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# Assessment of Selected Environmental Surveillance and Monitoring Programs at the Waste Isolation Pilot Plant (1985-1992)

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# NMED ASSESSMENT OF SELECTED WIPP ENVIRONMENTAL SURVEILLANCE AND MONITORING PROGRAMS

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# NMED ASSESSMENT OF SELECTED WIPP ENVIRONMENTAL SURVEILLANCE AND MONITORING PROGRAMS

Draft One

## 1.0 Purpose

The purpose of this review is to assess the scope of the environmental monitoring and surveillance programs implemented at the Waste Isolation Pilot Plant (WIPP). The objective is identify potential improvements concerning program scope, data verification, and monitoring coverage at the WIPP facility. Specifically, an appraisal of past and current sampling locations, constituents monitored, and schedule of sampling will form the ground work for an NMED/WIPP environmental oversight and monitoring plan.

## 2.0 Scope

This report assesses the radiological and nonradiological environmental monitoring and surveillance programs that have been implemented during the preoperational phase of the WIPP project. Ground water, surface water, sediment, and inorganic soils programs are emphasized. The scope includes a description of sampling program plans and environmental studies appearing in the following WIPP documents:

- WIPP Ecological and Site Environmental Reports (1985-1991), and Annual Water Quality Data Reports (1986-1989);
- Operational Environmental Monitoring Plan (OEMP) (DOE/WIPP 88-025);
- Ground Water Protection Management Plan (GWPMP) (DOE/WIPP 90-008); and
- Ground Water Monitoring Program Procedures Manual (GWMP) (WIPP 02-1/Rev 2) and Environmental Procedures Manual (WIPP 02-3: Surface Water, Sediment and Soil Sampling Procedures).
- Final Safety Analysis Report (FSAR) (WP 02-9)

This assessment may reference data analysis, detection limits, and other analytical aspects of the DOE/WIPP Operational Environmental Monitoring Plan (OEMP 88-025); however, a summary review of these subjects is presented in an accompanying report (see Pat McCasland NMED/WIPP). The EEG preoperational surveillance program is referenced, where appropriate, in order to effectively guide NMED surveillance and monitoring plan efforts.

## 3.0 Statement of Problem

Environmental protection programs implemented at WIPP are guided or enforced by a variety of Federal and State regulations and DOE Orders. Some aspects of the environmental monitoring/surveillance program at the WIPP facility continue to be driven by environmental impact assessment commitments, in conformance with the National Environmental Policy Act (NEPA) (FEIS, 1980: FSEIS, 1990 DOE/EIS-0026). For regulations under review, such as RCRA CFR 264, the facility operates under DOE Order 5400.1 "General Environmental Protection Program" (DOE, 1988d). DOE Order 5400.1 may or may not be less stringent than the State or Federal regulation for which the 5400.1 order is designed to pattern; however, it forms the basis for future conformance, if required.

Figure 1 shows the primary government regulatory and DOE/WIPP drivers influencing radiological and nonradiological environmental surveillance at the WIPP facility. The Operational Environmental Monitoring Plan (OEMP), required by DOE Order 5400.1, contains the overall fundamental strategy for protecting the environment. Elements and modifications of the OEMP monitoring and/or surveillance programs plans often appear in other DOE/WIPP plans and/or procedures as well. Pat McCasland has summarized the OEMP as it was proposed in 1988 in a separate document.

Figure 1 shows OEMP environmental monitoring parameters divided into two programs: Radiological Environmental Surveillance (RES) and Nonradiological Environmental Surveillance (NES). The RES emphasizes radiological impact assessment over a rather large geographical area surrounding (50 mile radius) and encompassing the WIPP facility. The NES program concentrates on nonradiological effects of construction and operation, on or near the WIPP facility, such as air quality monitoring. The RES and NES identify the constituents to be monitored, sampling schedules, and other analytical requirements. The Ecological Monitoring Program (EMP) originally defined nonradiological constituents and sampling frequencies for an ongoing monitoring program, but in recent years the NES appears to have adopted these guidelines.

The Radiological Baseline Program (RBP) provides preoperational analytical objectives for the radiological environmental baseline of the RES. Preoperational and operational radiological programs differ in many respects, including radionuclide arrays:

- o <u>RBP</u>. The analytical array described for the RBP includes:

  Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, U-233, AM-241, Am-243, Th-232, Cm-244, NP-237, Ra-226, Cs-137, Sr-90, K-40, Co-60, natural uranium and thorium.

## DOE/WIPP DRIVERS

DOE Order 5400.1

Operational Environmental Monitoring Plan

**Radiological Environmental Surveillance**

- Airborne
- Soil
- Sediment
- Surface Water
  - Facility Run-off
  - Rural Water Tanks
- Ground Water
- Vegetation
- Wildlife
- External Radiation

**Scope of this Report**

- Ground Water Sampling
- Soil Sampling
- Sediment Sampling
- Surface Water Sampling

**Non-Radiological Environmental Surveillance**

- Air Quality
- Soil
- Sediment
- Surface Water
  - Facility Run-off
  - Rural Water Tanks
- Ground Water
- Vegetation
- Wildlife
- Meteorology
- Environmental Photography

National Environmental Policy Act | Performance Assessment CFR 191 | RCRA Concerns

## REGULATORY DRIVERS

Figure 1: A list of primary DOE and CFR programs requiring comprehensive environmental assessment for WIPP. Note Ground Water, Surface Water, Soil Chemistry, and sediment are the focus of this paper.

- o <u>OEMP</u> The analytical requirements for the OEMP include:

  Pu-238, Pu-239, Pu-240, Pu-241, U-233, U-235, Am-241, Th-232, Ra-226, Cs-137, Sr-90, K-40, Co-60, Be-7, natural uranium and natural thorium.

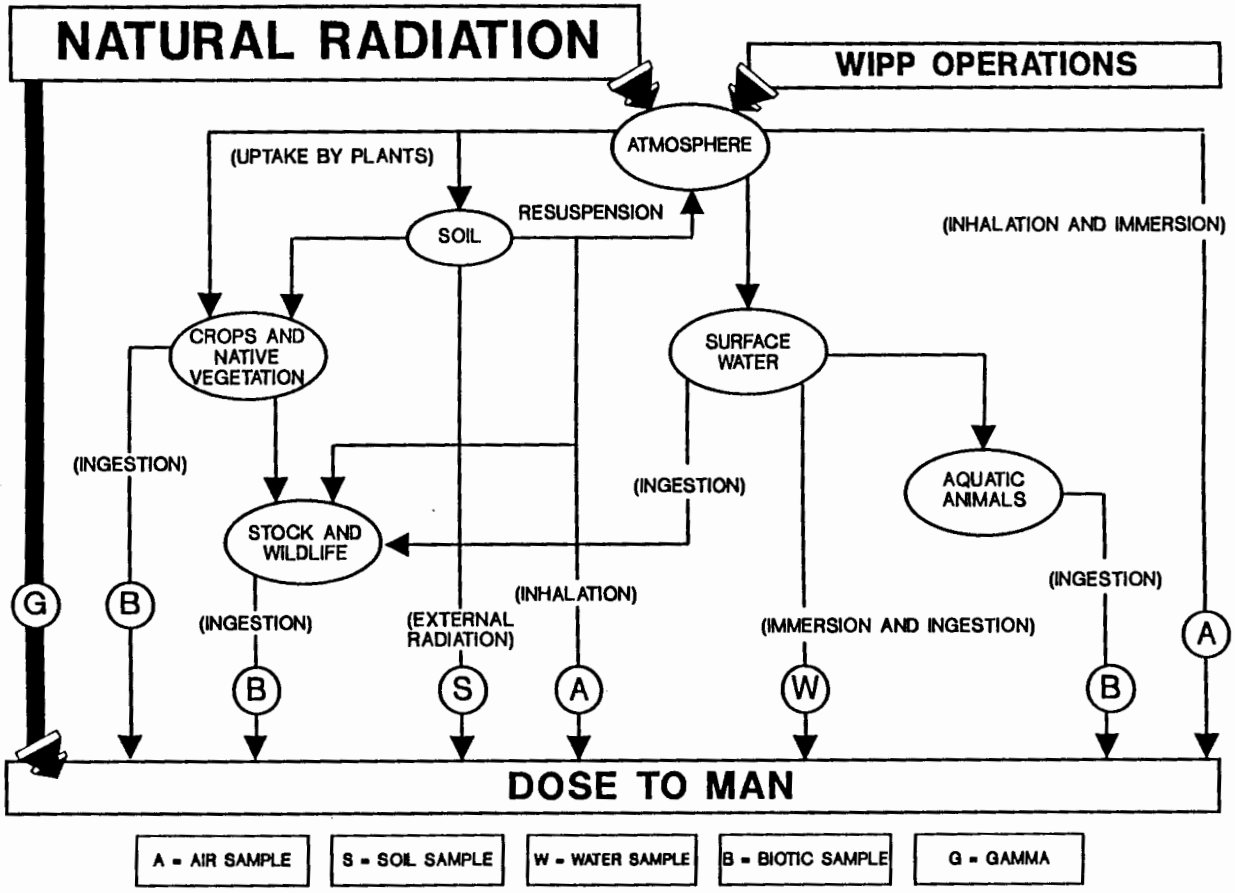
Radiological and nonradiological baseline data have been collected annually since 1985 and reported in a variety of documents. An evaluation of annual environmental reports reveals that changes have occurred from year to year in regard to sampling locations, constituents monitored, and procedures and hardware used in the environmental program. Such changes have occurred in spite of the overall plans described in the RBP and OEMP, and reveal trends which may be caused by modification of scientific or regulatory assumptions, or even budget or staffing factors. One recent change, which may influence the approach and design of some environmental programs, is the regulatory distinction being drawn between surveillance and monitoring.

Given the embryonic status of the NMED oversight and monitoring agreement, and the preoperational status of the WIPP facility, it is appropriate for NMED to provide input to the radiological and nonradiological environmental baseline. One approach could be to identify data which could be statistically improved through further sampling. Another would be to identify holes in the baseline coverage. For example, the Environmental Evaluation Group (EEG) has focused only on the radiological baseline and risk analysis. Except for nonradiological split sampling of ground water in 1985 and 1986, which was geared toward finger-printing the Culebra Formation for radionuclide transport, the EEG have not participated in the DOE/WIPP NES program. NMED contribution to the NES baseline program is one obvious opportunity, particularly in regard to the volatile organic compound (VOC) baseline.

## 4.0 Environmental Monitoring Program Assessment

Numerous DOE WIPP reports identify airborne emmisions as the most important pathway for radioactive and hazardous contaminant releases (FSAR, 1990; WP 02-9). An atmospheric release of contaminants would be represented in surface water, sediment and soil, and in turn, represented in the ecological environment (Figure 2). Direct ground water contamination is also recognized as a less probable, but potential, direct pathway to the environment (FSAR, 1990; EEG-49; EEG-34; SAND 89-7147). A sump underlying the Waste Handling Building provides a safeguard against migration of small amounts of liquids that might be generated from a spill or decontamination activities; however, the potential for contamination of soil and vadose zone contamination on or near the facility will not be precluded in this assessment.

**Figure 2: DOE position on primary pathway for contamination (radioactive and hazardous) to reach the environment as a result of transportation, handling, and waste storage activities at WIPP.**




Note: Pathways are discussed at length in the Final Safety Analysis Report; ground water and surface water are not precluded as potential direct pathways.

## 4.1 Ground Water Surveillance

Three programs implement environmental surveillance of ground water: Water Quality Sampling Program (WQSP), Water-Level Monitoring Plan (WLMP), and Pressure Density Monitoring Plan (PDMP) (DOE/WIPP 90-008; WP 02-1/Rev 2). They are described as follows:

The Water Quality Sampling Plan (WQSP) is a part of the "Ground Water Monitoring Program Procedures Manual" (WP 02-1/Rev 2). The objective of the WQSP is to define a "statistically sound" water quality baseline prior to the receipt of waste at the WIPP facility. Samples are taken annually. The WQSP supports the OEMP Radiological (RES) and Nonradiological Environmental Surveillance (NES) baseline and monitoring programs, as well as studies directed at groundwater flow regimes and the relationship between groundwater chemistry and radionuclide solubility (Plutonium and Uranium).

The Water-Level Monitoring Plan (WLMP) also occurs in WP 02-1/Rev 2. Measurements are taken monthly and quarterly at 65 operational well sites. The objective of the WLMP is to characterize ground water flow directions in the Forty-Niner and Culebra and Magenta Dolomite Members of the Rustler Formation, the Dewey Lake and Bell Canyon Formations, and along the Rustler/Salado contact.

The Water-Pressure Monitoring Plan (WPMP), the third element of WP 02-1/Rev 2, monitors formation pressures and densities. To accurately characterize hydraulic gradients of hydraulic flow systems in the vicinity of WIPP, potentiometric surfaces must be corrected for variations in fluid density that occur both vertically in the water bearing zone and aerially from well to well. Calculation of this "fresh water" head is necessary in the highly density-variable saline waters contained in the formations being monitored. These measurements were conducted between 1986 and 1988.

The RES and NES programs presented in the 1988 OEMP originally proposed groundwater sampling schedules as follows:

- Preoperational RES: Two rounds of sampling at 23 wells are stated as analytically adequate for a radiological baseline (OEMP, 1988). The 23 wells are identified in DOE/WIPP 85-002 as follows:

  H-2a, H-3a, H-3b3, H-4a, H-4b, H-5b, H-6a, H-6b, H-7b, H-8b, H-9b, H-11b3, H-12, P-14, P-17, DOE-1, DOE-2, WIPP-25, WIPP-26, WIPP-29, Engle Well, Ranch Well and Twin Well

The baseline radionuclide suite is presumed to be identical to that defined for all RBP analyses.

- Operational RES: Annual sampling at 14 well locations is stated as analytically adequate for operational monitoring. The 14 wells are identified in OEMP (1988) as follows:

  H-2, H-3, H-4, H-5, H-6, H-11, H-15, H-18, WIPP-19, DOE-1, DOE-2, Barn Well, Ranch Well, Mobley Well, Twin Well

No well subsets are identified (ie. H-2a etc.). The radionuclide suite is identical to that defined for all OEMP analyses (See Section 3.0).

- Preoperational NES: The 1988 EMP/OEMP outlines an annual monitoring program for nonradiological groundwater constituents. DOE/WIPP 85-002 "Ecological Monitoring Program" and the WQSP suggest that nonradiological sampling is conducted at the 23 WQSP wells used for the RBP program. WP 02-1/Rev 2 (WQSP-1990) identifies a list of 22 WQSP wells, which in some cases differs from the preoperational RES well list:

  H-2 (no subset), H-3b1, H-3b3, H-4b, H-4c, H-5b, H-5c, H-6b, H-6c, H-7b, H-9b, H-14, H-15, P-14, P-17, WIPP-19, WIPP-25, Barn Well, Ranch Well, and Twin Well.

- Operational NES: Early reports do not differentiate between preoperational and operational nonradiological programs, and there is no reference to an NES "baseline" (DOE/WIPP 85-002; OEMP 1988) However, several early annual environmental reports did suggest that the "ecological" program scope may change as new information becomes available.

The following sections provide a general description and assessment of the groundwater program as it has evolved. Documented RES and NES monitoring objectives, it appears, have been modified and augmented over the years. This section finds that 45 ground water wells, not 23, have actually been sampled, and that many of the original targeted wells have been sampled in exceedance of the baseline objectives, while others were never sampled. The statistical viability of the baseline is not assessed in detail; however, this review will show that such a study may be complicated by periodic changes in the annual analytical suite for successive sampling rounds of a particular well.

### 4.1.1 Sample Locations

Table 1 highlights the subset of 98 WIPP test holes (underlined) that have been modified to support ground water surveillance at the WIPP facility (SAND89-7147). Not counting private windmills, which are also underlined, these test holes were originally designed and used for a variety of purposes: WIPP site characterization, hydrologic testing (H-wells), and potash (P-wells) and oil resource evaluation (Cabin Baby). WIPP surveillance wells have cast-iron casings ranging from 6 inch to 10-3/4 inches in diameter. Seven wells have a pip and annulus construction to monitor two aquifers in the same borehole. Well casings are perforated in the zone of completion to draw samples. Well screens are not utilized. The WID Environmental Monitoring Section stresses that the wells are "observation" wells only, and were never designed or modified for long-term "monitoring" or "detection".

Most modified WIPP test wells in the program are completed in the Rustler Formation, which contains a continuous aquifer used for livestock watering in the region. Sandia and EEG studies have concurred that the Rustler Formation is the most likely pathway for contaminant migration under a number of different scenarios, including one in which the repository is breached by either natural forces or man-induced. The various hydrologic units in which WIPP observation wells are completed are illustrated in figure 3. Sampling studies of private wells have concentrated on the Dewey Lake Formation, a discontinuous zone of locally recharged perched groundwater (Table 1). The Fairview, Unger, and Ranch wells tap the Dewey Lake for livestock, while the Barn well is used by a local rancher for human consumption (DOE/WIPP 90-003). Figure 3 depicts the relative isolation of the WIPP repository; however, some workers do not preclude the possibility of man-induced blow-outs of brine pockets from formations underlying the Salado (Figure 3) (SAND91-0893).

Figure 4 shows all wells sampled as part of the WQSP between 1985 and 1991. Illegible well names can be identified in the last figure of this section. Arrows superimposed on Figure 4 represent the general direction of ground water flow in the Rustler. These flow directions are general and based on potentiometric fresh water head levels. Ground water flow can locally deviate from the general flow direction due to abundant fractures and dissolution cavities in the formation, and the variability of ground water composition inherent to the resolution provided by the observation wells (SAND 89-7147). Note that the Magenta Member/aquifer flow direction is highlighted while the Culebra flow direction is not.

Roughly 20 WQSP baseline observation wells are directly in the path of the dominant direction of ground water flow in the

## Table 1

### Documented WIPP Test Holes: Some Modified for Ground Water Surveillance

| Well | Zone | Well | Zone | Well | Zone |
|---|---|---|---|---|---|
| H-1 | (M,C) | P-1 | | USGS-1 | (C) |
| H-2a | (C) | P-2 | | DOE-1 | (C) |
| H-2b1 | (M) | P-3 | | DOE-2 | (C) |
| H-2b2 | (C) | P-4 | | DOE-2BC | (BC) |
| H-2c | (C) | P-5 | | D-268 | (C) |
| H-3b1 | (M) | P-6 | | ERDA-6 | |
| H-3b2 | (C) | P-7 | | ERDA-9 | (C) |
| H-3b3 | (C) | P-8 | | ERDA-10 | |
| H-3d1 | (DL,FN) | P-9 | | AEC-7 | (C) |
| H-4a | (M) | P-10 | | AEC-8 | (BC) |
| H-4b | (C) | P-11 | | Cabin Baby | (C) |
| H-4c | (M) | P-12 | | AIS Shaft | (C) |
| H-5a | (M,C) | P-13 | | Waste Shaft | |
| H-5b | (C) | P-14 | (C) | Exhaust Shaft | |
| H-5c | (M) | P-15 | (C) | Salt Hoist Shaft | |
| H-6a | (M) | P-16 | | Engle Well | (C) |
| H-6b | (C) | P-17 | (C) | | |
| H-6c | (M) | P-18 | (C) | | |
| H-7a | | P-19 | | | |
| H-7b1 | (C) | P-20 | | **Private Wells** | |
| H-7b2 | (C) | P-21 | | | |
| H-7c | (R/S) | WIPP-11 | | Barn Well | (DL) |
| H-8a | (M,C) | WIPP-12 | (C) | House Well | (DL) |
| H-8b | (C) | WIPP-13 | (C) | Twin Well | (DL) |
| H-8c | (R/S) | WIPP-14 | | Ranch Well | (DL) |
| H-9a | (C) | WIPP-15 | | Fairview | (DL) |
| H-9b | (C) | WIPP-16 | | Unger Well | (DL) |
| H-9c | (C) | WIPP-18 | (C) | Mobley Well | (DL) |
| H-10a | (M) | WIPP-19 | (C) | Clifton Well | (SR) |
| H-10b | (C) | WIPP-21 | (C) | Comanche Well | (SR) |
| H-10c | (R/S) | WIPP-22 | (C) | Poker Trap | (C) |
| H-11b1 | (C) | WIPP-25 | (M,C) | | |
| H-11b2 | (C) | WIPP-26 | (C) | | |
| H-11b3 | (C) | WIPP-27 | (M,C) | | |
| H-11b4 | | WIPP-28 | (R/S) | | |
| H-12 | (C) | WIPP-29 | (C) | | |
| H-14 | (C) | WIPP-30 | (M,C) | | |
| H-15 | (C) | WIPP-31 | | | |
| H-16 | (DL,M) | WIPP-32 | | | |
| H-17 | (C) | WIPP-33 | | | |
| H-18 | (C) | WIPP-34 | | | |
| | | WIPP-35 | | | |

**Explanation**

H - Hydrologic Test Hole
P - Potash Test Hole
H-12 Underline indicates wells used in water leveling and sampling programs (past and present), including private wells.

