 1992), it can be estimated that livestock typically ingest incidental soil materials at a rate equivalent to approximately 3.75 percent of their total diet.

Based on the relatively low risk potential for incidental ingestion of arsenic and lead for the onsite jackrabbit receptor modeled in the ecological risk assessment presented in Section 3.5, and the greatly diminished relative potential for livestock exposure to ingested soils originating at Pond 1, further assessment of inorganic constituents via the soils-livestock-human pathway was not considered to be warranted.

Environmental risk modeling for the soil-plant-livestock-human-pathway was based on a combination of methodologies presented in the Part 503 Technical Support document (Eastern Research, 1992) and the Risk Assessment Guidance for Superfund (RAGS) document (EPA, 1989a). In this instance, a highly conservative concentration value for benzo(a)pyrene in Pond 1 soils was defined, incidental ingestion rates and bioaccumulation rates for receiving livestock were calculated, and potential risk to a human receptor ingesting livestock tissue contaminated by benzo(a)pyrene (BAP) was estimated.

The following assumptions and default values were assigned to the parameters required as input to the estimate:

diet (dry wt.) for an average cow = 14,500 g/day
proportional rate of incidental soil ingestion = 0.0375 (3.75 percent)
total daily soil intake = 14,500 g/day x 0.0375 = 544 g soil/day
proportion of cattle foraging incurred at Pond 1 = 0.0083 (0.83 percent)
proportion of ingested soils obtained from Pond 1 = 544 g soil/day x 0.0083 = 4.5 g soil / day
assumed concentration of benzo(a)pyrene in Pond 1 soils = 300 mg/kg
total BAP exposure via soil ingestion = (4.5 g/day)(300 mg BAP/10^6 kg soil) =1.35 ug/day
ug BAP/g ingested soil = 1.35 ug BAP/4.5 g soil = 0.32 ug BAP/g ingested soil
assumed animal uptake slope for BAP = 4.215

The assumed dry weight daily dietary requirement for an average cow was discussed in Section 3.5. The livestock rate of incidental soil ingestion proportional to the daily diet was discussed above. The total estimated daily soil intake is derived by calculation, and the proportion of foraging which is pursued by livestock at the revegetated Pond 1 was derived in Section 3.6.2.2. The proportion of ingested soils obtained by the cattle receptor at Pond 1 is derived by calculation. The assumed soil concentration for BAP is based on the average value of all detection limits obtained during the RFI Phase II investigation for Pond 1 soils. The calculated total daily ingestion rate of BAP for livestock at Pond 1 is obtained by calculation, and the BAP ingestion rate per gram of soil is obtained by calculation. The assumed animal uptake response slope for BAP adopted the uptake response value specified for PCB constituents (Eastern Research, 1992).

Based on the information provided above, the theoretical BAP content in livestock tissue (e.g. beef fat) can be derived as follows:

$$(\textit{ug BAP/g tissue})(\textit{0.32 ug BAP/g ingested soil})^{-1} = \textit{4.215 (ug BAP/g tissue)}\ (\textit{ug BAP/g ingested soil})^{-1}$$

$$\textit{ug BAP/g tissue} = \textit{4.215 (ug BAP/g tissue) (ug BAP/g ingested) soil}^{-1}\ \textit{(0.32 ug BAP/g ingested soil)}$$

$$\textit{ug BAP/g tissue} = \textit{1.82}$$

Potential human health risks were derived by adapting the chemical ingestion equation presented as RAGS Exhibit 6-14 (EPA, 1989a). As shown with the minor modifications required for the current application, the ingestion formula takes the form:

$$\textit{Intake (mg BAP/kg/day)} = Ct \times IR \times CF \times FI \times EF \times ED \,/\, BW \times AT$$

where:

Ct = concentration of BAP in beef fat tissue
IR = ingestion rate mg/day
CR = 1×10^{-6} correction factor kg/mg
FI = fraction ingested from contaminated source
EF = exposure frequency
ED = exposure duration
BW = body weight
AT = averaging time

Input value for Ct is 0.00569 mg/kg/day, as derived in the conservative manner described above. The assumed ingestion rate is 15,500 mg beef fat/day as previously cited in Eastern Research (1992). The fraction ingested from the contaminated source is assumed to be 1.0. Although the exposed livestock is not intended for home consumption, but rather for wholesale, and ultimately, retail market distribution, it is conservatively assumed that the exposed individual will endure repeated exposures at a frequency of once per year. Therefore, selected exposure frequency value is 1 day per year. The exposure duration is assumed to be 30 years. The standard EPA default values for body weight (70 kg) and averaging time for carcinogen assessments (365 days x 70 years) were also selected. Using the parameter values presented above, normalized exposure of a hypothetical individual to BAP contained in livestock tissues is calculated as:

$$\text{Intake (mg BAP/kg/day)} = 1.82\ \text{mg/kg} \times 15{,}500\ \text{mg/day} \times 1 \times 10^{-6} \times 1.0 \times 1\ \text{day} \times 30\ \text{yrs} \ /\ 70\ \text{kg} \times 2.56 \times 10^{4}$$

$$\text{Intake (mg BAP/kg/day)} = 4.7 \times 10^{-7}$$

Finally, the oral potency slope factor for BAP is 7.3 $(\text{mg/kg/day})^{-1}$, so that:

$$\text{Estimated Carcinogenic Risk} = 4.7 \times 10^{-7}\ \text{mg/kg/day} \times 7.3\ (\text{mg/kg/day})^{-1}$$

$$\text{Estimated Carcinogenic Risk} = 3.4 \times 10^{-6}$$

The risk assessment calculations for the modeled soils-animal-human exposure pathway yielded a risk value within acceptable federal risk standards despite the fact that numerous conservative assumptions were incorporated into the evaluation:

- the 300 mg/kg concentration value for benzo(a)pyrene assumed for Pond 1 soils may overestimate actual soil concentrations of this constituent at Pond 1 by two or more orders of magnitude;

- the default animal uptake response slope value for PCB constituents is almost certain to be significantly higher than that which would legitimately be assigned to benzo(a)pyrene. The impact of this conservatism is not quantifiable, but could also possibly represent an overestimate on the order of one or more orders of magnitude.

- the bioavailability of benzo(a)pyrene is assumed to be 100 percent in both the soil media ingested by the livestock and the animal tissue ingested by the human receptor. While scientific literature on this topic is limited, the available database indicates that 50 percent bioavailability may constitute a more reasonable default assumption (Brainard and Beck, 1993), at least for the case of ingestion of benzo(a)pyrene-contaminated soils.

The current assessment was based on the assumption that a potent carcinogenic organic constituent (benzo(a)pyrene) was present in Pond 1 soils at highly elevated concentrations, was readily bioavailable to the modeled livestock receptor, and bioaccumulated in the receptor's tissues to an inordinate degree. Further, the structure of the exposure, ingestion and risk equations used in the estimate ensured that the impact of these multiple conservative assumptions were compounded in a distinctly non-additive fashion. However, despite these factors compounding factors, the assessment still yielded an overall risk estimation which fell within the bounds of acceptable environmental risk standards. Therefore, the results of the current estimate provides a clear demonstration that potential exposure to environmental contaminants at the site is highly minimal in nature.

3.7 Pond Seepage to River

In the vicinity of the active evaporation ponds a hydraulic gradient exists that transports fluids from the ponds to the groundwater and potentially to the Pecos River. The presence of a gradient from the ponds to the poor quality groundwater has been responsible for the detection of elevated levels of groundwater constituents in monitor wells adjacent to the evaporation ponds. The extent to which pond seepage has impacted the groundwater near the ponds has been documented through groundwater monitoring. The results of this monitoring and discussion of the results have been reported in the Phase I, II, and III RCRA Facility Investigations.

Monitoring of the Pecos River was performed during the recently completed Phase III RFI. Constituents sampled included volatiles, semi-volatiles and the metals arsenic, chromium, lead and nickel. No detections in excess of the method detection level were found for any of the above constituents (Table 5-2, RFI Phase III Report, RE/SPEC, 1995). In addition the USGS has maintained water quality records from 1937 to present at their gauging station located at the U.S. Highway 82 river crossing 6,200 ft. downstream from the evaporation pond complex. These records include monitoring analyses for a myriad of total and dissolved water quality parameters and sediments.

Historically, the Pecos River has been observed to have relatively poor water quality compared to other surface water streams in New Mexico. The New Mexico Water Quality Control Commission (NMWQCC) has recognized this fact by setting the concentration maximum for total dissolved solids, sulfate, and chloride at 14,000 mg/L; 3,000 mg/L; and 6,000 mg/L, respectively, for flows greater than 50 cfs in the vicinity of Artesia and recognizing that at lower discharges flow standards may not be attained (NMWQCC, 1995). Surface water standards adopted by the NMWQCC, together with other relevant state and federal standards, are shown in Table 3-14 for the several metals studied during the Phase III RFI. Surface water standards for chromium, lead, and nickel are not absolute but vary with hardness concentration with EPA applying an upper hardness limit of 400 mg/L as $CaCO_3$. In contrast, hardness of over 2,000 mg/L as $CaCO_3$ is commonly measured in the Pecos River.

Table 3-14 Water Quality Standards -- Pecos River Vicinity of Artesia

Standard Classification	Agency	Total Arsenic (mg/L)	Total Chromium (mg/L)[3]	Total Lead (mg/L)[4]	Total Nickel (mg/L)[5]	Dissolved Arsenic (mg/L)	Dissolved Chromium (mg/L)[3]	Dissolved Lead (mg/L)[4]	Dissolved Nickel (mg/L)[5]	TDS (mg/L)
Domestic MCL	EPA	0.05	0.10	0.015	0.10	- -	- -	- -	- -	500
Surface Water, fish, acute(1)	EPA	0.360	5.40	0.477	4.58	- -	- -	- -	- -	- -
Surface Water fish, chronic(1)	EPA	0.190	0.64	0.019	0.51	- -	- -	- -	- -	- -
Groundwater	WQCC	- -	- -	- -	- -	0.10	0.05	0.05	0.20	1,000
Surface Water, domestic(2)	WQCC	- -	- -	- -	- -	0.05	0.05	0.05	- -	- -
Surface Water, fish, acute, Pecos R.(2)	WQCC	- -	- -	- -	- -	- -	7.33	0.77	6.28	14,000
Surface Water, fish, chronic, Pecos R.(2)	WQCC	- -	- -	- -	- -	- -	0.87	0.03	0.70	14,000
Surface Water, livestock(2)	WQCC	- -	- -	- -	- -	0.20	1.0	0.10	- -	- -
Surface Water, irrigation(2)	WQCC	- -	- -	- -	- -	0.10	0.10	5.0	- -	- -

Source:

1. USEPA at 40 CFR § 131.36 (b)(1).
2. NM Water Quality Control Commission, Standards for Interstate and Intrastate Streams, January 1995, Sections 3101.B (domestic), 3101.D (irrigation), 3101.J (acute and chronic fisheries), 3101.K (livestock watering).
3. Acute chromium concentration calculated $Cr = e(0.819[\ln(hardness)]+3.688)$, chronic chromium concentration calculated $Cr = e(0.819[\ln(hardness)]+1.561)$, EPA hardness 400 mg/L as $CaCo_3$, Pecos River 15-yr 1980-1994 minimum hardness 580 mg/L $CaCo_3$
4. Acute lead concentration calculated $Pb = e(1.273[\ln(hardness)]-1.46)$, chronic lead concentration calculated $Pb = e(1.273[\ln(hardness)]-4.705)$, EPA hardness 400 mg/L as $CaCo_3$, Pecos River 15-yr 1980-1994 minimum hardness 580 mg/L $CaCo_3$
5. Acute nickel concentration calculated $Ni = e(0.846[\ln(hardness)]+3.3612)$, chronic nickel concentration calculated $Ni = e(0.846[\ln(hardness)]+1.1645)$, EPA hardness 400 mg/L as $CaCo_3$, Pecos River 15-yr minimum hardness 580 mg/L $CaCo_3$

Notwithstanding the relatively poor quality of the river, EPA has requested that impacts of groundwater contributions to surface water be addressed in the risk assessment because of the proximity of the evaporation ponds to the river. Review of constituents detected in pond fluids and in monitor wells located intermediate between the ponds and the river indicates that of the volatiles, semi-volatiles and metals sampled, only arsenic has the potential to migrate to the river in concentrations which might be of potential concern during periods of low-flow. Organic constituents are not being detected in groundwater samples in wells adjacent to the Pecos River. Metals, other than arsenic, sampled during the Phase III investigation did not contain severely elevated concentrations except for turbid samples taken from monitor wells purged at high flow rates. Resampling of these wells at low rates in June, 1995 eliminated chromium, lead and nickel as potential river contaminants. Therefore arsenic was the only constituent to be critically examined in the modeling exercise described below.

3.7.1 Modeling of Potential Surface Water Impacts

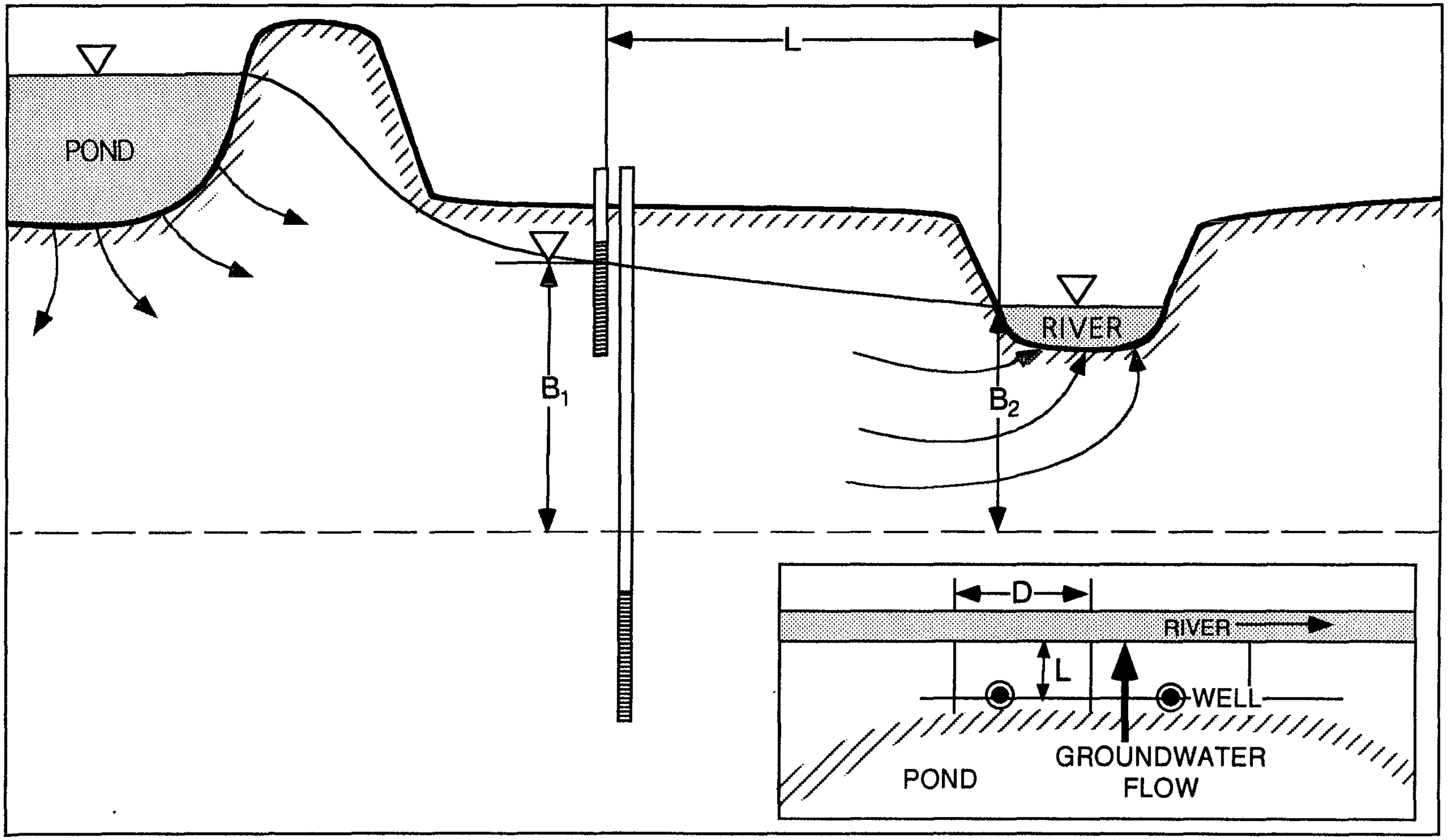
The groundwater adjacent to the evaporation ponds has been extensively studied for chemical water quality, and basic groundwater flow parameters of hydraulic conductivity and hydraulic gradient have been established. To ascertain the direction of movement of groundwater and contained constituents, groundwater elevations were measured and plotted during the Phase II RFI. This information was presented in the form of a shallow groundwater potentiometric map in the Phase II RFI report (KWBES, 1993, Figure 14). As could be expected, a hydraulic gradient exists from the active ponds to the surrounding groundwater. Information to draw the map was obtained during a period of relatively low river discharge and the gradient is shown on the map as extending to the Pecos River. This figure, together with the available hydrologic data, was used to approximate volumetric groundwater discharge to the river. This flow volume was combined with available groundwater and surface water quality data to provide an estimation of resultant water quality of the river. Finally, these results are compared with state numerical water quality standards.

3.7.1.1 Methodology

Volumetric groundwater flow (Q) is defined as the product of the hydraulic conductivity (K), the hydraulic gradient (I), and the vertical cross-sectional area (A) (Davis and DeWiest, 1966):

$$Q = KIA = K \cdot h/L \cdot BD$$

The hydraulic gradient is further defined as the change in groundwater elevation over a given distance (h/L). The cross-sectional area A through which water flows is determined by saturated thickness (B) times the linear distance perpendicular to the flow direction (D). For the pond location, these concepts are presented in Figure 3-4.



EQUATIONS

$$Q = KIA = K\frac{\Delta h}{L}A$$

$$Q = K\frac{(B_1 - B_2)}{L}\frac{(B_1 + B_2)D}{L}$$

$$Q = K\frac{(B_1^2 - B_2^2)D}{L}$$

Q=Volumetric Flow
K=Aquifer Hydraulic Condititivity
A=Average Vertical Cross Section Area
I =Hydraulic Gradient
B_1=Water Level Elevation at Well
B_2=Water Level Elevation at River
L=Distance from Well to River
D=Distance Along River

SCHEMATIC OF GROUNDWATER FLOW FROM EVAPORATION POND TO RIVER

CLIENT: NAVAJO REFINERY
ARTESIA, N.M.

Drawn by: DB	8/95
Drafted by: SDB	8/95
Approved by: DB	8/95

RE/SPEC

JOB# 318-2

FIGURE 3 - 4

The gradient is the change in head (h) between the upgradient monitor well and the river divided by the distance from the well to the river (L). For conditions as shown in Figure 3-4, the gradient is defined as (B_1-B_2) /L. As the hydraulic head decreases approaching the river, the cross-sectional area (B) also becomes smaller. To compensate for this change in area, an average value is calculated for the vertical height. Therefore the final volumetric flow equation is shown as:

$$Q = K \cdot (B_1-B_2)/L \cdot (B_1+B_2)/2 \cdot D$$

or:

$$Q = K \cdot (B_1^2-B_2^2)/2L \cdot D$$

Contours present on the 1993 shallow groundwater potentiometric map were utilized to draw the groundwater flow net (Figure 3-5). The net was constructed by drawing groundwater flow lines perpendicular to the contours. The dimensions of each rectangular flow tube were determined by the locations of the existing monitor wells. The flow line delineating the flow net boundary was placed equidistant between the flow tube monitor well and the adjacent well on either side of the flow tube. The rectangle dimensions are D, the distance between flow lines, and L, the length of a line connecting the monitor well with the river or downgradient contour line.

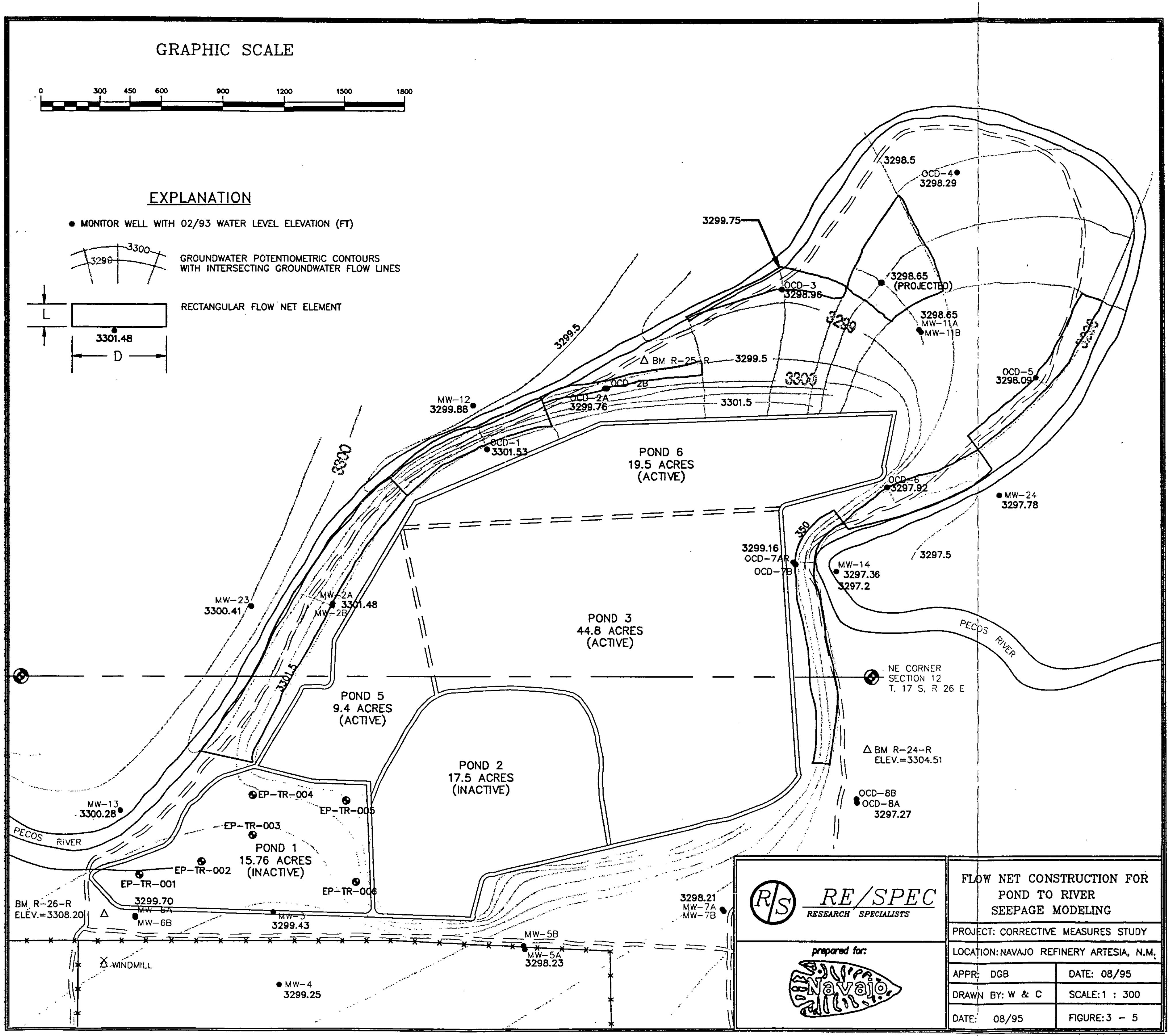
The flow tubes were constructed around the center line connecting the monitor well with the river or, similarly, a downgradient contour line so that a known concentration of a water quality constituent could be assigned to each individual flow tube. Based on analyses of the water quality in the monitor wells, arsenic is the constituent of greatest concern in the groundwater. Therefore, arsenic concentrations were used in the modeling effort. The product of the volumetric flow rate (Q) and the arsenic concentration (C) provides the mass transfer rate of arsenic from the groundwater to the river for a flow tube. The sum of arsenic from each individual flow tube is the total mass of arsenic added to the river per unit time:

$$QgCg = \Sigma Q_iC_i = Q_1C_1 + Q_2C_2 + Q_3C_3 + \ldots$$

The final concentration of arsenic in the river is equal to the mass of arsenic originally in the river (QrCr) plus the mass added by the groundwater divided by the total flow of the river including the groundwater component:

$$C_f = (QrCr + QgCg) \; / \; (Qr + Qg)$$

To calculate the final mass flow rate in groundwater (QrCr), a number of simplifying assumptions must be considered and understood in order to place the model results in the proper context. In this simplified model, sediments are assumed to be homogeneous and possess a constant hydraulic conductivity. It also is assumed flow in each series of flow tubes from the pond to the river along an individual flow line is constant with water neither being added or lost. Likewise, the concentration of arsenic within each flow tube is constant and, once attenuated in the groundwater after leaving the ponds, the resulting arsenic concentrations receive no further dilution or other attenuation prior to discharge into the river.



R/S RE/SPEC RESEARCH SPECIALISTS

prepared for:

Navajo

FLOW NET CONSTRUCTION FOR
POND TO RIVER
SEEPAGE MODELING

PROJECT: CORRECTIVE MEASURES STUDY	
LOCATION: NAVAJO REFINERY ARTESIA, N.M.	
APPR: DGB	DATE: 08/95
DRAWN BY: W & C	SCALE: 1 : 300
DATE: 08/95	FIGURE: 3 – 5

The assumptions regarding arsenic concentrations in groundwater remaining constant until flow reaches the river are likely highly conservative. Over time, as groundwater flows from the ponds to the river, the river elevation changes. Water is discharged from the river into the alluvial system during periods of high flow which decreases the amount of arsenic reaching the river and dilutes arsenic in the groundwater. During periods of low-flow this diluted water is returned to the river.

3.7.1.2 Parameter Selection

During the past several years, tests to determine aquifer hydraulic conductivities have been conducted by several consultants at the site. A statistical summary of the test results are presented in Appendix J, Table 1. Because of non-homogenous sediments, K values commonly can vary over several orders of magnitude at a site. A geometric mean is usually calculated to provide a representative hydraulic conductivity for such wide variation. However, at this site common K values range from about 1 to 30 feet/day. Because variation in hydraulic conductivities is relatively low, and to provide a conservative value, the arithmetic mean with a K value of 10 feet/day was chosen as a representative hydraulic conductivity for the modeling.

Flow gradients were easily established using available information from the shallow groundwater potentiometric map prepared for the Phase II RFI report. The shallow groundwater potentiometric map was constructed from ground and surface water measurements made in February, 1993, at a time of relatively low-flow. Water level elevations in the monitor wells that are located between the ponds and the river were used in preparing the map and river elevations were interpolated from a benchmark elevation of the river obtained at the time of the well and land survey. At that time river flow, at approximately 100 cfs, was less than 50 percent of mean flow for the year. Maximum, mean and minimum flows for 1993 were 1,430, 210 and 40 cfs, respectively (Cruz, et al., 1994). Therefore this potentiometric map provides a realistic representation of groundwater flow to the river during periods of generally minimum flow and can be utilized as a basis for the modeling effort.

Calculation of groundwater flow rates is complicated by the necessity to select a representative value of saturated aquifer thickness for transmittal of fluids to the river. During times of very low-flow the river is only a few feet deep and water movement from the shallow alluvial aquifer to the river occurs not only from the adjacent river bank but through upward seepage from below. Selection of a small value of B will underestimate flow while a high thickness will provide an unrealistically large volume contribution from the ponds. Because nested monitor wells are present between the ponds and the river with upper wells showing elevated levels of pond constituents not present in deeper wells, a length measured from the top of the water table to the top of the deeper well's sand pack was selected as the saturated thickness. This value averaged approximately 30 feet for paired wells at five locations north and east of the ponds. However, it is likely a conservative value because it is unknown how deep into the saturated zone contamination effects exist; in some areas seepage impacts may cease at a distance considerably less than 30 ft.

Within the past 12 months, groundwater sampling in the vicinity of the evaporation ponds has been performed in November, 1994; and January, February and June of 1995. Results of all but the June sampling were presented in the Phase III RFI. An updated summary of all 1994 and 1995 groundwater metals sampling information is presented in Appendix J, Table 2. As discussed in

Phase III RFI document, low-flow purging of monitor wells is necessary to avoid recovering turbid clay particles that typically show elevated arsenic concentrations either from pond releases or due to naturally occurring arsenic that has been mobilized by reducing conditions in the aquifer. Samples taken in November and January were not obtained using low-flow purging. Follow-up samples from February and June were obtained after purging at rates less that 2 liters per minute. Analytical results from low-flow purging samplings were used as inputs to the arsenic model.