SR - Santa Rosa Formation
DL - Dewey Lake Formation
FN - Forty-Niner Member (Rustler Fm)
M - Magenta Member (Rustler Fm)
C - Culebra Member (Rustler Fm)
R/S - Rustler Salado Contact
BC - Bell Canyon Formation

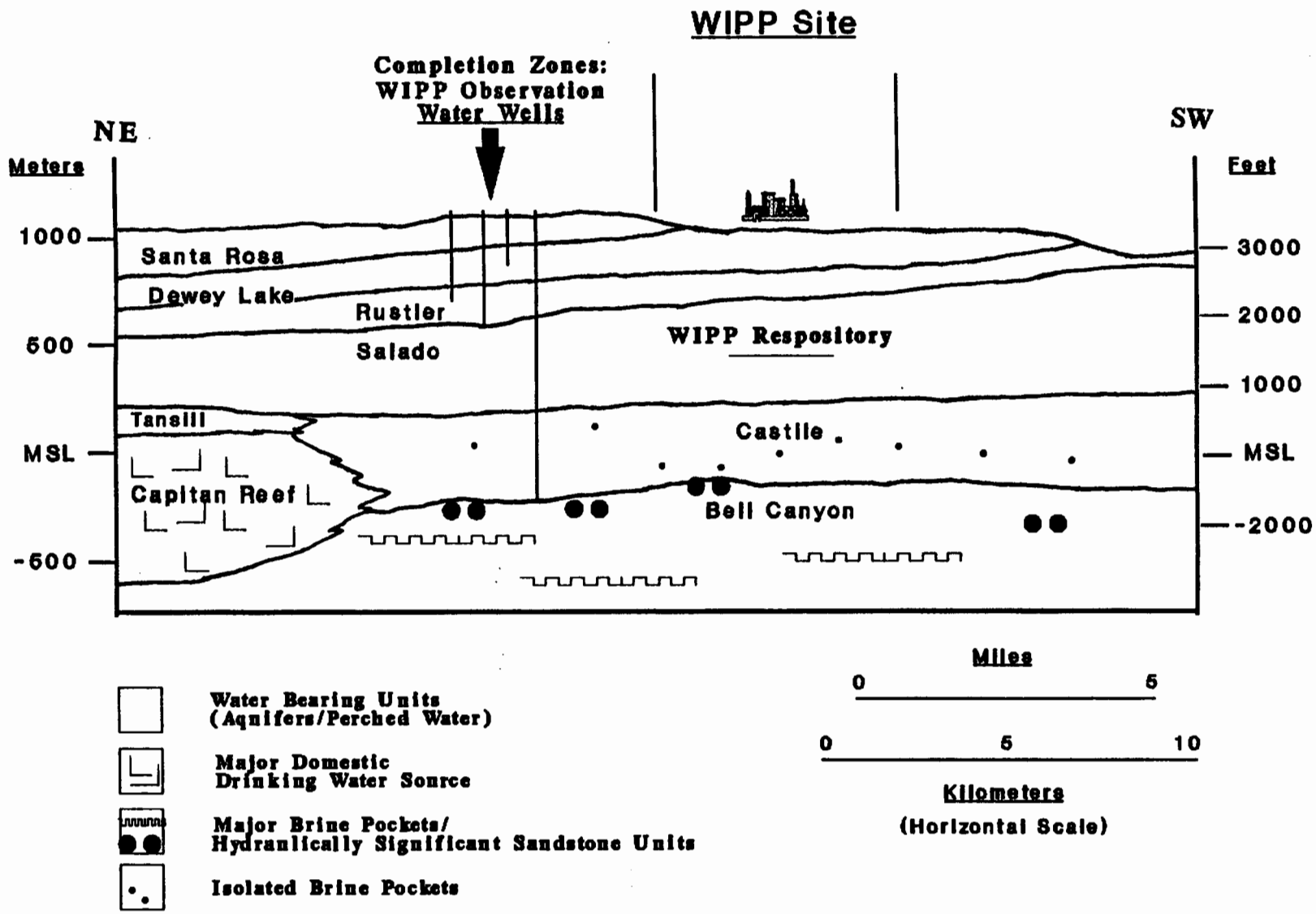



**Figure 3: Schematic geologic cross-section illustrating hydrologic units.**

Culebra (Figure 4). Four wells are located to the west in line with lateral Culebra flow and the dominant Magenta flow direction. Westward observation wells, however, are not completed in the Magenta formation, despite possible hydraulic continuity with shallow ground water in Nash Draw and nearby surface water bodies. The WIPP wells to the west in Nash Draw have the shallowest measured static water levels of WQSP observation wells, measuring in the Culebra between 10 (WIPP-29) and 135 (WIPP-26) feet below top of casing (TOC). Wells to the east of the facility, designed to encounter eastward lateral flow of the Culebra, are the least represented of WIPP WQSP baseline wells. It is uncertain why no modified WIPP test holes were completed for surveillance of the Dewey Lake perched aquifer.

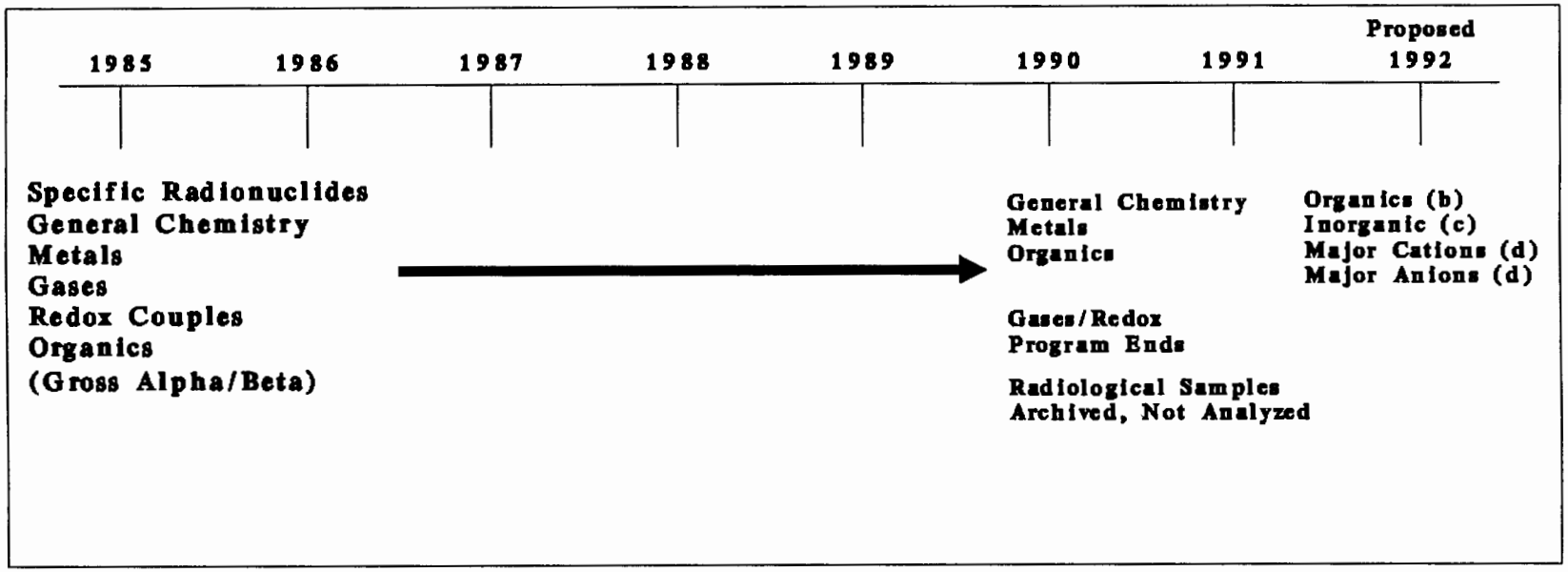
DOE WIPP does not appear to participate in the radiochemical sampling of nearby municipal water supplies. The EEG and EPA, however, have conducted radiological baseline studies for this pathway. The EEG has sampled drinking water systems for Carlsbad, Loving, and Otis four times, and the WIPP facility drinking supply twice. EEG's RES baseline studies are now limited to a handful of private wells; no split samples were accepted from Westinghouse by EEG in 1991. EPA conducts annual testing related to project Gnome, a decommissioned nuclear test site south of WIPP, and publishes collected data in EPA "Offsite Environmental Reports for Nuclear Test Areas Around the United States".

### 4.1.2 Constituents Sampled

Tables 2 and 3 outline the historical scope of the radiological and nonradiological environmental surveillance programs at WIPP since 1985. General chemistry, gas content and oxidation/reduction (redox) samples provide needed data on the solubility and transport of radionuclides in water-bearing zones. Gas and redox sampling ceased after 1989. The general chemistry and metals groups are used to identify mixing between aquifers (ie. Salado vs Rustler), as a check against the accuracy of field lab measurements taken during well drawdown, and as an environmental baseline.

Radiological sampling and analyses of groundwater occurred between 1985 and 1989. DOE WIPP 90-003 stated that groundwater baseline requirements defined in the original RBP were satisfied during this period and that future groundwater samples would be archived for RES analyses beginning in CY 1990. Table 3 lists the radionuclides analyzed in final groundwater samples through 1989. Note the following

Table 2: History of constituents monitored for the ground water baseline - Water Quality Sampling Program and OEMP(a)




(a) - Includes both radiological and nonradiological constituents defined originally in the Radiological Baseline Program (RBP) and Ecological Monitoring Program (EMP).

(b) Selected volatile and semi-volatile waste constituents

(c) Selected waste stream metals
(d) Selected metals and general Chemistry

## Table 3: List of constituents sampled for ground water baseline - Water Quality Sampling Program and OEMP(a)

| General Chemistry | Metals | Gases (c) | Redox Couples (c) | Radionuclides | Organics |
|---|---|---|---|---|---|
| Alkalinity | Aluminum | Argon | Ammonia | Am-243 (RBP) (b) | Volatiles |
| Bromide | Antimony | Oxygen | Nitrate | Pu-242 (RBP) | Semi-Volatiles |
| Chloride | Arsenic | Nitrogen | Total Iron | Am-241 (RBP/OEMP) | PCB's |
| Cyanide | Barium | Carbon Dioxide | Ferrous Iron | Pu-241 (RBP/OEMP) | Pest/Herbicides |
| Flouride | Beryllium | Carbon Monoxide | Arsenic (III) | Pu-239/240 (RBP/OEMP) | |
| Iodide | Boron | Methane | Arsenic (Total) | Pu-238 (RBP/OEMP) | |
| Nitrate | Cadmium | Ethane | Iodide | U-238 (RBP/OEMP) | |
| pH | Calcium | C-3 | Iodate | U-235 (OEMP) | |
| Phenolics | Cesium | C-4 | Selenium (IV) | U-234 | |
| Phosphate, Total | Chromium | C-5 | Selenium (Total) | U-233 (RBP/OEMP) | |
| Residue, Filterable | Cobalt | C-6 | | Th-232 (RBP/OEMP) | |
| Residue, Nonfilterable | Copper | Sum of CO2 | | Th-230 | |
| Specific Conductance | Iron | Total Gas | | Th-228 | |
| Sulfate | Lead | | | Ra-228 | |
| Total Organic Carbon | Lithium | | | Ra-226 (RBP/OEMP) | |
| Total Organic Halogen | Magnesium | | | Np-237 (RBP/OEMP) | |
| | Manganese | | | Cm-244 (RBP/OEMP) | |
| | Mercury | | | Pb-210 | |
| | Molybdenum | | | Cs-137 (RBP/OEMP) | |
| | Nickel | | | CO-60 (RBP) | |
| | Potassium | | | Po-210 | |
| | Selenium | | | Tritium (1988 Only) | |
| | Silica | | | K-40 (RBP/OEMP; 1988 Only) | |
| | Silver | | | Sr-90/Yt-90 (RBP/OEMP; 1988 Only) | |
| | Sodium | | | Be-7 (RBP, no recorded samples) | |
| | Strontium | | | | |
| | Thallium | | | | |
| | Tin | | | | |
| | Titanium | | | | |
| | Zinc | | | | |

Note: Compare with EEG Ground Water Analytical Suite:
Am-241, Pu-239/240, Pu-238, U-238, U-235, Th-232, Th-230, Th-228, Ra-228, Ra-226, Cs-137, Tritium, Sr-90, Gross A/B.

(a) Includes constituents monitored for Radiological Environmental Surveillance (RES) and Nonradiological Environmental Surveillance (NES).

(b) RBP - Radiological Baseline Program began in 1985 for preoperational radiological environmental data and component of RES. OEMP - Operational Environmental Monitoring Plan to change scope of RES program once facility is operational.

(c) Gases and Redox Couples mainly for performance assessment purposes.

inconsistencies found between preoperational and operational RES objectives and the actual RES analytical suite:

- Be-7 and U-235 are included in the 1988 OEMP, but an RES baseline has never been established;

- Cm-244 and Np-237 are radionuclides present in WIPP waste; however, they are not included in the operational analytical array; and

- Only one sampling round exists for baseline radionuclides K-40 and Sr-90.

Gross alpha and beta measurements were also part of the annual final sample analytical suite for ground water 1985-1989. No evidence was found to support a claim in FSAR (1990) of semi-annual gamma spectra or gross alpha or beta analyses.

Presently, general chemistry, metals, and organic pollutants, NES categories defined in the original EMP, are the principle groundwater constituents monitored and analyzed for WIPP on an annual basis. The organic component of the nonradiological groundwater sampling program has consistently included volatiles, semi-volatiles, PCB's and pesticides (Table 3). The organic constituents making up these chemical groups have conventionally been taken from hazardous substance lists published in the Code of Federal Regulations (CFR) with no emphasis on waste stream.

Table 4 is compilation of groundwater wells sampled between 1985 and 1991. Constituent sample rounds per well are compiled solely from published Ecological Monitoring Program Reports, Annual Water Quality Data Reports, and Site Environmental Reports for calendar years 1985 through 1990. Beginning in annual report 90-003 (CY-1989), all NES and RES groundwater analytical information was reported in Site Environmental Reports.

It is evident that RES analytical and statistical objectives have been met for the majority of original and new groundwater baseline and WQSP wells. Between 1985 and 1989, radiochemistry analyses are documented at 44 of the 45 wells that were sampled, nearly double the original 23 wells. Exceptions include:

- H-1, H-17, WIPP-13, and WIPP-30, which although never officially on a preoperational baseline list, have not been sampled a minimum of two times, a requirement of the RBP; and

- H-1, H-18, WIPP-13, WIPP-30, USGS-1, and the Air Intake Shaft (AIS), which were never verified by the EEG.

## Table 4
## Groundwater Wells Sampled for the Waste Isolation Pilot Plant 1985 -1991 and Constituent Sample Rounds 1985-1990.

| Baseline Wells | # of Samples RES | # of Samples NES | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | Proposed 1992 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1) H-1 | 1 | 1 | | | | | | | | |
| 2) H-2a | 3 | 3 | *H-3b1^* | H-2a^ | H-2a^ | H-1^ | H-2a^ | *H-2c<* | H-2c | H-2c |
| 3) H-2b1 | 0 | 1 | *H-3b3^* | *H-3b1^* | *H-3b1^* | H-4c^ | H-2b1< | H-3b1< | H-3b1 | H-3b3 |
| 4) H-2c | 2 | 2 | *H-4b^* | *H-3b3^* | H-3b3^ | H-5b^ | H-2c^ | H-3b3< | H-3b3 | H-4b |
| 5) H-3b1 | 5 | 5 | *H-5b^* | *H-4b^* | *H-4b^* | H-5c^ | H-3b1^ | H-4b< | H-4b | H-5b |
| 6) H-3b3 | 5 | 5 | *H-6b^* | *H-4c^* | H-4c^ | H-6c^ | H-3b3^ | H-4c< | H-4c | H-6c |
| 7) H-4b | 5 | 5 | H-8a< | *H-5b^* | H-6b^ | H-7b1^ | H-4b^ | H-5b+ | H-5b | H-11b3 |
| 8) H-4c | 5 | 5 | *H-9b^* | *H-5c^* | *H-6c^* | H-8b^ | H-4c^ | H-5c< | H-5c | H-14 |
| 9) H-5b | 5 | 6 | *H-11b3^* | *H-6b^* | *H-7b1^* | H-9b^ | H-5b< | H-6b+ | H-6b | WIPP-19 |
| 10) H-5c | 5 | 4 | *H-12^* | H-6c^ | *H-8b^* | H-12^ | H-5c< | H-6c+ | H-6c | |
| 11) H-6b | 6 | 6 | *WIPP-26^* | *H-7b1^* | *H-9b^* | H-14^ | H-6b< | H-7b1< | H-14 | |
| 12) H-6c | 5 | 4 | *WIPP-29^* | *H-8b^* | *H-11b3^* | H-15^ | H-6c< | H-9b+ | WIPP_19 | |
| 13) H-7b1 | 5 | 4 | *DOE-1^* | *H-11b3^* | *H-12^* | H-18^ | H-7b1< | H-11b3< | *Barn* | |
| 14) H-8a | 0 | 1 | *DOE-2BC^* | *P-14^* | *H-14^* | P-14^ | H-11b3< | H-18+ | Twin | |
| 15) H-8b | 3 | 3 | *DOE-2* | *P-17^* | *H-15^* | WIPP-19^ | H-14^ | WIPP-19< | Ranch | |
| 16) H-9b | 4 | 4 | *Engle^* | *WIPP-25^* | *H-17^* | WIPP-25^ | WIPP-19< | *Barn<* | | |
| 17) H-11b3 | 6 | 6 | | *DOE-1^* | H-18^ | WIPP-26^ | WIPP-25< | Twin< | **EEG** | |
| 18) H-12 | 3 | 2 | | *DOE-2^* | *P-14^* | WIPP-30^ | Barn< | Engle+ | | |
| 19) H-14 | 3 | 3 | | *Ranch^* | *P-17^* | DOE-2^ | Ranch< | Ranch< | *Barn* | |
| 20) H-15 | 3 | 3 | | *Twin^* | *WIPP-13>* | USGS-1^ | *Twin<* | | *Hill* | |
| 21) H-17 | 1 | 1 | | | *WIPP-19^* | AIS^ | **EEG** | **EEG** | *Ranch* | |
| 22) H-18 | 3 | 3 | | | *WIPP-25<* | *Barn^* | | | | |
| 23) P-14 | 3 | 3 | | | WIPP-29^ | *Twin^* | *Mobley* | *Barn* | | |
| 24) P-17 | 3 | 2 | | | *DOE-1^* | *Unger^* | | *Mobley* | | |
| 25) WIPP-13 | 1 | 1 | | | *Barn^* | *Mobley^* | | | | |
| 26) WIPP-19 | 5 | 5 | | | *Engle^* | *Fairview^* | | | | |
| 27) WIPP-25 | 3 | 4 | | | *Unger^* | *Comanche^* | | | | |
| 28) WIPP-26 | 3 | 3 | | | *Mobley^* | *Clifton^* | | | | |
| 29) WIPP-29 | 2 | 2 | | | *Fairview^* | *Ranch^* | | | | |
| 30) WIPP-30 | 1 | 1 | | | *Ranch^* | *Poker Trap^* | | | | |
| 31) DOE-1 | 3 | 4 | | | *Comanche^* | | | | | |
| 32) DOE-2 | 3 | 4 | | | *Clifton^* | **EEG** | | | | |
| 33) DOE-2(BC) | 1 | 1 | | | *Poker Trap^* | *2a* | | | | |
| 34) USGS-1 | 2 | 1 | | | | *3b3 (see note)* | | | | |
| 35) AIS | 1 | 1 | | | | | | | | |
| 36) Barn | 4 | 5 | | | | | | | | |
| 37) Twin | 4 | 5 | | | | | | | | |
| 38) Engle | 3 | 3 | | | | | | | | |
| 39) Unger | 2 | 2 | | | | | | | | |
| 40) Mobley | 2 | 2 | | | | | | | | |
| 41) Fairview | 2 | 2 | | | | | | | | |
| 42) Comanche | 2 | 2 | | | | | | | | |
| 43) Clifton | 2 | 2 | | | | | | | | |
| 44) Poker Trap | 2 | 2 | | | | | | | | |
| 45) Ranch | 4 | 4 | | | | | | | | |

### Explanation of Symbols

(^) - RES and NES samples, including organics.
(<) - Nonradiological samples only
(>) - RES and NES samples, excluding organics.
(+) - Nonradiological; only samples having organic analyses during CY 1990

DOE-1 - Underline indicates EEG general chemistry analysis
*DOE-1 - Italics indicate EEG radiochemistry analysis*

Note: No record of DOE sampling in 1986 of 2a and 3b3
Note: CY 1991 samples not counted in # of rounds per well

As stated earlier, a preoperational and operational NES distinction has never been stated in the literature. Nevertheless, if a two sample baseline is assumed, the number of NES sample rounds per well suggests that the following wells are deficient:

H-1, H-2b1, H-8a, H-17, WIPP-13, WIPP-30, and the AIS.

NES baseline wells have yet to be verified by any independent oversight group, regardless of an assumed statistical acceptability.

4.1.3 Findings, Issues, and Opportunities

1) Non-Radiological Surveillance. NMED needs to immediately begin verification of collected NES general chemistry, metals and organic environmental data. The objectives would be to establish an NMED NES baseline prior to receipt of mixed waste, and to monitor current impacts of the facility.

2) Radiological Surveillance. NMED can contribute to improvements in the radiological environmental surveillance program, as identified in Section 4.1.2. Gross alpha and beta, and gamma spectroscopy, and analysis for actinides, also represent operational parameters for NMED to explore monitoring.

3) 1992 Sampling and NMED Observation. NMED needs to develop procedures and prepare for eventual participation in the WQSP final sample collection process outlined in Table 5. Sample parameters, sample volumes, and number of samples to be taken at each well CY 1992 location are described in table 5. Final samples are withdrawn after 24 to 48 hours of continuous pumping, when "serial" sampling indicates a chemical steady state. Groundwater sampling is scheduled March through October during CY 1992.

4) Eight wells are proposed for sampling in 1992 (Larry Madl, Pers. Comm. 1992). The 8 wells, listed in table 4 and highlighted in figure 5, are a subset of the operational wells proposed in the 1988 OEMP. All of the proposed 1992 wells have been sampled from five to six times, and are located within the ZONE II boundary. Zone II encompasses the surface projection of the proposed underground development of the repository. This well selection represents a fundamental change in operational sampling strategy which may be incorporated into the next revision of the OEMP (in progress).

5) NMED may have to concentrate on WIPP observation wells located within two miles of the fenced boundary (Zone II) for CY

## Table 5
## WQSP Final Samples Checklist Procedure and Distribution

| SAMPLE NUMBER | PARAMETERS | SAMPLE FOR | DESTINATION | NUMBER OF | CONTAINERS VOLUME | TYPE | ACID WASH | SAMPLE FILTER | PRESERVATIVE | COLLECTION TIME |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GENERAL CHEMISTRY | W | IT PITTS. | 2 | 1 LITER | PLASTIC | NO | NO | NONE | _____ |
| 2 | ANIONS | W | IT PITTS. | 2 | 1 LITER | PLASTIC | YES | YES | NONE | _____ |
| 3 | TOC/TOX | W | IT PITTS. | 1 | 500 ml | AMBER GLASS | NO | NO | H2SO4, pH<2 | _____ |
| 4 | PHENOLS/PHOSPHATE | W | IT PITTS. | 1 | 1 LITER | AMBER GLASS | NO | NO | H2SO4, pH<2 | _____ |
| 5 | METALS/CATIONS | W | IT PITTS. | 1 | 1 LITER | PLASTIC | YES | YES | HNO3, pH<2 | _____ |
| 6 | MERCURY | W | IT PITTS. | 2 | 8 oz. | GLASS | NO | YES | HNO3, pH<2 | _____ |
| 7 | CYANIDE | W | IT PITTS. | 1 | 1 LITER | PLASTIC | NO | NO | NAOH, pH<12 | _____ |
| 8 | GENERAL CHEMISTRY | EEG | EEG | 1 | 1 LITER | PLASTIC | NO | YES | NONE | _____ |
| 9 | RADIONUCLIDES | EEG | EEG | 2 | 1 Gal. | PLASTIC | YES | YES | HNO3, pH<2 | _____ |
| 10 | TRITIUM | EEG | EEG | 1 | 8 oz. | GLASS | NO | NO | NONE | _____ |
| 11 | GENERAL | SNL | SNL | 1 | 1 LITER | PLASTIC | NO | NO | NONE | _____ |
| 12 | GENERAL | SNL | SNL | 3 | 1 LITER | PLASTIC | YES | YES | NONE | _____ |
| 13 | GENERAL | SNL | SNL | 3 | 1 LITER | PLASTIC | YES | YES | HNO3, pH<2 | _____ |
| 14 | ISOTOPES | SNL | SNL | 2 | 4 oz. | GLASS | NO | NO | NONE | _____ |
| 15 | RADIONUCLIDES | W | WESTINGHOUSE | 2 | 1 Gal. | PLASTIC | YES | YES | HNO3, pH<2 | _____ |
| 16 | TRITIUM | W | WESTINGHOUSE | 1 | 8 oz. | GLASS | NO | NO | NONE | _____ |



Well Number:
Filter Type: Whatman
Pore Size: 0.45 um

1992. NMED or NMED/EPA could develop the capability of independent groundwater sampling; however, for the immediate future, NMED can only initiate independent sampling schedule in the following cases:

- o Radiological verification of public drinking water fields;
- o Nonradiological baseline sampling of public drinking water fields; and
- o RES and NES sampling of private drinking wells in the vicinity of WIPP (windmills).

6) Ongoing NES issues that must be resolved by NMED include the validity of the groundwater organic sampling program and limits of detection for nonradiological constituents. Fundamental questions that need to be addressed in a subsequent assessment include:

- o the lack of or deficiency in groundwater VOC sampling procedures;
- o potential decreases in VOC concentrations in groundwater during sampling, caused by possible turbulence of the ground water as it is pulled through perforated openings in the well completion zone;
- o verification that the methodology and threshold values for lower limits of detection for nonradiological constituents are consistent with EPA and New Mexico Drinking Water Standards;
- o modification of current reporting practices that include only data above the limit of detection; measured values are not presented.

7) Table 6 lists the NES constituents proposed for contract lab analysis for the 1992 sampling season. The proposed 1992 constituent array represents a swing away from what Westinghouse considers unnecessary sampling, with more emphasis on waste stream constituents likely to be transported to the WIPP repository. A cursory comparison with Tru-Con waste stream codes indicates an overall correlation with the proposed waste stream sampling plan. There are exceptions, however, such as methyl ethyl ketone (Lawrence Livermore), that suggest NMED should scrutinize and verify the proposed 1992 sampling plan in more depth.

8) An operational RES program is proposed for CY 1992, on the assumption that mixed waste may be received at the site (Larry

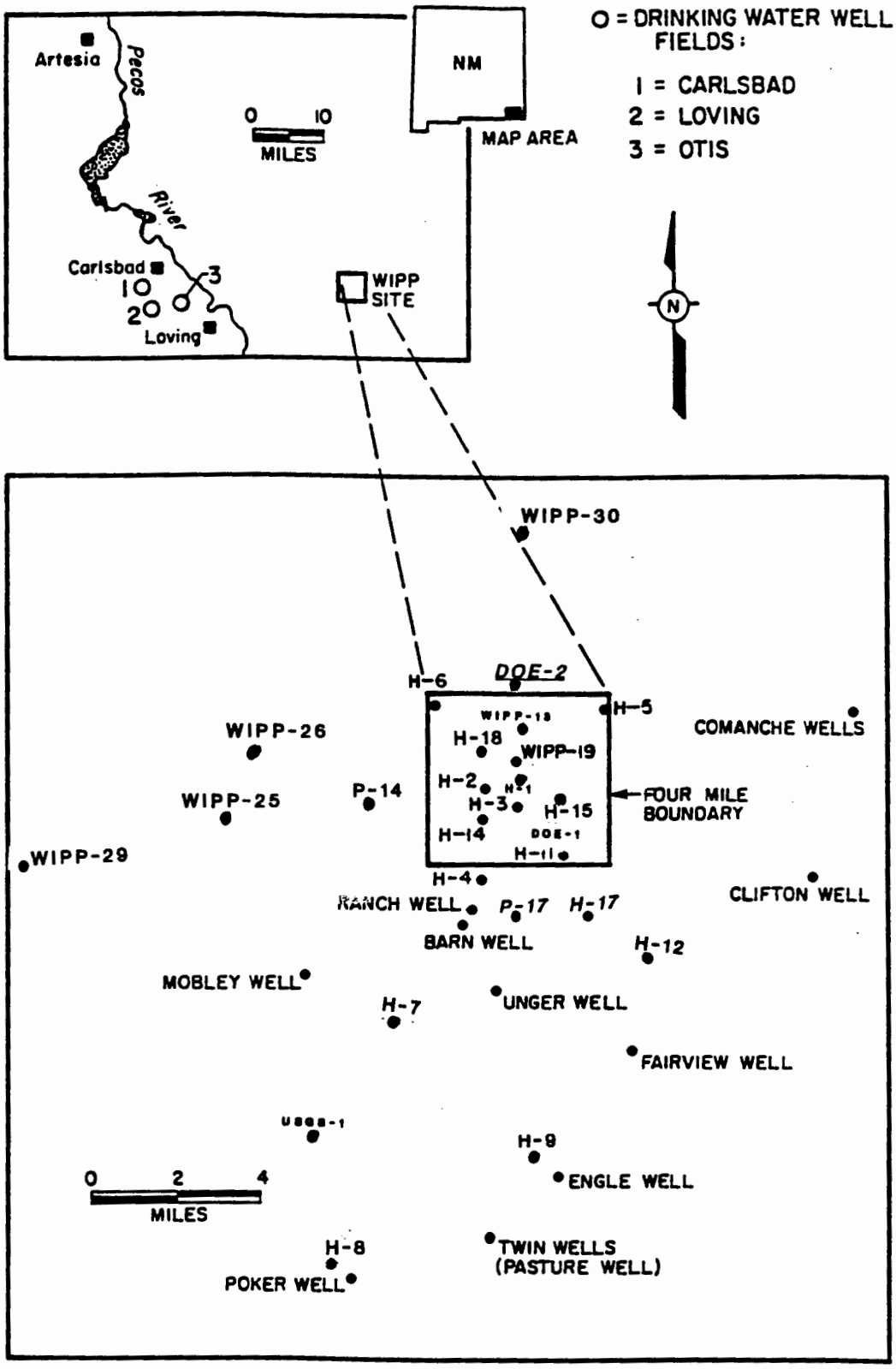



**Figure 5: Preliminary well locations selected for 1992 WQSP**

The ground water wells shown above represent all locations sampled for the Water Quality Sampling Plan (WQSP) 1985-1991. This figure is a diagrammtic depiction of well locations presented in figure 4, which shows topography and Rustler groun water flow.

## Table 6: Preliminary List of Constituents Proposed for Ground Water Analysis for 3/92 - 10/92.

| Organic Compounds (VOC's and Semi-VOC's) | Inorganic Compounds (Metals) | Cations | Anions |
|---|---|---|---|
| Acetone | Cadmium | Sodium | Chloride |
| Perchloroethylene (Tetrachloroethylene) | Beryllium | Magnesium | Sulfate |
| NitroBenzene | Lead | Potassium | Bromide |
| 1,1,1-Trichloroethane | Mercury | Calcium | Fluoride |
| Carbon Tetrachloride | Silver | | Alkalinity |
| 1,1,2-Trichloro-1,2,2-Trifluoroethane | Selenium | | |
| Methylene Chloride | Chromium | | |
| Xylene | Barium | | |
| Methanol (Methyl Alcohol) | Reactive Lithium | | |
| Butanol (Butyl Alcohol) | Iron | | |
| Toluene | | | |
| Ethylbenzene | | | |
| Trichloroethylene | | | |
| Tetrachloroethylene | | | |
| 1,2-Dichloroethylene | | | |
| Chloroform | | | |
| 1,1,2,2-Tetrachloroethane | | | |
| Cyclohexane | | | |
| Dichloroethane | | | |
| Sodium Chromate | | | |

Note: Organic and inorganic compounds are designed as waste stream specific. NMED has not verified accuracy.

Madl, personal communication). The following underlined radionuclides are proposed:

> Pu-238, Pu-239, Pu-240, Pu-241, U-233, U-234, U-238, Am-241, Th-228, Th-230, Th-232, Ra-226, Cs-137, Sr-90, Co-60, Cm-244 and Np-237

The proposed list deviates from the OEMP (1988); however, responds to the conclusion in Section 4.1.2 regarding the absence of Cm-244 and Np-237 on the 1988 OEMP list of RES operational parameters.

9) Current groundwater observation wells are not suitable for detection, and will not have the operating life necessary for long-term monitoring. Unofficially, there is acceptance that new monitoring wells will be required or voluntarily operated in response to CFR 191 Performance Assessment issues, regardless of a proposed No-Migration (CFR 268) or groundwater monitoring waiver (CFR 264) determination. When the need for a CFR 191 "groundwater monitoring" network is officially recognized, consideration should be given to the following:

- Well completions in the Dewey Lake perched aquifer within Zone II;
- Well completion in the westward direction of WIPP in the Magenta formation, within or just outside Zone II, to account for hydraulic continuity with shallow ground water or surface water bodies;
- Continued monitoring of the Culebra within or just outside Zone II, including eastward of the WIPP facility; and
- Continued analyses for all RES and NES WIPP waste stream components.

## 4.2 Surface Water Surveillance

Procedures for radiological (RES) and nonradiological (NES) sampling and handling of surface water are contained as sections in the controlled document "Environmental Procedures Manual" :

RES Surface Water and Sediment Sampling Procedures WP 02-309.

NES Surface Water and Sediment Sampling Procedures WP 02-345.

As with all environmental monitoring at the WIPP facility, the RES and NES sampling frequency and analytical requirements of the surface water and sediment monitoring programs are derived from the Radiological Baseline Program (RBP), the Ecological Monitoring Program (EMP), and the Operational Environmental Monitoring Plan (DOE/WIPP 88-025). These programs, as originally proposed, consisted of the following:

- Preoperational RES: Annual sampling at 10 locations until operational sampling begins. The RBP analytical array consists of Tritium and RBP "specific radionuclides" defined in Section 3.0 of this report.

- Operational RES: Annual sampling at 8 of 10 baseline locations. The radionuclide analytical array is identical to other OEMP "specific radionuclides", but also includes monitoring of gross alpha and beta.

- Preoperational NES: Annual sampling at 10 existing RBP sampling locations (OEMP, 1988). No limit on the number of sampling rounds required for a statistically accurate baseline is defined in OEMP (1988). The EMP provided for sampling of the following constituents groups:

  - General Chemistry
  - Metals
  - Organics

- Operational NES: The 1988 OEMP proposes operational NES biennial sampling for Hill Tank and Red Tank only. Specific operational parameters include:

  - Total Dissolved Solids (TDS),
  - Ph
  - General chemistry, metals, and organic analyses.

The 1988 OEMP sampling schedule also commits to preoperational and operational semi-annual RES and NES sampling and analyses

of liquid influent and effluent associated with the sewage system (OEMP, 1988-Section 6.1). This sampling program is a component of WIPP Facility Operations (WP 04-1) and is not administered by the Environmental Monitoring Section. No reference to this program appears in annual environmental monitoring reports.

### 4.2.1 Sample Locations

Figure 6 is a generalized map view of baseline RES and NES surface water sampling locations. Sampling sites include livestock tanks, locations along the Pecos River, and salt lakes in the region. All RES and NES sampling was conducted between 1985 and 1988.

- RES Sampling. Eight RES baseline locations were sampled in December 1985, the same eight locations in April and October 1986, six locations in 1987, and ten locations in 1988. DOE WIPP sampling occurred at these locations according to the following schedule:

  1985: Upper Pecos River in Artesia, Brantley Lake/Lake McMillan, Lake Carlsbad/Pecos River, Pierce Canyon, Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank.

  1986: Upper Pecos River, Brantley Lake, Lake Carlsbad, Pierce Canyon/Malaga Bend, Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank.

  1986: Upper Pecos River, Brantley Lake, Lake Carlsbad, Pierce Canyon, Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank, Hill Tank, Noye Tank.

  1987: Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank, Hill Tank, Noye Tank.

  1988: Upper Pecos River, Brantley Lake, Lake Carlsbad, Pierce Canyon, Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank, Hill Tank, Noye Tank.

Underlined locations above indicate that a split sample was collected by EEG. In addition, the group collected samples from many of these same locations during 1989, 1990 and 1991. The EEG has focused solely on radiological analyses.

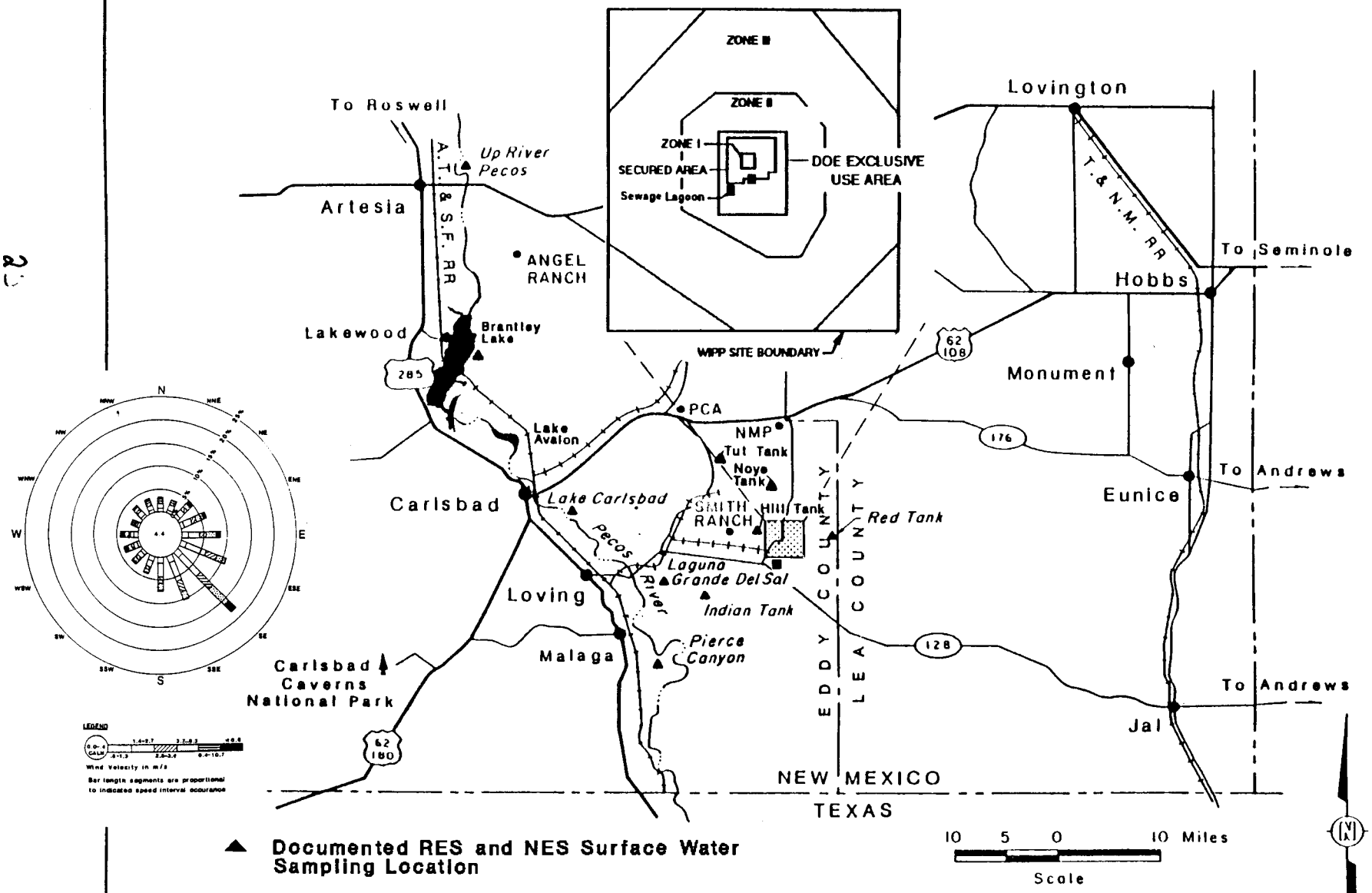



**Figure 6: Surface water sampling locations and 1986 windrose. Box symbols depict undocumented sampling sites.**

- NES Sampling. NES sampling was conducted at four fixed locations 1986-1988; once in CY 1986, twice in 1987, and once in 1988. NES surface water sampling focused on Hill Tank, Red Tank, Indian Tank and Laguna Grande de Sal.