As mentioned previously, flow and arsenic concentrations in the river are monitored by the U.S.G.S. at the nearby Artesia gauge. Based on information from this and other gauging stations, the state of New Mexico determines critical low-flow for New Mexico streams. Critical low-flow is defined as the minimum average four consecutive day flow which occurs with a frequency of once in three years (4Q3), and below this value stream standards may not be attained (NMWQCC, 1995). The NM Environment Department has determined that the critical low-flow for the Artesia station is 2.335 cfs (Personal communication, Glenn Saums, Health Program Manager, Surface Water Quality Bureau, NMED, July, 1995). Therefore, this flow value is required to be used as Qr in the seepage calculation.

To determine a low-flow arsenic concentration to utilize in the formula, U.S.G.S. records for the 15 year period from 1980 through 1994 were reviewed (Appendix J, Table 3). Total and dissolved arsenic samples were obtained at least twice yearly during this time period. Total arsenic ranged from less than 0.001 mg/L to 0.010 mg/L while dissolved arsenic varied from below 0.001 mg/L to only 0.003 mg/L. Total arsenic was highest during times of high flow; values of 0.004 mg/L or greater occurred at flows higher than 300 cfs. This result can be expected given that at the higher flows, increased turbidity occurs as the fine-grained bank and bottom sediments are mobilized. Unlike total arsenic, it appears that dissolved arsenic concentrations are independent of flow volume. At concentrations of 0.001 mg/L, flow ranged from 13 to 367 cfs; at 0.002 mg/L, the range was from 7.8 to 862 cfs; and for 0.003 mg/L, the flow range was 86 to 848 cfs.

In addition to any potential ecological impacts of arsenic from groundwater inflow, there was a possibility that seepage from the ponds could lead to elevated background readings at the downstream U.S.G.S. gauge. However, a review of the low-flow data does not show an elevated level of arsenic even at a flow as low as 7.8 cfs, which is slightly greater than three times the value of the critical low-flow value of 2.335 cfs. Therefore, the review of the existing data shows no obvious evidence of impact to the river. Based on this information, a low-flow concentration of 0.002 mg/L was selected for use in the modeling effort.

3.7.1.3 Model Output

A spreadsheet program was written to calculate and summarize groundwater flow and arsenic contributions from each portion of the flow net using the input parameters described above. An example of the program calculations and resulting output for the input parameters selected and discussed above is shown in Appendix J, Table 4. The program was designed so that differing combinations of groundwater and river parameters, and flow net configurations can be quickly inserted in the spreadsheet to perform a sensitivity analysis. Table 3-14 presents the results of this exercise which used differing values of saturated thickness, hydraulic conductivity, and 1994 and 1995 groundwater monitoring results for arsenic. Using the generally conservative parameters discussed above, the model produced a low-flow arsenic value of 0.006 mg/L.

A low-flow river concentration of 0.002 mg/L arsenic was assigned to calculate a resultant final concentration of arsenic in the river. Using the model and available data, small low-flow arsenic concentrations in the river can be readily determined for any initial combination of river discharge and initial arsenic concentrations. For example, if flow is increased to the 7.8 cfs value discussed in the section above, the final concentration drops from 0.006 to 0.003 mg/L.

3.7.2 Discussion of Model Results

As shown in Table 3-15, the impact of groundwater discharge to the Pecos River during periods of low-flow could result in arsenic concentration ranging from 0.003 to 0.025 mg/L in the river, with 0.006 mg/L being the most likely concentration. This value, and indeed all of the values in Table 3-14, are less than any of the numerous federal and state standards for arsenic for drinking water, groundwater, fisheries, livestock and irrigation which have been promulgated in New Mexico. These standards and their source reference were presented previously in Table 3-14 and may be compared with the Table 3-15 model results.

A low-flow condition exists at the exceedingly small value of 2.335 cfs. By definition, the 4Q3 low-flow statistically occurs only once every three years for four days at a time. For example, in 1993 the 4Q3 low-flow did not occur. As reported earlier (Section 3.7.1.2), the 1993 low and mean flows were 40 and 210 cfs, respectively. Because of the occasional nature of low-flow, impacts, if any, would be transient and in any case would not cause exceedance of existing standards. The much more frequent scenario, therefore, is one where any impacts are too small to measure and ecologically insignificant.

The groundwater modeling exercise for arsenic was performed using existing hydrologic conditions and constituent concentrations at the evaporation ponds. This environment is artificial in that seepage is accelerated by the hydraulic head in the ponds. When the ponds cease receiving fluids (scheduled to occur in 18 to 24 months) and are dried and closed, groundwater movement will resume its generally southerly movement. Under conditions of low hydraulic head the flow of groundwater and movement of water quality constituents to the river will be essentially eliminated north of the ponds and the impact to the river of any remaining unattenuated, low concentration constituents in the groundwater will be negligible.

South of the ponds, the average hydraulic head in the alluvial sediments is approximately six times less than that present in the immediate vicinity of the active ponds. Using the same metal information as utilized in the model and keeping in mind that organic constituents south of Pond 1 are being naturally attenuated, it can be seen that river impacts from seepage of groundwater constituents from the area southeast of the ponds to the river will be similarly insignificant.

Table 3-15 Seepage Impacts to Pecos River -- Results of Pond Groundwater Modeling

Saturated Thickness (ft)	K (ft/day)	Mon. Well Arsenic Sampling (date)	Final River Arsenic Conc. (mg/L)	Saturated Thickness (ft)	K (ft/day)	Mon. Well Arsenic Sampling (date)	Final River Arsenic Conc. (mg/L)
10	5.55	Jun-95	0.003	30	5.55	Jun-95	0.004
10	5.55	Nov-94	0.004	30	5.55	Nov-94	0.007
10	10.02	Jun-95	0.003	**30**	**10.02**	**Jun-95**	**0.006**
10	10.02	Nov-94	0.005	30	10.02	Nov-94	0.010
10	33.42	Jun-95	0.007	30	33.42	Jun-95	0.014
10	33.42	Nov-94	0.011	30	33.42	Nov-94	0.025
20	5.55	Jun-95	0.004				
20	5.55	Nov-94	0.005				
20	10.02	Jun-95	0.005				
20	10.02	Nov-94	0.008				
20	33.42	Jun-95	0.011				
20	33.42	Nov-94	0.019				

Notes: K - Hydraulic conductivity, feet per day; Arsenic concentration - milligrams per liter

3.8 Corrective Measures Alternatives

On the basis of a thorough evaluation of the overall environmental risk posed by contaminants in Pond 1 soils and in the underlying and downgradient groundwater, the following conclusions have been reached. The location and environmental setting of the Navajo Evaporation Ponds is such that the probability that the site will be subject to future industrial use or human residential occupation, in either the immediate or distant future, must be considered to be extremely remote. Furthermore, based on the nature and magnitude of contamination and the existing scientific literature database, there is no evidence indicating that the site does or will pose a threat of significant ecological harm to the surrounding environment, including cattle or other mammals, birds, and fish, through direct or indirect exposure pathways.

In the absence of any indication of meaningful environmental risk, no further corrective measures are deemed to be warranted. Therefore, a comparative evaluation of corrective measures alternatives has not been undertaken.

Navajo has no intention of selling the property of which the subject site is a part. Upon final closure of the unit, Navajo will submit documentation to establish that a legally binding covenant will be placed upon the property deed to the effect that any future use of the property will be expressly limited to agricultural purposes.

3.9 Proposed Alternate Concentration Limits for Groundwater

Phase I, II and III RFI studies have characterized groundwater constituent concentrations downgradient from Pond 1. The Phase I and Phase II results for metals, volatiles and semivolatiles together with EPA maximum contaminant levels (MCL's) are shown in Table 3-6. Updated information for 1994 and 1995 samplings was shown in Table 2-3. Complete information is presented in Appendices D, E, and F. Low-flow purging has reduced turbidity and most sample results are at or less than the corresponding MCL for that constituent. However, for some wells arsenic and benzene continue to exceed the MCL by relatively small values.

As has been discussed above, at the current site, groundwater is non-potable for drinking without extensive treatment which would remove both inorganic and organic contaminants. Also, the physical location is subject to frequent flooding rendering it unsuitable for human residential use. Therefore, the use of alternate constituent concentration limits for groundwater downgradient from Pond 1 is appropriate.

Accordingly, groundwater concentration levels 10 times the established MCL's have been selected as alternate concentration limits (ACL's) for all constituents. Since the maximum exceedance for any constituent currently does not exceed five times the MCL, a level of 10 provides a buffer range that allows for laboratory variability in analyses. This is especially important in the analysis of arsenic in groundwater since matrix interference can commonly cause reported concentrations to be higher than are actually present (KWBES, RFI Phase II report, p. 138). If concentrations greater than 10 times the MCL are observed during the period of post-closure monitoring, such occurrence will trigger a re-evaluation of the health risks that may be present at the site.

4.0 POND 1 RISK MANAGEMENT STRATEGY

On the basis of the available information, Navajo has concluded that future land use of Pond 1 for agricultural purposes related to livestock production poses very minimal risks to human health and the environment. Navajo proposes to ensure that the site will be utilized only for the designated agricultural activity by imposing legal deed restrictions on the property to prohibit any alternative land usages which might result in a higher frequency and duration of human attendance at the site. It is anticipated that a formal deed restriction document will be prepared and submitted to EPA during the course of the formal unit closure process.

Remaining risk management issues are associated with closure and post-closure monitoring requirements, and community relations and information dissemination. These items are discussed in the following sections.

4.1 Closure and Post-Closure Environmental Monitoring

Navajo believes that the existing environmental risk information is sufficient to demonstrate that residual contaminants in Pond 1 soils pose minimal risk to human health and the environment, and that further soil monitoring would serve no meaningful purpose. Therefore, no additional environmental monitoring is proposed for Pond 1 soils.

Groundwater monitoring is currently being performed in the area of the evaporation ponds pursuant to a schedule authorized by the NMOCD as a condition of ground water discharge plan approval. The NMOCD groundwater discharge plan is scheduled for renewal in 1996, at which time it is anticipated that NMOCD and EPA groundwater monitoring requirements can be effectively merged into a single monitoring program. In the interim, Navajo expects to enter into a dialog with EPA regarding interim groundwater monitoring requirements to be conducted during the unit closure process.

4.2 Community Relations Activities

Navajo currently operates under the auspices of a community relations plan which was created as part of the original RFI Phase II Workplan for Three-Mile Ditch and the Evaporation Ponds, and approved by EPA as part of the final Workplan. The community relations plan includes requirements for public notices, scheduled meetings, identification of a Community Relations Coordinator, creation of a public information repository and reading room, and a mailing list to actively interested parties.

5.0 REFERENCES

Adams, Michael, P.M. Bolger, and Ellis Gunderson, 1994. *Dietary Intake and Hazards of Arsenic,* in: William R. Chappell, Charles Abernathy and C. Cothern, (eds.), Arsenic Exposure and Health, Science and Technology Letters.

Agency for Toxic Substances and Disease Registry, 1990. *Case Studies in Environmental Medicine: Lead Toxicity,* U.S. Department of Health and Human Services, HE-20.7917:1.

Anderson, C.E., 1983. *Arsenicals as Feed Additives for Poultry and Swine,* in: W.H. Lederer and R.J. Fernsterheim (eds.), Arsenic: Industrial Biomedical ane Environmental Perspectives. Van Nostrand Reinhold. New York.

Anderson, Todd A., E.A. Guthrie, and Barbara Walton, 1993. *Bioremediation in the Rhizosphere,* Environmental Sciences Technology, 27:2630-2636.

Arthur, W.J., III, and R.J. Gates, 1988. *Trace Element Intake Via Soil Ingestion in Pronghorns and in Black-Tailed Jackrabbits,* J. Range Management, 41:162-166.

Bertrand, J.C., P. Caumette, G. Mille, M. Gilewicz, and M. Denis, 1989. *Anaerobic Degradation of Hydrocarbons,* Oxford Scientific Progress, 73:333-350.

Beyer, W.N., C. Stafford, and D. Best, 1990. *Trace Elements in Soil and Biota in Confined Disposal Facilities For Dredged Materials.* Environmental Pollution, 65:19-32.

Brainard, J. and B. Beck, 1993. *A Review of the Bioavailability of Petroleum Constituents,* in: P. Kostecki and E. Calabrese (eds.), Hydrocarbon Contaminated Soils and Groundwater, Vol. 3, Lewis Publishers, Chelsea, Michigan.

Brown, K.W., Gordon B. Evans, and B.D. Frentrup, eds., 1983. *Hazardous Waste Land Treatment,* Butterworth Publishers, Boston, London.

Charbonneau, S.M., K. Spencer, F. Bryce and E. Sandi, 1978. *Arsenic Excretion by Monkeys Dosed with Arsenic-Containing Fish or With Inorganic Arsenic,* Bulletin of Environmental Contamination and Toxicology, 20:470-477.

Cruz, R.R., R.K. DeWees, D.E. Funderburg, R.L. Lepp, D. Ortiz, and D. Shaull, 1994. *Water Resources Data, New Mexico, Water Year 1993,* U.S. Geological Survey Water-Data Report NM-93-1, U.S. Govt. Printing Office, Washington, D.C.

Davis, Stanley, N., and R.J.M. DeWiest, 1966. *Hydrogeology.* John Wiley and Sons, New York.

Dick-Peddie, William, 1993. *New Mexico Vegetation - Past, Present and Future,* University of New Mexico Press, Albuquerque, New Mexico.

Dragun, J., 1988. *The Soil Chemistry of Hazardous Materials,* Hazardous Materials Control Research Institute, Silver Spring, Maryland.

Eastern Reseach Group, 1992. *Technical Support Document for Land Application of Sewage Sludge,* prepared for U.S. EPA, Office of Water, Washington, D.C., NTIS #PB93-110575, Lexington, MA, November.

ENSR Consulting and Engineering, 1995. *Navajo Refining Company Evaporation Ponds Closure Plan,* March.

Faries, F.C., John Sweeten, and J.C. Reagor, 1990. *Water Quality: Its Relationship to Livestock,* Texas Agricultural Extension Service, Pub. No. L-2374.

Gold, Lois, T.H. Sloan, B.R. Stern, N.B. Manley, and B. Ames, 1992. *Rodent Carcinogens: Setting Priorities,* Science, 258:261-265.

Gruen, K, H.G. Vaessen, J.J. Kliest, J.L. de Boer, T. van Ooik, A. Timmerman, and R.F. Klug, 1994. *Bioavailability of Inorganic Arsenic from Bog Ore-Containing Soil in the Dog*. Environmental Health Perspectives, 102:182-184.

Hamasaki, Tetsuo, Hisamitsu Nagase, Yoshitada Yoshioka, and Takahiko Sata, 1995. *Formation distribution and ecotoxicity of Methylmetals of tin, mercury and Arsenic in the environment.* Critical Reviews in Environ. Science and Technology, 25:45-91.

Haschek, W.M., D.J. Lisk, and R.A. Stehn, 1979. *Accumulations of Lead in Rodents from Two Old Orchard sites in New York.* In: Animals As Monitors of Environmental Pollutants, National Academy of Sciences, Washington D.C.

Hem, John D., 1992. *Study and Interpretation of the Chemical Characteristics of Natural Water, Third Ed.,* U.S. Geological Survey Water-Supply Paper 2254, U.S. Govt. Printing Office, Washington, D.C.

Ishini, N., K. Tsuchiya, M. Vahter, and B.A. Fowler, 1986. *Arsenic*, in: L. Frieberg (ed.), Handbook on the Toxicology of Metals, Elvesier, Amsterdam, p. 43-83.

Johnson, L.R. and J.G. Farmer, 1991. *Use of Human Metabolic Studies and Urinary Arsenic Speciation in Assessing Arsenic Exposure.* Bulletin of Environmental Contamination and Toxicology, 46:53-61.

KWBES (K. W. Brown Environmental Services), 1993. *RCRA Facility Investigation Three-Mile Ditch and Evaporation Ponds, Phase II (Revised), Navajo Refinery, Artesia, New Mexico,* prepared for U.S. EPA, Region VI, Dallas, TX, 163 p., five volumes, College Station, TX, November.

Macintyre, T.M., 1970. *Effect of Bunker C Oil on Sheep,* Canadian Journal of Animal Science, 50:748-749.

Mariah Associates, Inc., 1990. *RCRA Facility Investigation Three-Mile Ditch and Evaporation Ponds, Phase I (Revised), Navajo Refinery, Artesia, New Mexico,* prepared for U.S. EPA, Region VI, Dallas, TX, two volumes, Laramie, WY, October.

Menzie, C.A., B. Potocki, and J. Santodonato, 1992. *Exposure to Carcinogenic PAHs in the Environment,* Environmental Science and Technology, 26:1278-1284.

Mower, R.W., J.W. Hood, R.L. Cushman, R. Borton, and S.E. Galloway, 1964. *An Appraisal of Potential Ground-Water Salvage Along the Pecos River Between Acme and Artesia, New Mexico,* U.S. Geologic Survey Water Supply Paper No. 1659, U.S. Govt. Printing Office, Washington D.C.

Nagy, K.A., 1987. *Field Metabolic Rate and Food Requirment Scaling in Mammals and Birds*, Ecology Monographs, 57:111-128.

National Academy of Sciences, 1974. *Nutrients and Toxic Substances in Water for Livestock and Poultry,* National Academy of Sciences, Washington, D.C.

National Academy of Sciences, 1977a. *Drinking Water and Health,* Safe Drinking Water Committee, Advisory Center on Toxicology, National Research Council, National Academy of Sciences, Washington D.C.

National Academy of Sciences, 1977b. *Arsenic.* Committee on Medical and Biologic Effects of Environmental Pollutants, National Academy of Sciences, Washington, D.C.

National Academy of Sciences, 1980. *Mineral Tolerances of Domestic Animals*, NAS subcommittee on mineral toxicity in animals. National Academy Press, Washington, D.C.

National Academy of Sciences, 1989. *Recommended Dietary Allowances, 10th ed.*, Food and Nutrition Board, Committee on Life Sciences, National Research Council, National Academy of Sciences, Washington D.C.

New Mexico Water Quality Control Commission (NMWQCC), 1995. *Water Quality Standards for Interstate and Intrastate Streams in New Mexico.* New Mexico Water Quality Control Commission, Santa Fe, New Mexico.

O'Neil, P., 1995. *Arsenic*, in: B.J. Alloway, ed. Heavy Metals in Soils, Blackie Academic and Professional, London, p. 113-119.

Paterson, S., D. Mackay, D. Tam, and W. Shiu, 1990. *Uptake of Organic Chemicals By Plants: A Review of Processes, Correlations and Models*, Chemosphere, 21:297-331.

RE/SPEC Inc., 1994. *RCRA Facility Investigation Phase III Workplan Three-Mile Ditch and Evaporation Ponds (Draft), Navajo Refining Company Artesia, New Mexico,* prepared for U.S. EPA, Region VI, Dallas, TX, Albuquerque, New Mexico, July.

RE/SPEC Inc., 1995. *RCRA Facility Investigation Phase III Report Three-Mile Ditch and Evaporation Ponds, Navajo Refining Company Artesia, New Mexico,* prepared for U.S. EPA, Region VI, Dallas, TX, two volumes, Albuquerque, New Mexico, April.

Robinson, T.W., 1965. *Introduction, Spread and Areal Extent of Saltcedar (Tamarix) in the Western States,* U.S. Geologic Survey Professional Paper 491-A, U.S. Govt. Printing Office, Washington, D.C.

Rowe, L.D., J.W. Dollahite, and B.J. Camp, 1973. *Toxicity of Two Crude Oils and of Kerosine to Cattle,* Journal of the American Veterinary Medical Association, 162:61-66.

Ryan, J.A., R. Bell, J.M Davidson, and G.A. O'Connor, 1989. *Plant Uptake of Non-Ionic Organic Chemicals From Soils,* Chemosphere, 17:2299-2323.

Simpson, C.F., B.L. Damron, and R. Harms, 1976. *Lead Poisoning in Animal Models,* MSS Information Corporation, New York.

Sullivan, Brian P., 1995. *Part 503 Sludge Rules: Applicability to Metals Contaminated Soils, The National Environmental Journal, July/August, 1995, p.40-45.*

Superfund Week, 1995. *EPA's Swine Model Eases Lead Cleanup Goals*, July 28, 1995, 9(27):6-7.

Thelin, Gail P., and R.J. Pike, 1991. *Landforms of the Conterminous United States,* U.S. Geological Survey manuscript for Map I-2206.

Travis, Curtis C., and Sheri T. Hester, 1991. *Global Chemical Pollution*, Environmental Science and Technology, 25: 815-819.

U.S. Army Medical Research and Development Command, 1988. *Evaluation of Military Field-Water Quality, Vol. 9, Data for Assessing Health Risks in Potential Theaters of Operation for U.S. Military Forces,* Lawrence Livermore National Laboratory, UCRL-21008 Vol. 9, U.S. Govt. Printing Office, Washington, D.C.

U.S. Bureau of Land Management, Undated. *What You Need to Know About Livestock Grazing on the Public Lands,* U.S. BLM Albuquerque District Office, Albuquerque, New Mexico.

U.S. Environmental Protection Agency, 1989a. *Risk Assessment Guidance for Superfund: Vol. Human Health Evaluation Manual (Part A),* Office of Emergency and Remedial Response, December 1989, EPA/540/1-89-002.

U.S. Environmental Protection Agency, 1989b. Science Advisory Board's Review of the Arsenic Issues Relating to the Proposed Phase II Proposed Regulations from the Office Of Drinking Water. EPA-SAB-EHC-89-038.

U.S. Environmental Protection Agency, 1992a. *Framework for Ecological Risk Assessment,* U.S. EPA Risk Assessment Forum, EPA/630/R-92/001.

U.S. Environmental Protection Agency, 1992b. *Estimating Exposure to Dioxin-Like Compounds,* U.S. EPA Office of Reseach and Development, EPA/600/6-88/005B.

U.S. Environmental Protection Agency, 1993a. *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening, Region III Technical Guidance Manual,* January, 1993, EPA/903/R-93-001.

U.S. Environmental Protection Agency, 1993b. *Wildlife Exposure Factors Handbook,* U.S. EPA Office of Health and Environmental Assessment, EPA.600/R-93/187a.

U.S. Environmental Protection Agency, 1993c. *A Review of Ecological Assessment Case Studies from a Risk Assessment Perspective.* U.S. EPA Risk Assessment Forum, EPA/630/R-92/005.

U.S. Environmental Protection Agency, 1994a. *Ecological Risk Assessment Issue Papers,* U.S. EPA Office of Research and Development, EPA/630/R-94/009.

U.S. Environmental Protection Agency, 1994b. U.S. Environmental Protection Agency, 1994. *Technical Background Document for Soil Screening Guidance - Review Draft,* Office of Solid Waste and Emergency Response. EPA/540/R-94/106.

U.S. Environmental Protection Agency, 1995. *EPA Region 3 Risk-Based Concentration Table,* prepared by Dr. Roy L. Smith, Senior Toxicologist, February 9, 1995.

U.S. Geological Survey, 1971. *Elemental Composition of Surficial Materials in the Conterminous United States,* Geological Survey Professional Paper 574-D, U.S. Govt. Printing Office, Washington D.C.

Vance, David B., 1995. *Arsenic: Chemical Behavior and Treatment,* The National Environmental Journal, May/June, 1995, p. 60-64.

Woolson, E.A., 1977. *Fate of Arsenicals in Different Environmental Substrates,* Environmental Health Perspectives, 19:73-81.

APPENDIX A

Appendix A

APPENDIX A

EVAPORATION POND 1 RFI PHASE II
SOILS DATA

Table A-1. RFI Phase II soil sampling, Evaporation Pond 1 — oil and grease and volatile organic compounds (mg/kg).

Sample	Sample depth (ft)	Oil and grease (%)	Acetone	Benzene	Ethyl-benzene	Methylene chloride	Toluene	Xylenes (total)
EP-TR-001-01	1	8.27	0.387	0.03	0.443	< 0.028	0.622	2.05
EP-TR-001-02	3	1.11	0.437	< 0.034	0.128	< 0.034	0.082	0.484
EP-TR-001-03	6	0.4	0.295	< 0.025	0.052	< 0.025	0.032	0.159
EP-TR-001-04	9	0.06	0.176	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-001-05	13	< 0.05	< 0.012	< 0.006	< 0.006	0.014	< 0.006	< 0.006
EP-TR-002-01	1	18.49	< 0.391	< 0.196	0.59	< 0.196	0.376	1.57
EP-TR-002-02 [b]	3	0.96	0.442	< 0.007	0.488	< 0.007	0.083	1270
EP-TR-002-03 [c]	6	0.08	0.556	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-002-04	9	0.08	0.043	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
EP-TR-002-05	13	< 0.05	< 0.014	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-01	1	7.05	< 0.061	< 0.031	< 0.031	< 0.031	< 0.031	0.264
EP-TR-003-02	3	< 0.05	0.228	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-03	3 (duplicate)	0.26	0.189	< 0.007	< 0.007	0.015	< 0.007	< 0.007
EP-TR-003-04	6	0.05	< 0.014	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-05	11	<0.05	0.033	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-004-01	1	16.07	< 0.314	< 0.157	0.332	< 0.157	< 0.157	< 0.157
EP-TR-004-02	3	0.10	0.079	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-004-03	6	< 0.05	0.184	< 0.034	< 0.034	< 0.034	< 0.034	< 0.034
EP-TR-004-04	9	< 0.05	< 0.012	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-005-01	1	0.19	< 0.012	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-005-02	3	0.11	0.264	< 0.007	< 0.007	<7	< 0.007	< 0.007
EP-TR-005-03	6	0.13	0.235	< 0.007	< 0.007	91	< 0.007	< 0.007
EP-TR-005-04	9	0.10	0.172	< 0.006	< 0.006	0.122	< 0.006	< 0.006
EP-TR-006-01	1	12.56	< 0.263	< 0.132	< 0.132	< 0.132	0.147	< 0.132
EP-TR-006-02	3	0.12	0.7	< 0.032	< 0.032	0.147	< 0.032	< 0.032
EP-TR-006-03	6	0.05	0.054	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-006-04	9	< 0.05	0.028	< 0.006	< 0.006	0.008	< 0.006	< 0.006
EP-TR-006-05	0-1	18.61	< 4.320	< 2.160	2.34	< 2.160	3.06	6.51

a = Trackhoe bucket grab sample of pond surface sludges adjacent to trench EP-TR-006.
b = 2-butanone (0.127 mg/kg) and carbon disulfide (0.033 mg/kg) also detected.
c = 2-butanone (146 mg/kg) also detected.

Table A-2. RFI Phase II soil sampling, Evaporation Pond — pH, electrical conductivity, and total metals concentrations (mg/kg).

Sample	Sample depth (ft)	pH	Electrical conductivity (mmhos/cm)	Arsenic	Chromium	Lead	Nickel	Zinc
EP-TR-001-01	1	8.5	2.9	26.1	74	389	21	54
EP-TR-001-02	3	8.5	4.9	3.9	29	17	26	64
EP-TR-001-03	6	7.5	6.4	7.6	17	7	24	44
EP-TR-001-04	9	7.6	5.0	2.2	16	4	23	25
EP-TR-001-05	13	8.1	2.6	2.4	16	1	20	36
EP-TR-002-01	1	8.3	3.6	38.6	1011	93	37	303
EP-TR-002-02	3	8.8	2.8	1.8	19	10	21	49
EP-TR-002-03	6	7.5	6.1	8.6	17	6	24	41
EP-TR-002-04	9	7.9	5.3	4	16	5	28	37
EP-TR-002-05	13	7.9	5.3	9.9	16	6	31	42
EP-TR-003-01	1	8.1	3.1	22.6	633	73	14	434
EP-TR-003-02	3	7.8	5.8	9.1	30	14	23	57
EP-TR-003-03	3 (duplicate)	7.7	6.5	10.3	26	12	22	55
EP-TR-003-04	6	7.7	5.0	7.1	24	7	14	53
EP-TR-003-05	11	7.7	4.0	3.3	20	6	10	32
EP-TR-004-01	1	8.2	8.0	19.7	398	28	12	194
EP-TR-004-02	3	9.1	3.3	1.4	14	4	7	21
EP-TR-004-03	6	9.5	2.7	8.7	34	14	22	73
EP-TR-004-04	9	8.2	1.9	3.1	9	3	5	37
EP-TR-005-01	1	7.6	6.6	1.6	32	9	14	40
EP-TR-005-02	3	8.5	6.4	1.5	19	7	13	33
EP-TR-005-03	6	9.4	4.2	3.9	25	11	18	48
EP-TR-005-04	9	8.7	5.1	11.6	26	8	14	38
EP-TR-006-01	1	7.7	7.0	39.9	235	153	37	161
EP-TR-006-02	3	9.1	3.9	2.4	29	9	13	63
EP-TR-006-03	6	7.6	6.3	6.5	18	4	10	31
EP-TR-006-04	9	8.7	2.6	2.2	12	7	10	31
EP-TR-006-05 [a]	1	8.6	6.0	16.1	320	36	14	320

[a] = Trackhoe bucket grab sample of pond surface sludges adjacent to trench EP-TR-006.