- Liquid Effluent. The DOE/WIPP 91-008 SER for CY 1990 identified several undocumented RES and NES surface water program sampling sites, and suggested that annual samples had been collected at these locations 1985-1988 for the RES and NES surface water baseline. This investigation establishes verbal confirmation of RES and NES sampling at the sewage lagoon; however, there are no published RES or NES analyses for the sewage lagoon, or published sampling plans or environmental data for the two sites depicted within or near the secured boundary in Figure 6. The sampling location identified in DOE/WIPP 91-008 and figure 6, near the intersection of Highway 128 and the South Access Road, is also undocumented.

Atmospheric migration of hazardous and radioactive particulates is deemed the primary pathway for contamination of surface waters in the vicinity of WIPP (FSAR, 1990). Figure 6 indicates that the present configuration is designed more for the predominant southeast wind direction, and that NE and SE azimuths are emphasized less.

There is reference in DOE/WIPP 87-002 that in some cases nearby Laguna Tres has been sampled and reported as Laguna Grande de Sal in analyses summaries. Laguna Tres is one of several shallow surface water bodies in the area. Since 1942, these smaller lakes appear to have become fully developed as a result of potash spoil ponds, debris and effluent and oil-well brine discharge in the area (Hunter, 1985). Laguna Grande, the largest and only recognized natural feature of the area, is also reported to have grown substantially during this time period (Brinster, 1991). Nevertheless, all are influenced by natural processes, such as collection of precipitation, surface drainage, and groundwater discharge from springs and seeps tapping the Rustler formation. They may prove to be viable surface water sampling sites, at least for determining an RES and NES baseline.

The WID Environmental Monitoring Section (EMS) is in the process of proposing a 1992 Surface Water surveillance plan and is also planning to make fundamental changes to the program in the next OEMP (in revision). The 1992 locations, if approved, have not yet been selected as of January, 1992, and the OEMP surface water section has not been revised. Potential issues that should be addressed include:

- An assessment of past and potential surface water sampling locations based on an analysis of run-off patterns from

watersheds supplying a particular surface water body. Aerial photographs and detailed topographic maps will be required for this analysis.

- Environmental protection of surface water bodies in the vicinity of the facility which may be mostly of artificial origin. The Environmental Protection Agency (EPA) has taken steps to protect nearby Laguna Quatro from oil field residual liquids, including sampling for hazardous constituents. Aerial radiological surveys indicate that Laguna Quatro is also a strong gamma radiation source (EG&G, 1989).

- NMED sampling of additional artificial/natural surface water bodies in a baseline or monitoring program.

### 4.2.2 Constituents Sampled

The RES and NES constituent groups analyzed for each surface water sampling site are presented in Figure 7. Analytical results of laboratory analyses used to compile the matrix are reported in Ecological Monitoring Program reports (EMP) and Annual Site Environmental reports (SER) for CY 1985, 1986, 1987, and 1988. RES and NES sampling activities are now published together in annual SER's.

- RES Sampling. Radiological analytical laboratory analyses (1985-1988) reveal that 20 radionuclides have been sampled for the surface water radiological baseline. These elements are underlined and keyed to the combined radionuclide arrays proposed in the original RBP and OEMP.

| | | | |
|---|---|---|---|
| Pu-238 | (RBP/OEMP)* | Cm-244 | (RBP) |
| Pu-239 | (RBP/OEMP)* | Np-237 | (RBP) |
| Pu-240 | (RBP/OEMP)* | Ra-226 | (OEMP)* |
| Pu-241 | (RBP/OEMP) | Ra-228 | * |
| Pu-242 | (RBP) | Th-228 | * |
| U-233 | (RBP/OEMP)* | Th-230 | (RBP/OEMP)* |
| U-234 | * | Th-232 | (RBP/OEMP)* |
| U-235 | (OEMP)* | Cs-137 | (RBP/OEMP)* |
| U-238 | (RBP/OEMP)* | Am-241 | (RBP/OEMP)* |
| Sr-90 | (RBP/OEMP)* | Am-243 | (RBP) |
| Be-7 | (OEMP) | Co-60 | (RBP/OEMP) |
| H-3 | * | K-40 | (RBP/OEMP) |

A review of the literature and comparison of the proposed and actual sampling programs reveals several observations:

- Ten locations have been sampled two to three times for the radionuclides listed above, most are below limits of detection (LD), and microcurie/ml values for LD's are not listed;

## Figure 7: Constituents Monitored and Sample Rounds for WIPP Surface Water Environmental Baseline 1985-1988

● Radiological (RES) ○ Non-Radiological (NES) (C) Composite (RES samples only)

(5) # of Sample Rounds

| | Radiological Tritium | General Chemistry | Metals Cations | Nutrients | Phenols/ Phosphate | Cyanides | Mercury | VOC (400 ml glass) | TOC/TOX | TDS/TSS |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper River Pecos (Artesia) | (C) 4 | | | | | | | | | |
| Brantley Lake | ● 4 | | | | | | | | | |
| Lake Carlsbad | ● 4 | | | | | | | | | |
| Pierce Canyon (Malaga Bend) | (C) 4 | | | | | | | | | |
| Laguna Grande de la Sal (y Tres) | (C) 5 | (4) | (4) | (?) | (4) | (?) | | (2.5) | (4) | (4) |
| Red Tank | (C) 5 | (4) | (4) | (?) | (4) | (?) | | (2.5) | (4) | (4) |
| Hill Tank | (C) 3 | (4) | (4) | (?) | (4) | (?) | | (2.5) | (4) | (4) |
| Tut Tank | ● 5 | | | | | | | | | |
| Indian Tank | (C) 5 | (4) | (4) | (?) | (4) | (?) | | (2.5) | (4) | (4) |
| Noye Tank | (C) 3 | | | | | | | | | |
| Sewage Lagoon | No Data Available | | | | No Data Available | | | | No Data Available | |

Sources: Unpublished notes obtained from Westinghouse and WIPP annual environmental monitoring reports.

Note: Composite sample indicates RES or NES analysis was conducted on a mixture of several subsamples.
Note: DOE/WIPP 88-025 (OEMP) also lists Gross Alpha and Beta. No documentation of this analysis was observed.
Note: Unpublished records indicate sampling for nutrients and cyanides, but no published documentation was found.
Note: VOC sample round of 2.5 indicates that acetone was the only organic constituent analyzed for CY 1987.

- Np-237, Th-230, and Th-232 have only been sampled once for the ten 1988 locations, and H-3 (Tritium) only once for the 1987 locations;

- Noye Tank has been sampled only once for Am-241 and Cm-244.

- RBP radionuclides Pu-242, Am-243 and Be-7 have not been analyzed at any station.

EEG has sampled at the seven locations underlined in Section 4.2.1 to verify measurements for 15 RBP/OEMP radionuclides (asterix). The EEG has already begun surveillance for gross alpha and beta.

Annual SER CY 1990 91-008 suggests that two years of sampling data are adequate for a preoperational baseline at DOE nuclear facilities (DOE Order 5400.1). Except for the improvements bulleted above, a preoperational RES baseline has been established for most locations listed in Figure 7.

- NES Sampling. Nonradiological laboratory analyses for surface water for the CY period 1986-1988 show that general chemistry, metals, and organic constituent groups identified in Figure 7 are composed of the following:

| General Chemistry | Metals | |
|---|---|---|
| Bicarbonate | Arsenic | Sodium |
| Carbonate | Barium | Strontium |
| Chloride | Calcium | Zinc |
| Phosphate (Total) | Cesium | |
| Total Dissolved Solids | Chromium | |
| Total Suspended Solids | Lithium | |
| Sulfate | Magnesium | |
| Total Organic Carbon | Potassium | |
| Total Organic Halogen | Selenium | |

Organics

| | |
|---|---|
| VOC: | Acetone (3 rounds; detected)<br>1,2 Dichloroethane (1 round; detected)<br>1,1 Dichloroethylene (1 round; detected)<br>Methylene Chloride (1 round; detected)<br>Toluene (1 round; detected) |
| Semi-Voc: | Bis(2-ethylexyl)phthalate ( 1 round; detected)<br><br>N-Nitrosodiphenylamine (Diphenylamine) (1 round; detected) |
| Pesticide/PCB: | (2 rounds; none detected) |

Several NES constituents in the WIPP waste stream are unaccounted for in the database collected 1986-1988. Table 6 of Section 4.1.3 is a preliminary list of waste stream specific constituents that should be considered for nonradiological surface water analyses ie. lead, xylene, etc. The organic group clearly requires further sampling rounds to establish statistical accuracy. Sampling for nutrients and cyanides, indicated in figure 7, is not confirmed in published annual environmental reports; however, unpublished sources indicate that such sampling has occurred.

- Liquid Effluent. The RBP required a one time analyses of liquid effluent for "specific radionuclides", while the 1988 OEMP proposed a semi-annual analyses for the following:

  - gross alpha and beta (liquid influent/effluent)
  - pH (liquid influent/effluent)
  - TSS (liquid influent/effluent)
  - Specific radionuclides (liquid influent/effluent)
  - Selected general chemistry, metals, and organics (liquid effluent only).

The environmental RES and NES data (1985-1988) reviewed for this study did not confirm the sampling and analyses claimed for the sewage lagoon, or the undocumented effluent sampling station near the facility's secured boundary (Figure 6).

### 4.2.3 Findings, Issues, and Opportunities

1) Nonradiological Surveillance. NMED needs to begin verification of baseline values at all surface water sampling sites for general chemistry, metals and organics, whether or not WID EMS reestablishes sampling activities in CY 1992. Baseline measurements and monitoring may yet be required at other locations.

2) Table 6 of Section 4.1.3 lists proposed waste stream specific constituents that should, at a minimum, be considered for nonradiological surface water analyses.

3) NMED needs to verify organic sampling procedures (WP 02-345), and develop NMED or adopt DOE WIPP procedure for taking samples and/or receiving split samples.

4) Radiological Surveillance. There are opportunities for NMED to improve RES baseline and monitoring coverage. These include:

- o Hill Tank and Tut Tank, which have not been radiologically verified by an oversight group yet;
- o Analyses for Pu-242, Am-243, Np-237, Th-230, Th-232 for all existing surface water sampling sites;
- o Analyses for Am-241 and Cm-244 for Noye Tank; and

NMED should also begin planning for operational monitoring of gross alpha and beta, and consider gamma spectroscopic analysis.

5) 1992 Sampling and NMED Observation. Selection of 1992 sampling locations can be accomplished by a variety of strategies:

- o verifying all existing NES and selected RES analyses;
- o adding to the statistical baseline data base; and
- o NMED selection of additional locations.

6) Many unsampled salt lakes in the vicinity of WIPP may be viable sampling locations. Existing NES and RES constituent levels in these lakes, possibly derived from run-off or effluent from potash mining and oil operations, must be documented to gauge future measurements against.

7) NMED should immediately begin analysis of run-off patterns from watersheds supplying previously sampled and unsampled surface water bodies, livestock tanks, and other closed depressions capable of collecting surface water.

8) Aerial photographs and detailed topographic maps will be required for assessment of past, present, and potential surface water sample sites.

9) The existing DOE WIPP sampling locations are chosen adequately to encounter an atmospheric release from the prevailing wind directions; however, any surface water bodies located to the southeast and northeast of the facility should also be monitored.

10) NMED needs to track any changes in the scope of the proposed OEMP (revision beginning 1/15/92) or in the 1992 proposal for surface water monitoring.

11) Opportunities for monitoring storm water run-off from the WIPP facility are identified in an assessment of the soil program in Section 4.4. NMED should consider periodic NES and RES sampling of WIPP run-off, as well as soils located within drainages outside the facility, for evidence of contaminated ponding or sedimentation caused by rain or unauthorized discharges.

12) This investigation reveals no documented DOE WIPP RES or NES sewage sampling history, which is required for the RBP. Liquid effluent and influent baseline objectives and monitoring locations are unsubstantiated in annual environmental monitoring reports, even though communication with site personnel indicate that environmental sampling has occurred. Other liquid effluent issues:

- o EEG sampled the sewage lagoon 1989, 1990, and 1991; and discussions with DOE WIPP indicate that Westinghouse has not participated in split sampling with them.

- o New Mexico Environment Department Water Quality Bureau is currently reviewing a WIPP effluent discharge permit (contact Bob Garcia, 827 - 0027) that focuses on regulatory-driven quarterly and/or semi-annual operational sampling of the sewage lagoon. Does the Mixed Waste sampling plan rely on their regulatory - driven sampling program, or are we able to design a more rigorous NMED effluent sampling program based on the DOE/NMED agreement?

- o DOE WIPP indicates their next focus (1992) will be storm water run-off, and that retention basins may be constructed off-site to catch facility run-off. EEG collects samples of WIPP storm water after seasonal rains. DOE WIPP has not collected such samples and appears eager to avoid a NMED promulgated mandatory sampling program.

13) A sump located beneath the Waste Handling Building (WHB) is designed to collect water from the fire sprinkler system or other free liquids introduced into the facility. The sump acts as a safeguard to contain any contaminated liquids released during spills or decontamination activities that might occur in the waste handling area. The 1988 OEMP identifies the sump as a regular RES sample site. The sump should also be an NES sample site.

For worst-case planning purposes, this assessment does not preclude the possibility that a liquid spill could escape the WHB or occur in the loading area. In the event a release did occur and reached the storm run-off drainage system, NMED and DOE would need to make plans to sample soil/sediment down-gradient from facility storm drain exist points.

## 4.3 Sediment Surveillance

Procedures for radiological (RES) and nonradiological (NES) sediment sampling protocol are found in the "Environmental Procedures Manual" :

RES Surface Water and Sediment Sampling Procedures WP 02-309.

NES Surface Water and Sediment Sampling Procedures WP 02345.

A plan for RES and NES surveillance of sediments is included in the Operational Environmental Monitoring Plan (OEMP, 1988). The RBP and EMP sampling schedule and monitoring program proposed in that document are described as follows:

- Preoperational RES: Annual sampling at 5 RBP locations, corresponding to selected surface water sampling sites (OEMP, 1988). The RES baseline analytical array includes only RBP "specific radionuclides (OEMP, 1988; See Section 3.0).

- Operational RES: Biennial sampling at 6 OEMP locations, including sewage lagoon outfall for gross alpha and beta and specific radionuclides (OEMP, 1988; see Section 3.0).

- NES: No specific measurement frequency or constituents are defined for preoperational or operational surveillance of sediment locations in the 1988 OEMP. Such plans may be located in a document referenced in Ecological Program Reports (1985-1988): Prill and Buckle (DOE/WIPP 88-007; 1988) "Guidance Manual, Surface Water and Sediment Sampling Program for WIPP". This planning document, however, was never distributed to the WIPP library and was not located.

The 1988 OEMP also commits to operational NES and RES biennial sampling and analyses of sediment associated with the sewage system. The program is not administered by the Environmental Monitoring Section, and preoperational baseline data from the lagoon, if any exists, have not been reported in annual environmental monitoring reports.

### 4.3.1 Sample Locations

Surface water sampling and sediment sampling were often conducted simultaneously between 1985 and 1988 as part of the Radiological Baseline Program (RBP) and the Ecological Monitoring Program (EMP). NES and RES sampling terminated in

1988. Documented sediment sampling locations were sampled according to the following schedule:

1985: Pierce Canyon (Malaga Bend), Laguna Grande de Sal, Upper Pecos (Artesia), Indian Tank (RES analyses only).

1986: Laguna Grande de Sal, Indian Tank, Red Tank, Hill Tank (NES analyses)

Pierce Canyon, Laguna Grande de Sal, Upper Pecos, Indian Tank, Hill Tank (RES analyses- twice)

1987: Laguna Grande de Sal, Indian Tank, Red Tank, Hill Tank (NES analyses - twice)

Indian Tank, Hill Tank, Noye Tank, Red Tank (BUR?) (RES analyses)

1988: Indian Tank, Red Tank, Hill Tank (NES analyses)

Pierce Canyon, Indian Tank, Hill Tank, Upper Pecos (RES analyses)

The generalized map view presented in Figure 8 includes the 7 documented sediment sampling locations listed above. Boxed sites are undocumented locations. Claimed for the first time in DOE/WIPP 91-008, no 1985-1988 environmental reports, including the 1988 OEMP, identify these sites as sampling locations. The undocumented sites include the two depicted within or near the secured boundary, and the single unlabeled sampling location near the intersection of Highway 128 and the South Access Road.

The seven identified sampling sites appear to have been selected mainly to monitor the build-up of radionuclides originating from the atmospheric transport and sedimentation of air-deposited contaminants. Secondary transport of air-deposited contaminants within surface drainages may not have been fully considered in the selection of sediment sampling sites (Larry Madl, 1991; pers. comm.). Cursory analyses of 50 foot-interval computer-generated contour maps, however, indicate that Hill Tank and Red Tank are located within broad horseshoe-shaped watersheds draining from west of their locations, and Indian Tank receives drainage from the southeast, including the Gnome site. An analysis of 10 foot contour maps suggests Tut Tank is located on a broad, flat surface that drains part of upper Nash Draw. Noye Tank, north of the site, is located on a ridge and appears to be poorly located to receive sediment.

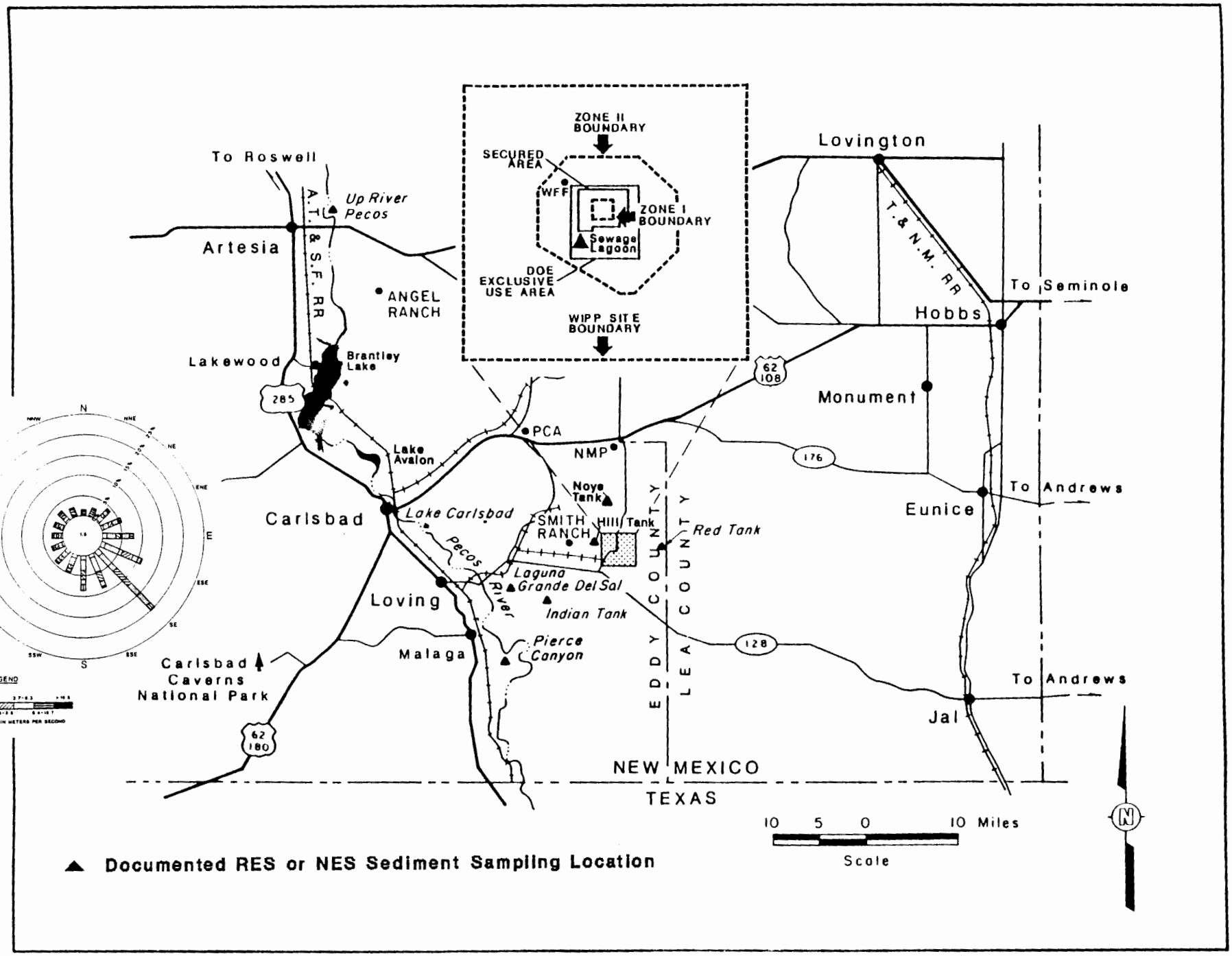



Figure 8: Sediment sampling locations documented in annual [illegible] reports, and 1987 Windrose

Liquid Effluent. 1985-1988 environmental monitoring reports do not report preoperational sampling of sediment in the sewage pond. Personal communications with site personal indicate that such sampling has been conducted by WID Facility Operations but may not have been published.

### 4.3.2 Constituents Sampled

Figure 9 is a matrix showing the array of constituents that have been monitored at each respective sediment sampling station.

- RES Sampling. Radiological laboratory work conducted on sediment samples between 1985 and 1988 focused on 15 radionuclides. These elements are underlined and compared with the original RES analytical suites proposed in the RBP and OEMP:

| | | | |
|---|---|---|---|
| Pu-238 | (RBP/OEMP) | Cm-244 | (RBP) |
| Pu-239 | (RBP/OEMP) | Np-237 | (RBP) |
| Pu-240 | (RBP/OEMP) | Ra-226 | (OEMP) |
| Pu-241 | (RBP/OEMP) | Ra-228 | |
| Pu-242 | (RBP) | Th-228 | |
| U-233 | (RBP/OEMP) | Th-230 | (RBP/OEMP) |
| U-234 | | Th-232 | (RBP/OEMP) |
| U-235 | (OEMP) | Cs-137 | (RBP/OEMP) |
| U-238 | (RBP/OEMP) | Am-241 | (RBP/OEMP) |
| Sr-90 | (RBP/OEMP) | Am-243 | (RBP) |
| Be-7 | (OEMP) | Co-60 | (RBP/OEMP) |
| | | K-40 | (RBP/OEMP) |

The following observations are evident:

- Several RBP constituents are absent from the sampling record, including Pu-242, Cm-244, Np-237, Am-241 and Am-243.
- Five of the seven sediment sampling sites have been sampled 3 to 5 times for each radionuclide. Many measured concentrations are evidently below limits of detection (LD); however, no microcurie/gram values for LD's are reported for independent verification.
- Noye Tank and Red Tank have only been sampled once, and U-233, U-234, U-235, and U-238 were not analyzed.
- Operational radionuclide Be-7 has not been analyzed for the baseline.

## Figure 9: Constituents Monitored and Sample Rounds for WIPP Sediment Environmental Baseline 1985-1988

● Radiological (RES) ○ Non-Radiological (NES) (C) Composite (RES constituents only)

(4) Sample Rounds

| | Radiological Tritium | General Chemistry | Metals Cations | Nutrients | Phenols/ Phosphate | Cyanides | Mercury | VOC (400 ml glass) | TOC/TOX | TDS/TSS |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper River Pecos (Artesia) | (C) 4 | | | | | | | | | |
| Brantley Lake | | | | | | | | | | |
| Lake Carlsbad | | | | | | | | | | |
| Pierce Canyon (Malaga Bend) | (C) 4 | | | | | | | | | |
| Laguna Grande de la Sal | ● 3 | (3) | (3) | | (3) | | | (2) | | |
| Red Tank | ● 1 | (4) | (4) | | (4) | | | (2) | (3) | |
| Hill Tank | (C) 4 | (4) | (4) | | (4) | | | (2) | (3) | |
| Tut Tank | | | | | | | | | | |
| Indian Tank | (C) 5 | (4) | (4) | | (4) | | | (2) | (3) | |
| Noye Tank | (C) 1 | | | | | | | | | |
| Sewage Lagoon Outfall | No baseline information encountered | | | | | | | | | |

Sources: Unpublished notes obtained from Westinghouse and annual environmental monitoring reports (see references).

Note: Composite sample is mixture of several subsamples used to represent a single site for radiological analyses.
Note: DOE/WIPP 88-025 (OEMP) also lists Gross Alpha and Beta. No documentation of this analysis was observed.

A relatively new interpretation presented in Annual SER CY 1990 91-008 suggests that two years of sampling data are adequate for a preoperational baseline at DOE nuclear facilities. This provision, cited in DOE Order 5400.1, appears to supercede the 1988 WIPP site-specific OEMP, and suggests that a preoperational RES baseline has been established for the following locations:

- o Pierce Canyon (Malaga Bend) - 26 km SSW of WIPP
- o Laguna Grande de Sal - 19 km WSW of WIPP
- o Indian Tank - 13 km SW of WIPP
- o Hill Tank - 4 km WNW of WIPP
- o Upper Pecos (Artesia) - 69 km NW of WIPP

o <u>NES Sampling</u>. Nonradiological laboratory analyses for sediment for the CY period 1986-1988 show that general chemistry, metals, and organic constituent groups identified in Figure 9 are composed of the following:

| General Chemistry | Metals |
|---|---|
| Bicarbonate | Arsenic |
| Carbonate | Barium |
| Chloride | Calcium |
| Phosphate (Total) | Cesium |
| Sulfate | Chromium |
| Total Organic Carbon | Lithium |
| Total Organic Halogen | Magnesium |
| | Potassium |
| | Selenium |
| | Sodium |
| | Strontium |
| | Zinc |

<u>Organics</u>

| | |
|---|---|
| VOC: | Acetone (3 rounds; detected)<br>1,2 Dichloroethane (1 round; detected)<br>1,1 Dichloroethylene (1 round; detected)<br>Methylene Chloride (1 round; detected)<br>Toluene (1 round; detected) |
| Semi-Voc: | Bis(2-ethylexyl)phthalate ( 1 round; detected)<br><br>N-Nitrosodiphenylamine (Diphenylamine) (1 round; detected) |
| Pesticide/PCB: | (2 rounds; none detected) |

No RES and NES data could be found to verify sediment sampling and analyses conducted for the sewage lagoon (1985-1988), or the two undocumented effluent sampling stations near the facility's secured boundary (Figure 8).

4.3.3 Findings, Issues, and Opportunities

1) Non-Radiological Surveillance. NMED should begin verifying baseline values in CY 1991 for both general chemistry, metals and organics. A suitable NMED NES analytical sampling plan should be designed, minimally, for waste stream constituents (table 6; Section 4.1.3). NMED should also consider verifying NES analytical values already obtained by DOE WIPP, especially organic constituents analyzed only once per location (1 round).

2) Mercury and lead have not been analyzed for the NES baseline. Sediments will document any accumulations of heavy metals, including lead, lead 210, and mercury, because of the affinity of clays to these elements. These elements are components of the waste stream destined for WIPP.

Radiological Surveillance. Opportunities for NMED to improve the RES baseline and monitoring coverage include:

- o RES baseline analyses for Pu-242, Cm-244, Np-237, Be-7, Am-241 and Am-243.
- o RES Analyses for Noye and Red Tank.
- o Verification of all existing radiological data; no record of EEG radiochemical sediment analyses are published.
- o Selection of additional sampling sites in closer proximity to the WIPP site.

3) NMED should consider establishing a sediment RES and NES baseline for other smaller intermittent lakes or closed depressions nearer the site, possibly Red Tank, Red Lake, Laguna Quatro, or sediment accumulation areas within Zone II. Two of the five sites used for the existing baseline are far field - 26 and 69 kilometers from site.

Near field areas provide an excellent monitoring system to detect any build-up of transuranic (Pu-239) and activation products (Co-60, Nb-95, Cs--137) which may occur either by primary air-deposition or secondary transport by sheet-flow or run-off. Soil sampling may be more appropriate for some areas transitional between terrestrial and sedimentary environments.

5) NMED should consider obtaining sediment cores from nearby intermittent bodies of surface water. Such samples are recommended for the following reasons:

- o Sediment cores can provide evidence of the history of the water body, documenting whether or to what extent the surface water body is of artificial or natural origin.

- o Sediment cores can be used to test for potential waste constituents with depth, since contaminated sediments are susceptible to being reentrained, redeposited and sampled after a baseline erroneously establishes the absence of these constituents.

- o Sediment cores can be used to precisely model lake fluctuations during the Pleistocene, which can be used to better understand future hydrologic environments; no studies of this kind have been done to assess long-term performance (containment) of the repository.

6) NMED has the opportunity to assist in selecting a sampling schedule at the WIPP facility. Sampling locations for 1992, if proposed and approved, have not yet been selected as of January, 1992 and the OEMP section concerning sediments has not been revised.

7) Microcuries/gm (RES) and mg/kg (NES) values for sediment and microcuries/ml (RES) and mg/ml or PPM values for surface water, should be reported and compared to an LD value in an adjacent column in future DOE WIPP environmental reports to assist oversight groups in verifying data and tracking annual changes in LD standards.

## 4.4 Nonradiological and Radiological Soil Monitoring

The Radiological Environmental Surveillance (RES) and Non-Radiological Environmental Surveillance (NES) programs for soil are described in the 1988 Operational Environmental Monitoring Plan (OEMP). Procedures for RES and NES soil sampling protocol are found in the "Environmental Procedures Manual" :

- RES Soil Sampling Procedures WP 02-307
- NES Soil Sampling /Procedures WP 02-336

Soil chemistry and soil microbiota studies were originally designed as a nonradiological program to assess any impact from operational or construction activities at the WIPP facility. This assessment focuses on soil chemistry studies, opportunities for other types of nonradiological soil sampling, and radioanalytical surveillance of soils at the WIPP facility.

### 4.4.1 Sample Locations

Unlike ground water and surface water sampling programs, soil sampling locations differ for radiological and nonradiological surveillance.

- RES Baseline Program. The preoperational RES baseline was established in annual samples collected in calendar years (CY) 1985 and 1987. (DOE/WIPP 86-002; DOE/WIPP 88-009). By design, the soil radioanalytical baseline was to be defined at 28 soil sampling sites and only two annual samples were to be required for statistical accuracy (OEMP, 1988).

  Table 7 is a combined inventory of preoperational radiological soil sampling locations visited in 1985 and 1987. CY 1985 and 1987 are the only years with supporting analytical lab data. Archived sample sets exist for thirty-seven locations sampled during CY 1988, and seven localities sampled each in CY 1989 and 1990. No radiological soil sampling was conducted during CY 1986 and 1991.

  Table 7 contains an abundance of radiological soil sampling sites. Presumably, the radiological baseline is supported by 28 of the 37 surface collection sites (0-2 cm), as these are the only soil stations tested twice:

| | | |
|---|---|---|
| R01 - R016 | WNE - WEE | Railroad Spur<br>Gnome<br>Hobbs Hwy<br>Monument |

## Table 7

## Inventory of Radiochemical Sampling Locations and Analytical Arrays (1985-1987): Soil Radiological Baseline

### 37 Surface Collection Sites (0-2 cm)

| | | | |
|---|---|---|---|
| R01 | R08 | WNE | Angel Ranch - 53 km E |
| R02 | R09 | WNN | Artesia - 68 km NW |
| R03 | R10 | WNW | Carlsbad - 42 km W |
| R04 | R11 | WSE | Railroad Spur - 10 km WSW |
| R05 | R12 | WSS | Eunice - 60 km E |
| R06 | R13 | WSW | Gnome - 14 km SSW |
| R07 | R15 | WWW | Hobbs - 72 km ENE |
| | R16 | WEE | Hobbs Hwy - 18 km W |
| | | | Jal - 64 km E |
| | | | Loving - 29 km WSW |
| | | | Monument - 56 km ENE |
| | | | New Mexico Potash - 14 km N |
| | | | PCA - 26 km NW |

**K-40, CO-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232**
**U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241**
**Cs-137, Np-237, Am-241, Cm-244**

### 28 Intermediate Depth Collections Sites (2-5 cm)

| | | | |
|---|---|---|---|
| R01 | R08 | WNE | Railroad Spur - 10 km WSW |
| R02 | R09 | WNN | Gnome - 14 km E |
| R03 | R10 | WNW | |
| R04 | R11 | WSE | Hobbs Hwy - 18 km W |
| R05 | R12 | WSS | Monument - 56 km ENE |
| R06 | R13 | WSW | |
| R07 | R15 | WWW | |
| | R16 | WEE | |

**K-40, CO-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232**
**U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241**
**Cs-137, Np-237, ~~Am-241~~, ~~Cm-244~~**

### 28 Lower Depth Collection Sites (5-10 cm)

| | | | |
|---|---|---|---|
| R01 | R08 | WNE | Railroad Spur - 10 km WSW |
| R02 | R09 | WNN | Gnome - 14 km E |
| R03 | R10 | WNW | |
| R04 | R11 | WSE | Hobbs Hwy - 18 km W |
| R05 | R12 | WSS | Monument - 56 km ENE |
| R06 | R13 | WSW | |
| R07 | R15 | WWW | |
| | R16 | WEE | |

**K-40, CO-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232**
**U-233, U-234, U-235, U-238, ~~Pu-238~~, Pu-~~239/24~~0, ~~Pu-241~~**
**Cs-137, Np-237, ~~Am-241~~, ~~Cm-244~~**

Note 1: Locations sampled and analyzed only once per horizon are underlined; radionuclides analyzed once are striken out.

Note 2: R01 through R-16 are 16 former TLD stations located at all azimuths approximately 8 km from WIPP.

Note 3: WNE through WEE are eight sites at or near secured fenced boundary at all azimuths from WIPP.

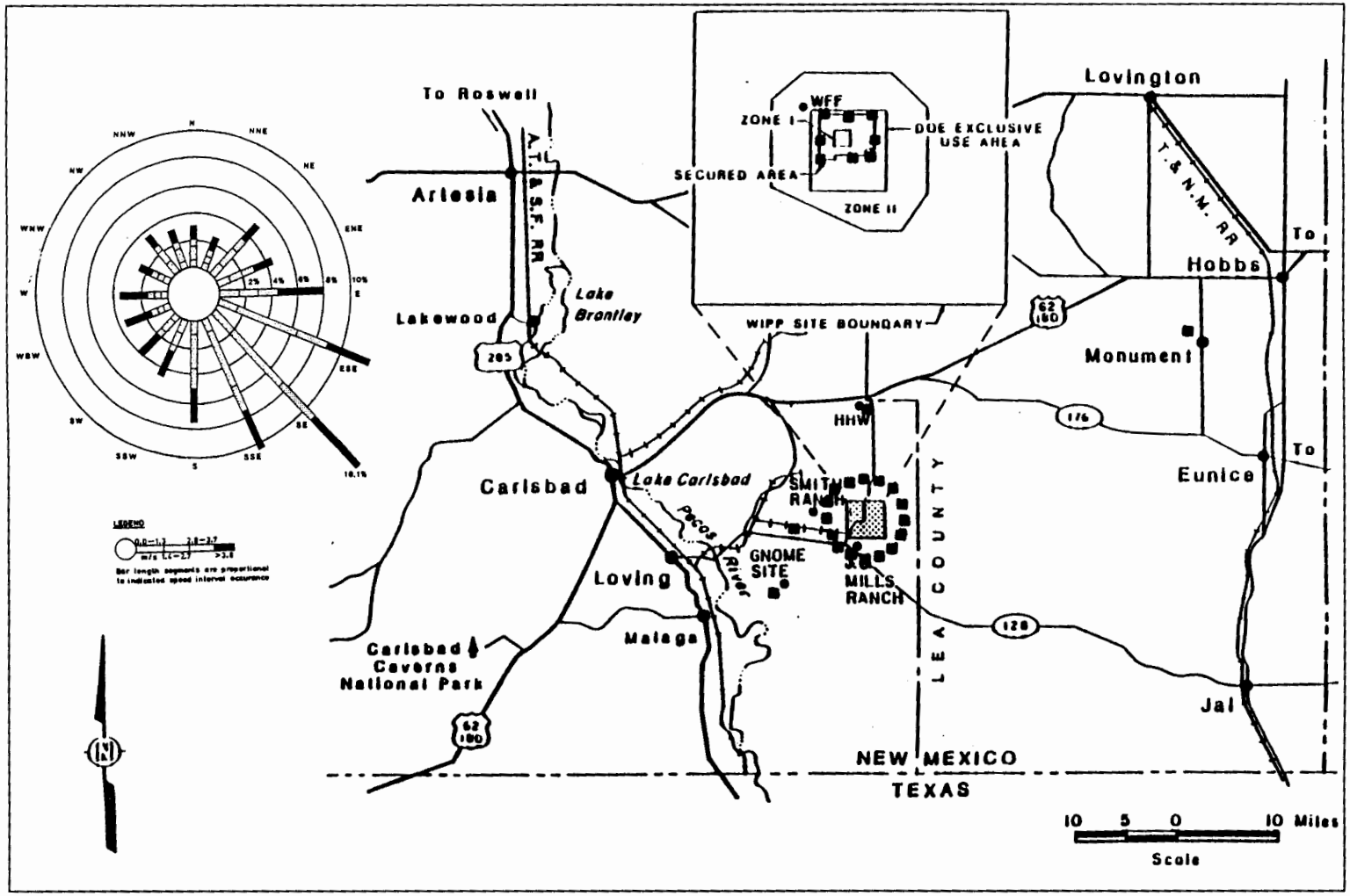
Nine additional sample sites were added in 1987, including sites such as Angel Ranch, Artesia, and New Mexico Potash. Only one round of analyses was conducted for the nine sites; however, they were sampled again in 1988 and 1989 and archived at the facility (DOE/WIPP 88-009). Eight soil sampling sites at or near the secured fence boundary (WNE - WEE) have also been sampled and analyzed only once at intermediate (2-5 cm) and deeper (5-10 cm) soil horizons.