APPENDIX B

Appendix B

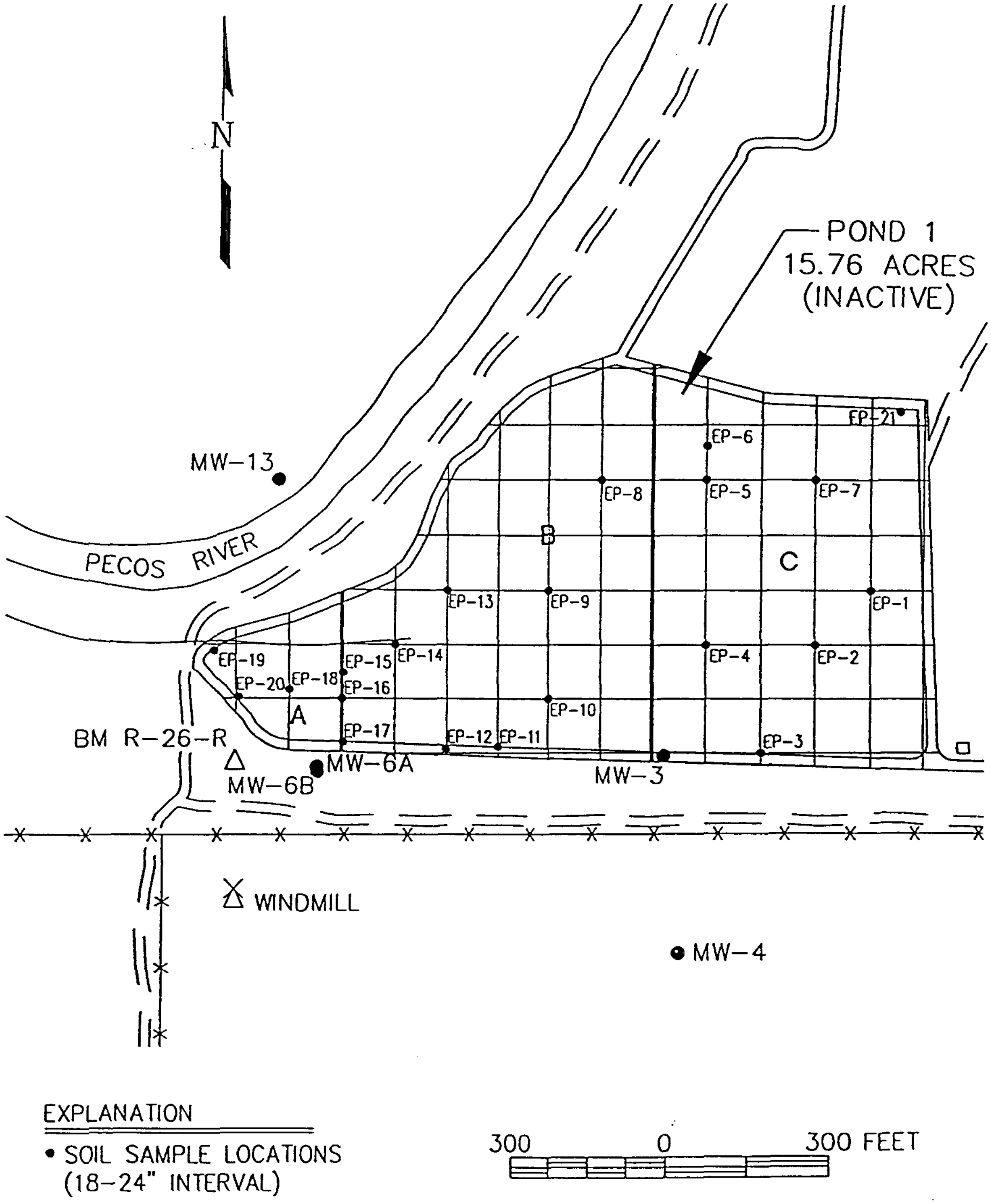
APPENDIX B

EVAPORATION POND 1 SOILS TPH DATA

(NOVEMBER, 1993)

Table B-1. Pond 1 Soil TPH Concentrations: 1.5 - 2.0 ft.
(November 1993 sample event)

Location	TPH (mg/kg)	pH
EP-1	<10	
EP-2	32	
EP-3	1970	8.4
EP-4	59	
EP-5	25600	
EP-6	48300	8.6
EP-7	32400	
EP-8	2890	
EP-9	21000	8.2
EP-10	2940	
EP-11	33500	
EP-12	105000	9.0
EP-13	81700	
EP-14	2940	
EP-15	51100	8.7
EP-16	58200	
EP-17	41100	
EP-18	33600	7.4
EP-19	27900	
EP-20	110000	
EP-21	99400	
AVG.	**38982**	**8.4**



RE/SPEC INC. RESEARCH SPECIALISTS

Pond 1 soil sample locations,
TPH sampling, November 1993.

Navajo

PROJECT: 622093004-110 (POND1)
LOCATION: ARTESIA, NEW MEXICO

APPR:	DATE: 11/23/93
DRAWN BY: RMO	SCALE AS SHOWN
DATE: 11/23/93	FIGURE: B-1

Appendix C

APPENDIX C

APPENDIX C

HYDROCARBON FRACTION ANALYSIS

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

CASE NARRATIVE

On March 6, 1995, one soil sample was received for analysis at Inter-Mountain Laboratories (IML), Bozeman, Montana. The chain of custody form requested analysis for Waste Oil Range Organics. Client / Project name was listed as RE/SPEC /Navajo/CMS / Artesia, New Mexico.

Enclosed are the results of these analyses. This sample was analyzed using several chromatographic temperature programs and compared to three different petroleum standards. Using a mixed sweet crude oil as a standard the concentration of the sample is 10000 mg/Kg. This profile uses an elevated temperature program to allow higher molecular weight components to be released from the chromatography column.

The normal Total Petroleum Hydrocarbons-Diesel Range Organics (DRO) used by the Montana Underground Storage Tank program gave quantitations of Diesel Range Organics of 2400 mg/Kg and a Total Extractable Hydrocarbon value of 11000 mg/Kg. The DRO method defines diesel range organics as those components between carbon components C10 - C28.

Analysis of this sample was also done comparing this sample to a standard containing compounds from C18 - C44. This requires an elevated temperature program when compared to the DRO method. A fractional breakout of the components of this sample is given. The sample has carbon components ranging from C18 - C44.

Included are various chromatographs to give a visual characterization of this sample compared to the above listed standards.

Limits of detection for each instrument/analysis are determined by sample matrix effects, instrument performance under standard conditions, and dilution requirements to maintain chromatography output within calibration ranges. Quantitations have been calculated on an as received basis.

Dirk M. Millhouse
IML-Bozeman

re:resm30cr

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

DIESEL RANGE ORGANICS - DRO

Client: RE/SPEC/NAVAJO/CMS
Sample ID: #1 Pond
Project ID: Artesia, New Mexico
Lab ID: B952103 0494S10935
Matrix: Soil

Date Reported: 03/30/95
Date Sampled: 12/02/94
Date Received: 03/06/95
Date Extracted: 03/09/95
Date Analyzed: 03/20/95

Parameter	Result	PQL	Units
Diesel Range Organics	2400	5.0	mg/kg
Diesel Range Organics as Diesel	ND	5.0	mg/kg
Total Extractable Hydrocarbons	11000	5.0	mg/kg

ND - Not Detected at Practical Quantitation Level (PQL).

Reference: DRO - USEPA Method for Determination of Diesel Range Organics. Revision 3, 05/08/92. WTPH-D Total Petroleum Hydrocarbons Analytical Methods for Soil, Washington State Department of Ecology, Revision 3, October 1991.

Analyst Shawn Rethig

Reviewed

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

CRUDE RANGE ORGANICS - CRO
Mixed Sweet Crude Oil

Client:	RE/SPEC/NAVAJO/CMS	
Sample ID:	#1 Pond	
Project ID:	Artesia, New Mexico	
Lab ID:	B952103	0494S10935
Matrix:	Soil	

Date Reported:	03/30/95
Date Sampled:	12/02/94
Date Received:	03/06/95
Date Extracted:	03/09/95
Date Analyzed:	03/20/95

Parameter	Result	PQL	Units
Crude Range Organics	10000	5.0	mg/kg

ND - Not Detected at Practical Quantitation Level (PQL).

Reference: DRO - USEPA Method for Determinination of Diesel Range Organics. Revision 2, February 1992.
WTPH-D Total Petroleum Hydrocarbons Analytical Methods for Soil, Washington State Department of Ecology, Revision 3, October 1991.

Analyst Shawn Rettis

Reviewed

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

QUALITY ASSURANCE / QUALITY CONTROL

LAB QA/QC
DIESEL RANGE ORGANICS - DRO
METHOD BLANK

Date Analyzed: **03/10/95**
Lab ID: MBS00068
Matrix: Sand
Date Extracted 03/09/95

Parameter	Result	PQL	Units
Diesel Range Organics	ND	5.0	mg/kg

ND - Not Detected at Practical Quantitation Level (PQL).

Reference: DRO - USEPA Method for Determination of Diesel Range Organics. Revision 3, 05/08/92. WTPH-D Total Petroleum Hydrocarbons Analytical Methods for Soil, Washington State Department of Ecology, Revision 3, October 1991.

Analyst Shawn Rettig

Reviewed

LAB QA/QC
DIESEL RANGE ORGANICS - DRO
BLANK SPIKE

Date Analyzed:	03/10/95	
Lab ID:	BSS00068	BS1
Matrix:	Sand	
Date Extracted:	03/09/95	

Parameter	Spike Added (mg/kg)	Sample Result (mg/kg)	Spike Result (mg/kg)	BS Recovery %	QC Limits Rec.
Diesel Range Organics	25	0	19	76	50 -150

Note: Spike Recoveries are calculated using zero for Sample result if Sample result was less than PQL (Practical Quantitation Level).

Spike Recovery: 0 out of 1 outside QC limits.

Analyst Shaun Rettig

Reviewed

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

Table of Contents

C:\HPCHEM\1\DATA\9901002.D\SIGNAL1.D

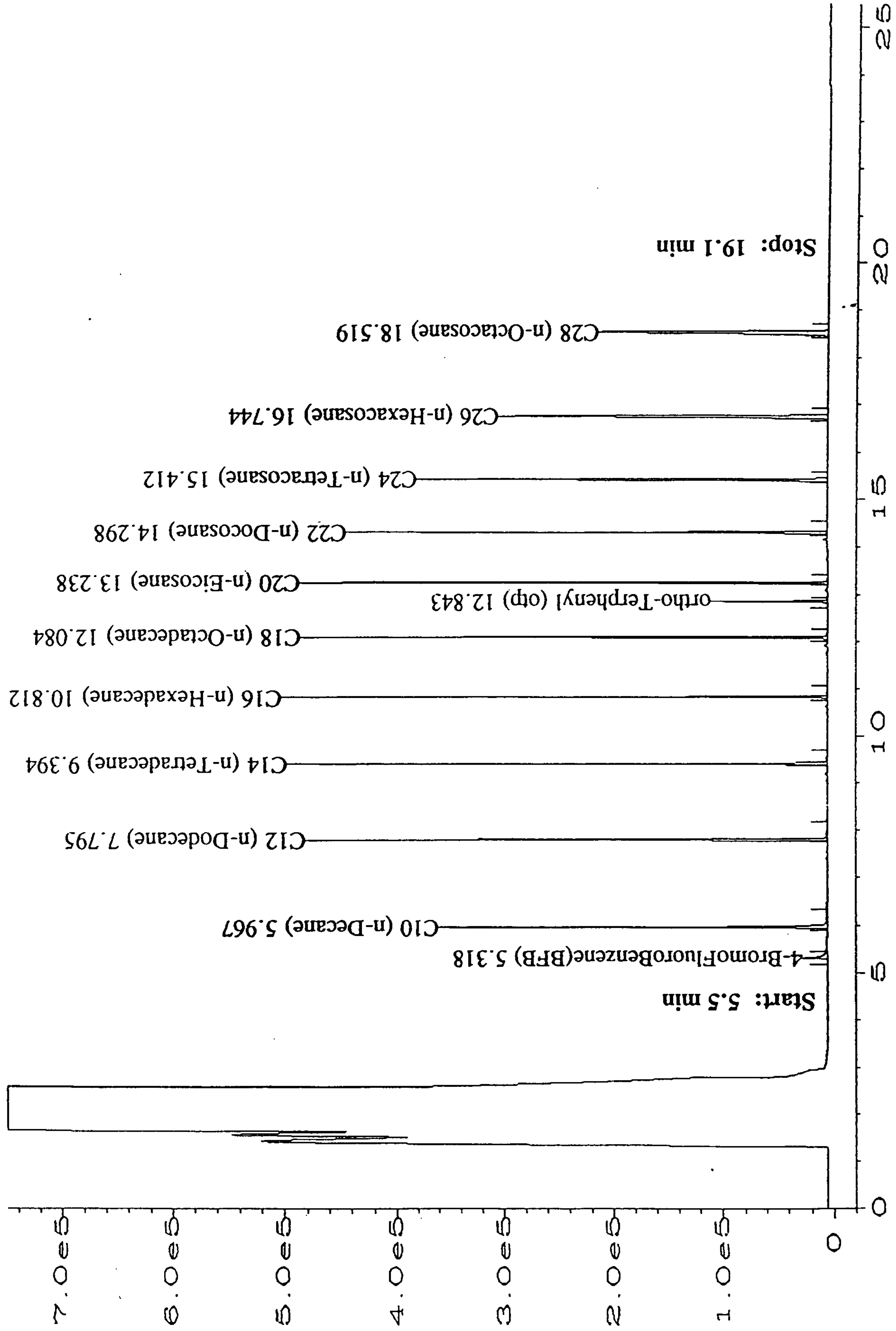


Figure 1: Diesel Component Standard, 100 ug/ml

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

C:\HPCHEM\1\DATA\9801003.D\SIGNAL1.D

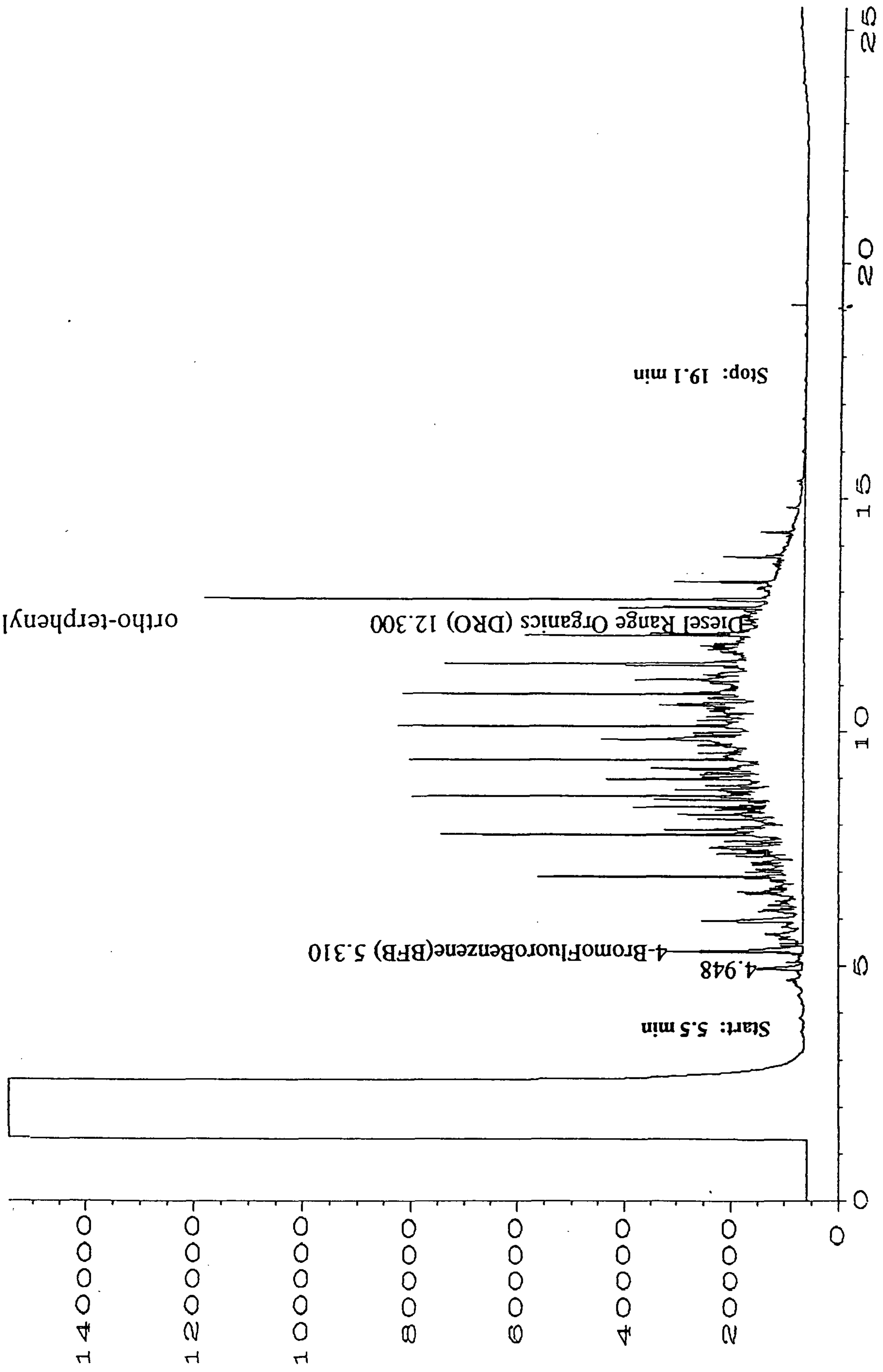


Figure 2: Commercial Diesel #2 Standard, 1000 ug/ml

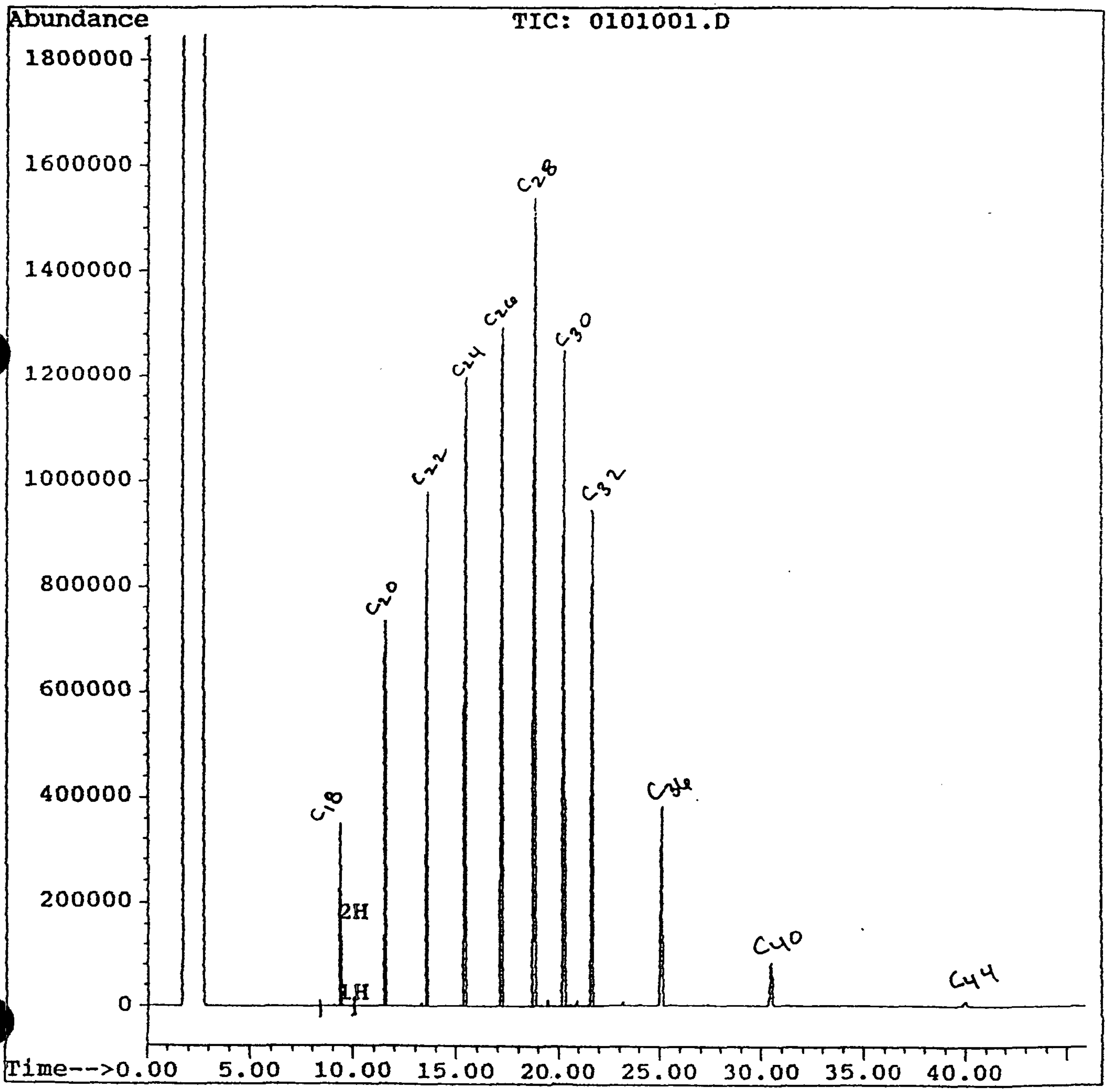
Quantitation Report

Data File : C:\HPCHEM\5\DATA\MARCH95\0320\0101001.D Vial: 1
Acq On : 20 Mar 95 01:14 PM Operator: Shawn
Sample : C18-C44 (ASTM PS-18-44D) Inst : GC#2
Misc : Supelco # 4-8928; Conc. varied; (F-02-2 Multiplr: 1.00
Quant Time: Mar 20 14:02 1995

Method : C:\HPCHEM\5\METHODS\CRORTE.M
Title : Diesel range hydrocarbons
Last Update : Wed Mar 15 16:46:26 1995
Response via : Multiple Level Calibration

Volume Inj. :
Signal Phase :
Signal Info :

FIG. 3



```
                              Quantitation Report

    Data File : C:\HPCHEM\5\DATA\MARCH95\0320\0301003.D      Vial: 3
    Acq On    : 20 Mar 95  02:55 PM                      Operator: Shawn
    Sample    : B95-2103 1:10                            Inst    : GC#2
    Misc      :                                          Multiplr: 1.00
    Quant Time: Mar 30  8:22 1995

    Method         : C:\HPCHEM\5\METHODS\SPECIAL.M
    Title          : Diesel range hydrocarbons
    Last Update    : Thu Mar 30 08:21:23 1995
    Response via   : Multiple Level Calibration

    Volume Inj.    :
    Signal Phase   :
    Signal Info    :
```

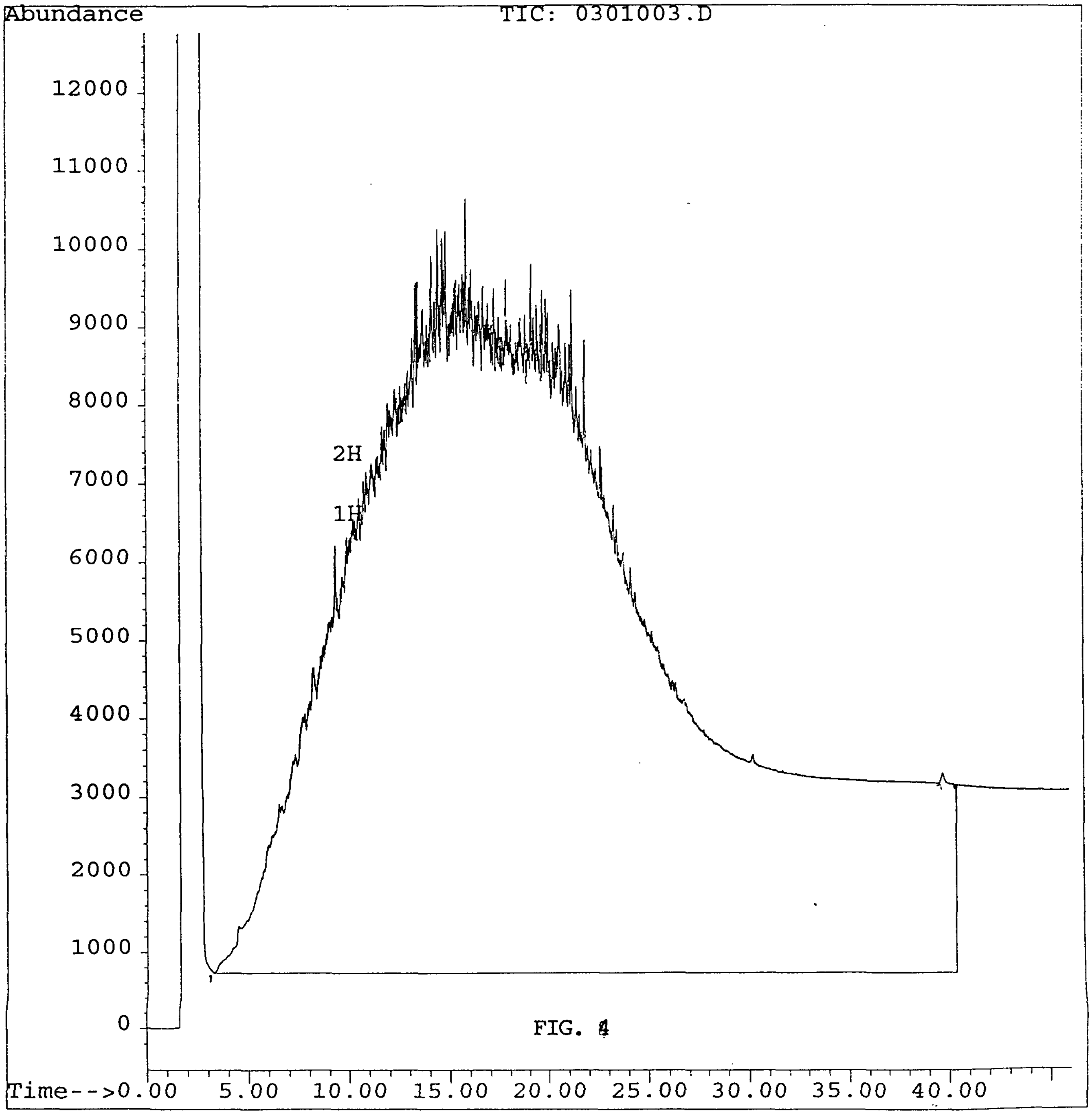


FIG. 4

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

Sample Characterization

Sample ID	Lab ID
Pond #1	B952103

Approx. Carbon Range Ratio's

C18	9	%
C20	11	%
C22	12	%
C24	16	%
C26	13	%
C28	15	%
C30	11	%
C32	10	%
C34-C36	2	%
C40	1	%
C44	.2	%

FIG. 5

iml
Inter-Mountain Laboratories, Inc.

CHAIN OF CUSTODY RECORD

Client/Project Name RE/SPEC / Navajo/cms	**Project Location** Artesia, NM	**ANALYSES / PARAMETERS**
Sampler: (Signature)	**Chain of Custody Tape No.**	

Sample No./ Identification	Date	Time	Lab Number	Matrix	No. of Containers	WRO				Remarks
Sample #1 Pond	12/02/94	1331	0494510935 B95 2103	Soil	1	✓				1- 8oz w/~ 2oz
										no ice
										cooler temp. 11.9°
										Sample intact

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
	03/03/95	1303	Fed Ex. (Carrier)		
Relinquished by: (Signature) Fed Ex. (Carrier)	**Date**	**Time**	**Received by: (Signature)** Valerie Herzog	**Date** 3/6/95	**Time** 10am
Relinquished by: (Signature)	**Date**	**Time**	**Received by laboratory: (Signature)**	**Date**	**Time**

Inter-Mountain Laboratories, Inc.

☐ 1633 Terra Avenue
Sheridan, Wyoming 82801
Telephone [illegible]7) 672-8945

☐ 1714 Phillips Circle
Gillette, Wyoming 82716
Telephone (307) 682-8945

☐ 2506 West Main Street
Farmington, NM 87401
Telephone (505) 326-4737

☐ 1160 Research Dr.
Bozeman, Montana 59715
Teleph[illegible] (406) 586-8450

☒ 11183 SH 30
College Station, TX 77845
Telephone (409) 776-8945

☐ 3304 Longmire Drive
College Station, TX 77845
Telephone (409) 774-4999

26270

Appendix D

APPENDIX D

APPENDIX D

EVAPORATION POND RFI PHASE II GROUNDWATER DATA

Table D-1. Volatile organic compounds detected during field sampling, Evaporation Pond area, Navajo Refinery, RFI Phase II.

			Acetone		Benzene		2-Butanone (MEK)		Carbon disulfide		Ethylbenzene		Methylene chloride		Toluene		Xylenes (total)	
Well ID	Laboratory	Date sampled	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)
Evaporation Pond	C922424	11/20/92	0.092	0.010	0.043	0.005			0.032	0.005	0.016	0.005			0.061	0.005	0.045	0.005
MW-03	C922322	11/12/92			0.017	0.005					0.016	0.005			0.021	0.005	0.025	0.005
MW-04	C922333	11/12/92			0.021	0.005					0.019	0.005			0.009	0.005	0.032	0.005
MW-05A(Field Duplicate)	C922335	11/11/92			0.013	0.005					0.006	0.005			0.028	0.005	0.008	0.005
MW-06A	C922323	11/12/92									0.007	0.005			0.006	0.005	0.014	0.005
MW-06B	C930278	1/30/93			0.009	0.005	0.048	0.010	0.117	0.005					0.006	0.005		
MW-12	C922658	12/18/92											0.007	0.005				
MW-14	C922655	12/17/92											0.020	0.005				
OCD-7B	C930279	1/30/93			0.009	0.005												
Windmill	C922656	12/17/92											0.010	0.005				

PQL = Practical quantitation limit.

Table D-2. Semivolatile organic compounds detected during field sampling, Evaporation pond area, Navajo Refinery, RFI Phase II.

Well ID	Laboratory number	Date sampled	B2EP Result (µg/L)	B2EP PQL (µg/L)	DNBP Result (µg/L)	DNBP PQL (µg/L)	DM24 Result (µg/L)	DM24 PQL (µg/L)
MW-2B	C922653	12/16/92	28	25				
MW-14	C922655	12/17/92			66	25		
MW-14 (Field Dup)	C922654	12/17/92			78	25		
MW-20	C930223	1/26/93			27	25		
OCD-8B	C930203	1/23/93	35	25				
OCD-8B (Field Dup)	C930204	1/23/93	21	20				
Evaporation Pond	C922424	11/20/92					180	50

PQL = Practical Quantitative Limit
B2EP = bis(2-Ethylhexyl)phthalate
DNBP = Di-n-butyl phthalate
DM24 = 2,4-Dimethylphenol
MN1 = 1-Methylnaphthalene
MN2 = 2-Methylnaphthalene
NAPH = Naphthalene

Table D-3. Results of metals analyses, Evaporation Ponds, Navajo Refinery, RFI Phase II.

Well sample identification	Laboratory number	Date samples	TAS[a]	TAS[b]	TAS[c]	DAS[d]	TCR[e]	DCR[f]	TPB[g]	DPB[h]	TNI[i]	TNI[j]	DNI[k]	pH	EC[l]
NEP-GW-EPA-1	C922391/15722	18-Nov-92	ND	ND		ND	ND	ND	ND	ND	0.08	ND	0.06	7.2	5340
NEP-GW-MW-01-01	C922278/15632	10-Nov-92	0.02	0.023	0.01	ND	3.65	ND	ND	ND	0.35	0.22	0.2	7.5	14900
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92	0.022			ND	3.62	ND	ND	ND	0.34		0.18	7.5	14900
NEP-GW-MW-02A	C922280/15633	10-Nov-92	0.087	0.117	0.09	0.073	0.1	ND	ND	ND	0.12	ND	0.1	7.4	11300
NEP-GW-MW-02B	C922653/16029	16-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.04		ND	7.4	3430
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92	ND			ND	ND	ND	ND	ND	0.03		ND	7.4	3430
NEP-GW-MW-03	C922322/15647	12-Nov-92	0.078	0.096		0.054	0.03	ND	ND	ND	0.12	0.04	0.08	7.3	7220
NEP-GW-MW-04	C922333/15644	12-Nov-92	0.08	0.112	0.136	0.069	ND	ND	ND	ND	0.11	ND	0.07	7.3	7610
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92	0.085			0.071	ND	ND	ND	ND	0.09		0.07	7.3	7620
NEP-GW-MW-05A	C922334/15645	11-Nov-92	0.074	0.089		0.063	0.03	ND	ND	ND	0.27	0.12	0.25	7.2	28000
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92	0.077			0.062	0.02	ND	ND	ND	0.26		0.26	7.2	28100
NEP-GW-MW-05B	C930136/W00059	22-Jan-93	0.131	0.15	0.162	0.106	ND	ND	ND	ND	ND		ND	7.1	9310
NEP-GW-MW-06A	C922323/15648	12-Nov-92	0.065			0.03	0.05	ND	ND	ND	0.11	0.04	0.04	7.4	4950
NEP-GW-MW-06B	C930278/W00344	30-Jan-93	0.021	0.02		0.016	ND	ND	ND	ND	ND		ND	11.9	6410
NEP-GW-MW-07A	C922281/15634	11-Nov-92	0.038	0.037	0.05	0.03	0.07	ND	ND	ND	0.13	ND	0.09	7.2	13900
NEP-GW-MW-07B	C930106/W00056	21-Jan-93	0.014	0.013	0.016	0.011	ND	ND	ND	ND	ND		ND	7.5	10700
NEP-GW-MW-10	C922390/15721	18-Nov-92	0.011	0.011		0.007	0.02	ND	ND	ND	0.09		0.07	7.2	6190
NEP-GW-MW-11A	C922567/15975	12-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.19		0.18	7.1	23700
NEP-GW-MW-11B	C930205/W00184	23-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		ND	7.3	20500
NEP-GW-MW-12	C922658/16033	18-Dec-92	ND	ND		ND	0.02	ND	ND	ND	0.05		ND	7.2	18700
NEP-GW-MW-13	C922659/16034	18-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.03		ND	7.5	5180
NEP-GW-MW-14	C922655/16031	17-Dec-92	0.012	0.012		0.01	ND	ND	ND	ND	0.04		ND	7.4	11200
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-92	0.01			0.007	0.02	ND	ND	ND	0.03		ND	7.3	10900
TMD-GW-MW-15	C930105/W00055	20-Jan-93	0.01	0.006		0.006	0.03	ND	ND	ND	ND		ND	7.5	3590
NEP-GW-MW-17	C930209/W00189	26-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		0.01	7.7	2600
NEP-GW-MW-18A	C930207/W00187	25-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.03		0.01	7.3	16400
NEP-GW-MW-18B	C930602/W01466	11-Mar-93	ND	ND			0.02		ND		ND			7.7	4650
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-93	ND				0.02		ND		ND			7.7	4640
NEP-GW-MW-19	C930208/W00188	26-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		ND	7.6	7280
NEP-GW-MW-22A	C930282/W00347	29-Jan-93	0.013	0.013		0.011	ND	ND	ND	ND	ND		ND	7.4	5750
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93	0.014			0.011	ND	ND	ND	ND	0.02		ND	7.4	5790
NEP-GW-MW-22B	C930283/W00348	29-Jan-93	0.007	0.008		0.005	ND	ND	ND	ND	0.01		0.01	7.1	6180
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93	0.008			0.005	ND	ND	ND	ND	ND		ND	7.1	6180
NEP-GW-MW-23	C930229/W00271	28-Jan-93	0.007	0.008		0.006	ND	ND	ND	ND	ND		ND	7.2	15900
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93	0.007			0.006	ND	ND	ND	ND	ND		ND	7.2	15900
NEP-GW-MW-24	C930281/W00346	28-Jan-93	ND	ND		ND	ND	ND	ND	ND	ND		ND	7.3	16300
NEP-GW-OCD-1	C922324/15649	13-Nov-92	0.097	0.115	0.154	0.071	0.06	ND	0.03	ND	0.16	0.05	0.11	7.2	14200
NEP-GW-OCD-2A	C922357/15669	15-Nov-92	0.067	0.084		0.043	0.04	ND	ND	ND	0.15	ND	0.12	7	15400
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93	0.007	0.005	0.018	0.006	ND	ND	ND	ND	0.01		ND	7.3	14700
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92	0.069			0.043	0.04	ND	ND	ND	0.14		0.13	7	15400
NEP-GW-OCD-3	C922358/15670	16-Nov-92	0.021	0.022		ND	0.19	ND	0.06	ND	0.28	0.09	0.12	7.1	17300
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92	0.015	0.017		0.005	ND	ND	ND	ND	0.15		0.11	7.2	19000

Table D-3. Continued.

Well sample identification	Laboratory number	Date samples	TAS [a]	TAS [b]	TAS [c]	DAS [d]	TCR [e]	DCR [f]	TPB [g]	DPB [h]	TNI [i]	TNI [j]	DNI [k]	pH	EC [l]
NEP-GW-OCD-5	C922399/15728	16-Nov-92	0.008	0.008		0.007	ND	ND	ND	ND	0.13	ND	0.12	7.2	17800
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92	0.009			0.008	ND	ND	ND	ND	0.12		0.12	7.2	17900
NEP-GW-OCD-5 (Dup of Fld D)	C922394/15731	17-Nov-92	0.008			0.007	ND	ND	ND	ND	0.13		0.12	7.2	17900
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92	0.036	0.048		0.028	ND	ND	ND	ND	0.14	ND	0.13	7.1	14500
NEP-GW-OCD-7 (Fld Blank)	C922395/15725	18-Nov-92	ND				ND		ND		0.04				
NEP-GW-OCD-7A	C922389/15720	18-Nov-92	0.021	0.023		0.012	0.02	ND	ND	ND	0.15		0.13	7.3	13300
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93	0.175			0.154	0.02	ND	ND	ND	0.02		0.02	7.3	10500
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93	0.005	0.005		ND	ND	ND	ND	ND	0.01		ND	7.6	6110
NEP-GW-OCD-8A	C922393/15723	17-Nov-92	0.032	0.037		0.019	ND	ND	ND	ND	0.12	ND	0.11	7	12400
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.02		ND	7.3	7490
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93	ND			ND	ND	ND	ND	ND	0.03		0.01	7.7	7270
Pecos River at OCD 7	C922425/W01464	20-Nov-92												7.3	7080
NEP-Windmill	C922656/16032	17-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.02		ND	7.4	6610
Evaporation Pond at OCD-7	C922424/15745/W01463	20-Nov-92	0.167				ND		ND		0.06			7.6	10900

Key	Test description/method	Detection limits
a	Total arsenic — Method 7061	0.005
b	Total arsenic — Method 7061 — Verification	0.005
c	Total arsenic — Method 7060 — Verification	0.005
d	Dissolved arsenic — Method 701	0.01
e	Total chromium — Method 7191	0.02
f	Dissolved chromium — Method 7191	0.02
g	Total lead — Method 7421	0.02
h	Dissolved lead — Method 7421	0.02
i	Total nickel — Method 7520	0.01
j	Total nickel — Method 7520 — verification	0.05
k	Dissolved nickel — Method 7520	0.01
l	Electrical conductivity, µmhos/cm at 25 ° C	

ND = Not detected.

Standards	EPA Drinking Water (mg/L)	NMWQCC Groundwater
As	0.05	0.1
Cr	0.1	0.5
Pb	0.015 (Action level)	0.05
Ni	0.1	0.2 (irrigation)

Table D-4. Results of inorganic water quality analyses, Evaporation Pond, Navajo Refinery, RFI Phase II.

Well sample ID	Laboratory no.	Date sampled		pH (Laboratory)	Electrical Conductivity at 25°C (Laboratory)	Total dissolved solids at 180°C	Total calcium	Total alkalinity	Total hardness	Flouride	Calcium	Calcium	Magnesium	Magnesium	Potassium	Potassium
			Detection level	0.1	1	1	1	1	1	0.1	1		1		1	
			Units	(s.u.)	(µmhos/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(meq/L)	(mg/L)	(meq/L)	(mg/L)	(meq/L)
NEP-GW-EPA-1	C922391/15722	18-Nov-92		7.2	5340	3750	3670	167	1960	0.8	495	24.70	176	14.47	7.1	0.18
NEP-GW-MW-01-01	C922278/15632	10-Nov-92		7.5	14900	11200	10500	406	3880	1.1	764	38.12	480	39.47	14.0	0.36
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92		7.5	14900	11300	NA	408	NA	1.1	769	NA	480	NA	16.0	NA
NEP-GW-MW-02A	C922280/15633	10-Nov-92		7.4	11300	8430	8430	523	1980	9.9	573	28.59	134	11.02	14.0	0.36
NEP-GW-MW-02B	C922653/16029	16-Dec-93		7.4	3430	2500	2320	160	1220	1.2	304	15.17	112	9.21	20.0	0.51
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92		7.4	3430	2540	NA	160	NA	1.2	300	NA	112	NA	18.0	NA
NEP-GW-MW-03	C922322/15647	11-Nov-92		7.3	7220	5310	4570	285	1630	3.0	457	22.80	119	9.79	12.0	0.31
NEP-GW-MW-04	C922333/15644	12-Nov-92		7.3	7610	5360	5080	234	1410	1.8	370	18.46	119	9.79	5.5	0.15
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92		7.3	7620	5360	NA	233	NA	1.8	376	NA	121	NA	5.0	NA
NEP-GW-MW-05A	C922334/15645	11-Nov-92		7.2	28000	24300	22300	423	5650	3.3	585	29.19	1020	83.88	9.0	0.23
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92		7.2	28100	24400	22200	427	5640	3.3	579	28.89	1020	83.88	9.3	0.23
NEP-GW-MW-05B	C930136/W00059	22-Jan-93		7.1	9310	7350	7160	328	2460	1.5	650	32.44	204	16.78	13.0	0.33
NEP-GW-MW-06A	C922323/15648	12-Nov-92		7.4	4950	3540	3300	136	1090	2.7	282	14.07	93	7.65	3.5	0.10
NEP-GW-MW-06B	C930278/W00344	30-Jan-93		11.9	6410	3800	3660	428	1620	0.4	648	32.34	1	0.08	27.0	0.69
NEP-GW-MW-07A	C922281/15634	11-Nov-92		7.2	13900	11500	11000	302	2780	1.4	471	23.50	389	31.99	12.0	0.31
NEP-GW-MW-07B	C930106/W00056	21-Jan-93		7.5	10700	9220	7980	293	1670	1.4	547	27.30	74	6.09	14.0	0.36
NEP-GW-MW-10	C922390/15721	18-Nov-92		7.2	6190	4400	4380	223	1340	1.1	417	20.81	72	5.92	7.4	0.18
NEP-GW-MW-11A	C922567/15975	12-Dec-92		7.1	23700	16100	15200	331	3980	1.0	964	48.10	384	31.58	31.0	0.79
NEP-GW-MW-11B	C930205/W00184	23-Jan-93		7.3	20500	14000	13600	217	5950	0.9	961	47.95	317	26.07	41.0	1.05
NEP-GW-MW-12	C922658/16033	18-Dec-92		7.2	18700	13500	12400	358	4470	1.1	788	39.32	608	50.00	19.0	0.49
NEP-GW-MW-13	C922659/16034	18-Dec-92		7.5	5180	3630	3370	254	1340	0.7	352	17.56	112	9.21	17.0	0.43
NEP-GW-MW-14	C922655/16031	17-Dec-93		7.4	11200	8230	7780	405	2320	1.0	456	22.75	288	23.68	18.0	0.46
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-93		7.3	10900	7890	7550	396	2260	1.0	444	22.16	280	23.03	21.0	0.54
TMD-GW-MW-15	C930105/W00055	20-Jan-93		7.5	3590	2790	2670	150	1190	1.1	308	15.37	102	8.39	11.0	0.28
NEP-GW-MW-17	C930209/W00189	26-Jan-93		7.7	2600	2230	2020	121	1370	1.1	387	19.31	99	8.14	13.0	0.33
NEP-GW-MW-18A	C930207/W00187	25-Jan-93		7.3	16400	12600	11900	286	4530	1.6	721	35.98	664	54.61	30.0	0.77
NEP-GW-MW-18B	C930602/W01466	11-Mar-93		7.7	4650	3710	3550	164	2110	1.1	588	29.34	157	12.91	17.0	0.43
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-94		7.7	4640	3710	NA	164	NA	1.1	577	NA	154	NA	16.0	NA
NEP-GW-MW-19	C930208/W00188	26-Jan-93		7.6	7280	5720	5150	210	2790	0.9	745	37.18	226	18.59	10.0	0.26
NEP-GW-MW-22A	C930282/W00347	29-Jan-93		7.4	5750	4410	4220	159	1520	1.5	421	21.01	114	9.38	6.0	0.15
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93		7.4	5790	4400	4290	159	1560	1.5	434	21.66	117	9.62	7.0	0.18
NEP-GW-MW-22B	C930283/W00348	29-Jan-93		7.1	6180	4700	4510	213	1720	1.0	461	23.00	139	11.43	4.0	0.10
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93		7.1	6180	4720	NA	212	NA	1.0	464	NA	139	NA	5.0	NA
NEP-GW-MW-23	C930229/W00271	28-Jan-93		7.2	15900	11700	10500	349	3890	0.8	988	49.30	347	28.54	14.0	0.36
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93		7.2	15900	11700	NA	349	NA	0.8	986	NA	342	NA	14.0	NA
NEP-GW-MW-24	C930281/W00346	28-Jan-93		7.3	16300	11600	10786	242	2951	1.0	787	39.27	240	19.74	38.0	0.97
NEP-GW-OCD-1	C922324/15649	13-Nov-92		7.2	14200	10300	8570	526	1860	5.7	487	24.30	156	12.83	7.2	0.18
NEP-GW-OCD-2A	C922357/15669	15-Nov-92		7.0	15400	11800	10900	404	2780	1.2	565	28.19	333	27.38	8.1	0.20
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92		7.0	15400	11700	NA	394	NA	1.2	567	NA	313	NA	9.0	NA
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93		7.3	14700	11600	11100	408	4140	0.9	844	42.12	494	40.63	13.0	0.33
NEP-GW-OCD-3	C922358/15670	16-Nov-92		7.1	17300	11600	10300	281	3340	0.9	922	46.01	268	22.04	29.0	0.74
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92		7.2	19000	13100	11800	197	2790	0.9	724	36.13	240	19.74	50.0	1.28
NEP-GW-OCD-5	C922399/15728	16-Nov-92		7.2	17800	12400	12000	199	3070	1.0	847	42.27	232	19.08	37.0	0.95
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92		7.2	17900	12400	11900	202	3050	1.0	846	42.22	228	18.75	36.0	0.92
NEP-GW-OCD-5 (LabDup of Fld D)	C922394/15731	17-Nov-92		7.2	17900	12400	NA	205	NA	1.0	849	NA	225	NA	36.0	NA
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92		7.1	14500	10900	10400	495	2550	2.9	675	33.68	210	17.27	15.0	0.38
NEP-GW-OCD-7A	C922389/15720	18-Nov-92		7.3	13300	10300	9570	564	2670	4.1	620	30.94	274	22.53	8.5	0.23
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93		7.3	10500	8350	7940	511	2390	6.6	652	32.53	186	15.30	14.0	0.36
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93		7.6	6110	5060	4840	141	1850	1.2	547	27.30	117	9.62	10.0	0.26
NEP-GW-OCD-8A	C922393/15723	17-Nov-92		7.0	12400	9670	9050	434	2850	2.5	633	31.59	308	25.33	11.0	0.28
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93		7.3	7490	5400	5240	164	2930	0.9	834	41.62	207	17.02	12.0	0.31
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93		7.7	7270	5270	5130	163	2840	0.9	807	40.27	202	16.61	14.0	0.36
NEP-Navajo Effluent	C930367/W00731	11-Feb-93		8.9	9300	7348	4840	829	279	151.0	21	1.05	55	4.52	22.0	0.56
Evaporation Pond at OCD 7	C922424/15745	16-Nov-92		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Evaporation Pond at OCD 7	C922424/15745/W01463	16-Nov-92		7.6	10900	7080	6620	534	354	36.3	46	2.30	58	4.77	67.0	1.31
NEP-Windmill	C922656/16032	17-Dec-92		7.4	6610	4740	4450	163	1530	1.1	316	15.77	180	14.80	14.0	0.36
Pecos River at OCD 7	C922425/W01464	16-Nov-92		7.3	7080	5110	4735	165	2190	0.9	571	28.49	186	15.30	13.0	0.33

Table D-4. Continued.

				Sodium	Sodium	HCO_3	HCO_3	CO_3	CO_3	OH	OH	Chloride	Chloride	SO_4	SO_4	Cation sum	Anion sum	Percent difference
Well sample ID	Laboratory no.	Date sampled	Detection level Units	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	(meq)	(meq)	(%)
NEP-GW-EPA-1	C922391/15722	18-Nov-92		480	20.88	204	3.34	0	0.00	0	0.00	989	27.90	1420	29.56	60.23	60.80	-0.47
NEP-GW-MW-01-01	C922278/15632	10-Nov-92		2130	92.65	495	8.11	0	0.00	0	0.00	3750	105.78	3020	62.88	170.60	176.77	-1.78
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92		2130	NA	NA	NA	NA	NA	NA	NA	3740	NA	3010	NA	NA	NA	NA
NEP-GW-MW-02A	C922280/15633	10-Nov-92		2170	94.39	638	10.46	0	0.00	0	0.00	2120	59.8	3180	66.21	134.36	134.47	-0.78
NEP-GW-MW-02B	C922653/16029	16-Dec-93		268	11.66	195	3.20	0	0.00	0	0.00	497	14.02	1020	21.24	36.55	38.46	-2.55
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92		268	NA	NA	NA	NA	NA	NA	NA	498	NA	1020	NA	NA	NA	NA
NEP-GW-MW-03	C922322/15647	11-Nov-92		975	42.41	348	5.70	0	0.00	0	0.00	1820	51.34	1020	21.24	75.31	78.28	-1.93
NEP-GW-MW-04	C922333/15644	12-Nov-92		1180	51.33	285	4.67	0	0.00	0	0.00	1380	38.93	1880	39.14	79.73	82.74	-1.85
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92		1170	NA	NA	NA	NA	NA	NA	NA	1410	NA	1870	NA	NA	NA	NA
NEP-GW-MW-05A	C922334/15645	11-Nov-92		5250	228.36	516	8.46	0	0.00	0	0.00	5410	152.61	9770	203.41	341.66	364.48	-3.23
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92		5150	224.01	520	8.52	0	0.00	0	0.00	5470	154.30	9740	202.79	337.01	365.61	-4.07
NEP-GW-MW-05B	C930136/W00059	22-Jan-93		1600	69.60	400	6.56	0	0.00	0	0.00	1760	49.65	2730	56.84	119.15	113.05	2.63
NEP-GW-MW-06A	C922323/15648	12-Nov-92		700	30.45	166	2.72	0	0.00	0	0.00	654	18.45	1490	31.02	52.27	52.19	0.08
NEP-GW-MW-06B	C930278/W00344	30-Jan-93		574	24.97	0	0.00	37	1.22	125	7.33	968	27.31	1180	24.57	58.08	60.43	-1.98
NEP-GW-MW-07A	C922281/15634	11-Nov-92		2930	127.45	368	6.03	0	0.00	0	0.00	2750	77.57	4260	88.69	183.25	172.29	3.08
NEP-GW-MW-07B	C930106/W00056	21-Jan-93		1990	86.56	357	5.85	0	0.00	0	0.00	1880	53.03	3300	68.71	120.31	127.59	-2.94
NEP-GW-MW-10	C922390/15721	18-Nov-92		970	42.19	272	4.46	0	0.00	0	0.00	982	27.70	1800	37.48	69.10	69.64	-0.39
NEP-GW-MW-11A	C922567/15975	12-Dec-92		3860	167.90	404	6.62	0	0.00	0	0.00	7108	200.51	2610	54.34	248.37	261.47	-2.57
NEP-GW-MW-11B	C930205/W00184	23-Jan-93		3410	148.33	265	4.34	0	0.00	0	0.00	5950	167.84	2790	58.09	223.40	230.27	-1.51
NEP-GW-MW-12	C922658/16033	18-Dec-92		2560	111.35	437	7.16	0	0.00	0	0.00	4980	140.48	3250	67.67	201.16	215.31	-3.40
NEP-GW-MW-13	C922659/16034	18-Dec-92		596	25.92	310	5.08	0	0.00	0	0.00	914	25.78	1230	25.61	53.12	56.47	-3.06
NEP-GW-MW-14	C922655/16031	17-Dec-93		1720	74.82	493	8.08	0	0.00	0	0.00	2150	60.65	2900	60.38	121.71	129.11	-2.95
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-93		1650	71.77	483	7.92	0	0.00	0	0.00	2080	58.67	2830	58.92	117.50	125.51	-3.30
TMD-GW-MW-15	C930105/W00055	20-Jan-93		447	19.44	182	2.98	0	0.00	0	0.00	564	15.91	1150	23.94	43.48	42.83	0.75
NEP-GW-MW-17	C930209/W00189	26-Jan-93		109	4.74	147	2.41	0	0.00	0	0.00	122	3.44	1220	25.40	32.52	31.25	1.99
NEP-GW-MW-18A	C930207/W00187	25-Jan-93		2420	105.26	348	5.70	0	0.00	0	0.00	3930	110.86	3950	82.24	196.62	198.80	-0.55
NEP-GW-MW-18B	C930602/W01466	11-Mar-93		356	15.48	200	3.28	0	0.00	0	0.00	661	18.65	1670	34.77	58.16	56.70	1.27
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-94		353	NA	NA	NA	NA	NA	NA	NA	668	NA	1690	NA	NA	NA	NA
NEP-GW-MW-19	C930208/W00188	26-Jan-93		718	31.23	256	4.20	0	0.00	0	0.00	1370	38.65	1950	40.60	87.26	83.45	2.23
NEP-GW-MW-22A	C930282/W00347	29-Jan-93		799	34.75	193	3.16	0	0.00	0	0.00	835	23.55	1950	40.60	65.29	67.31	-1.52
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93		809	35.19	193	3.16	0	0.00	0	0.00	844	23.81	1990	41.43	66.65	68.40	-1.30
NEP-GW-MW-22B	C930283/W00348	29-Jan-93		830	36.10	259	4.25	0	0.00	0	0.00	983	27.73	1970	41.02	70.63	73.00	-1.65
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93		827	NA	NA	NA	NA	NA	NA	NA	983	NA	1950	NA	NA	NA	NA
NEP-GW-MW-23	C930229/W00271	28-Jan-93		2180	94.82	425	6.97	0	0.00	0	0.00	4240	119.61	2570	53.51	173.02	180.09	-2.00
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93		2160	NA	NA	NA	NA	NA	NA	NA	4260	NA	2660	NA	NA	NA	NA
NEP-GW-MW-24	C930281/W00346	28-Jan-93		2500	108.74	295	4.84	0	0.00	0	0.00	4170	117.63	2910	60.59	168.72	183.06	-4.08
NEP-GW-OCD-1	C922324/15649	13-Nov-92		2230	97.00	642	10.52	0	0.00	0	0.00	1930	54.44	3450	71.83	134.31	136.79	-0.91
NEP-GW-OCD-2A	C922357/15669	15-Nov-92		2510	109.18	493	8.08	0	0.00	0	0.00	3220	90.83	3990	83.07	164.95	181.98	-4.91
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92		2600	NA	NA	NA	NA	NA	NA	NA	3200	NA	3980	NA	NA	NA	NA
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93		2320	100.91	498	8.16	0	0.00	0	0.00	3710	104.65	3450	71.83	183.99	184.64	-0.18
NEP-GW-OCD-3	C922358/15670	16-Nov-92		2330	101.35	281	4.61	0	0.00	0	0.00	4130	116.50	2520	52.47	170.14	173.58	-1.00
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92		3120	135.71	240	3.93	0	0.00	0	0.00	4500	126.94	3010	62.67	192.86	193.54	-0.18
NEP-GW-OCD-5	C922399/15728	16-Nov-92		3030	131.80	243	3.98	0	0.00	0	0.00	4720	133.15	2980	62.04	194.10	199.17	-1.29
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92		2930	127.45	246	4.03	0	0.00	0	0.00	4760	134.27	3000	62.46	189.34	200.76	-2.93
NEP-GW-OCD-5 (LabDup of Fld D)	C922394/15731	17-Nov-92		2970	NA	NA	NA	NA	NA	NA	NA	4780	NA	2990	NA	NA	NA	NA
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92		2550	110.92	603	9.89	0	0.00	0	0.00	3000	84.63	3670	76.41	162.25	170.93	-2.61
NEP-GW-OCD-7A	C922389/15720	18-Nov-92		2120	92.21	687	11.26	0	0.00	0	0.00	2480	69.96	3730	77.66	145.91	158.88	-4.26
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93		1950	84.82	623	10.21	0	0.00	0	0.00	2040	57.55	2800	58.30	133.01	126.06	2.68
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93		813	35.36	172	2.82	0	0.00	0	0.00	690	19.46	2570	53.51	72.54	75.79	-2.19
NEP-GW-OCD-8A	C922393/15723	17-Nov-92		1930	83.95	529	8.67	0	0.00	0	0.00	2290	64.60	3620	75.37	141.15	148.64	-2.58
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93		651	28.32	200	3.28	0	0.00	0	0.00	1630	45.98	1810	37.68	87.27	86.94	0.19
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93		628	27.32	199	3.26	0	0.00	0	0.00	1580	44.57	1800	37.48	84.56	85.31	-0.44
NEP-Navajo Effluent	C930367/W00731	11-Feb-93		1290	56.11	1011	16.57	0	0.00	0	0.00	1920	54.16	1034	21.53	62.24	92.26	-19.43
Evaporation Pond at OCD 7	C922424/15745	16-Nov-92		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Evaporation Pond at OCD 7	C922424/15745/W0 1463	16-Nov-92		2000	86.99	651	10.67	0	0.00	0	0.00	2180	61.50	1950	40.60	95.77	112.77	-8.15
NEP-Windmill	C922656/16032	17-Dec-92		872	37.93	199	3.26	0	0.00	0	0.00	1190	33.57	1780	37.06	68.86	73.89	-3.52
Pecos River at OCD 7	C922425/W01464	16-Nov-92		733	31.88	201	3.30	0	0.00	0	0.00	1470	41.47	1660	34.56	76.00	79.32	-2.14

Appendix E

APPENDIX E

APPENDIX E

EVAPORATION POND RFI PHASE III GROUNDWATER DATA

Table E-1 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 Disulfi-de**	**Semi-volatile Organics [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-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-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	NA
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-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	NA
MW-5C [c]	20-Jan-95	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA
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	NA
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	0.01	<0.005	<0.005	<0.010
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-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	NA
MW-15 [e]	24-Feb-95	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA
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

Notes:

[a] All semivolatile constituents less than the reported detection limits presented in the table.
[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.
Federal MCL Standards (mg/L): benzene, 0.005; ethylbenzene, 0.70; 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.