Figure 10 is a generalized map view of the 28 baseline radiological soil sampling stations. R01 through R-16 encircle the WIPP facility along an approximate 8 km diameter. WNE through WEE are located closer to the facility, within 300 to 500 meters of the exhaust shaft. These 24 baseline stations form two lines of preoperational measurements at all azimuths to the exhaust shaft, which is considered as the most probable, but not only, pathway for radiological contamination. The exact locations of the 24 sites could not be confirmed from small-scale figures presented in annual DOE WIPP reports.

- <u>RES Operational Program</u>: Once the facility becomes operational, the 1988 OEMP proposes biennial radiological sampling of soil (every two years). Figure 11 shows the seven proposed operational radiological monitoring stations. Note that operational locations differ from those identified for the preoperational program. Smith Ranch, Mills Ranch, and a location on Highway 128 near the Eddy/Lea County line are not part of the original baseline data set (Figure 11). Two other locations are located within gentle swales draining the Waste Handling Building (FAC 411) but do not appear to coincide with the radiological baseline sampling locations. A sampling location adjacent to the WIPP Far Field (WFF) air monitoring station is also not a baseline station.

  Site Environmental Reports (SER) for CY 1989 and 1990 contend that seven operational sampling sites were sampled and archived for each of those years (DOE WIPP 90-003; DOE WIPP 91-008). Presumably, these are operational stations; however, only the SER for CY 1990 shows a map of the stations. The Gnome site is inexplicably included as an operational sampling site, and the Highway 128 location on Figure 11 is omitted. This change, if real, is not in agreement with the 1988 OEMP or FSAR (1990) and should be investigated. No field activities of the radiological soil sampling program occurred during 1991.

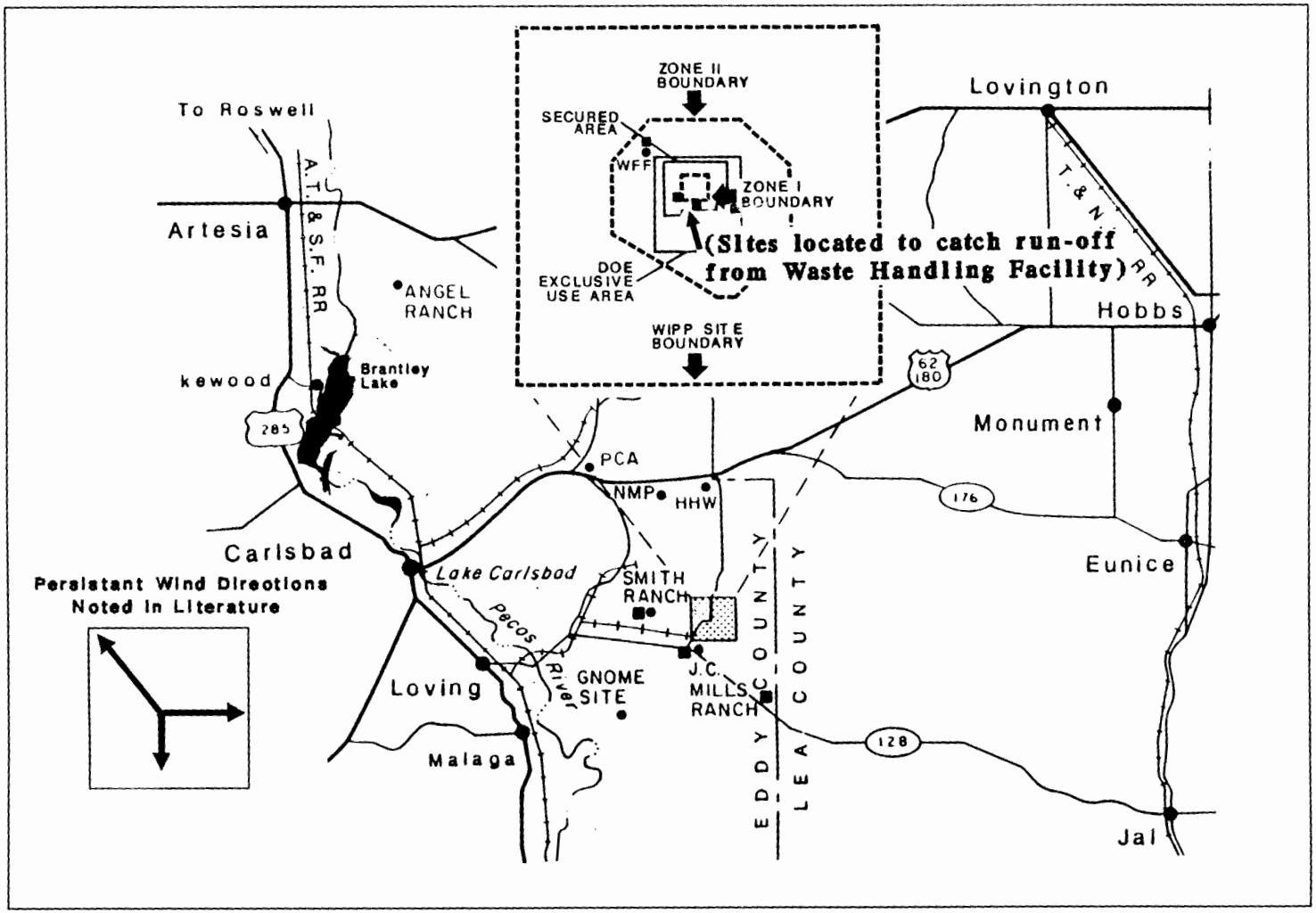
## Soil RES Baseline Locations




■ Soil Sampling Location (Not shown are nine locations sampled and analyzed in 1987, and sampled and archived in 1988 and 1989; and Smith Ranch and J.C. Mills Ranch which were sampled and archived in in 1989 and 1990)

**Figure 10: Inventory of radiological sampling locations supporting Soil Radiological Baseline listed in Table 7. The windrose for 1985 is added for reference.**

## Operational Radiological Sampling Locations




■ Soil Sampling Location

**Figure 11: Proposed operational radiological soil sampling locations identified in 1988 OEMP. Note that operational and preoperational baseline sampling locations differ.**

10 5 0 10 Miles
Scale

Assuming an atmospheric radioactive release from the exhaust shaft, AIR-DOS predictive models used by DOE and NMED can be used to identify the direction of contaminant transport. These predictive models should be used to identify potential operational locations, as contaminant transport can occur in any given azimuth from the exhaust shaft. The program, however, does not incorporate topographic effects which might influence the potential for secondary transport of air-deposited contaminants ie. in swales or shallow depressions. Analyses of AIR-DOS modeling scenarios, supported by high resolution topographic maps of the area, provide an opportunity to assess RES soil baseline locations and pre-plan and select real-time RES sampling locations following an unauthorized release.

- Operational NES. The nonradiological soil sampling program is designed to monitor impacts from ongoing facility operations and mining operations (surface tailings). Therefore, the NES program for soil is currently operational, in disagreement with SER for CY 1990, which stated that an "adequate baseline"..has been established. Two programs propose NES soil sampling schedules:

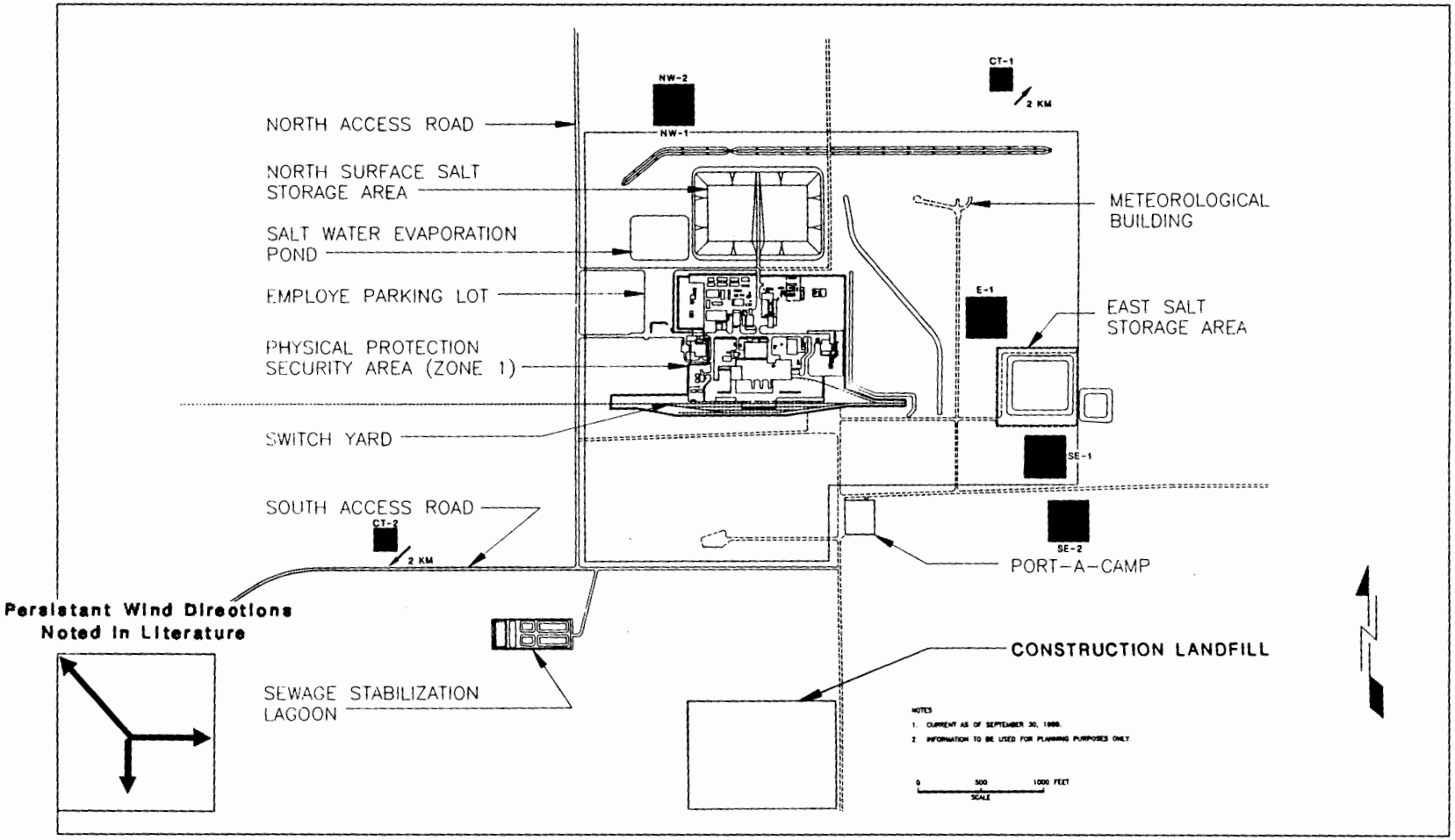
    - The Ecological Monitoring Program (EMP) requires quarterly surveillance of seven stations;

    - The OEMP sets a sampling frequency of twice a year (biannual).

Seven nonradiological soil sampling sites were monitored quarterly between 1985 and 1989. Five soil sampling sites were positioned near the north and east salt storage areas (Figure 12). Two additional stations are positioned for control, one to the northeast and the other to the southwest. The sampling sites are combined as follows for data analysis:

| | |
|---|---|
| Near Field Plots - SE-1, NE-1, E-1 | Within meters of salt piles. |
| Far-Field Plots SE-2, NW-1 | Within 100 meters of salt piles. |
| Control Plots CT-1, CT-2 | More than two kilometers from the facility perpendicular to the prevailing wind direction. |

## Documented Nonradiological Soil Sample Locations




■ Soil Sampling Location

**Figure 12: Documented nonradiological soil sampling sites located between 1985 and 1989. All sites are within Zone II and were designed to monitor construction and operational impacts, particularly the effects of mining.**

Figure 13 is a regional view of cumulative NES sampling sites as presented in SER for CY 1990 (DOE WIPP 91-008). Smith Ranch, J.C. Mills Ranch, and the Gnome Site are shown as nonradiological soil sampling sites, along with the plots located closer to the facility. This investigation reveals that the contractor responsible for NES soil sampling (IT) did not sample during CY 1990, despite a reference to sampling being conducted at these sites during that calendar year (DOE/WIPP 91-008). NES soil sampling sites were not visited in CY 1991.

The accumulation of caliche and salt soil on the soil surrounding the WIPP facility is controlled initially by wind direction and velocity. NW-1, NW-2, and E-1 are within the prevailing wind direction and do not indicate any accumulation in the upper soil profile. The data collected between 1985 and 1989 confirm this conclusion, and suggest that accumulation is occurring at the caliche horizon.

### 4.4.2 Constituents Sampled

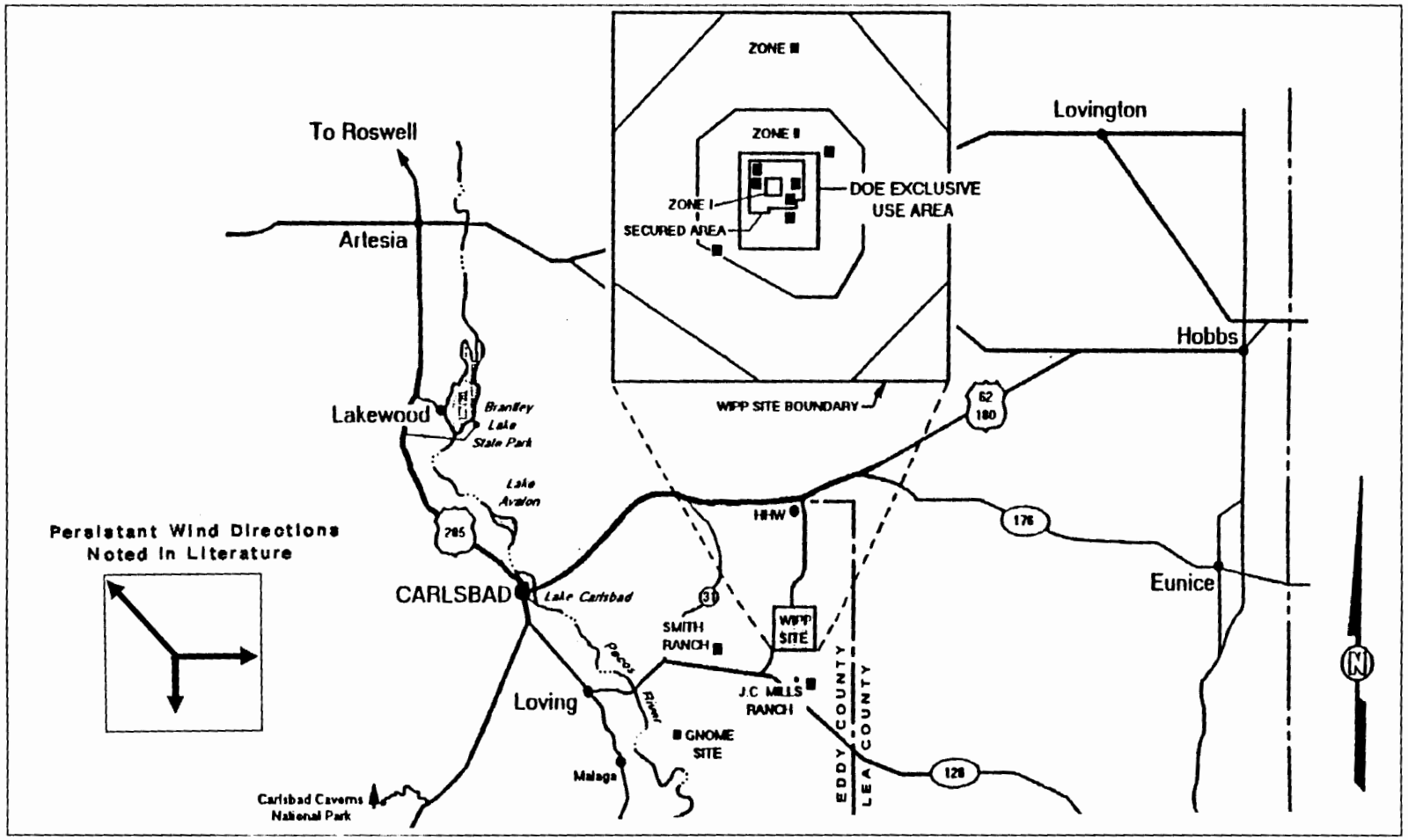
- RES Baseline Program. Table 7 is an inventory of radionuclides that have been analyzed for the preoperational baseline. The RES soil baseline is composed of samples collected at three depths in the soil profile: 1) surface (0-2cm); 2) intermediate (2-5cm); and 3) deep (5-10 cm). Each soil horizon possesses an analytical suite for the specific radionuclides labeled in Table 7. Each RES soil baseline sample is a composite (mixture) of 10 randomly selected subsamples.

  The preoperational radiological analytical array described in the 1988 OEMP consists of the following radionuclides:

  Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, U-233, Am-241, Am-243, Th-232, Cm-244, Np-237, Ra-226, Cs-137,Sr-90, K-40, Co-60, natural uranium and natural thorium.

  The actual preoperational RES baseline represented in Table 7 reveals that soils have not been radiochemically analyzed for Am-243 and Pu-242, as prescribed in the 1988 OEMP. The actual radiological analytical suite also includes U-234, U-235, and U-238, and Ra-228 and Th-228. In addition, as noted earlier, natural thorium and Th-232 are both listed in the 1988 OEMP analytical suite, leaving uncertainty as to whether Th (nat) refers to Th-228 or Th-230. Note in Table 7 that the plutonium series and Am-241 and Cm-244 are not tested in the subsoil.

## Suspect Regional NES Soil Sampling Locations Indicated in SER CY 1990




■ Soil Sampling Location

10 5 0 10 MILES
SCALE

**Figure 13: Suspect regional NES soil sampling locations. No evidence was found of sampling and archiving at sites outside Zone II in CY 1990.**

- RES Operational Program. The proposed operational radiological array for soil differs from the preoperational analytical array. The 1988 OEMP suggests the following radionuclides will be sampled once the facility becomes operational:

  Pu-238, Pu-239, Pu-240, Pu-241, U-233, U-235, Am-241, Th-232, Ra-226, Cs-137, Sr-90, K-40, Co-60, Be-7, natural uranium and natural thorium.

  The 1988 OEMP does not identify radionuclide analysis by depth in the soil horizon, as was done during the radiological baseline studies. A "Methods of Soil Analysis" table is provided in appendix B identifying specific procedures for radiological analyses (WAESD Procedures A-524, A-508, and OI-86-4). According to current plans, the monitoring program will also include analyses for gross alpha and beta.

  A recurring sampling strategy adopted at the WIPP facility is to establish an RES baseline for selected radionuclides in the waste stream, but to omit these radionuclides from operational surveillance. Np-237 and Cm-244 are part of the soil RES baseline, yet are not to be monitored as part of the soil operational monitoring plan. Presumably, the reasons for this strategy may be:

  - Costs; gamma spectroscopy and gross alpha and beta may act to provide a screening mechanism for further analyses.

  - Radionuclides such as Np-237 and Cm-244 represent such a minute percentage of the total radionuclide activity and mass of mixed waste destined for the WIPP facility.

  The reasons for this practice, as documented in annual reports and the 1988 OEMP, should be explored. U-233, U-235, U-238 and Th-232 are also low activity components of WIPP waste; however, they are to be monitored. Pu-242 is a lower activity and lower mass component of the total WIPP waste, yet is often analyzed despite not being prescribed in the original baseline or operational monitoring plan.

- Operational NES. NES samples are collected at three locations of the soil profile: 1) surface (0-2cm); 2) intermediate 30-45 cm; and 3) 60-75cm. To elaborate further on sampling frequency, environmental monitoring reports indicate that surface samples are taken quarterly according to the EMP schedule and annually in the subsurface to determine whether ions accumulate at "any point in the soil profile" (see 4.4.1 Operational NES). Due to the low

clay and organic content of the soils around the site, ions are flushed to the underlying caliche layer.