Table E-1 Summary of Navajo Evaporation Ponds groundwater volatile/semivolatile sample analyses, RFI Phase III, 1995 (concluded)

		Volatile Organics (mg/l)						
Sample ID	Date	Benzene	Toluene	Ethyl-benzene	Xylenes (total)	Methyl ethyl ketone	Carbon Disulf-ide	Semi-volatile Organics [a]
OCD-1	5-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
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-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-6	6-Nov-94	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010
OCD-7A	7-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010
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	NA
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	NA
Pond 3	6-Nov-94	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA

Notes:

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

[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; ethylbenzene, 0.70; 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.

Table E-2 Results of Groundwater Metals Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995

Sample ID	Date Sampled	Total Dissolved Solids (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 (Lab Dup.)	05-Nov-94	7,670	**0.158**	0.030	<0.01	0.03	**0.259**	<0.02	<0.1	0.03
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 (Fld Dup. 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-4A	10-Nov-94	5,410	**0.156**	0.090	**0.07**	**0.13**	0.076	<0.02	<0.1	<0.05
MW-4A (Fld Dup. 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-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-5A	08-Nov-94	14,600	**0.127**	0.084	**0.02**	**0.15**	**0.132**	<0.02	<0.1	0.05
MW-5A (Fld Dup. 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-5B	08-Nov-94	6,570	**0.213**	<0.02	<0.01	<0.01	**0.178**	<0.02	<0.01	<0.01
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				

Notes on final page of table

Table E-2 Results of Groundwater Metals Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	Date Sampled	Total Dissolved Solids (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-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 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-11A	06-Nov-94	19,200	0.013	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-11A (Lab Dup.)	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-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
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. (Lab Dup.)	20-Jan-95	4,500	<0.005	<0.02	<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 on final page of table

Table E-2 Results of Groundwater Metals Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (concluded)

Sample ID	Date Sampled	Total Dissolved Solids (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-1	05-Nov-94	8,970	**0.103**	0.024	**0.02**	0.07	0.072	<0.02	<0.01	0.04
OCD-2A	15-Nov-94	11,000	0.048	0.077	**0.03**	0.08	0.041	<0.02	<0.1	<0.01
OCD-2B	05-Nov-94	4,070	0.006	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
OCD-3	05-Nov-94	12,200	0.028	0.043	**0.02**	0.04	<0.005	<0.02	<0.01	<0.01
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-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 (Lab Dup.)	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-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-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

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

Arsenic analyses by SW-846 Method 7061, except MW-2A by method 6010A

Bold: Exceedance of listed standard

Table E-3 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-4	MW-4 (Field Dup.3)	MW-4C (Bail)	MW-4C (Pump)
Date Sampled	05-Nov-94	05-Nov-94	05-Nov-94	05-Nov-94	05-Nov-94	05-Nov-94	10-Nov-94	10-Nov-94	20-Jan-95	20-Jan-95
Lab pH (SU)	7.7	7.1	7.1	7.5	7.4	7.1	7.4	7.1	7.3	7.8
Lab EC (umhos/cm)	14,500	10,600	10,600	3,310	3,330	7,500	7,480	7,690	5,510	5,420
TDS (180°C)	10,200	7,620	7,670	2,490	2,610	5,970	5,410	5,600	3,830	3,840
Calcium (mg/L)	862	542	541	379	359	608	495	502	351	336
Magnesium (mg/L)	459	91	90	133	120	204	139	156	150	153
Potassium (mg/L)	8	10	10	4	3	7	3	5	2	2
Sodium (mg/L)	2,130	2,100	2,110	295	280	983	1,230	1,240	626	622
Bicarbonate (mg/L)	472	701	706	199	198	357	311	605	278	276
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	3,590	1,910	1,910	868	738	1,120	1,310	1,390	784	777
Sulfate (mg/L)	2,800	2,610	2,570	746	746	2,290	2,370	1,900	1,370	1,320
Fluoride (mg/L)	1.2	14.3	14.3	1.1	1.0	2.6	1.9	1.7	1.2	1.1
Cations (meq/L)	173.42	126.27	126.23	42.78	40.05	90.06	89.76	91.99	57.13	56.48
Anions (meq/L)	167.46	119.53	118.83	43.28	39.59	85.16	91.21	88.58	55.18	53.90
Balance (% Diff.)	1.75	2.74	3.02	-0.58	0.58	2.80	-0.80	1.89	1.74	2.34

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

Table E-3 Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	MW-5A	MW-5A (Field Dup.2)	MW-5B	MW-5C (Bail)	MW-5C (Pump)	MW-6A	MW-6B	MW 7A	MW 7B	MW-7B	MW-10
Date Sampled	08-Nov-94	08-Nov-94	08-Nov-94	20-Jan-95	20-Jan-95	08-Nov-94	08-Nov-94	06-Nov-94	06-Nov-94	15-Jan-95	09-Nov-94
Lab pH (SU)	7.0	7.3	7.3	7.4	7.4	7.5	7.8	7.7	7.6	7.4	7.6
Lab EC (umhos/cm)	17,500	17,100	8,750	4,820	4,570	4,720	4,390	12,900	7,190	9,110	5,960
TDS (180°C)	14,600	14,700	6,570	3,750	3,430	3,650	3,190	10,200	5,600	6,620	4,420
Calcium (mg/L)	536	567	543	503	480	390	362	409	512	543	395
Magnesium (mg/L)	587	546	168	126	126	94	81	336	190	238	83
Potassium (mg/L)	8	3	7	6	4	2	6	7	8	8	4
Sodium (mg/L)	3,370	3,120	1,020	428	388	512	520	2,520	895	1,200	937
Bicarbonate (mg/L)	475	473	371	212	224	175	32	349	255	287	279
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	3,320	3,310	1,720	515	540	727	803	2,450	1,230	1,460	993
Sulfate (mg/L)	5,350	5,400	1,170	1,660	1,450	1,400	1,180	3,380	2,160	2,550	1,570
Fluoride (mg/L)	2.9	2.4	1.4	1.2	1.0	2.2	0.6	7.1	1.1	1.3	1.0
Cations (meq/L)	221.80	208.98	85.64	54.24	51.30	49.52	47.51	157.89	80.31	98.99	67.39
Anions (meq/L)	212.88	213.62	79.02	52.62	49.12	52.61	47.70	145.15	83.89	98.89	65.30
Balance (% Diff.)	2.05	-1.10	4.02	1.52	2.17	-3.03	-0.20	4.20	-2.18	0.05	1.58

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

Table E-3 Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	MW-11A	MW-11A (Lab Dup.)	MW-11B	MW-14	MW-15	MW-15	MW-15 (Lab Dup.)	MW-18A	MW-18B	MW-19	MW-22A
Date Sampled	06-Nov-94	06-Nov-94	06-Nov-94	10-Nov-94	09-Nov-94	24-Feb-95	24-Feb-95	09-Nov-94	09-Nov-94	10-Nov-94	09-Nov-94
Lab pH (SU)	7.1	7.1	7.2	7.2	7.5	7.6	7.6	7.3	7.2	7.5	7.6
Lab EC (umhos/cm)	27,800	27,800	19,600	16,800	4,860	2,880	2,880	23,000	4,680	6,990	6,760
TDS (180°C)	19,200	19,200	13,600	12,600	3,660	2,200	2,200	17,700	3,670	5,360	4,740
Calcium (mg/L)	1,065	1,106	842	733	372	263	262	731	576	720	374
Magnesium (mg/L)	442	441	187	469	113	79	77	956	163	216	99
Potassium (mg/L)	23	24	38	10	8	4	4	51	4	11	6
Sodium (mg/L)	4,920	4,800	3,640	2,960	519	332	329	3,980	326	661	1,170
Bicarbonate (mg/L)	407	409	134	1,344	175	124	125	400	185	255	201
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0
Chloride (mg/L)	9,260	9,030	5,890	3,680	743	443	451	5,790	635	1,170	1,170
Sulfate (mg/L)	1,770	1,760	1,840	3,760	1,470	943	917	4,880	1,590	2,020	1,660
Fluoride (mg/L)	0.8	0.8	0.8	0.8	1.2	1.1	1.1	2.3	1.0	0.9	1.1
Cations (meq/L)	303.94	301.02	216.80	204.15	50.65	34.17	33.82	289.45	56.45	82.74	77.98
Anions (meq/L)	304.72	297.85	206.57	204.14	54.37	34.17	33.86	271.29	54.12	79.19	70.85
Balance (% Diff.)	-0.13	0.53	2.42	0.00	-3.54	0.00	-0.06	3.24	2.11	2.19	4.79

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

Table E-3 Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	MW-22B	MW-23		OCD-1	OCD-2A	OCD-2B	OCD-3	OCD-4	OCD-5	OCD-6	OCD-7A
Date Sampled	09-Nov-94	10-Nov-94		05-Nov-94	15-Nov-94	05-Nov-94	05-Nov-94	06-Nov-94	06-Nov-94	06-Nov-94	07-Nov-94
Lab pH (SU)	7.6	7.1		7.2	7.1	7.6	7.2	7.2	7.4	7.7	7.2
Lab EC (umhos/cm)	6,040	21,500		11,700	14,400	5,190	17,500	18,000	16,800	12,800	10,800
TDS (180°C)	4,480	15,600		8,970	11,000	4,070	12,200	12,400	12,100	9,500	8,320
Calcium (mg/L)	409	1,033		601	581	692	1,025	795	744	527	575
Magnesium (mg/L)	145	504		142	238	46	274	248	230	164	173
Potassium (mg/L)	35	15		7	11	12	27	62	36	13	8
Sodium (mg/L)	875	3,800		2,170	2,830	480	2,750	3,270	3,040	2,590	1,960
Bicarbonate (mg/L)	199	695		756	615	46	300	234	287	754	642
Carbonate (mg/L)	0	0		0	0	0	0	0	0	0	0
Chloride (mg/L)	910	5,560		2,200	2,800	828	5,680	4,820	4,520	2,210	2,000
Sulfate (mg/L)	1,820	3,800		2,940	3,510	1,630	2,000	2,690	2,620	3,510	2,920
Fluoride (mg/L)	0.8	0.8		6.0	1.2	0.4	0.8	1.0	1.0	3.7	5.1
Cations (meq/L)	71.30	258.87		136.37	171.87	59.51	193.96	203.82	189.34	152.96	128.26
Anions (meq/L)	66.86	247.30		135.68	162.31	58.08	206.73	195.77	186.81	147.83	127.66
Balance (% Diff.)	3.21	2.29		0.25	2.86	1.22	-3.19	2.01	0.67	1.71	0.23

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

Table E-3 Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (continued)

Sample ID	OCD-7A (Lab Dup.)	OCD-7A	OCD-7B	OCD-7C	OCD-7C (Bail)	OCD-7C (Pump)	OCD-8A	OCD-8B		Pond Windmill	Pond Windmill
Date Sampled	07-Nov-94	24-Feb-95	07-Nov-94	24-Feb-95	21-Jan-95	21-Jan-95	06-Nov-94	06-Nov-94		09-Nov-94	20-Jan-95
Lab pH (SU)	7.2	7.3	7.6	7.0	7.3	7.1	7.4	7.6		7.6	7.6
Lab EC (umhos/cm)	10,800	10,100	6,880	10,400	7,140	12,100	12,200	7,460		5,870	6,610
TDS (180°C)	8,340	8,590	5,190	8,680	5,280	8,730	9,560	5,550		4,260	4,450
Calcium (mg/L)	575	571	715	650	620	643	634	822		330	298
Magnesium (mg/L)	173	225	105	217	134	216	345	190		165	173
Potassium (mg/L)	7	3	13	11	14	11	9	6		3	4
Sodium (mg/L)	1,970	1,850	824	1,880	789	1,900	2,140	588		697	841
Bicarbonate (mg/L)	641	706	118	525	320	456	497	164		176	144
Carbonate (mg/L)	0	0	0	0	0	0	0	0		0	0
Chloride (mg/L)	2,020	1,930	1,120	2,250	1,000	2,160	2,340	1,740		1,130	1,070
Sulfate (mg/L)	2,920	2,950	2,060	3,110	2,040	2,860	3,480	1,780		1,440	1,550
Fluoride (mg/L)	4.9	1.1	1.2	1.2	1.7	1.0	2.7	0.8		0.9	1.0
Cations (meq/L)	128.64	127.44	80.49	132.35	76.65	132.97	153.36	82.39		60.46	65.79
Anions (meq/L)	128.39	127.47	76.52	136.71	76.03	127.93	146.46	88.81		64.67	64.75
Balance (% Diff.)	0.10	-0.01	2.53	-1.62	0.41	1.93	2.30	-3.75		-3.36	0.80

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

Table E-3 Results of Inorganic Water Quality Analyses, Evaporation Pond Area, Navajo Refinery, RFI Phase III, 1995 (concluded)

Sample ID	Pnd.Wind (Lab Dup.)		Pond 3	Pond 5		NPR-RW-1	NPR-RW-2
Date Sampled	20-Jan-95		06-Nov-94	06-Nov-94		11-Nov-94	11-Nov-94
Lab pH (SU)	7.6		7.2	7.1		7.9	7.8
Lab EC (umhos/cm)	6,610		12,600	8,030		6,630	6,680
TDS (180°C)	4,500		8,220	4,630		4,580	4,610
Calcium (mg/L)	301		38	33		555	547
Magnesium (mg/L)	175		86	61		178	164
Potassium (mg/L)	6		86	51		6	7
Sodium (mg/L)	847		2,670	1,260		696	696
Bicarbonate (mg/L)	143		251	315		191	188
Carbonate (mg/L)	0		0	0		0	0
Chloride (mg/L)	1,120		2,300	1,370		1,300	1,280
Sulfate (mg/L)	1,570		2,720	958		1,510	1,460
Fluoride (mg/L)	1.0		158.4	126.8		0.7	0.7
Cations (meq/L)	66.40		127.19	62.92		72.76	71.24
Anions (meq/L)	66.61		125.45	63.78		71.24	69.49
Balance (% Diff.)	-0.16		0.69	-0.68		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.

Appendix F

APPENDIX F

APPENDIX F

EVAPORATION POND JUNE 1995 GROUNDWATER DATA

Inter-Mountain Laboratories, Inc.

CHAIN OF CUSTODY RECORD

Client/Project Name NAVAJO Refining CO/RFI Phase III

Project Location Artesia NM

Sampler: (Signature) WH Boyd

Chain of Custody Tape No.

ANALYSES / PARAMETERS

Sample No./ Identification	Date	Time	Lab Number	Matrix	No. of Containers	8240 VOC-BTEX	Semi-Mono/Naph.	Metals As, Cr, Ni, Pb	Water Chem.	Remarks
										Metals Methods As-7061
MW-5C	6/21/95	1115	0695600954	Water	4	✓		✓	✓	CR, Pb, Ni 7000
MW-5B		1410	955							Series:
MW-5A		1440	956			✓		✓	✓	CR-7191
MW-3		1520	957			✓		✓	✓	Pb-7421
MW-6A	6/22/95	1000	958			✓	✓	✓	✓	Ni-7520
MW-2A	6/22/95	1045	959					✓		
OCB-1		1115	960			✓		✓	✓	
OCB-2A		1155	961					✓		
OCB-3		1235	962			✓		✓	✓	
OCB-5		1515	963			✓		✓	✓	
~~TRIP BLANK~~			964			✓				
										REC'D: COOL +
										INTACT.

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
WH Boyd	6/23/95	1030			

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time

Relinquished by: (Signature)	Date	Time	Received by laboratory: (Signature)	Date	Time
			Bom L Hat	6/24/95	1135

Inter-Mountain Laboratories, Inc.

☐ 1633 Terra Avenue
Sheridan, Wyoming 82801
Telephone (307) 672-8945

☐ 1714 Phillips Circle
Gillette, Wyoming 82716
Telephone (307) 682-8945

☐ 2506 West Main Street
Farmington, NM 87401
Telephone (505) 326-4737

☐ 1160 Research Dr.
Bozeman, Montana 59715
Telephone (406) 586-8450

☐ 11183 SH 30
College Station, TX 77845
Telephone (409) 776-8945

☒ 3304 Longmire Drive
College Station, TX 77845
Telephone (409) 774-4999

25452

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client:	**NAVAJO REFINING COMPANY**		
Project Name:	RFI-Phase III / Artesia, NM	Report Date:	07/05/95
Sample ID:	MW - 5C	Date Sampled:	06/21/95
Sample Number:	0695G00954	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	07/05/95
Preservative:	Cool, HCl	Date Analyzed:	07/05/95
Condition:	Intact, pH < 2	Time Analyzed:	10:39 AM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-Xylene	ND	1.0
o-Xylene	ND	1.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	106%	75 - 125%
Bromofluorobenzene	101%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Elevated detection limit due to dilution required to reduce matrix effects.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 5C
Lab ID: 0495W05647/0695G00954
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	ND*	0.005 mg/L	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 5C
Lab ID: 0495W05647/0695G00954
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.2 s.u.	0.1	SW-846 9040
Conductivity (Lab)	4200 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	3490 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	179 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1670 mg/L	1	Calculation
Fluoride	1.1 mg/L	0.1	EPA 340.2

Calcium	474 mg/L	23.65 meq/L	1 mg/L	SW-846 6010A
Magnesium	119 mg/L	9.79 meq/L	1 mg/L	SW-846 6010A
Potassium	4 mg/L	0.11 meq/L	1 mg/L	SW-846 6010A
Sodium	404 mg/L	17.57 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	218 mg/L	3.57 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	609 mg/L	17.18 meq/L	1 mg/L	SW-846 9251
Sulfate	1460 mg/L	30.40 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	51.12 meq/L		N/A	Calculation
Major Anion Sum	51.15 meq/L		N/A	Calculation
Cation/Anion Balance	-0.03 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 5B
Lab ID: 0495W05648/0695G00955
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.087 mg/L	0.005	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 5B
Lab ID: 0495W05648/0695G00955
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.0 s.u.	0.1	SW-846 9040
Conductivity (Lab)	9050 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	7110 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	307 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	2060 mg/L	1	Calculation
Fluoride	1.4 mg/L	0.1	EPA 340.2

Calcium	530 mg/L	26.45 meq/L	1 mg/L	SW-846 6010A
Magnesium	178 mg/L	14.65 meq/L	1 mg/L	SW-846 6010A
Potassium	7 mg/L	0.19 meq/L	1 mg/L	SW-846 6010A
Sodium	1490 mg/L	64.68 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	374 mg/L	6.13 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	1770 mg/L	49.96 meq/L	1 mg/L	SW-846 9251
Sulfate	2470 mg/L	51.49 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	105.97 meq/L		N/A	Calculation
Major Anion Sum	107.58 meq/L		N/A	Calculation
Cation/Anion Balance	-0.75 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client:	**NAVAJO REFINING COMPANY**		
Project Name:	RFI-Phase III / Artesia, NM	Report Date:	07/05/95
Sample ID:	MW - 5A	Date Sampled:	06/21/95
Sample Number:	0695G00956	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	07/05/95
Preservative:	Cool, HCl	Date Analyzed:	07/05/95
Condition:	Intact, pH < 2	Time Analyzed:	12:04 PM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	5.0
Toluene	34	5.0
Ethylbenzene	6.0	5.0
p,m-Xylene	50	5.0
o-Xylene	ND	5.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	118%	75 - 125%
Bromofluorobenzene	115%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Elevated detection limit due to dilution required to reduce matrix effects.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 5A
Lab ID: 0495W05649/0695G00956
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.099 mg/L	0.005	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 5A
Lab ID: 0495W05649/0695G00956
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.2 s.u.	0.1	SW-846 9040
Conductivity (Lab)	15400 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	13100 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	383 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	3730 mg/L	1	Calculation
Fluoride	2.9 mg/L	0.1	EPA 340.2

Calcium	546 mg/L	27.25 meq/L	1 mg/L	SW-846 6010A
Magnesium	575 mg/L	47.33 meq/L	1 mg/L	SW-846 6010A
Potassium	7 mg/L	0.19 meq/L	1 mg/L	SW-846 6010A
Sodium	2990 mg/L	129.93 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	467 mg/L	7.66 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	3050 mg/L	85.92 meq/L	1 mg/L	SW-846 9251
Sulfate	5100 mg/L	106.18 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	204.70 meq/L		N/A	Calculation
Major Anion Sum	199.76 meq/L		N/A	Calculation
Cation/Anion Balance	1.22 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client:	**NAVAJO REFINING COMPANY**		
Project Name:	RFI-Phase III / Artesia, NM	Report Date:	07/05/95
Sample ID:	MW - 3	Date Sampled:	06/21/95
Sample Number:	0695G00957	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	07/05/95
Preservative:	Cool, HCl	Date Analyzed:	07/05/95
Condition:	Intact, pH < 2	Time Analyzed:	3:02 PM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	17
Toluene	ND	17
Ethylbenzene	18	17
p,m-Xylene	ND	17
o-Xylene	30	17

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	131%	75 - 125%
Bromofluorobenzene	99%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Matrix Interference resulted in high recovery of a,a,a- Trifluorotoluene.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 3
Lab ID: 0495W05650/0695G00957
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.031 mg/L	0.005	SW-846 7061A
Total Chromium	0.006 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 3
Lab ID: 0495W05650/0695G00957
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/21/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.2 s.u.	0.1	SW-846 9040
Conductivity (Lab)	6660 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	5250 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	317 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1860 mg/L	1	Calculation
Fluoride	3.0 mg/L	0.1	EPA 340.2

Calcium	499 mg/L	24.90 meq/L	1 mg/L	SW-846 6010A
Magnesium	148 mg/L	12.21 meq/L	1 mg/L	SW-846 6010A
Potassium	10 mg/L	0.26 meq/L	1 mg/L	SW-846 6010A
Sodium	935 mg/L	40.67 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	387 mg/L	6.34 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	1090 mg/L	30.72 meq/L	1 mg/L	SW-846 9251
Sulfate	2060 mg/L	42.87 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	78.04 meq/L		N/A	Calculation
Major Anion Sum	79.93 meq/L		N/A	Calculation
Cation/Anion Balance	-1.20 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml
Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client: **NAVAJO REFINING COMPANY**
Project Name: RFI-Phase III / Artesia, NM
Sample ID: MW - 6A
Sample Number: 0695G00958
Sample Matrix: Water
Preservative: Cool, HCl
Condition: Intact, pH < 2

Report Date: 07/05/95
Date Sampled: 06/22/95
Date Received: 06/24/95
Date Extracted: 07/05/95
Date Analyzed: 07/05/95
Time Analyzed: 3:38 PM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	5.0
Toluene	ND	5.0
Ethylbenzene	5.9	5.0
p,m-Xylene	ND	5.0
o-Xylene	11	5.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	96%	75 - 125%
Bromofluorobenzene	97%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Elevated detection limit due to dilution required to reduce matrix effects.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8270
SEMIVOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**		
Project:	RFI Phase III/Artesia, NM	Report Date:	06/26/95
Sample ID:	MW-6A	Date Sampled:	06/22/95
Laboratory ID:	0695G00958	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	06/26/95
Condition:	Intact	Date Analyzed:	06/26/95
Preservative:	Cool	Time Analyzed:	3:43 PM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Acenaphthene	ND	0.020
Acenaphthylene	ND	0.020
Anthracene	ND	0.020
Benzo(a)anthracene	ND	0.020
Benzo(b)fluoranthene	ND	0.020
Benzo(k)fluoranthene	ND	0.020
Benzo(g,h,i)perylene	ND	0.020
Benzo(a)pyrene	ND	0.020
Benzoic acid	ND	0.020
Benzyl alcohol	ND	0.020
Bis(2-chloroethoxy)methane	ND	0.020
Bis(2-chloroethyl)ether	ND	0.020
Bis(2-chloroisopropyl)ether	ND	0.050
Bis(2-ethylhexyl)phthalate	ND	0.050
4-Bromophenyl phenyl ether	ND	0.020
Butyl benzyl phthalate	ND	0.020
p - Chloroaniline	ND	0.020
p - Chloro - m - cresol	ND	0.020
2 - Chloronaphthalene	ND	0.020
2 - Chlorophenol	ND	0.020
4-Chlorophenyl phenyl ether	ND	0.020
Chrysene	ND	0.020
o - Cresol	ND	0.020
m,p - Cresol	ND	0.020
Di - n - butylphthalate	ND	0.050
Dibenz(a,h)anthracene	ND	0.020
o - Dichlorobenzene	ND	0.020
m - Dichlorobenzene	ND	0.020
p - Dichlorobenzene	ND	0.020
3,3 - Dichlorobenzidine	ND	0.020
2,4 - Dichlorophenol	ND	0.020
Diethyl phthalate	ND	0.020
2,4 - Dimethylphenol	ND	0.020
Dimethyl phthalate	ND	0.020

ND - Analyte not detected at stated limit of detection

EPA Method 8270
SEMIVOLATILE ORGANIC COMPOUNDS

Client: **NAVAJO REFINING COMPANY**
Project: RFI Phase III/Artesia, NM
Sample ID: MW-6A
Laboratory ID: 0695G00958

Report Date: 06/26/95
Date Sampled: 06/22/95
Date Analyzed: 06/26/95

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
4,6 - Dinitro -2- methylphenol	ND	0.050
2,4 - Dinitrophenol	ND	0.050
2,4 - Dinitrotoluene	ND	0.020
2,6 - Dinitrotoluene	ND	0.020
Di-n-octyl phthalate	ND	0.050
Fluoranthene	ND	0.020
Fluorene	ND	0.020
Hexachlorobenzene	ND	0.020
Hexachlorocyclopentadiene	ND	0.050
Hexachloroethane	ND	0.020
Hexachlorobutadiene	ND	0.020
Ideno(1,2,3-cd)pyrene	ND	0.020
Isophorone	ND	0.020
2 - Methylnaphthalene	ND	0.020
Naphthalene	ND	0.020
Mono-Naphthalene	ND	0.020
o - Nitroaniline	ND	0.020
m - Nitroaniline	ND	0.020
p - Nitroaniline	ND	0.020
Nitrobenzene	ND	0.020
o - Nitrophenol	ND	0.020
p - Nitrophenol	ND	0.020
n - Nitrosodimethylamine	ND	0.020
n - Nitrosodiphenylamine	ND	0.020
n-Nitroso-di-n-propylamine	ND	0.020
Pentachlorophenol	ND	0.050
Phenanthrene	ND	0.020
Phenol	ND	0.020
Pyrene	ND	0.020
1,2,4 - Trichlorobenzene	ND	0,020
2,4,5 - Trichlorophenol	ND	0.020
2,4,6 - Trichlorophenol	ND	0.020

ND - Analyte not detected at stated limit of detection

EPA Method 8270
SEMIVOLATILE HYDROCARBONS
ADDITIONAL DETECTED COMPOUNDS

Client: **NAVAJO REFINING COMPANY**
Project: RFI Phase III/Artesia, NM
Sample ID: MW-6A
Laboratory ID: 0695G00958

Report Date: 06/26/95
Date Sampled: 06/22/95
Date Analyzed: 06/26/95

Tentative Identification	Retention Time (Minutes)	Concentration* (mg/L)
Unknown hydrocarbon	8.6	0.08
Hydrocarbon envelope	8 - 32	-

* - Concentration calculated using assumed Relative Response Factor = 1

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
2 - Fluorophenol	43%	21 - 110%
Phenol - d5	45%	10 - 110%
Nitrobenzene - d5	57%	35 - 114%
2 - Fluorobiphenyl	81%	43 - 116%
2,4,6 - Tribromophenol	74%	10 - 123%
Terphenyl - d14	95%	33 - 141%

References:

Method 3510: Separatory Funnel Liquid-Liquid Extraction.
Method 8270: Gas Chromatography / Mass Spectrometry for Semivolatile Organics
Test Methods for Evaluating Solid Wastes, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments:

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
hone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 6A
Lab ID: 0495W05651/0695G00958
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.034 mg/L	0.005	SW-846 7061A
Total Chromium	0.015 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

eviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 6A
Lab ID: 0495W05651/0695G00958
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.6 s.u.	0.1	SW-846 9040
Conductivity (Lab)	4280 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	3340 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	148 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1030 mg/L	1	Calculation
Fluoride	2.8 mg/L	0.1	EPA 340.2

Calcium	274 mg/L	13.67 meq/L	1 mg/L	SW-846 6010A
Magnesium	84 mg/L	6.91 meq/L	1 mg/L	SW-846 6010A
Potassium	1 mg/L	0.03 meq/L	1 mg/L	SW-846 6010A
Sodium	632 mg/L	27.49 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	181 mg/L	2.97 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	647 mg/L	18.25 meq/L	1 mg/L	SW-846 9251
Sulfate	1290 mg/L	26.86 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	48.10 meq/L		N/A	Calculation
Major Anion Sum	48.07 meq/L		N/A	Calculation
Cation/Anion Balance	0.03 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 2A
Lab ID: 0495W05652/0695G00959
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.023 mg/L	0.005	SW-846 7061A
Total Chromium	0.012 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client:	NAVAJO REFINING COMPANY		
Project Name:	RFI-Phase III / Artesia, NM	Report Date:	07/05/95
Sample ID:	OCD - 1	Date Sampled:	06/22/95
Sample Number:	0695G00960	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	07/05/95
Preservative:	Cool, HCl	Date Analyzed:	07/05/95
Condition:	Intact, pH < 2	Time Analyzed:	7:30 PM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	5.0
Toluene	ND	5.0
Ethylbenzene	ND	5.0
p,m-Xylene	ND	5.0
o-Xylene	ND	5.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	100%	75 - 125%
Bromofluorobenzene	104%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Elevated detection limit due to dilution required to reduce matrix effects.

Analyst

Review

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 1
Lab ID: 0495W05653/0695G00960
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.051 mg/L	0.005	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 1
Lab ID: 0495W05653/0695G00960
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.4 s.u.	0.1	SW-846 9040
Conductivity (Lab)	11200 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	8660 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	591 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1920 mg/L	1	Calculation
Fluoride	7.7 mg/L	0.1	EPA 340.2

Calcium	558 mg/L	27.84 meq/L	1 mg/L	SW-846 6010A
Magnesium	127 mg/L	10.45 meq/L	1 mg/L	SW-846 6010A
Potassium	8 mg/L	0.20 meq/L	1 mg/L	SW-846 6010A
Sodium	2150 mg/L	93.52 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	721 mg/L	11.82 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	2150 mg/L	60.56 meq/L	1 mg/L	SW-846 9251
Sulfate	2880 mg/L	59.90 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	132.01 meq/L		N/A	Calculation
Major Anion Sum	132.28 meq/L		N/A	Calculation
Cation/Anion Balance	-0.10 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 2A
Lab ID: 0495W05654/0695G00961
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.020 mg/L	0.005	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client:	**NAVAJO REFINING COMPANY**		
Project Name:	RFI-Phase III / Artesia, NM	Report Date:	07/06/95
Sample ID:	OCD - 3	Date Sampled:	06/22/95
Sample Number:	0695G00962	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	07/06/95
Preservative:	Cool, HCl	Date Analyzed:	07/06/95
Condition:	Intact, pH < 2	Time Analyzed:	6:27 PM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-Xylene	ND	1.0
o-Xylene	ND	1.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	97%	75 - 125%
Bromofluorobenzene	91%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Elevated detection limit due to dilution required to reduce matrix effects.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
hone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 3
Lab ID: 0495W05655/0695G00962
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	ND*	0.005 mg/L	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	0.02 mg/L	0.01	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

eviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 3
Lab ID: 0495W05655/0695G00962
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration		PQL	Method
pH (Lab)	7.7	s.u.	0.1	SW-846 9040
Conductivity (Lab)	17800 µmhos/cm		1	SW-846 9050
Total Dissolved Solids (180° C)	13500	mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	239	mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	3610	mg/L	1	Calculation
Fluoride	1.0	mg/L	0.1	EPA 340.2

Calcium	975	mg/L	48.65	meq/L	1 mg/L	SW-846 6010A
Magnesium	285	mg/L	23.46	meq/L	1 mg/L	SW-846 6010A
Potassium	39	mg/L	1.00	meq/L	1 mg/L	SW-846 6010A
Sodium	2990	mg/L	129.84	meq/L	1 mg/L	SW-846 6010A
Bicarbonate	291	mg/L	4.77	meq/L	1 mg/L	EPA 310.1
Carbonate	ND*		0.00		1 mg/L	EPA 310.1
Chloride	5290	mg/L	149.20	meq/L	1 mg/L	SW-846 9251
Sulfate	2460	mg/L	51.18	meq/L	5 mg/L	SW-846 9036
Major Cation Sum	202.95	meq/L			N/A	Calculation
Major Anion Sum	205.15	meq/L			N/A	Calculation
Cation/Anion Balance	-0.54	% Diff			N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client:	NAVAJO REFINING COMPANY		
Project Name:	RFI-Phase III / Artesia, NM	Report Date:	07/06/95
Sample ID:	OCD - 5	Date Sampled:	06/22/95
Sample Number:	0695G00963	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	07/06/95
Preservative:	Cool, HCl	Date Analyzed:	07/06/95
Condition:	Intact, pH < 2	Time Analyzed:	7:32 PM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	5.0
Toluene	ND	5.0
Ethylbenzene	ND	5.0
p,m-Xylene	ND	5.0
o-Xylene	ND	5.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	98%	75 - 125%
Bromofluorobenzene	92%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Elevated detection limit due to dilution required to reduce matrix effects.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 5
Lab ID: 0495W05656/0695G00963
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	ND*	0.005 mg/L	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	0.01 mg/L	0.01	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 5
Lab ID: 0495W05656/0695G00963
Matrix: Water
Condition: Intact

Report Date: 07/11/95
Receipt Date: 06/26/95
Sample Date: 06/22/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.7 s.u.	0.1	SW-846 9040
Conductivity (Lab)	16900 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	12500 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	190 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	2810 mg/L	1	Calculation
Fluoride	1.1 mg/L	0.1	EPA 340.2

Calcium	757 mg/L	37.77 meq/L	1 mg/L	SW-846 6010A
Magnesium	223 mg/L	18.35 meq/L	1 mg/L	SW-846 6010A
Potassium	40 mg/L	1.02 meq/L	1 mg/L	SW-846 6010A
Sodium	3180 mg/L	138.41 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	231 mg/L	3.79 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	4700 mg/L	132.64 meq/L	1 mg/L	SW-846 9251
Sulfate	2760 mg/L	57.42 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	195.55 meq/L		N/A	Calculation
Major Anion Sum	193.85 meq/L		N/A	Calculation
Cation/Anion Balance	0.44 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

BTEX
AROMATIC VOLATILE ORGANICS

Client:	**NAVAJO REFINING COMPANY**		
Project Name:	RFI-Phase III / Artesia, NM	Report Date:	07/06/95
Sample ID:	Trip Blank	Date Sampled:	NA
Sample Number:	0695G00964	Date Received:	06/24/95
Sample Matrix:	Water	Date Extracted:	07/06/95
Preservative:	Cool, HCl	Date Analyzed:	07/06/95
Condition:	Intact, pH < 2	Time Analyzed:	8:06 PM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-Xylene	ND	1.0
o-Xylene	ND	1.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	105%	75 - 125%
Bromofluorobenzene	85%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments: Matrix Interference resulted in high recovery of a,a,a- Trifluorotoluene.

Analyst

Review

Inter-Mountain Laboratories, Inc.

CHAIN OF CUSTODY RECORD

Client/Project Name NAVAJO RFI Phase III	**Project Location** ARTESIA NM
Sampler: (Signature) AG Boyd	**Chain of Custody Tape No.**

ANALYSES / PARAMETERS

Sample No./ Identification	Date	Time	Lab Number	Matrix	No. of Containers	BTEX 8240	Metals As, Cr, Ni, Pb	Water Chemistry		Remarks
NCL Boring #1	6/24/95	1645	0695600971	Water	2	✓				Rush - 10 work days
NCL Boring #2	"	1715	972	"	2	✓				" "
NCL Boring 7	6/25/95	1605	973	"	2	✓				" "
OCD 7AR	6/26/95	1530	974	"	4	✓	✓	✓		
OCD 7C	"	1610	975	"	2		✓	✓		
~~OCD~~ MW-10	"	1745	976	"	1		✓			
MW-15	6/27/95	1630	977	"	3	✓		✓		
Trip Blank	—	—	978	"	1	✓				
										Recd Cool & Intact

Relinquished by: (Signature) AG Boyd	**Date** 6/28/95	**Time** 8:45am	**Received by: (Signature)**	**Date** 6/29/95	**Time** 900
Relinquished by: (Signature)	**Date**	**Time**	**Received by: (Signature)**	**Date**	**Time**
Relinquished by: (Signature)	**Date**	**Time**	**Received by laboratory: (Signature)**	**Date**	**Time**

Inter-Mountain Laboratories, Inc.

☐ 1633 Terra Avenue
Sheridan, Wyoming 82801
Telephone (307) 672-8945

☐ 1714 Phillips Circle
Gillette, Wyoming 82716
Telephone (307) 682-8945

☐ 2506 West Main Street
Farmington, NM 87401
Telephone (505) 326-4737

☐ 1160 Research Dr.
Bozeman, Montana 59715
Telephone (406) 586-8450

☐ 11183 SH 30
College Station, TX 77845
Telephone (409) 776-8945

☒ 3304 Longmire Drive
College Station, TX 77845
Telephone (409) 774-4999

25424

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client: **NAVAJO REFINING COMPANY**
Project : RFI Phase III
Sample ID: OCD 7AR
Laboratory ID: 0695G00974
Sample Matrix: Water
Preservative: Cool, HCl
Condition: Intact, pH <2

Report Date: 07/06/95
Date Sampled: 06/26/95
Date Received: 06/29/95
Date Extracted: 07/02/95
Date Analyzed: 07/02/95
Time Analyzed: 10:58 PM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	ND	0.005
Ethylbenzene	ND	0.005
Toluene	ND	0.005
Xylenes (total)	ND	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
Dibromofluoromethane	113%	86 - 118%
Toluene-d8	94%	88 - 110%
Bromofluorobenzene	113%	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above.

Analyst

Review

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 7AR
Lab ID: 0495W05728/0695G00974
Matrix: Water
Condition: Intact

Report Date: 07/12/95
Receipt Date: 06/29/95
Sample Date: 06/26/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.159 mg/L	0.005	SW-846 7061A
Total Chromium	0.009 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 7AR
Lab ID: 0495W05728/0695G00974
Matrix: Water
Condition: Intact

Report Date: 07/12/95
Receipt Date: 06/29/95
Sample Date: 06/26/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.4 s.u.	0.1	SW-846 9040
Conductivity (Lab)	10700 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	8110 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	490 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	2040 mg/L	1	Calculation
Fluoride	7.6 mg/L	0.1	EPA 340.2

Calcium	593 mg/L	29.59 meq/L	1 mg/L	SW-846 6010A
Magnesium	135 mg/L	11.11 meq/L	1 mg/L	SW-846 6010A
Potassium	11 mg/L	0.28 meq/L	1 mg/L	SW-846 6010A
Sodium	1860 mg/L	80.90 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	598 mg/L	9.80 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	1990 mg/L	56.16 meq/L	1 mg/L	SW-846 9251
Sulfate	2800 mg/L	58.19 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	121.88 meq/L		N/A	Calculation
Major Anion Sum	124.15 meq/L		N/A	Calculation
Cation/Anion Balance	-0.92 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 7C
Lab ID: 0495W05729/0695G00975
Matrix: Water
Condition: Intact

Report Date: 07/12/95
Receipt Date: 06/29/95
Sample Date: 06/26/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.012 mg/L	0.005	SW-846 7061A
Total Chromium	0.007 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: OCD - 7C
Lab ID: 0495W05729/0695G00975
Matrix: Water
Condition: Intact

Report Date: 07/12/95
Receipt Date: 06/29/95
Sample Date: 06/26/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.2 s.u.	0.1	SW-846 9040
Conductivity (Lab)	11500 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	8900 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	378 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	2540 mg/L	1	Calculation
Fluoride	1.2 mg/L	0.1	EPA 340.2

Calcium	646 mg/L	32.24 meq/L	1 mg/L	SW-846 6010A
Magnesium	225 mg/L	18.52 meq/L	1 mg/L	SW-846 6010A
Potassium	11 mg/L	0.28 meq/L	1 mg/L	SW-846 6010A
Sodium	2000 mg/L	86.95 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	461 mg/L	7.56 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	2450 mg/L	69.11 meq/L	1 mg/L	SW-846 9251
Sulfate	2860 mg/L	59.48 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	137.99 meq/L		N/A	Calculation
Major Anion Sum	136.14 meq/L		N/A	Calculation
Cation/Anion Balance	0.67 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 10
Lab ID: 0495W05730/0695G00976
Matrix: Water
Condition: Intact

Report Date: 07/12/95
Receipt Date: 06/29/95
Sample Date: 06/26/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.009 mg/L	0.005	SW-846 7061A
Total Chromium	0.007 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client: **NAVAJO REFINING COMPANY**

Project :	RFI Phase III	Report Date:	07/06/95
Sample ID:	MW-15	Date Sampled:	06/27/95
Laboratory ID:	0695G00977	Date Received:	06/29/95
Sample Matrix:	Water	Date Extracted:	07/02/95
Preservative:	Cool, HCl	Date Analyzed:	07/02/95
Condition:	Intact, pH <2	Time Analyzed:	7:43 PM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	ND	0.005
Ethylbenzene	ND	0.005
Toluene	ND	0.005
Xylenes (total)	ND	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
Dibromofluoromethane	117%	86 - 118%
Toluene-d8	90%	88 - 110%
Bromofluorobenzene	95%	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 15
Lab ID: 0495W05731/0695G00977
Matrix: Water
Condition: Intact

Report Date: 07/12/95
Receipt Date: 06/29/95
Sample Date: 06/27/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.7 s.u.	0.1	SW-846 9040
Conductivity (Lab)	4580 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	3400 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	127 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1310 mg/L	1	Calculation
Fluoride	0.8 mg/L	0.1	EPA 340.2

Calcium	357 mg/L	17.81 meq/L	1 mg/L	SW-846 6010A
Magnesium	102 mg/L	8.40 meq/L	1 mg/L	SW-846 6010A
Potassium	4 mg/L	0.11 meq/L	1 mg/L	SW-846 6010A
Sodium	568 mg/L	24.71 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	154 mg/L	2.52 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	798 mg/L	22.51 meq/L	1 mg/L	SW-846 9251
Sulfate	1280 mg/L	26.57 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	51.03 meq/L		N/A	Calculation
Major Anion Sum	51.61 meq/L		N/A	Calculation
Cation/Anion Balance	-0.57 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**		
Project :	RFI Phase III	Report Date:	07/02/95
Sample ID:	Trip Blank	Date Sampled:	N/A
Laboratory ID:	0695G00978	Date Received:	06/29/95
Sample Matrix:	Water	Date Extracted:	07/02/95
Preservative:	Cool, HCl	Date Analyzed:	07/02/95
Condition:	Intact, pH <2	Time Analyzed:	4:06 PM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	ND	0.005
Ethylbenzene	ND	0.005
Toluene	ND	0.005
Xylenes (total)	ND	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
Dibromofluoromethane	97%	86 - 118%
Toluene-d8	97%	88 - 110%
Bromofluorobenzene	94%	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above.

Analyst

Review

Inter-Mountain Laboratories, Inc.

CHAIN OF CUSTODY RECORD

Client/Project Name NAVAJO Refining Co	**Project Location** ARTESIA, NM		
Sampler: (Signature) W G Boyd	**Chain of Custody Tape No.**		

ANALYSES / PARAMETERS

Sample No./ Identification	Date	Time	Lab Number	Matrix	No. of Containers	8240 BTEX+MEK+CS2	8270 Full Suite	Metals As, Cr, Pb, Ni	7000 series Water Chem	Remarks
MW-4A	6/28/95	1030	0655600981	Water	6	✓	✓	✓	✓	~~A&B~~
MW-4C	"	1120	982	"	4	✓		✓	✓	
Pipe Effluent	"	1340	983	"	5	✓	✓	✓	✓	will call w/ metals
MW-22A	"	1535	984	"	2			✓	✓	
MW-7A	"	1650	985	"	2			✓	✓	
NCL Up Grad Well	6/29/95	1030	986	" Full suite 8240	5	✓	✓	✓	✓	will call w/ metals
MW-18(NCL)	"	1110	987	" Rush!	2	✓				BTEX ONLY for 8240
Trip Blank	—	—	988	"	2	✓				
										recd. cool intact

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
W G Boyd	6/29/95	1330		6/30/95	0900
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Date	Time	Received by laboratory: (Signature)	Date	Time

Inter-Mountain Laboratories, Inc.

☐ 1633 Terra Avenue
Sheridan, Wyoming 82801
Telephone (307) 672-8945

☐ 1714 Phillips Circle
Gillette, Wyoming 82716
Telephone (307) 682-8945

☐ 2506 West Main Street
Farmington, NM 87401
Telephone (505) 326-4737

☐ 1160 Research Dr.
Bozeman, Montana 59715
Telephone (406) 586-8450

☐ 11183 SH 30
College Station, TX 77845
Telephone (409) 776-8945

☒ 3304 Longmire Drive
College Station, TX 77845
Telephone (409) 774-4999

25423

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**
Project :	Artesia, NM
Sample ID:	MW-4A
Laboratory ID:	0695G00981
Sample Matrix:	Water
Preservative:	Cool, HCl
Condition:	Intact, pH<2

Report Date:	07/18/95
Date Sampled:	06/28/95
Date Received:	06/30/95
Date Extracted:	07/11/95
Date Analyzed:	07/11/95
Time Analyzed:	11:07 PM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	0.015	0.005
Toluene	0.008	0.005
Ethylbenzene	0.019	0.005
m,p-Xylene	0.008	0.005
o-Xylene	0.028	0.005
Methyl ethyl ketone	0.012	0.020
Carbon disulfide	ND	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
1,2-Dichloroethane-d4	99%	86 - 118%
Toluene-d8	103%	88 - 110%
Bromofluorobenzene	**1418%**	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above. One surrogate recovery is out of acceptance limit due to matrix interference.

Analyst

Review

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8270
SEMIVOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**		
Project:	Artesia, NM	Report Date:	07/03/95
Sample ID:	MW-4A	Date Sampled:	06/28/95
Laboratory ID:	0695G00981	Date Received:	06/30/95
Sample Matrix:	Water	Date Extracted:	06/30/95
Condition:	Intact	Date Analyzed:	07/03/95
Preservative:	Cool	Time Analyzed:	11:34 AM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Acenaphthene	ND	0.050
Acenaphthylene	ND	0.050
Anthracene	ND	0.050
Benzo(a)anthracene	ND	0.050
Benzo(b)fluoranthene	ND	0.050
Benzo(k)fluoranthene	ND	0.050
Benzo(g,h,i)perylene	ND	0.050
Benzo(a)pyrene	ND	0.050
Benzoic acid	ND	0.050
Benzyl alcohol	ND	0.050
Bis(2-chloroethoxy)methane	ND	0.050
Bis(2-chloroethyl)ether	ND	0.050
Bis(2-chloroisopropyl)ether	ND	0.125
Bis(2-ethylhexyl)phthalate	ND	0.125
4-Bromophenyl phenyl ether	ND	0.050
Butyl benzyl phthalate	ND	0.050
p - Chloroaniline	ND	0.050
p - Chloro - m - cresol	ND	0.050
2 - Chloronaphthalene	ND	0.050
2 - Chlorophenol	ND	0.050
4-Chlorophenyl phenyl ether	ND	0.050
Chrysene	ND	0.050
o - Cresol	ND	0.050
m,p - Cresol	ND	0.050
Di - n - butylphthalate	ND	0.125
Dibenz(a,h)anthracene	ND	0.050
o - Dichlorobenzene	ND	0.050
m - Dichlorobenzene	ND	0.050
p - Dichlorobenzene	ND	0.050
3,3 - Dichlorobenzidine	ND	0.050
2,4 - Dichlorophenol	ND	0.050
Diethyl phthalate	ND	0.050
2,4 - Dimethylphenol	ND	0.050
Dimethyl phthalate	ND	0.050

ND - Analyte not detected at stated limit of detection

EPA Method 8270
SEMIVOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**		
Project:	Artesia, NM	Report Date:	07/03/95
Sample ID:	MW-4A	Date Sampled:	06/28/95
Laboratory ID:	0695G00981	Date Analyzed:	07/03/95

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
4,6 - Dinitro -2- methylphenol	ND	0.125
2,4 - Dinitrophenol	ND	0.125
2,4 - Dinitrotoluene	ND	0.050
2,6 - Dinitrotoluene	ND	0.050
Di-n-octyl phthalate	ND	0.125
Fluoranthene	ND	0.050
Fluorene	ND	0.050
Hexachlorobenzene	ND	0.050
Hexachlorocyclopentadiene	ND	0.125
Hexachloroethane	ND	0.050
Hexachlorobutadiene	ND	0.050
Ideno(1,2,3-cd)pyrene	ND	0.050
Isophorone	ND	0.050
2 - Methylnaphthalene	ND	0.050
Naphthalene	ND	0.050
Mono-Naphthalene	ND	0.050
o - Nitroaniline	ND	0.050
m - Nitroaniline	ND	0.050
p - Nitroaniline	ND	0.050
Nitrobenzene	ND	0.050
o - Nitrophenol	ND	0.050
p - Nitrophenol	ND	0.050
n - Nitrosodimethylamine	ND	0.050
n - Nitrosodiphenylamine	ND	0.050
n-Nitroso-di-n-propylamine	ND	0.050
Pentachlorophenol	ND	0.125
Phenanthrene	ND	0.050
Phenol	ND	0.050
Pyrene	ND	0.050
1,2,4 - Trichlorobenzene	ND	0.050
2,4,5 - Trichlorophenol	ND	0.050
2,4,6 - Trichlorophenol	ND	0.050

ND - Analyte not detected at stated limit of detection

EPA Method 8270
SEMIVOLATILE HYDROCARBONS
ADDITIONAL DETECTED COMPOUNDS

Client: **NAVAJO REFINING COMPANY**
Project: Artesia, NM
Sample ID: MW-4A
Laboratory ID: 0695G00981

Report Date: 07/03/95
Date Sampled: 06/28/95
Date Analyzed: 07/03/95

Tentative Identification	Retention Time (Minutes)	Concentration (mg/L)
Unknown hydrocarbon	8.65	0.29
Hydrocarbon envelope	7 - 29	-

* - Concentration calculated using assumed Relative Response Factor = 1

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
2 - Fluorophenol	64%	21 - 110%
Phenol - d5	68%	10 - 110%
Nitrobenzene - d5	91%	35 - 114%
2 - Fluorobiphenyl	**124%**	43 - 116%
2,4,6 - Tribromophenol	95%	10 - 123%
Terphenyl - d14	140%	33 - 141%

References:

Method 3510: Separatory Funnel Liquid-Liquid Extraction.
Method 8270: Gas Chromatography / Mass Spectrometry for Semivolatile Organics
Test Methods for Evaluating Solid Wastes, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments:

Analyst

Review

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 4A
Lab ID: 0495W05736/0695G00981
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.061 mg/L	0.005	SW-846 7061A
Total Chromium	0.006 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 4A
Lab ID: 0495W05736/0695G00981
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.3 s.u.	0.1	SW-846 9040
Conductivity (Lab)	7520 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	5750 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	247 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1820 mg/L	1	Calculation
Fluoride	1.9 mg/L	0.1	EPA 340.2

Calcium	472 mg/L	23.55 meq/L	1 mg/L	SW-846 6010A
Magnesium	157 mg/L	12.92 meq/L	1 mg/L	SW-846 6010A
Potassium	2 mg/L	0.06 meq/L	1 mg/L	SW-846 6010A
Sodium	1250 mg/L	54.50 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	301 mg/L	4.93 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	1630 mg/L	46.07 meq/L	1 mg/L	SW-846 9251
Sulfate	1820 mg/L	37.91 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	91.03 meq/L		N/A	Calculation
Major Anion Sum	88.90 meq/L		N/A	Calculation
Cation/Anion Balance	1.18 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client: **NAVAJO REFINING COMPANY**
Project : Artesia, NM
Sample ID: MW-4C
Laboratory ID: 0695G00982
Sample Matrix: Water
Preservative: Cool, HCl
Condition: Intact, pH<2

Report Date: 07/18/95
Date Sampled: 06/28/95
Date Received: 06/30/95
Date Extracted: 07/11/95
Date Analyzed: 07/11/95
Time Analyzed: 11:45 PM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	0.015	0.005
Toluene	ND	0.005
Ethylbenzene	ND	0.005
m,p-Xylene	ND	0.005
o-Xylene	ND	0.005
Methyl ethyl ketone	ND	0.020
Carbon disulfide	ND	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
1,2-Dichloroethane-d4	95%	86 - 118%
Toluene-d8	107%	88 - 110%
Bromofluorobenzene	**1142%**	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above. One surrogate recovery is out of acceptance limit due to matrix interference.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 4C
Lab ID: 0495W05737/0695G00982
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.065 mg/L	0.005	SW-846 7061A
Total Chromium	0.006 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 4C
Lab ID: 0495W05737/0695G00982
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.1 s.u.	0.1	SW-846 9040
Conductivity (Lab)	5100 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	3970 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	233 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1520 mg/L	1	Calculation
Fluoride	1.3 mg/L	0.1	EPA 340.2

Calcium	355 mg/L	17.71 meq/L	1 mg/L	SW-846 6010A
Magnesium	153 mg/L	12.59 meq/L	1 mg/L	SW-846 6010A
Potassium	2 mg/L	0.05 meq/L	1 mg/L	SW-846 6010A
Sodium	645 mg/L	28.06 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	284 mg/L	4.66 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	1010 mg/L	28.58 meq/L	1 mg/L	SW-846 9251
Sulfate	1300 mg/L	27.05 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	58.41 meq/L		N/A	Calculation
Major Anion Sum	60.28 meq/L		N/A	Calculation
Cation/Anion Balance	-1.58 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**		
Project :	Artesia, NM	Report Date:	07/18/95
Sample ID:	Pipe Effluent	Date Sampled:	06/28/95
Laboratory ID:	0695G00983	Date Received:	06/30/95
Sample Matrix:	Water	Date Extracted:	07/12/95
Preservative:	Cool, HCl	Date Analyzed:	07/12/95
Condition:	Intact, pH<2	Time Analyzed:	12:23 AM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	0.047	0.005
Toluene	0.077	0.005
Ethylbenzene	0.032	0.005
m,p-Xylene	0.170	0.005
o-Xylene	0.105	0.005
Methyl ethyl ketone	0.161	0.020
Carbon disulfide	0.006	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
1,2-Dichloroethane-d4	99%	86 - 118%
Toluene-d8	101%	88 - 110%
Bromofluorobenzene	261%	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above. One surrogate recovery is out of acceptance limit due to matrix interference.