Nonradiological constituents sampled include:

- o pH
- o Electrical Conductivity ($10^{-6}$ ohms/cm)
- o Sodium cations (mg/liter)
- o Chloride cations (mg/liter)
- o Magnesium cations (mg/liter)
- o Calcium cations (mg/liter)
- o Potassium cations (mg/liter)

Environmental monitoring reports 1985-1989 indicate that windborne caliche and salt are deposited in small quantities downwind from and immediately adjacent to the site. Cations are apparently moved down the soil profile two to four meters (6.5 to 13 ft) to the underlying caliche layer where it accumulates.

DOE WIPP has not established a baseline for organic contaminants in soils in and around the site. An unauthorized release of organic chemicals, either as mixed waste or during other operations, may have an impact on and outside the facility.

### 4.4.3 Findings, Issues, and Opportunities

1) A significant opportunity for NMED is to expand the nonradiological soil sampling program to include organic and mixed waste components in the WIPP facility waste stream. EEG has not participated in any nonradiological baseline sampling verification and the 1988 OEMP did not adequately emphasize RCRA constituents.

2) Liquids generated by decontamination activities during the clean-up of a spill or waste handling accident are unlikely but should not be precluded. For worst-case planning and sampling purposes, quantities of liquid hazardous or mixed waste should be assumed capable of washing into low-lying drainages adjacent to WIPP. This suggests sampling be conducted in terrestrial/sedimentary settings near the facility ie. swales and shallow depressions down-gradient from WIPP storm drains.

   Recent informal discussions with DOE WIPP and NMED Ground Water Bureau indicate that the WIPP facility is seeking to conform to EPA storm water regulations by constructing off-site drainage facilities. Consideration is also being given to constructing retention or diversion basins in the drainages immediately offsite. Two 10-year or 100-year storm-generated runoff will guide the engineering design of the project. This project may effect the type of NMED sampling in these areas ie. surface water, sediment, or soil.

3) NMED could provide RES baseline for operational stations. The EEG has not taken radiological samples at WIPP operational sampling sites and DOE WIPP has not defined a baseline for operational stations with analytical lab data.

4) Thirteen of the Far Field stations (Table 7) have only been sampled once; only Railroad Spur, Gnome, Hobbs Highway, and Monument have been sampled twice for the assumed baseline statistical accuracy. NMED should investigate the following:

   - Why were these sites chosen and only sampled once ?
   - Why were Smith Ranch and Mills Ranch, two important demographic selections, not included in the baseline data set ?
   - Where are the exact locations of the far field sampling sites, are their positions consistent with the predictive AIRDOS-EPA computer code, and are they likely soil/sediment depocenters for air entrained contaminants based on field examination ?
   - What other nearby contamination sources might complicate interpretation of baseline or operational measurements, for instance salt mining/processing activities or petroleum operations in the vicinity ?

5) NMED soil sampling site selection should include reconnaissance on a site-specific basis, and detailed analyses of AIR-DOS modeling scenarios, supported by high resolution topographic maps. AIRDOS specifically provides NMED an opportunity to establish further baseline locations and pre-plan and select real-time sampling locations following an unauthorized release.

6) NMED selection of RES sites should also include analyses of the OEMP statistical viability of two preoperational samples per sampling location.

7) The apparent change in operational NES stations noted in the SER for CY 1990, notably the Gnome Site and Highway 128, is not in agreement with the 1988 OEMP or FSAR (1990) and should be investigated during the revision of the OEMP (ongoing).

8) Environmental monitoring reports consistently state that salts deposited at the surface are flushed through the soil to the underlying caliche layer. Although NW-1, NW-2, and E-1 are within the prevailing wind direction and confirm that no accumulation has occurred in the upper soil profile, caliche is by textbook definition part of the soil profile so there is accumulation in this geologic unit; it does not disappear from the system.

9) If cations are moved down the soil profile two to four meters (6.5 to 13 ft) to the underlying caliche layer, the existing NES soil program is insufficient to monitor impact. Salt is being deposited, however, because the deepest samples are taken at .75 m, there is no evidence for the rate of accumulation. This may have implications for site impact and should be discussed.

## 5.0 Conclusions and Issues Summary

The task of assessing the environmental program at the Waste Isolation Pilot Plant is complicated by abundant discrepancies involving planned and actual sampling schedules, locations, and RES and NES analytical arrays that have been utilized throughout the life of the project. Nevertheless, the program has been comprehensive and has generated an enormous amount of environmental data during the last seven years (through 1992). A preliminary review of this data identifies one critical objective: NMED must begin immediately to verify and establish a baseline for nonradiological constituents, and develop and operational monitoring plan for RES and NES constituents. The EEG has not participated in any significant verification of nonradiological environmental parameters. Opportunities for improving the RES baseline data and RES operational sampling plans are also evident and are presented in this report. Additional actions and selected issues for consideration are presented below.

1) Establish a plan for nonradiological surveillance, including baseline verification and operational monitoring for general chemistry, metals, and volatile and semi-volatile organic constituents. The groundwater sampling season will begin in March, 1992.

2) Proceed with further assessment of the environmental program at the WIPP facility to assist in the objective above by:

   - Confirming the waste stream at the WIPP facility for mixed waste and hazardous waste;

   - Detailing sampling histories for monitoring locations, including confirming whether an independent statistical evaluation suggests that the number of rounds per constituent per location are adequate.

   - Conducting detailed analysis of the quality of RES or NES data collected, including a review of sampling procedures.

   - Conducting an in depth review of current data analysis and statistical and environmental modeling programs.

   - Verifying that WIPP analytical arrays of nonradiological environmental constituents are consistent with New Mexico ~~Drinking Water~~ WQCC Standards.

3) Utilize computer-assisted mapping, becoming more available for the site and surrounding area, to plot large-scale, high resolution environmental monitoring maps. Conventional figures used to depict RES and some NES sampling sites are inadequate for detailed

assessment of their location. Other computer-mapping information requested for site assessment and/or selection:

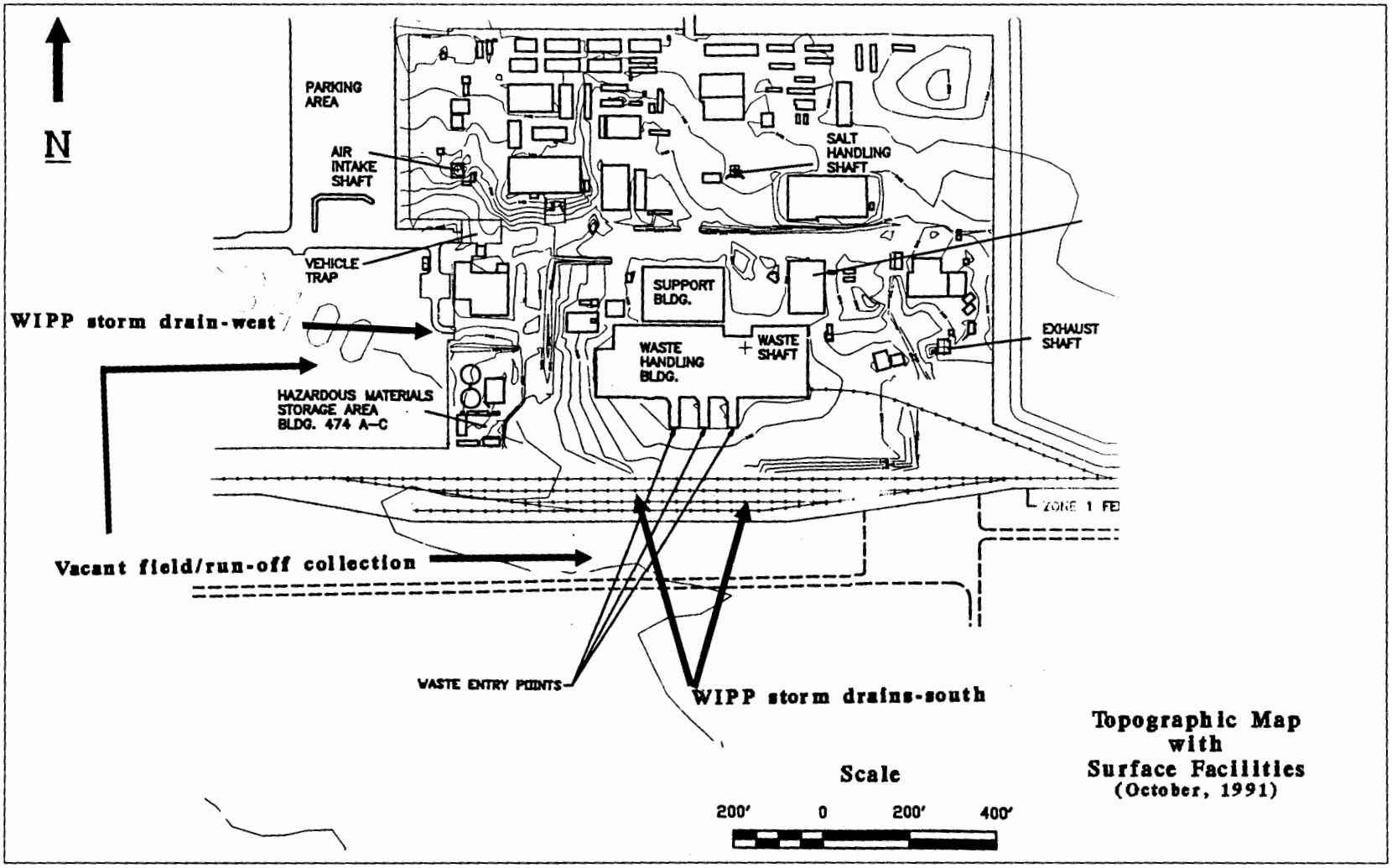
- o sample locations used in official baseline,
- o sample locations discarded from official baseline, and
- o number of rounds sampled for each constituent for each site.
- o surveyed one-foot to 5-foot contour interval maps, for identification of drainages near the facility and within the four mile boundary.

4) The existing DOE/WIPP program tends to preclude many low-risk pathways for contamination, which may or may not be acceptable for an NMED program, given the unique nature, longevity and public interest in the project. These reasons warrant that worst-case scenarios not be precluded. The facility needs to meet New Mexico Regulations, but it may also be prudent to advocate additional monitoring safeguards, despite the not unreasonable risks posed by the facility.

5) For worst-case planning and sampling purposes, NMED should consider the following:

- o Do not preclude a pathway; engineering controls and procedures can fail.
- o Do not overemphasize southeasterly wind directions for baseline sampling or potential operational/emergency assessment sampling locations; winds are multidirectional depending on season. DOE WIPP has overemphasized southeasterly wind direction to some extent in the design of their monitoring programs.
- o Consider the potential for precipitation during an atmospheric release. DOE WIPP needs to relook at soil/sediment/surface water sampling locations for possible secondary transport of air-deposited radioactive contaminants.
- o Do not preclude the potential for ground water contamination. There will likely remain an inherent uncertainty, even after a test phase, that will require monitoring or detection, especially after the repository is closed.
- o Do not preclude the potential for quantities of liquid hazardous or mixed waste to wash into low-lying drainages adjacent to the WIPP facility. Figure 14 shows potential sampling locations to the west and south of the facility, within shallow swales and depressions down-gradient from WIPP storm drains.
- o Do not preclude the potential for intentional and illegal releases by DOE contractor or subcontractor personnel.

**Figure 14: Near-Field WIPP Facility Effluent Run-off and Potential Soil/Sediment/Surface Water Sampling Sites**



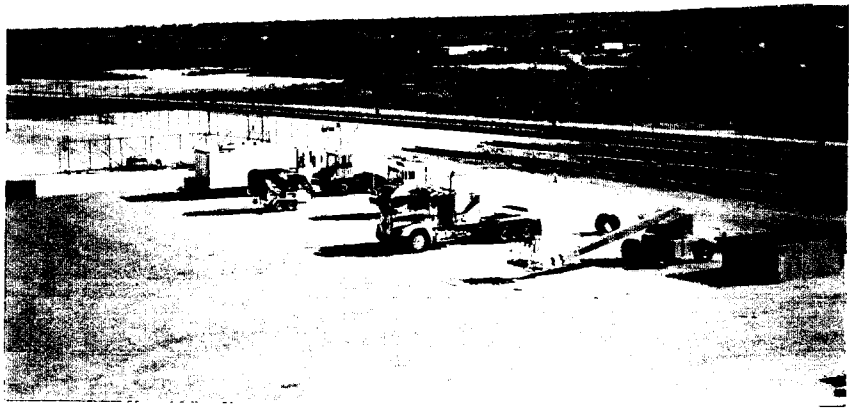

Note: Figure 14 continued on following page includes photos of WIPP storm drains and run-off collection areas.

Note: One-foot contour intervals outside of fenced boundary are approximate.

**Figure 14: Near-Field WIPP Facility Effluent Run-off and Potential Soil/Sediment/Surface Water Sampling Sites - Continued**

WIPP Storm Drain-West

Vacant Field/Storm Drain Outfall-West



WIPP Storm Drain/Run-Off Collection-South

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# APPENDICES

# Appendix A

## Examples of Environmental Data Presentation

## Groundwater, Surface Water, Sediment, Soil

# RES Data Reporting Format

TABLE A-15

RADIONUCLIDE CONCENTRATIONS IN GROUNDWATER SAMPLES
1987
(µCi/ml)
(CONTINUED)

| LOCATION CODE | Th-228 (E-09) | Th-230 | Th-232 | U-233 (E-10) | U-234 (E-10) | U-235 (E-11) | U-238 (E-10) |
|---|---|---|---|---|---|---|---|
| H-12 | LD | LD | LD | LD | 5.2 (1.9) | LD | 1.2 (.93) |
| H-09b | LD | LD | LD | LD | 160 (13) | 57 (30) | 74 (8.9) |
| H-08b | LD | --- | --- | --- | --- | --- | --- |
| WIPP-13 | LD | LD | LD | LD | 93 (9.4) | 16 (13) | 18 (4.2) |
| H-07b | LD | LD | LD | LD | 74 (5.9) | 18 (9.8) | 27 (3.5) |
| WIPP-29 | LD | LD | LD | 1.1 (1.1) | 250 (8.8) | 55 (15) | 120 (6.0) |
| WIPP-26 | --- | --- | --- | --- | --- | --- | --- |
| WIPP-25 | --- | --- | --- | --- | --- | --- | --- |
| H-15 | 6.2 (4.6) | | LD | LD | 110 (10) | 44 (24) | 4.0 (2.2) |
| H-14 | LD | LD | LD | LD | 97 (5.6) | LD | 12 (2.0) |
| P-14 | LD | LD | LD | LD | 41 (5.2) | LD | 16 (3.2) |
| WIPP-19 | LD | LD | LD | LD | 160 (11) | LD | 23 (4.3) |
| DOE-1 | --- | --- | --- | --- | --- | --- | --- |
| H-02a[4] | LD | LD | LD | LD | 120 (9.6) | 20 (17) | 16 (3.4) |
| H-02a | LD | LD | LD | LD | LD | LD | LD |
| H-03b3 | LD | LD | LD | LD | 120 (9.6) | LD | 14 (3.2) |
| H-03b1 | LD | LD | LD | LD | LD | LD | LD |
| H-11 | 4.7 (4.5) | LD | LD | LD | 88 (6.2) | LD | 17 (2.7) |
| H-04b | LD | LD | LD | LD | 110 (7.5) | LD | 17 (3.0) |
| H-04c | LD | LD | LD | LD | 51 (8.1) | LD | 5.3 (2.8) |
| P-17 | LD | LD | LD | LD | LD | LD | LD |
| H-17 | LD | LD | LD | LD | 110 (8.7) | LD | 18 (3.5) |
| H-06c | LD | LD | LD | LD | 130 (9.4) | 14 (11) | 30 (4.6) |
| H-18 | LD | LD | LD | LD | 92 (20) | 170 (87) | 23 (9.2) |
| H-06b | LD | LD | LD | LD | 60 (7.7) | 23 (16) | 15 (3.9) |

TABLE A-16

RADIONUCLIDE CONCENTRATIONS IN PRIVATE WELLS
1987[1]
(µCi/ml)

| WELL NAME | H-3 | K-40 | Co-60 | Sr-90 | Cs-137 | Ra-226 | Ra-228 (E-09) | Th-228 (E-09) | Th-230 (E-10) | Th-232 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mobley Well | LD[2] | LD | LD | LD | LD | LD | LD | LD | LD | LD |
| Comanche Well | LD | LD | LD | LD | LD | LD | LD | LD | LD | LD |
| Clifton Well | LD | LD | LD | LD | LD | LD | LD | 9.6 (7.8) | LD | LD |
| Barn Well | LD | LD | LD | LD | LD | LD | 2.8 (2.5) | LD | LD | LD |
| Fairview Windmill | LD | LD | LD | LD | LD | LD | LD | LD | ---[3] | LD |
| Unger Windmill | LD | LD | LD | LD | LD | LD | LD | LD | LD | LD |
| Engle Windmill | LD | LD | LD | LD | LD | LD | LD | | 3.6 (3.0) | LD |
| Poker Trap Windmill | LD | LD | LD | LD | LD | LD | LD | 7.8 (6.9) | LD | LD |
| Ranch Well | LD | LD | LD | LD | LD | LD | LD | LD | LD | LD |

| WELL NAME | U-233 | U-234 (E-10) | U-235 (E-11) | U-238 (E-10) | Np-237 | Pu-238 | Pu-238/240 | Pu-241 | Am-241 | Cm-244 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mobley Well | LD | 67 (9.5) | LD | 31 (6.4) | LD | LD | LD | LD | --- | --- |
| Comanche Well | LD | 52 (5.6) | LD | 29 (4.2) | LD | LD | LD | LD | --- | --- |
| Clifton Well | LD | 230 (16) | 62 (28) | 120 (11) | LD | LD | LD | LD | --- | --- |
| Barn Well | LD | 29 (4.1) | LD | 14 (2.8) | LD | LD | LD | LD | LD | LD |
| Fairview Windmill | LD | 21 (3.4) | 10 (8.6) | 11 (2.4) | LD | LD | LD | LD | --- | --- |
| Unger Windmill | LD | 40 (5.2) | 14 (10) | 21 (3.7) | LD | LD | LD | LD | --- | --- |
| Engle Windmill | LD | 11 (4.2) | 100 (17) | 2.9 (2.2) | LD | LD | LD | LD | --- | --- |
| Poker Trap Windmill | LD | 31 (7.1) | 28 (25) | 17 (5.2) | LD | LD | LD | LD | --- | --- |
| Ranch Well | LD | 8.9 (8.8) | 19 (18) | 28 (5.0) | LD | LD | LD | LD | --- | --- |

(1) Data Presentation Format: Numbers are to the exponent at the top of the column; number in parenthesis is two standard deviations.