Analyst

Review

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8270
SEMIVOLATILE ORGANIC COMPOUNDS

Client: **NAVAJO REFINING COMPANY**
Project: Artesia, NM
Sample ID: Pipe Effuent
Laboratory ID: 0695G00983
Sample Matrix: Water
Condition: Intact
Preservative: Cool

Report Date: 07/03/95
Date Sampled: 06/28/95
Date Received: 06/30/95
Date Extracted: 06/30/95
Date Analyzed: 07/03/95
Time Analyzed: 1:50 PM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Acenaphthene	ND	0.10
Acenaphthylene	ND	0.10
Anthracene	ND	0.10
Benzo(a)anthracene	ND	0.10
Benzo(b)fluoranthene	ND	0.10
Benzo(k)fluoranthene	ND	0.10
Benzo(g,h,i)perylene	ND	0.10
Benzo(a)pyrene	ND	0.10
Benzoic acid	ND	0.10
Benzyl alcohol	ND	0.10
Bis(2-chloroethoxy)methane	ND	0.10
Bis(2-chloroethyl)ether	ND	0.10
Bis(2-chloroisopropyl)ether	ND	0.25
Bis(2-ethylhexyl)phthalate	ND	0.25
4-Bromophenyl phenyl ether	ND	0.10
Butyl benzyl phthalate	ND	0.10
p - Chloroaniline	ND	0.10
p - Chloro - m - cresol	ND	0.10
2 - Chloronaphthalene	ND	0.10
2 - Chlorophenol	ND	0.10
4-Chlorophenyl phenyl ether	ND	0.10
Chrysene	ND	0.10
o - Cresol	ND	0.10
m,p - Cresol	ND	0.10
Di - n - butylphthalate	ND	0.25
Dibenz(a,h)anthracene	ND	0.10
o - Dichlorobenzene	ND	0.10
m - Dichlorobenzene	ND	0.10
p - Dichlorobenzene	ND	0.10
3,3 - Dichlorobenzidine	ND	0.10
2,4 - Dichlorophenol	ND	0.10
Diethyl phthalate	ND	0.10
2,4 - Dimethylphenol	ND	0.10
Dimethyl phthalate	ND	0.10

ND - Analyte not detected at stated limit of detection

EPA Method 8270
SEMIVOLATILE ORGANIC COMPOUNDS

Client: **NAVAJO REFINING COMPANY**
Project: Artesia, NM
Sample ID: Pipe Effuent
Laboratory ID: 0695G00983

Report Date: 07/03/95
Date Sampled: 06/28/95
Date Analyzed: 07/03/95

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
4,6 - Dinitro -2- methylphenol	ND	0.25
2,4 - Dinitrophenol	ND	0.25
2,4 - Dinitrotoluene	ND	0.10
2,6 - Dinitrotoluene	ND	0.10
Di-n-octyl phthalate	ND	0.25
Fluoranthene	ND	0.10
Fluorene	ND	0.10
Hexachlorobenzene	ND	0.10
Hexachlorocyclopentadiene	ND	0.25
Hexachloroethane	ND	0.10
Hexachlorobutadiene	ND	0.10
Ideno(1,2,3-cd)pyrene	ND	0.10
Isophorone	ND	0.10
2 - Methylnaphthalene	ND	0.10
Naphthalene	ND	0.10
Mono-Naphthalene	ND	0.10
o - Nitroaniline	ND	0.10
m - Nitroaniline	ND	0.10
p - Nitroaniline	ND	0.10
Nitrobenzene	ND	0.10
o - Nitrophenol	ND	0.10
p - Nitrophenol	ND	0.10
n - Nitrosodimethylamine	ND	0.10
n - Nitrosodiphenylamine	ND	0.10
n-Nitroso-di-n-propylamine	ND	0.10
Pentachlorophenol	ND	0.25
Phenanthrene	ND	0.10
Phenol	ND	0.10
Pyrene	ND	0.10
1,2,4 - Trichlorobenzene	ND	0.10
2,4,5 - Trichlorophenol	ND	0.10
2,4,6 - Trichlorophenol	ND	0.10

ND - Analyte not detected at stated limit of detection

EPA Method 8270
SEMIVOLATILE HYDROCARBONS
ADDITIONAL DETECTED COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**	Report Date:	07/03/95
Project:	Artesia, NM	Date Sampled:	06/28/95
Sample ID:	Pipe Effuent	Date Analyzed:	07/03/95
Laboratory ID:	0695G00983		

Tentative Identification	Retention Time (Minutes)	Concentration (mg/L)
Unknown hydrocarbon	4.04	0.3
Hydrocarbon envelope	7 - 30	-

* - Concentration calculated using assumed Relative Response Factor = 1

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
2 - Fluorophenol	45%	21 - 110%
Phenol - d5	47%	10 - 110%
Nitrobenzene - d5	60%	35 - 114%
2 - Fluorobiphenyl	80%	43 - 116%
2,4,6 - Tribromophenol	58%	10 - 123%
Terphenyl - d14	83%	33 - 141%

References:

Method 3510: Separatory Funnel Liquid-Liquid Extraction.
Method 8270: Gas Chromatography / Mass Spectrometry for Semivolatile Organics
Test Methods for Evaluating Solid Wastes, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments:

Analyst

Review

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: Pipe Effluent
Lab ID: 0495W05738/0695G00983
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.082 mg/L	0.005	SW-846 7061A
Total Chromium	0.009 mg/L	0.005	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: Pipe Effluent
Lab ID: 0495W05738/0695G00983
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.2 s.u.	0.1	SW-846 9040
Conductivity (Lab)	2430 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	1760 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	267 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	521 mg/L	1	Calculation
Fluoride	36.6 mg/L	0.1	EPA 340.2

Calcium	77 mg/L	3.82 meq/L	1 mg/L	SW-846 6010A
Magnesium	80 mg/L	6.59 meq/L	1 mg/L	SW-846 6010A
Potassium	18 mg/L	0.46 meq/L	1 mg/L	SW-846 6010A
Sodium	298 mg/L	12.96 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	326 mg/L	5.34 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	307 mg/L	8.66 meq/L	1 mg/L	SW-846 9251
Sulfate	493 mg/L	10.26 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	23.83 meq/L		N/A	Calculation
Major Anion Sum	24.26 meq/L		N/A	Calculation
Cation/Anion Balance	-0.89 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 22A
Lab ID: 0495W05739/0695G00984
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.028 mg/L	0.005	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 22A
Lab ID: 0495W05739/0695G00984
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.4 s.u.	0.1	SW-846 9040
Conductivity (Lab)	6450 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	4740 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	163 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	1180 mg/L	1	Calculation
Fluoride	1.2 mg/L	0.1	EPA 340.2

Calcium	328 mg/L	16.37 meq/L	1 mg/L	SW-846 6010A
Magnesium	88 mg/L	7.24 meq/L	1 mg/L	SW-846 6010A
Potassium	3 mg/L	0.07 meq/L	1 mg/L	SW-846 6010A
Sodium	1140 mg/L	49.46 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	199 mg/L	3.26 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	1370 mg/L	38.51 meq/L	1 mg/L	SW-846 9251
Sulfate	1510 mg/L	31.52 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	73.14 meq/L		N/A	Calculation
Major Anion Sum	73.28 meq/L		N/A	Calculation
Cation/Anion Balance	-0.10 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**		
Project :	Artesia, NM	Report Date:	07/18/95
Sample ID:	MW-7A	Date Sampled:	06/28/95
Laboratory ID:	0695G00985	Date Received:	06/30/95
Sample Matrix:	Water	Date Extracted:	07/12/95
Preservative:	Cool, HCl	Date Analyzed:	07/12/95
Condition:	Intact, pH<2	Time Analyzed:	1:01 AM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	ND	0.005
Toluene	ND	0.005
Ethylbenzene	ND	0.005
m,p-Xylene	ND	0.005
o-Xylene	ND	0.005
Methyl ethyl ketone	ND	0.020
Carbon disulfide	ND	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
1,2-Dichloroethane-d4	94%	86 - 118%
Toluene-d8	103%	88 - 110%
Bromofluorobenzene	**779%**	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above. One surrogate recovery is out of acceptance limit due to matrix interference.

Analyst

Review

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 7A
Lab ID: 0495W05740/0695G00985
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
Total Metals			
Total Arsenic	0.022 mg/L	0.005	SW-846 7061A
Total Chromium	ND*	0.005 mg/L	SW-846 7191
Total Lead	ND*	0.01 mg/L	SW-846 7421
Total Nickel	ND*	0.05 mg/L	SW-846 7520

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml **Inter-Mountain Laboratories, Inc.**

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

WATER QUALITY REPORT

Client: Navajo Refining Co.
Project: RFI Phase III / Artesia, NM
Sample ID: MW - 7A
Lab ID: 0495W05740/0695G00985
Matrix: Water
Condition: Intact

Report Date: 07/13/95
Receipt Date: 06/30/95
Sample Date: 06/28/95

Parameter	Concentration	PQL	Method
pH (Lab)	7.2 s.u.	0.1	SW-846 9040
Conductivity (Lab)	12000 µmhos/cm	1	SW-846 9050
Total Dissolved Solids (180° C)	8960 mg/L	10	EPA 160.1
Total Alkalinity (as CaCO3)	287 mg/L	1	EPA 310.1
Total Hardness (as CaCO3)	2310 mg/L	1	Calculation
Fluoride	1.5 mg/L	0.1	EPA 340.2

Calcium	383 mg/L	19.11 meq/L	1 mg/L	SW-846 6010A
Magnesium	330 mg/L	27.16 meq/L	1 mg/L	SW-846 6010A
Potassium	6 mg/L	0.15 meq/L	1 mg/L	SW-846 6010A
Sodium	2290 mg/L	99.61 meq/L	1 mg/L	SW-846 6010A
Bicarbonate	350 mg/L	5.74 meq/L	1 mg/L	EPA 310.1
Carbonate	ND*	0.00	1 mg/L	EPA 310.1
Chloride	2500 mg/L	70.41 meq/L	1 mg/L	SW-846 9251
Sulfate	3410 mg/L	71.02 meq/L	5 mg/L	SW-846 9036
Major Cation Sum	146.03 meq/L		N/A	Calculation
Major Anion Sum	147.17 meq/L		N/A	Calculation
Cation/Anion Balance	-0.39 % Diff		N/A	Calculation

*ND - Parameter not detected at stated Practical Quantitation Limit.

Reference: SW-846 - "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", United States Environmental Protection Agency, Final Update 1, July 1992.

EPA - "Methods for Chemical Analysis of Water and Wastes", United States Environmental Protection Agency, EPA 600/4-79-020, Revised March, 1983.

Reviewed By:

Robert Alford

Robert Alford
Supervisor, Water Laboratory

iml

Inter-Mountain Laboratories, Inc.

Inorganics Laboratory
11183 SH 30 College Station, Texas 77845
Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
3304 Longmire Drive College Station, Texas 77845
Phone (409) 774-4999 Fax (409) 696-0692

EPA Method 8240
VOLATILE ORGANIC COMPOUNDS

Client:	**NAVAJO REFINING COMPANY**		
Project :	Artesia, NM	Report Date:	07/18/95
Sample ID:	Trip Blank	Date Sampled:	NA
Laboratory ID:	0695G00988	Date Received:	06/30/95
Sample Matrix:	Water	Date Extracted:	07/12/95
Preservative:	Cool, HCl	Date Analyzed:	07/12/95
Condition:	Intact, pH<2	Time Analyzed:	2:54 AM

Analyte	Concentration (mg/L)	Detection Limit (mg/L)
Benzene	ND	0.005
Toluene	ND	0.005
Ethylbenzene	ND	0.005
m,p-Xylene	ND	0.005
o-Xylene	ND	0.005
Methyl ethyl ketone	ND	0.020
Carbon disulfide	ND	0.005

ND - Analyte not detected at stated limit of detection

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
1,2-Dichloroethane-d4	90%	86 - 118%
Toluene-d8	103%	88 - 110%
Bromofluorobenzene	113%	86 - 115%

Reference: Method 8240A: Gas Chromatography / Mass Spectrometry for Volatile Organics Test Methods for Evaluating Solid Waste, SW - 846, Final Update II, United States Environmental Protection Agency, September 1994.

Comments: A capillary column is used instead of a packed column as in the reference above.

Analyst

Review

Appendix G

APPENDIX G

APPENDIX G

DERIVATION OF SOIL CONCENTRATION-BASED LIMITS FOR METAL CONSTITUENTS FROM PART 503 MUNICIPAL SLUDGE REGULATIONS

DERIVATION OF SOIL CONCENTRATION-BASED LIMITS FOR METAL CONSTITUENTS FROM PART 503 MUNICIPAL SLUDGE REGULATIONS

Under the authority of Sections 405(d) and (e) of the Clean Water Act, EPA regulations exist to protect public health and the environment from any reasonably anticipated adverse effects of certain pollutants that may be present in surface-applied sewage sludge (40 CFR Part 503, Subpart B-Land Application). Subpart B of the regulations specifies pollutant limits for certain metal constituents which are typically contained in sewage sludge. The sludge land application pollutant limits are listed in Tables 1-4 of 40 CFR 503.13. Depending upon the environmental setting (home garden, agricultural or forest land) in which sludge application occurs, pollutant limits are established on the basis of one or more of the following criteria: ceiling concentrations (mg/kg) for pollutants contained in the sludge; maximum cumulative applied pollutant load (kg/ha); or the maximum annual loading rates for pollutant constituents of concern (kg/ha).

The Part 503 sludge pollutant limits were established on the basis of a comprehensive risk assessment conducted by the EPA Office of Science and Technology, the results of which were published in the Technical Support Document for Land Application for Sewage Sludge (November, 1992). In order to conduct that risk assessment, various sources of technical data were combined with conservative default assumptions to evaluate the potential for adverse effects to human health and the environment. In the following discussion, relevant information cited from the technical support document are referenced by page number.

As described above, the pollutant limits specified in 40 CFR 503.13 refer to constituent concentrations associated with the sludge itself, rather than resulting concentrations of constituents persisting in the soil once application activities have ceased. Therefore, for many of the environmental pathways targeted for risk evaluation (pp. 5-2), it was necessary for EPA to assign various default characteristics for a generic soil in order to derive soil-based pollutant concentration values that could be employed in a more direct manner for the evaluation of potential adverse health effects and the execution of fate and migration modeling.

It is apparent that, as a matter of necessity, EPA started with soil-based pollutant concentration limits for several environmental pathways of concern, and subsequently established sludge-based pollutant limits that would not exceed the soil-based limits. Because the default soil characteristics employed in the risk assessment are specified in the Part 503 technical support document, it is possible to derive soil-based maximum pollutant concentration values that correspond to the sludge-based pollutant limits presented in 40 CFR 503.13. In particular, two of the default soil assumptions provide the information necessary to derive the soil-based pollutant limits: that sludge is incorporated into the soil to a depth of 15 cm, and that the total mass of that soil interval possesses a weight of 2×10^9 g dry weight/ha (pp. 5-19).

The comparison of the Pond 1 soils with the Part 503 pollutant limit criteria was conducted on the basis of an agricultural land scenario. Thus, the relevant Part 503 pollutant limit for this scenario are specified at 40 CFR 503.13(a)(2)(i) and 40 CFR 503.13 (Table 2). In turn, the cumulative pollutant loading rates presented in Table 2 were extracted from the analysis of the most limiting environmental exposure pathway for each constituent, which is presented as Table 6-2 of the support document (p.6-5). Table 6-2 presents the limiting results for each pathway for inorganic pollutants, reported as reference cumulative application rate of pollutant. For three of the Pond 1 constituents of concern, the most limiting environmental pathway passes from sludge through the soil medium to the receptor (Table D-1). For the remaining two Pond 1 constituents of concern (arsenic and lead) the most limiting exposure pathway does not pass through the soil medium, but instead proceeds directly from sludge to receptor The following table summarizes the most limiting environmental pathway and associated maximum pollutant limit for the Pond 1 inorganic constituents of concern.

Table D-1. Most Limiting Environmental Pathway and Pollutant Limit for Inorganic Pollutants Contained in Sewage Sludge

Constituent	Limiting Pathway	Pollutant Limit (1)
Chromium	Sludge to Soil to Plant	3000 kg/ha
Nickel	Sludge to Soil to Plant	420 kg/ha
Zinc	Sludge to Soil to Plant	2800 kg/ha
Arsenic	Sludge to Human	41 ug/g
Lead	Sludge to Human	300 ug/g

(1) Pollutant limits for chromium, nickel and zinc are based on a reference cumulative application rate (RPc) expressed as kg pollutant/ha. Pollutant limits for arsenic and lead are based on a reference sludge concentration (RSc) expressed as ug pollutant/g sludge.

Based on the assumed mass of sludge-incorporated soil and the reference cumulative application rates (RPc) of chromium, nickel, and lead for their most limiting pathway, the soil-based cumulative loading limit for each constituent may be simply calculated. For example, for the case of chromium, the reference cumulative application rate (RPc) = 3,000 kg/ha, which is incorporated into a 15 cm-deep soil zone having a mass of 2 x 10^9 g (2 x 10^6 kg). Therefore:

$$\textbf{3000 kg chromium per ha-15 cm / 2 x } \mathbf{10^6} \textbf{ kg soil per ha-15 cm}$$
$$\textbf{= 1500 kg chromium / 1 x } \mathbf{10^6} \textbf{ kg soil = 1500 ppm}$$

In the case of the remaining Pond 1 constituents of concern (arsenic and lead), calculation of soil-based pollutant limits is more straightforward, since worst-case exposure to these constituents was determined to occur when sludge is directly ingested by a human receptor. Therefore, the specified pollutant limits for these are not strictly medium-dependent, and can thus be validly compared to other forms of potentially ingestible solid media, such as soil. Since the RSc values for arsenic and lead are expressed in ug/g, the conversion to parts per million requires no additional calculations. For instance, in the case of arsenic, using the RSc value presented in Table 6-2 of the support document (p.6-5):

41 ug arsenic / g containing media = 41 ppm arsenic.

As a final note, the pollutant limit for lead established on the basis of the sludge-to-human pathway was originally determined according to the EPA integrated uptake biokinetic (IUBK) model, which resulted in an allowable sludge concentration of 500 ppm lead. However, EPA subsequently made a policy decision to reduce the allowable limit to 300 ppm, based on the observation that animals fed up to 10 percent of their diet as sewage sludge did not exhibit alterations in their lead body burden until the lead concentration in the sludge exceeded 300 ppm. Therefore, the Part 503 pollutant limit for lead represents a relatively conservative health-based standard.

APPENDIX H

RISK ASSESSMENT CALCULATIONS

Appendix H

APPENDIX H

Appendix H-1: Residential Exposure Scenario

Soils Risk Assessment : Inorganics

$$\text{Intake (mg/Kg/day)} = \frac{CS \cdot IR \cdot CF \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$$

Variables	Values noncarcinogens	 carcinogens
CS = Chem. conc. in soil (mg/Kg)	varies w/ constituents	
IR = soil ingestion rate (mg/day)	200	100
CF = conversion factor (10^{-6} Kg/mg)	$1 \cdot 10^{-6}$	$1 \cdot 10^{-6}$
FI = fraction from contam. source (no unit)	1.0	1.0
EF = exposure frequency (day/yr)	365 d/y	365 d/y
ED = exposure duration (yrs)	70	30
BW = body weight (Kg)	16	70
AT = averaging time (days)	$2.555 \cdot 10^4$	$2.555 \cdot 10^4$
Derivable formula	In. = $\frac{CS \cdot 5.11}{4.088 \cdot 10^5}$	$\frac{CS \cdot 2.56}{1.79 \cdot 10^6}$

Intake estimates

Constituent	max CS	Intake - non carcinogenic	Intake - carcinogenic
As	39.9	$4.988 \cdot 10^{-4}$ mg/kg/d	$5.698 \cdot 10^{-5}$ mg/kg/d
Cr	1011	$1.264 \cdot 10^{-2}$	$1.43 \cdot 10^{-4}$
Ni	37	$4.625 \cdot 10^{-4}$	NA
Zn	434	$5.425 \cdot 10^{-3}$	NA

noncancer Haz Quotient = Intake / RfD

cancer risk = Intake × Potency Factor

Risk

	Intake (non carc.)	RfD_o	Haz. Quot.	Intake (carcin.)	Potency Factor	Risk
As	$4.988 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	1.66	$5.7 \cdot 10^{-5}$	1.75	$9.98 \cdot 10^{-5}$
Cr	$1.264 \cdot 10^{-2}$	1.0	$1.26 \cdot 10^{-2}$	NA	NA	NA
Ni	$4.625 \cdot 10^{-4}$	$2.0 \cdot 10^{-2}$	$2.3 \cdot 10^{-2}$	NA	NA	NA
Zn	$5.425 \cdot 10^{-3}$	$3.0 \cdot 10^{-1}$	$1.8 \cdot 10^{-2}$	NA	NA	NA

NA = not applicable

Soils Risk Assessment : organics

$$\text{Intake (mg/Kg/day)} = \frac{CS \cdot IR \cdot CF \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$$

Variables	Values	
	noncarcinogens	carcinogens
CS = Chem. conc. in soil (mg/Kg)		
IR = soil ingestion rate (mg/day)	200	100
CF = conversion factor (10^{-6} Kg/mg)	$1 \cdot 10^{-6}$	$1 \cdot 10^{-6}$
FI = fraction from contam. source (no unit)	1.0	1.0
EF = exposure frequency (day/yr)	365 d/y	365 d/y
ED = exposure duration (yrs)	70	30
BW = body weight (Kg)	16	70
AT = averaging time (days)	2.555·104	$2.555 \cdot 10^4$
Derivable formula	$In. = \frac{CS \cdot 5.11}{4.088 \cdot 10^5}$	$\frac{CS \cdot 2.56}{1.79 \cdot 10^6}$

Intake estimates

constituent	max CS	Intake - non carcinogenic,	Intake - carcinogenic

Intake Estimates - VOAs

constituent	Max CS	Intake non-carcinogenic	Intake carcinogenic
acetone	0.387	$4.84 \cdot 10^{-6}$	$5.53 \cdot 10^{-7}$
benzene	0.03	$3.75 \cdot 10^{-7}$	$4.29 \cdot 10^{-8}$
ethylbenzene	0.59	$7.38 \cdot 10^{-7}$	$8.43 \cdot 10^{-7}$
methylene chloride	0.076	$9.50 \cdot 10^{-7}$	$1.09 \cdot 10^{-7}$
toluene	0.622	$7.78 \cdot 10^{-6}$	$8.89 \cdot 10^{-7}$
xylenes	2.05	$2.56 \cdot 10^{-5}$	$2.93 \cdot 10^{-6}$

Soils Risk Assessment

VOAs (cont)

constit.	Intake (non-carcinog.)	RfDo	Haz Quo.	Intake (carcinog.)	Potency factor	Risk
acetone	$4.84 \cdot 10^{-6}$	$1.0 \cdot 10^{-1}$	$4.8 \cdot 10^{-5}$	$5.53 \cdot 10^{-7}$	NA	NA
benzene	$3.75 \cdot 10^{-7}$	NA	NA	$4.29 \cdot 10^{-8}$	$2.9 \cdot 10^{-2}$	$1.24 \cdot 10^{-9}$
ethylbenzene	$7.38 \cdot 10^{-7}$	$1.0 \cdot 10^{-1}$	$7.38 \cdot 10^{-5}$	$8.43 \cdot 10^{-7}$	NA	NA
methylene chloride	$9.5 \cdot 10^{-7}$	$6.0 \cdot 10^{-2}$	$1.58 \cdot 10^{-5}$	$1.09 \cdot 10^{-7}$	$7.5 \cdot 10^{-3}$	$8.1 \cdot 10^{-10}$
Toluene	$7.78 \cdot 10^{-6}$	$2.0 \cdot 10^{-1}$	$3.89 \cdot 10^{-5}$	$8.89 \cdot 10^{-7}$	NA	NA
xylenes	$2.56 \cdot 10^{-5}$	$2.0 \cdot 10^{0}$	$1.28 \cdot 10^{-5}$	$2.93 \cdot 10^{-6}$	NA	NA

Soils Risk Assessment : Organics (cont)

Intake Estimates - SVOAs

Constituent	Max CS	Intake-noncarcinogenic	Intake - carcinogeni
benzo(g,h,i) perylene	150	$1.88 \cdot 10^{-3}$	$2.14 \cdot 10^{-4}$
benzo(a) pyrene	150	↓	↓
chrysene	150		
dibenzofuran	150		
2,4, dimethylphenol	150		
fluorene	150		
naphthalene	150		
2-methylnapthalene	150		
phenanthrene	150		
pyrene	150		

noncarcinogen HQ = Intake / RfD_o

cancer risk = Intake x Potency factor

constit.	Intake (non carcin.)	RfD_o	Haz Quo.	Intake (carcin.)	Potency Factor	Risk
benzo(g,h,i) perylene	$1.88 \cdot 10^{-3}$	NA	NA	$2.14 \cdot 10^{-4}$	$1.55 \cdot 10^{-1}$	$3.3 \cdot 10^{-5}$
benzo(a) pyrene	↓	NA	NA	↓	7.3	$1.6 \cdot 10^{-3}$
chrysene		NA	NA		NA	NA
dibenzofuran		NA	NA		NA	NA
2,4, dimethylphenol		$2 \cdot 10^{-2}$	$9.4 \cdot 10^{-2}$		NA	NA
fluorene		$4 \cdot 10^{-2}$	$4.7 \cdot 10^{-2}$		NA	NA
naphthalene		$4 \cdot 10^{-2}$	$4.7 \cdot 10^{-2}$		NA	NA
2-methylnapthalene		NA	NA		NA	NA
phenanthrene		$2.9 \cdot 10^{-2}$	$6.48 \cdot 10^{-2}$		NA	NA
pyrene		$3.0 \cdot 10^{-2}$	$6.27 \cdot 10^{-2}$		NA	NA

Groundwater - Residential Exposure Scenari

$$\text{Intake}(mg/kg/d) = \frac{CW \cdot IR \cdot EF \cdot ED}{BW \cdot AT}$$

CW = chem. conc. in water (mg/l) — variable
IR = Ingestion rate (liters/d) = 1.4 l
EF = Exposure frequency (d/yr) = 365 days
ED = Exposure duration (yrs) = 70 yrs
BW = Body weight (kg) = 70 yrs
AT = $70_{yr} \cdot 365 d/y$ = $4.55 \cdot 10^{+3}$

~~derivable general equation:~~ $\frac{CW \cdot 3.58 \cdot 10^{4}}{1.79 \cdot 10^{6}}$ = Intak

constituent	max concentration (CW)	Intake (mg/L)	RfDo	Haz Quot. (Int/RfD)	Oral Slope Factor mg(kg·d)$^{-1}$	Cancer Risk (Intake·SF
As	0.22	$4.40 \cdot 10^{-3}$	$3 \cdot 10^{-4}$	$1.47 \cdot 10^{1}$	1.75	$7.7 \cdot 10^{-3}$
Cr	0.05	$1.00 \cdot 10^{-3}$	1.0	$1.00 \cdot 10^{-3}$	NA	—
Ni	0.12	$2.40 \cdot 10^{-3}$	$2 \cdot 10^{-2}$	$1.20 \cdot 10^{-1}$	NA	—
benzene	0.041	$8.00 \cdot 10^{-4}$	NA	NA	$2.90 \cdot 10^{-2}$	$2.32 \cdot 10^{-5}$
Ethylbenzene	0.032	$6.41 \cdot 10^{-4}$	$1.0 \cdot 10^{-1}$	$6.00 \cdot 10^{-3}$	NA	—
toluene	0.021	$4.20 \cdot 10^{-4}$	$2.0 \cdot 10^{-1}$	$2.10 \cdot 10^{-3}$	NA	—
xylene	0.032	$6.41 \cdot 10^{-4}$	2.0	$3.21 \cdot 10^{-5}$	NA	—
2-hexanone	0.023	$4.60 \cdot 10^{-4}$	NA	NA	NA	—
2-butanone	0.048	$9.61 \cdot 10^{-4}$	$6.0 \cdot 10^{-1}$	$1.60 \cdot 10^{-3}$	NA	—
carbon disulfide	0.017	$3.40 \cdot 10^{-4}$	$1.0 \cdot 10^{-1}$	$2.34 \cdot 10^{-2}$	NA	—
Bis(2-chloro) isopropyl ether	0.022	$4.40 \cdot 10^{-4}$	$4.0 \cdot 10^{-2}$	$1.10 \cdot 10^{-2}$	NA	—

Σ $7.72 \cdot 10^{-3}$

Appendix H-2: Agricultural Exposure Scenario

Agricultural Exposure Scenario

Risk Estimations

non cancer HQ = Intake/RFD

Cancer risk = Intake • Potency factor

Constituent	Intake (non-carcino.)	RfD	Hazard Quotient	Intake (carcinogen)	Potency Factor	Risk
As	$6.08 \cdot 10^{-6}$	$3 \cdot 10^{-4}$	$2.0 \cdot 10^{-2}$	$1.30 \cdot 10^{-6}$	1.75	$2.28 \cdot 10^{-6}$
Cr	$1.54 \cdot 10^{-4}$	1.0	$1.54 \cdot 10^{-4}$	$3.30 \cdot 10^{-5}$	NA	NA
Ni	$5.64 \cdot 10^{-6}$	$2.0 \cdot 10^{-2}$	$2.8 \cdot 10^{-4}$	$1.21 \cdot 10^{-6}$	NA	NA
Zn	$6.61 \cdot 10^{-5}$	$3.0 \cdot 10^{-1}$	$2.2 \cdot 10^{-4}$	$1.42 \cdot 10^{-5}$	NA	NA
VOAs						
acetone	$5.90 \cdot 10^{-8}$	$1.0 \cdot 10^{-1}$	$5.9 \cdot 10^{-7}$	$1.26 \cdot 10^{-8}$	NA	NA
benzene	$4.57 \cdot 10^{-9}$	NA	NA	$9.80 \cdot 10^{-10}$	$2.9 \cdot 10^{-2}$	$2.84 \cdot 10^{-1}$
ethylbenzene	$9.0 \cdot 10^{-8}$	$1.0 \cdot 10^{-1}$	$9 \cdot 10^{-7}$	$1.93 \cdot 10^{-8}$	NA	NA
methylene chloride	$1.16 \cdot 10^{-8}$	$6.0 \cdot 10^{-2}$	$1.9 \cdot 10^{-7}$	$2.48 \cdot 10^{-9}$	$7.5 \cdot 10^{-3}$	$1.86 \cdot 10^{-11}$
toluene	$9.48 \cdot 10^{-8}$	$2.0 \cdot 10^{-1}$	$4.7 \cdot 10^{-7}$	$2.03 \cdot 10^{-8}$	NA	NA
xylenes	$3.12 \cdot 10^{-7}$	$2.0 \cdot 10^{0}$	$1.56 \cdot 10^{-7}$	$6.70 \cdot 10^{-8}$	NA	NA
SVOAs						
benzo(ghi)perylene	$4.57 \cdot 10^{-5}$	NA	NA	$9.8 \cdot 10^{-6}$	$1.5 \cdot 10^{-1}$	$1.47 \cdot 10^{-6}$
benzo(a) pyrene	↓	NA	NA	↓	7.3	$7.15 \cdot 10^{-5}$
chrysene		NA	NA			
dibenzofuran		NA	NA			
2,4 dimethylphenol		$2 \cdot 10^{-2}$	$2.3 \cdot 10^{-3}$			
fluorene		$4 \cdot 10^{-2}$	$1.1 \cdot 10^{-3}$			
naphthalene		$4 \cdot 10^{-2}$	$1.1 \cdot 10^{-3}$			
2-methylnapthalene		NA	NA			
phenanthrene		$2.9 \cdot 10^{-2}$	$1.6 \cdot 10^{-3}$			
pyrene		$3.0 \cdot 10^{-2}$	$1.5 \cdot 10^{-3}$			

Total Cumulative Cancer Risk → $7.53 \cdot 10^{-5}$

Agricultural Exposure Scenario

$$\text{Intake (mg/kg/day)} = \frac{CS \cdot IR \cdot CF \cdot FI \cdot EF \cdot ED}{BW \cdot AT}$$

Variables	noncarcinogens	carcinogens
CS = chem. concentration in soil		
IR = soil ingestion rate	25 mg/d	25 mg/d
CF = conversion factor	$1 \cdot 10^{-6}$	$1 \cdot 10^{-6}$
FI = fraction from contam. source		
EF = exposure freq.	156 d/y	156 d/y
ED = exposure duration	15 yr	15 yr
BW = body weight	70 Kg	70 Kg
AT = averaging time	$5.48 \cdot 10^3$ days	$2.56 \cdot 10^4$ days

Derivable formulas:

noncarcinogen intake

$$\text{Intake} = \frac{CS \cdot 25 \cdot (1 \cdot 10^{-6}) \cdot 1 \cdot (156) \cdot (15)}{70 \cdot 5.48 \cdot 10^3}$$

$$= \frac{CS \cdot 5.85 \cdot 10^{-2}}{3.84 \cdot 10^5}$$

---

carcinogenic intake

$$\text{Intake} = \frac{CS \cdot 25 (1 \cdot 10^{-6}) \cdot 1 \cdot 156 \cdot 15}{70 \cdot 2.56 \cdot 10^4}$$

$$= \frac{CS \cdot 5.85 \cdot 10^{-2}}{1.79 \cdot 10^6}$$

Agricultural Exposure Scenario

Intake estimates : inorganics + organics

onstituent	max CS	Intake - non carcinogenic	Intake - carcinogen
As	39.9	$6.08 \cdot 10^{-6}$	$1.30 \cdot 10^{-6}$
Cr	1011	$1.54 \cdot 10^{-4}$	$3.30 \cdot 10^{-5}$
Ni	37	$5.64 \cdot 10^{-6}$	$1.21 \cdot 10^{-6}$
Zn	434	$6.61 \cdot 10^{-5}$	$1.42 \cdot 10^{-5}$
VOAs			
acetone	0.387	$5.90 \cdot 10^{-8}$	$1.26 \cdot 10^{-8}$
benzene	0.03	$4.57 \cdot 10^{-9}$	$9.8 \cdot 10^{-10}$
ethylbenzene	0.59	~~8~~$9.0 \cdot 10^{-8}$	$1.93 \cdot 10^{-8}$
methylene chloride	0.076	$1.16 \cdot 10^{-8}$	$2.48 \cdot 10^{-9}$
toluene	0.622	$9.48 \cdot 10^{-8}$	$2.03 \cdot 10^{-8}$
xylenes	2.05	$3.12 \cdot 10^{-7}$	$6.70 \cdot 10^{-8}$
SVOAs			
benzo(ghi)perylene	300	$4.57 \cdot 10^{-5}$	$9.8 \cdot 10^{-6}$
benzo(a) pyrene	↓	↓	↓
chrysene			
dibenzofuran			
2,4 dimethylphenol			
fluorene			
naphthalene			
2-methylnapthalene			
phenanthrene			
pyrene			

APPENDIX I

RELEVANT BIOLOGICAL DATA FROM BIOTA INFORMATION SYSTEM OF NEW MEXICO (BISON)

BISON-M - Life History
Species: Black-tailed Jack Rabbit (Lepus californicus (2 ssp.))
Species Id 050591
Date 01 AUG 95

LIFE HISTORY:

DESCRIPTION

Lepus californicus is the commonly observed jack rabbit in New Mexico. It might be confused only with the white-tailed jack rabbit from which it differs in possessing a definite black dorsal tail stripe. It is distinguished from the white-sided jack rabbit as indicated in the next species account *23*.The ears are black-tipped externally and it doesn't have white extending up onto the rump *41*.

ARIZONA

Medium size in all external characters; dorsum brownish to grizzled; sides of body brownish; venter creamy white with a narrow mid-dorsal black stripe extending onto the back; ears medium in length with a terminal black patch externally; skull medium in size, especially evident in greatest skull length and zygomatic breadth *34*.

REPRODUCTION

THE BREEDING SEASON OCCURS JANUARY THROUGH JULY BASED ON UTAH STUDIES *20*.
THE MATING SYSTEM IS PROMISCUOUS. THEY HAVE NO PAIR BOND *19,20*.
THEY DISPLAY ON THE GROUND *20*. THE NEST SITE IS ON THE GROUND OR A DEPRESSION *15*. THERE IS NO NEST STRUCTURE *20*. THE GESTATION PERIOD IS 40-47 DAYS, WITH AN AVERAGE OF 43 *20*. THE AVERAGE LITTER SIZE RANGES FROM 1.9 TO 4.9 DEPENDING ON AUTHOR *20*. 2-7 LITTERS PER YEAR ARE REPORTED *00,20*. THE YOUNG ARE PRECOCIAL AT BIRTH *15,20*. ALTHOUGH PRECOCIAL THE YOUNG ARE SUCKLED 2-3 WEEKS BY THE FEMALE *15*. THE AGE AT SEXUAL MATURITY IS 7 TO 8 MONTHS IN MALES. MOST FEMALES DO NOT BREED UNTIL 1 YEAR *19,20*.

ARIZONA

In southern Arizona, female black-tailed hack rabbits were pregnant 11 months of the year (all except November) and were breeding in every month, according to Vorhies and Taylor (1933:496). Seventy females had and average number of 2.24 (1-6) embryos per litter. Nursing females are frequently pregnant. Most females in Arizona have more than one litter per year. Some authors suggest that there may be only a two-week period between pregnan- cies. Females in southern Arizona have a gestation period of 43 (41-47) days (Haskell and Reynolds, 1947:135). Thus, a female could have four or more litters per year. Undoubtedly, the number of litters is dependent, in part, upon climatic conditions and available food. Young are born in nests that vary from little more than forms to hair-lined, globular, below-ground nests. Young are precocial -- furred and with eyes open at birth. Young are nursed exclusively for the first ten days, followed with solid food to supplement nursing. There is some evidence that they may continue to do some suckling until 12 or 13 weeks of age (Sparks, 1968). In southern Arizona, young weigh about 110 grams at birth; at about six weeks, 500 grams; adult weight averages 2300 grams. By about the thirty-second week, jacks attain adult weight; by the twenty-eighth week, total length (Haskell and Reynolds, 1947:132). Females do not produce young in the same year in which they are born *34*.

BISON-M - Life History
Species: Black-tailed Jack Rabbit (Lepus californicus (2 ssp.))
Species Id 050591
Date 01 AUG 95

BEHAVIOR

THE BLACK-TAILED JACK RABBIT FORAGES BY GRAZING AND BROWSING *15*. THEY FORAGE ON THE GROUND, HERBACEOUS VEGETATION, AND SHRUBS *15,16*. THEY ARE NON-TERRITORIAL *20*. THE HOME RANGE SIZE IS LESS THAN 20.2 HECTARES IN CALIFORNIA, 16.2 IN KANSAS AND IDAHO, 30 HECTARES REPORTED AS ACTIVITY AREA ON SHORTGRASS PRAIRIE IN COLORADO *20,21*. THE DISPERSION IS RANDOM AND CLUMPED. EVIDENCE SUGGESTS SOME TENDENCY TO CONCENTRATE IN WINTER FEEDING AREAS AND IN AREAS OF SHRUB COVER *14,21*. THE YOUNG DISPERSE AT ABOUT 3 WEEKS OF AGE *15*. THEY ARE MOST ACTIVE AT DAWN OR DUSK OR AT NIGHT,BUT THEY ARE ALSO ACTIVE DURING THE DAY *14*. THEY HAVE SOME TENDENCY FOR ANIMALS TO MOVE INTO WINTER FEEDING AREAS, SUCH MOVEMENTS RARELY ENTAIL MORE THAN A MILE OF MOVEMENT BY INDIVIDUALS *22*.

ARIZONA

They prefer to forage where livestock grazing has reduced vegetation. During the day they rest in forms, which are shallow depressions that the rabbits dig themselves. They move from forms into open places in late afternoon. If the form is not in a place with sufficient grass for foraging, the jack rabbits may move some distance each day to suitable forage areas. Vorhies and Taylor (1933:483) thought that daily movements of one or two miles each way were fairly common in southern Arizona, and some were known to make round trips of 10 miles each day. They are good runners and leapers (can usually outrun a single coyote). They are known to maintain a speed of 35 miles per hour for one-half mile. When they detect possible danger, blacktails often stand high on their hind legs to get a better sight or sound of the object *34*. Males are frequently involved in fighting, some of it fierce. The males rear up on their hind legs and strike at each other with their forefeet, usually causing the fur to fly. Biting each other, especially on the ears, occurs also. A sexually active male, with nose close to the ground, seeks a female. If a male is encountered, a fight or a chase may ensue. If a female is encountered she may lower her ears and come about to face the intruder. If the mal still advances, the female may jump and strike at the male or she may jump straight up in the air, the male charge under her, and the female turn around to face the male. Sometimes the male jumps in the air and the female charges under. Sometimes this performance is followed by a chase of the female with attempted copulation. When copulation occurs, it takes place in only a few seconds *34*.

When feeding on mesquite, black-tailed jack rabbits rear up on their hind legs to reach the tufts of green leaves in the axils of the mesquite spines (Vorhies and Taylor, 1933:527). When feeding on tall grasses, Vorhies and Taylor (1933:536) say these rabbits cut the stem down and eat the lower, succulent one-fifth *34*.

LIMITING FACTORS

These animals seem to depend on green or succulent vegetation for water, although they do drink when water is available, as attested by Hall (1946)
23.

BISON-M - Life History
Species: Black-tailed Jack Rabbit (Lepus californicus (2 ssp.))
Species Id 050591
Date 01 AUG 95

POPULATION ATTRIBUTES

POPULATIONS FLUCTUATE IN CYCLES. THE DENSITY HAS VARIED FROM 0.1 HECTARE TO 3 PER HECTARE IN OTHER STATES ON RANGE. IN AGRICULTURAL AREAS DENSITY MAY EXCEED 34 PER HECTARE *20*. THE MORTALITY RATE FROM BIRTH TO 12 MONTHS IS FROM 35-67 PERCENT IN KANSAS, 91 PERCENT IN IDAHO, 24-71 PERCENT IN UTAH, ADULT MORTALITY RANGED FROM 9-87 PERCENT AVERAGE 57 PERCENT IN UTAH *20*. THE TURNOVER RATE IS 2-3 YEARS *15*.

ARIZONA

Their numbers may increase when an extensive control program of predators, such as coyotes, has been carried out. In open juniper woodland, blacktail numbers are relatively low. When junipers are cleared, as has been the case in many places in the Southwest, the grasses may become more extensive, and black-tailed jack rabbits will become far more abundant *34*.

LIFE HISTORY CODES

0100 Origin: Native to NM
0310 Senses: Hearing - Keen
0900 Breeding/Spawning Season: Spring
0905 Breeding/Spawning Season: Summer
0910 Breeding/Spawning Season: Fall
0915 Breeding/Spawning Season: Winter
0920 Breeding/Spawning Season: January
0925 Breeding/Spawning Season: February
0930 Breeding/Spawning Season: March
0935 Breeding/Spawning Season: April
0940 Breeding/Spawning Season: May
0945 Breeding/Spawning Season: June
0950 Breeding/Spawning Season: July
0955 Breeding/Spawning Season: August
0960 Breeding/Spawning Season: September
0965 Breeding/Spawning Season: October
0970 Breeding/Spawning Season: November
0975 Breeding/Spawning Season: December
1130 Gestation/Incubation Period: 1-2 months (29-60 days)
1199 Gestation/Incubation Period: Specified in Comments
1500 Birth/Hatching of young: January
1505 Birth/Hatching of young: February
1510 Birth/Hatching of young: March
1515 Birth/Hatching of young: April
1520 Birth/Hatching of young: May
1525 Birth/Hatching of young: June
1530 Birth/Hatching of young: July
1535 Birth/Hatching of young: August
1540 Birth/Hatching of young: September
1545 Birth/Hatching of young: October
1599 Birth/Hatching of young: Specified in Comments
2099 Dispersal of Young: Specified in Comments (age & month)

BISON-M - Life History
Species: Black-tailed Jack Rabbit (Lepus californicus (2 ssp.))
Species Id 050591
Date 01 AUG 95

LIFE HISTORY CODES
2105 Offspring per Reproductive Effort: 2
2115 Offspring per Reproductive Effort: 3-4
2120 Offspring per Reproductive Effort: 5-7
2199 Offspring per Reproductive Effort: Specified in comments
2300 Reproductive Efforts per Year: 1
2305 Reproductive Efforts per Year: 2
2310 Reproductive Efforts per Year: 3
2315 Reproductive Efforts per Year: > 3
2399 Reproductive Efforts per Year: Specified in Comments
2505 Development of Young at Birth/Hatching: Precocial
2700 Parental Care of Young: Female
3115 Mating System (Per season): Promiscuity (Indiscriminate)
3315 Length of Pair Bond: No pair bond formed
3720 Birthing/Egg Laying Site: On the ground
3726 Birthing/Egg Laying Site: Depression/Scrape
3930 Nest Materials: Hair/Feathers/Down
3940 Nest Materials: No nest structure
5300 Activity Period: Nocturnal - Active at night
5305 Activity Period: Diurnal - Active in day
5310 Activity Period: Crepuscular - Active at dawn and/or dusk
5520 Foraging Strategy: Grazing
5525 Foraging Strategy: Browsing
5600 Foraging Sites: Ground surface/Waterbody bottom
5604 Foraging Sites: Herbaceous vegetation
5610 Foraging Sites: Shrub cover/canopy
6300 Display Site: Ground
6500 Dispersion/Distribution: Random/Erratic
6510 Dispersion/Distribution: Clumped
7135 Territoriality: Non-territorial

REFERENCES FOR LIFE HISTORY CODES - 15, 16, 19, 20, 00, 21, 14, 19 and 34
COMMENTS ON LIFE HISTORY CODES
+1199+ THE GESTATION PERIOD IS 40-47 DAYS, WITH AN AVERAGE OF 43 *20,34*.

+1599+ Pregnant every month except November and were breeding every month (Vorhies and Taylor, 1933:496) *34*.

+2099+ THE YOUNG DISPERSE AT ABOUT 3 WEEKS OF AGE *15*.

+2199+ THE AVERAGE LITTER SIZE RANGES FROM 1.9 TO 4.9 DEPENDING ON AUTHOR *20*. One to six embryos per litter (Vorhies and Taylor, 1933) *34*.

+2399+ 2-7 LITTERS PER YEAR ARE REPORTED *00, 20*. Undoubtedly, in part, dependent upon climatic conditions and available food *34*.

BISON-M - Life History
Species: Black-tailed Jack Rabbit (Lepus californicus (2 ssp.))
Species Id 050591
Date 01 AUG 95

SPECIES ASSOCIATIONS:

RELATIONSHIP	ASSOCIATION	REFERENCES
COMPETITION:	ANIMALS:	34
COMPETITION:	CHORDATA (Vertebrates)	34
COMPETITION:	Mammalia	34
COMPETITION:	Bovidae	34
COMPETITION:	Equidae	34
PREDATION-PREDATOR:	ANIMALS:	34
PREDATION-PREDATOR:	CHORDATA (Vertebrates)	34
PREDATION-PREDATOR:	Aves	34
PREDATION-PREDATOR:	Accipitridae	34
PREDATION-PREDATOR:	Falconidae	34
PREDATION-PREDATOR:	Strigidae	34
PREDATION-PREDATOR:	Tytonidae	34
PREDATION-PREDATOR:	Mammalia	34
PREDATION-PREDATOR:	Canidae	34
PREDATION-PREDATOR:	Canis spp.	34
PREDATION-PREDATOR:	Urocyon spp.	34
PREDATION-PREDATOR:	Felidae	34
PREDATION-PREDATOR:	Lynx spp.	34
PREDATION-PREDATOR:	Mustelidae	34
PREDATION-PREDATOR:	Taxidea spp.	34

COMMENTS ON SPECIES ASSOCIATIONS

TULAREMIA AND PREDATION BY DOMESTIC DOGS, HAWKS, AND SNAKES, ROAD KILLS, HUNTER HARVEST *20*.

These animals seem to depend on green or succulent vegetation for water, although they do drink when water is available, as attested by Hall (1946) *23*.

Blacktails will compete with livestock for new grasses and may reduce the gain for the livestock. However, grazing by livestock may enhance the habitat for jack rabbits *34*. Blacktails are preyed upon by coyotes, bobcats and probably badgers, gray foxes, and raptorial birds *34*.

APPENDIX I

Appendix I

APPENDIX J

POND TO RIVER SEEPAGE MODEL DATA AND CALCULATIONS

Table J1. Summary of Hydraulic Conductivity Measurements, Evaporation Pond Area, Navajo Refinery, Artesia, New Mexico

Well	Test	K (ft/day)	Test by:	Comment
MW-4	Slug 1	10.08	Mariah	
MW-4	Slug 2	7.25	Mariah	
MW-4C	Slug-in	2.69	Re/Spec	
MW-4C	Slug-out	2.68	Re/Spec	
MW-5C	Slug-in	12.50	Re/Spec	
MW-5C	Slug-out	13.30	Re/Spec	
MW-6A	Slug 1	26.87	Mariah	
MW-6A	Slug 2	3.97	Mariah	
MW-7A	Slug 1	2.67	Mariah	
MW-7A	Slug 2	1.09	Mariah	
MW-18B	Pumping	2.29	KWBES	Pumped well
MW-18B	Recovery	0.70	KWBES	Pumped well
MW-18T	Pumping	27.67	KWBES	Observation Well
MW-18T	Recovery	29.95	KWBES	Observation Well
OCD-3	Slug 1	1.98	Mariah	
OCD-3	Slug 2	2.30	Mariah	
OCD-7C	Slug-in	11.60	Re/Spec	
OCD-7C	Slug-out	12.70	Re/Spec	
Temp-well	- -	33.42	Geoscience	Vicinity Pond 1
EPA-1	Slug 1	2.63	Mariah	
EPA-1	Slug 2	1.98	Mariah	
Summary:				
Arithmetic mean		10.02		
Geometric mean		5.55		
Maximum		33.42		
Median		3.97		
Minimum		0.70		
Number tests		21		

Source: RFI Phase I, II and III RFI Reports, Three-Mile Ditch and Evaporation Pond Navajo Refinery, Artesia, New Mexico

Table J2 Groundwater Metals Sampling Results, 1994-1995, Navajo Refinery, Artesia, New Mexico

Sample ID	Date Sampled	Total Dissolved Solids (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)
Maximum Standards	*Agency*									
Domestic MCL	*USEPA*	500	*0.05*	*0.10*	*0.015*	*0.10*	- -	- -	- -	- -
Surface Water (Fish, Acute)	*USEPA*	- -	*0.360*	*5.40*	*0.477*	*4.58*	*(from EPA w/CaCO3 hardness of 400 mg/L)*			
Surface Water (Fish, Chronic)	*USEPA*	- -	*0.190*	*0.64*	*0.019*	*0.51*	*(from EPA w/CaCO3 hardness of 400 mg/L)*			
Groundwater	*NM*	*1,000*	- -	- -	- -	- -	*0.10*	*0.05*	*0.05*	*0.20*
Surface Water (Domestic)	*NM*	- -	- -	- -	- -	- -	*0.05*	*0.05*	*0.05*	- -
Surface Water (Fish, Acute, Pecos R.)	*NM*	*14,000@>50cfs*	*Cr, Pb, Ni calc. from CaCO3 hardness of 580 mg/L:*					*7.33*	*0.77*	*6.28*
Surface Water (Fish, Chronic, Pecos R.)	*NM*	*14,000@>50cfs*	*Cr, Pb, Ni calc. from CaCO3 hardness of 580 mg/L:*					*0.87*	*0.03*	*0.70*
Surface Water (Livestock)	*NM*	- -	- -	- -	- -	- -	*0.20*	*1.0*	*0.10*	- -
Surface Water (Irrigation)	*NM*	- -	- -	- -	- -	- -	*0.10*	*0.10*	*5.0*	- -
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 (Lab Dup.)	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 (Field Dup. 1)	05-Nov-94	2,610	<0.005	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01
MW-3	8-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 Dup.)	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 (Field Dup. 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 (Field Dup. 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	- -	- -	- -	- -

Table J2 Groundwater Metals Sampling Results, 1994-1995, Navajo Refinery, Artesia, New Mexico

Sample ID	Date Sampled	Total Dissolved Solids (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-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	7,110	**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	3,490	<0.005	<0.005	<0.01	<0.05	- -	- -	- -	- -
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 Dup.)	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 Dup.)	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 (Lab Dup.)	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

Table J2 Groundwater Metals Sampling Results, 1994-1995, Navajo Refinery, Artesia, New Mexico

Sample ID	Date Sampled	Total Dissolved Solids (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-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	5-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
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 (Lab Dup.)	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	8,110	**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	- -	- -	- -	- -
Pond Windmill (Lab Dup.)	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	- -	- -	- -	- -
NPR-RW-1	11-Nov-94	4,580	<0.005	<0.005	<0.01	<0.01	- -	- -	- -	- -
NPR-RW-2	11-Nov-94	4,610	<0.005	<0.005	<0.01	<0.01	- -	- -	- -	- -

Table J3. Pecos River Arsenic Measurements, 1980-1994

Water Year	Max. Total Arsenic (ug/L)	Date	River Flow (cfs)	Max. Dissolved Arsenic (ug/L)	Date	River Flow (cfs)
1980	10	24-Jun-80	419	1	25-Mar-80	17
1981	2	27-May-81	7.8	2	27-May-81	7.8
1982	8	26-Apr-82	862	2	26-Apr-82	862
1983	2	29-Jun-83	13	1	29-Jun-83	13
1984	1	1-Nov-83	75	1	1-Nov-83	75
1985	2	2-Jul-85	131	<1	2-Nov-84	100
1986	3	31-Jul-86	34	2	31-Jul-86	34
1987	4	31-Oct-86	367	1	31-Oct-86	367
1988	4	1-Sep-88	848	3	1-Sep-88	848
1989	2	5-Sep-89	138	2	26-Oct-88	100
1990	2	4-Sep-90	39	2	4-Sep-90	39
1991	<1	1-Nov-90	52	2	1-Nov-90	52
1992	3	26-Aug-92	86	3	26-Aug-92	86
1993	3	11-Aug-93	253	2	11-Aug-93	253
1994	2	16-Sep-94	98	1	16-Sep-94	98
Summary:						
Mean	3.3		228.2	1.7		196.8
Maximum	10		862	3		862
Median	2		98	2		86
Minimum	1		7.8	1		7.8
No. Samples	15		15	15		15

Notes:

Information Source: U.S. Geological Survey Water Data Reports, New Mexico, Water Years 1980-94.

ug/L - micrograms per liter, cfs - cubic feet per second

Table J4 Pond to River Seepage Model, Data Input, Calculations, and Data Results

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Evaporation Pond Seepage - Arsenic Concentrations, B=30, K=Arith Mean=10, 06-95 As Values, River Arsenic=0.002**												
2													
3													
4	**Well ID**	**Well Water Level Elevation (ft)**	**Saturated Thickness B (ft)**	**Datum Elevation (ft)**	**B1 Elevation (ft)**	**River or Contour Water Level Elev. (ft)**	**B2 Elevation (ft)**	**Maximum Hydraulic Conductivity K (ft/day)**	**Distance Well to River or Contour, L (ft)**	**Distance Along River or Contour, D (ft)**	**GW Flow Rate, Qg (cfs)**	**Total As Conc., Cg (mg/L)**	**CgQg**
5				*B6-C6*	*B6-D6*		*F6-D6*				*((E6*E6)-(G6*G6))*H6*J6/2/I6/86400*		*K6*L6*
6	MW-2A	3,301.48	30.00	3,271.48	30.00	3,299.75	28.27	10.02	180	1,550	0.05034	0.023	0.00116
7	OCD-1	3,301.53	30.00	3,271.53	30.00	3,299.30	27.77	10.02	120	800	0.04980	0.051	0.00254
8	OCD-2A	3,299.76	30.00	3,269.76	30.00	3,299.50	29.74	10.02	40	800	0.01801	0.020	0.00036
9	OCD-3	3,298.96	30.00	3,268.96	30.00	3,298.75	29.79	10.02	100	800	0.00582	0.005	0.00003
10	MW-11A	3,298.65	30.00	3,268.65	30.00	3,298.50	29.85	10.02	250	425	0.00088	0.013	0.00001
11	OCD-5	3,298.09	30.00	3,268.09	30.00	3,298.00	29.91	10.02	80	930	0.00363	0.005	0.00002
12	OCD-6	3,297.92	30.00	3,267.92	30.00	3,297.35	29.43	10.02	150	750	0.00982	0.039	0.00038
13	OCD-7A	3,299.16	30.00	3,269.16	30.00	3,298.00	28.84	10.02	120	1,300	0.04288	0.159	0.00682
14													
15	**Sum of Groundwater Inflow to River Vicinity of Ponds:**										0.18119	▨	0.01132
16													
17	**4Q3 River Flow and Arsenic Concentration (Dissolved):**										2.335	0.002	0.00467
18	**Flow and Concentration Sums:**										2.51619	▨	0.01599
19												*M18/K18*	
20	**Final Concentration:**											**0.006**	