(2) Less Than Detectable (Refer to Table 8-2)

(3) Indicates Not Analyzed

TABLE A-8

RADIONUCLIDE CONCENTRATIONS IN SURFACE WATER SAMPLES

DECEMBER 1985[1]

(µCi/ml)

| LOCATION CODE | H-3 | K-40 (E-07) | Co-60 | Sr-90 | Cs-137 | Ra-226 (E-09) | Ra-228 (E-09) |
|---|---|---|---|---|---|---|---|
| LGS | LD[2] | 210 (5.2) | LD | LD | LD | LD | LD |
| TUT | LD | LD | LD | LD | LD | LD | LD |
| RDT | LD | LD | LD | LD | LD | LD | LD |
| UPP | ---[3] | LD | LD | LD | LD | LD | 29 (26) |
| LMC | LD | LD | LD | LD | LD | LD | LD |
| PCN | LD | LD | LD | LD | LD | LD | LD |
| CBD | LD | LD | LD | LD | LD | LD | LD |
| INT | LD | LD | LD | LD | LD | 22 (3.1) | LD |

| LOCATION CODE | Th-228 (E-10) | U-233 | U-234 (E-10) | U-235 (E-11) | U-238 (E-10) | Pu-238 | Pu-239/240 |
|---|---|---|---|---|---|---|---|
| LGS | 32 (18) | LD | 210 (27) | 70 (56) | 110 (19) | LD | LD |
| TUT | LD | LD | 24 (6.5) | LD | 4.6 (3.0) | LD | LD |
| RDT | LD | LD | LD | LD | LD | LD | LD |
| UPP | LD | LD | 82 (10) | LD | 24 (5.6) | LD | LD |
| LMC | LD | LD | 28 (7.1) | 44 (31) | 19 (5.3) | LD | LD |
| PCN | LD | LD | 65 (6.3) | 20 (14) | 27 (4.2) | LD | LD |
| CBD | LD | LD | 30 (5.7) | LD | 15 (4.0) | LD | LD |
| INT | 130 (120) | LD | 10 (6.3) | LD | LD | LD | LD |

| LOCATION CODE | Pu-241 (E-09) | Np-237 | Th-230 (E-10) | Th-232 | Am-241 | Cm-244 |
|---|---|---|---|---|---|---|
| LGS | LD | --- | --- | --- | LD | LD |
| TUT | 38 (12) | --- | LD | LD | --- | --- |
| RDT | LD | LD | LD | LD | --- | --- |
| UPP | LD | --- | 26 (19) | LD | --- | --- |
| LMC | 28 (15) | LD | LD | LD | LD | LD |
| PCN | LD | LD | LD | LD | --- | --- |
| CBD | LD | LD | LD | LD | --- | --- |
| INT | LD | LD | --- | --- | LD | LD |

(1) Data Presentation Format: Numbers are to the exponent at the top of the column; number in parenthesis is two standard deviations.

(2) Less Than Detectable (Refer to Table 8-2)

(3) Indicates Not Analyzed

TABLE A-12

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES
1987[1]
(µCi/g)

| LOCATION CODE | K-40 (E-07) | Co-60 (E-09) | Sr-90 | Cs-137 (E-08) | Ra-228 (E-07) | Th-228 (E-08) | Ra-226 (E-07) |
|---|---|---|---|---|---|---|---|
| HLT | 200 (15) | LD[2] | LD | 25 (8.1) | 10 (3.6) | 71 (12) | 7.2 (3.0) |
| INT | 170 (15) | LD | LD | 68 (7.2) | 11 (3.5) | 85 (13) | 8.5 (2.9) |
| NOT | 180 (9.2) | LD | LD | 11 (3.5) | 6.0 (1.8) | 61 (8.6) | 5.2 (2.0) |
| NOT-DUP. | 170 (14) | LD | LD | LD | 7.7 (4.6) | 62 (14) | 6.0 (2.7) |

| LOCATION CODE | U-233 (E-08) | U-234 (E-09) | U-235 (E-08) | U-238 (E-08) | Pu-238 | Pu-239/240 | Pu-241 |
|---|---|---|---|---|---|---|---|
| HLT | LD | 40 (8.3) | LD | 41 (8.4) | LD | LD | LD |
| INT | LD | 44 (8.4) | LD | 57 (9.3) | LD | LD | LD |
| NOT | LD | 38 (8.8) | LD | 41 (9.1) | LD | LD | LD |
| NOT-DUP. | LD | 32 (6.4) | 28 (24) | 29 (6.1) | LD | LD | LD |

[1] Data Presentation Format: Numbers are to the exponent at the top of the column; number in parenthesis is two standard deviations.
[2] Less Than Detectable (Refer to Table 8-2)

TABLE A-5
RADIONUCLIDE CONCENTRATIONS IN 1987 SOIL SAMPLES
SURFACE COLLECTION[1]
(µCi/g)

| LOCATION CODE | K-40 (E-07) | Co-60 | Sr-90 | Cs-137 (E-08) | Ra-226 (E-07) | Ra-228 (E-07) | Th-228 (E-08) | Th-230 (E-07) | Th-232 (E-07) |
|---|---|---|---|---|---|---|---|---|---|
| R01 | 110 (6.7) | LD[2] | LD | 17 (3.4) | 4.1 (1.5) | 4.7 (1.8) | 38 (5.7) | 3.8 (2.1) | 4.4 (2.2) |
| R02 | 28 (6.7) | LD | LD | 5.8 (4.1) | 1.6 (1.5) | LD | 11 (7.8) | 1.4 (.50) | 1.1 (.43) |
| R03 | 44 (7.6) | LD | LD | 7.5 (3.7) | 2.3 (1.7) | 3.3 (2.4) | 22 (7.7) | 2.8 (.61) | 2.7 (.60) |
| R04 | 41 (5.5) | LD | LD | 3.2 (2.4) | 1.7 (1.4) | 2.1 (1.4) | 17 (5.9) | 2.6 (1.2) | 2.6 (1.1) |
| R05 | 43 (7.8) | LD | LD | LD | 2.7 (1.2) | 3.4 (2.1) | 21 (11) | LD | 4.9 (2.9) |
| R06 | 36 (9.2) | LD | LD | 13 (7.5) | 2.3 (1.1) | 5.3 (2.1) | 20 (10) | 1.4 (1.2) | 1.3 (.69) |
| R07 | 50 (10) | LD | LD | 9.8 (7.4) | 2.9 (2.2) | LD | 19 (15) | LD | 2.8 (1.1) |
| R08 | 40 (7.4) | LD | LD | 9.0 (5.2) | 2.8 (2.0) | 2.9 (2.7) | 30 (11) | 2.5 (1.8) | 3.5 (.89) |
| R09 | 37 (9.2) | LD | LD | LD | 2.3 (1.6) | LD | 15 (7.3) | 1.8 (.47) | 2.0 (.49) |
| R10 | 57 (9.6) | LD | LD | 18 (9.1) | 4.2 (1.5) | 4.4 (2.1) | 31 (13) | LD | LD |
| R11 | 100 (9.3) | LD | LD | 52 (6.0) | 5.7 (2.0) | 5.4 (2.4) | 51 (8.8) | LD | 3.1 (1.2) |
| R12 | 130 (17) | LD | LD | 23 (12) | 8.8 (3.8) | 8.7 (4.8) | 82 (19) | 5.3 (.80) | 3.5 (.66) |
| R13 | 59 (8.3) | LD | LD | 14 (4.4) | 2.7 (1.5) | 3.6 (2.3) | 23 (8.0) | LD | LD |
| R14 | 68 (12) | LD | LD | 26 (9.2) | 4.3 (1.6) | 5.9 (3.1) | 35 (17) | LD | LD |
| R15 | 51 (5.8) | LD | LD | 13 (3.2) | 3.1 (1.5) | 3.3 (1.4) | 27 (6.0) | ---[3] | --- |
| R16 | 46 (9.0) | LD | LD | 8.7 (6.4) | 3.3 (1.1) | 3.9 (3.0) | 34 (12) | --- | --- |
| WNE | 55 (6.0) | LD | LD | 7.2 (2.9) | 2.0 (1.5) | 2.2 (1.3) | 17 (5.7) | --- | --- |
| WNN | 53 (6.0) | LD | LD | 11 (3.4) | 2.6 (1.4) | 2.6 (1.6) | 17 (6.1) | --- | --- |
| WNW | 58 (6.2) | LD | LD | 6.7 (3.8) | 2.2 (1.4) | 2.5 (1.6) | 16 (5.4) | --- | --- |
| WSE | 62 (6.3) | LD | LD | 14 (3.8) | 2.6 (1.5) | 3.8 (1.6) | 28 (6.1) | --- | --- |
| WSS | 47 (9.2) | LD | LD | 15 (6.6) | 2.5 (2.1) | LD | 25 (7.9) | --- | --- |
| WSW | 58 (8.5) | LD | LD | 14 (4.3) | 2.0 (2.0) | 2.9 (1.9) | 24 (7.1) | --- | --- |
| WWW | 64 (8.7) | LD | LD | 12 (6.7) | 3.1 (2.0) | 4.6 (3.3) | 20 (10) | --- | --- |
| WEE | 56 (9.4) | LD | LD | LD | 3.4 (2.1) | LD | 33 (9.4) | --- | --- |
| ANR | 140 (12) | LD | LD | 58 (6.6) | 8.5 (2.6) | 8.8 (3.0) | 81 (11) | --- | --- |
| ART | 130 (20) | LD | LD | LD | 9.2 (5.5) | 7.2 (5.0) | 83 (23) | --- | --- |
| CBD | 42 (8.7) | LD | LD | 5.5 (3.9) | 2.9 (2.1) | 3.4 (1.9) | 20 (8.4) | --- | --- |
| DRR | 67 (12) | LD | LD | 11 (7.6) | 4.2 (2.3) | 3.7 (3.2) | 39 (14) | --- | --- |
| EUN | 43 (10) | LD | LD | 21 (7.3) | 3.3 (1.2) | 4.3 (2.4) | 19 (11) | --- | --- |
| GNO | 67 (6.7) | LD | LD | 19 (3.3) | 3.0 (1.5) | 3.8 (1.9) | 24 (6.2) | --- | --- |
| HBS | 62 (8.2) | LD | LD | 39 (4.3) | 4.3 (1.8) | 6.0 (2.1) | 38 (7.8) | --- | --- |
| HHW | 73 (13) | LD | LD | 39 (8.9) | 5.2 (3.3) | LD | 44 (14) | --- | --- |
| JAL | 59 (10) | LD | LD | 41 (7.5) | 5.6 (2.5) | 5.6 (2.6) | 38 (11) | --- | --- |
| LVG | 97 (9.8) | LD | LD | 5.9 (5.8) | 4.8 (2.6) | 4.4 (2.6) | 40 (9.3) | --- | --- |
| MNT | 140 (8.6) | LD | LD | 11 (3.7) | 11 (2.0) | 11 (2.3) | 91 (8.5) | --- | --- |
| NMP | 90 (9.3) | LD | LD | 15 (7.8) | 4.6 (2.6) | 2.9 (2.4) | 38 (13) | --- | --- |
| PCA | 60 (11) | LD | LD | 12 (8.3) | 4.4 (2.6) | 5.1 (3.3) | 27 (13) | --- | --- |

# NES Data Reporting Format

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

GENERAL CHEMISTRY

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| pH | | 7.1000 | | 7.1100 | | | | 01-31-90 |
| Specific Conductance | | 4060.0000 | | 4060.0000 | | | uMhos/cm@25C | 01-31-90 |
| Alkalinity (HCO3) | | 110.0000 | | 110.0000 | | | mg/l | 01-31-90 |
| Bromide | < | 2.0000 | < | 2.0000 | | | mg/l | 01-31-90 |
| Calcium Hardness | | 1500.0000 | | 1500.0000 | | | mg/l | 01-31-90 |
| Total Hardness | | 2200.0000 | NA | 0.0000 | | | mg/l | 01-31-90 |
| Chloride | | 190.0000 | NA | 0.0000 | | | mg/l | 01-31-90 |
| Alkalinity (CO3) | | 0.0000 | NA | 0.0000 | | | mg/l | 01-31-90 |
| Cyanide | < | 0.0100 | NA | 0.0000 | | | mg/l | 01-31-90 |
| Fluoride | | 2.8000 | NA | 0.0000 | | | mg/l | 01-31-90 |
| Iodide | < | 2.0000 | < | 2.0000 | | | mg/l | 01-31-90 |
| Nitrate | | 0.1100 | | 0.1200 | | | mg/l | 01-31-90 |
| Total Phenolics | | 0.0060 | | 0.0000 | | | mg/l | 01-31-90 |
| Phosphorus | < | 0.0100 | NA | 0.0000 | | | mg/l | 01-31-90 |
| Residue, Filterable @ 180 c | | 3600.0000 | | 3600.0000 | | | mg/l | 01-31-90 |
| Residue, Nonfilterable @ 105 c | < | 4.0000 | < | 4.0000 | | | mg/l | 01-31-90 |
| Silica | | 12.0000 | | 12.0000 | | | mg/l | 01-31-90 |
| Sulfate | | 1900.0000 | | 2000.0000 | | | mg/l | 01-31-90 |
| Total Organic Carbon | < | 1.0000 | < | 1.0000 | | | mg/l | 01-31-90 |
| Total Organic Halides | < | 0.0500 | < | 0.0500 | | | mg/l | 01-31-90 |

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

METALS ANALYSIS

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| Calcium | | 610.0000 | | 610.0000 | < 0.1 | < 0.1 | mg/l | 01-31-90 |
| Magnesium | | 150.0000 | | 150.0000 | < 0.1 | < 0.1 | mg/l | 01-31-90 |
| Potassium | | 7.6000 | | 7.5000 | < 0.1 | < 0.1 | mg/l | 01-31-90 |
| Sodium | | 220.0000 | | 220.0000 | < 0.1 | < 0.1 | mg/l | 01-31-90 |
| Aluminum | | 0.2000 | | 0.2000 | < 0.1 | < 0.1 | mg/l | 01-31-90 |
| Antimony | | 0.1200 | | 0.1000 | < .05 | < .05 | mg/l | 01-31-90 |
| Arsenic | < | 0.0020 | NA | 0.0000 | < .002 | < .002 | mg/l | 01-31-90 |
| Barium | < | 0.0500 | < | 0.0500 | < .005 | < .005 | mg/l | 01-31-90 |
| Beryllium | < | 0.0050 | < | 0.0050 | < .005 | < .005 | mg/l | 01-31-90 |
| Boron | | 1.2000 | | 1.3000 | < 0.02 | < 0.02 | mg/l | 01-31-90 |
| Cadmium | | 0.0130 | | 0.0110 | < .005 | < .005 | mg/l | 01-31-90 |
| Cesium | < | 0.2000 | < | 0.2000 | < 0.2 | < 0.2 | mg/l | 01-31-90 |
| Chromium | | 0.0600 | | 0.0600 | < .02 | < .01 | mg/l | 01-31-90 |
| Cobalt | | 0.0200 | | 0.0200 | < .01 | < .01 | mg/l | 01-31-90 |
| Copper | < | 0.1000 | < | 0.1000 | < .01 | < .01 | mg/l | 01-31-90 |
| Iron | < | 0.0300 | < | 0.0300 | < .03 | < .03 | mg/l | 01-31-90 |
| Lead | | 0.0900 | | 0.0800 | < .05 | < .05 | mg/l | 01-31-90 |
| Lithium | | 0.1600 | | 0.1600 | < .01 | < .01 | mg/l | 01-31-90 |
| Manganese | | 0.0390 | | 0.0360 | < .005 | < .005 | mg/l | 01-31-90 |
| Mercury | < | 0.0002 | < | 0.0002 | < .0002 | < .0002 | mg/l | 01-31-90 |
| Molybdenum | | 0.0500 | | 0.0500 | < .02 | < .02 | mg/l | 01-31-90 |
| Nickel | | 0.0300 | < | 0.0300 | < .03 | < .03 | mg/l | 01-31-90 |
| Selenium | < | 0.2000 | NA | 0.0000 | < .002 | < .002 | mg/l | 01-31-90 |
| Silver | | 0.0200 | | 0.0200 | < .01 | < .01 | mg/l | 01-31-90 |
| Strontium | | 7.9000 | | 8.0000 | < .01 | < .01 | mg/l | 01-31-90 |
| Thallium | < | 0.0100 | NA | 0.0000 | < .001 | < .001 | mg/l | 01-31-90 |
| Titanium | < | 0.0100 | < | 0.0100 | < .01 | < .01 | mg/l | 01-31-90 |
| Vanadium | | 0.0400 | | 0.0400 | < .01 | < .01 | mg/l | 01-31-90 |
| Zinc | | 2.2000 | | 2.2000 | < .02 | < .02 | mg/l | 01-31-90 |

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

VOLATILE HAZARDOUS SUBSTANCES

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| Chloromethane | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| Bromomethane | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| Vinyl chloride | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| Chloroethane | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| Methylene chloride | < | 5.0000 | NA | 0.0000 | T 6 | M 6 | ug/l | 01-31-90 |
| Acetone | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| Carbon disulfide | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| 1,1-Dichloroethene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| 1,1-Dichloroethane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| 1,2-Dichloroethene(Total) | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Chloroform | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| 1,2-Dichloroethane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| 2-Butanone | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| 1,1,1-Trichloroethane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Carbon tetrachloride | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Vinyl acetate | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| Bromodichloromethane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Freon-113 | < | 50.0000 | NA | 0.0000 | T< 50 | M< 50 | ug/l | 01-31-90 |
| 1,2-Dichloropropane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| cis-1,3-Dichloropropene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Trichloroethene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Dibromochloromethane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| 1,1,2-Trichloroethane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Benzene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| trans-1,3-Dichloropropene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Bromoform | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| 4-Methyl-2-pentanone | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| 2-Hexanone | < | 10.0000 | NA | 0.0000 | T< 10 | M< 10 | ug/l | 01-31-90 |
| Tetrachloroethene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

VOLATILE HAZARDOUS SUBSTANCES

(CONTINUED)

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Toluene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Chlorobenzene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Ethylbenzene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Styrene | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |
| Xylene (total) | < | 5.0000 | NA | 0.0000 | T< 5 | M< 5 | ug/l | 01-31-90 |

NOTE: "T" IN ASCID BLANK COLUMN INDICATES TRIP BLANK

"M" IN WATERBLANK COLUMN INDICATES METHOD BLANK

Freon-133 is 1,1,2-Trichloro-1,2,2-Trifluoroethane

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

SEMIVOLATILE HAZARDOUS SUBSTANCES

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| Phenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| bis(2-Chloroethyl)ether | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2-Chlorophenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 1-3-Dichlorobenzene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 1-4-Dichlorobenzene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Benzyl alcohol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 1,2-Dichlorobenzene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2-Methylphenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| bis(2-Chlorisopropyl)ether | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 4-Methylphenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| N-Nitroso-di-n-propylamine | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Hexachloroethane | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Nitrobenzene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Isophorone | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2-Nitrophenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2,4-Dimethylphenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Benzoic acid | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| bis(2-Chloroethoxy)methane | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2,4-Dichlorophenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 1,2,4-Trichlorobenzene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Naphthalene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 4-Chloroaniline | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Hexachlorobutadiene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 4-Chloro-3-methylphenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2-Methylnaphthalene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Hexachlorocyclopentadiene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2,4,6-Trichlorophenol | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2,4,5-Trichlorophenol | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

SEMIVOLATILE HAZARDOUS SUBSTANCES

(CONTINUED)

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| 2-Chloronaphthalene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2-Nitroaniline | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| Dimethylphthalate | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Acenaphthylene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2,6-Dinitrotoluene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 3-Nitroaniline | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| Acenaphthene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2,4-Dinitrophenol | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| 4-Nitrophenol | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| Dibenzofuran | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 2,4-Dinitrotoluene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Diethylphthalate | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 4-Chlorophenyl-phenylether | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Fluorene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 4-Nitroaniline | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| 4,6-Dinitro-2-methylphenol | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| N-Nitrosodiphenylamine | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 4-Bromophenyl-phenylether | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Hexachlorobenzene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Pentachlorophenol | < | 50.0000 | NA | 0.0000 | | M< 50 | ug/l | 01-31-90 |
| Phenanthrene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Anthracene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Di-n-butylphthalate | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Fluoranthene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Pyrene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Butylbenzylphthalate | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| 3,3'-Dichlorobenzidine | < | 20.0000 | NA | 0.0000 | | M< 20 | ug/l | 01-31-90 |
| Benzo(a)anthracene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

SEMIVOLATILE HAZARDOUS SUBSTANCES

(CONTINUED)

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| Chrysene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| bis(2-Ethylhexyl)phthalate | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Di-n-octylphthalate | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Benzo(b)fluoranthene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Benzo(k)fluoranthene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Benzo(a)pyrene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Indeno(1,2,3-cd)pyrene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Dibenzo(a,h,)anthracene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |
| Benzo(g,h,i)perylene | < | 10.0000 | NA | 0.0000 | | M< 10 | ug/l | 01-31-90 |

NOTE: "T" IN ASCID BLANK COLUMN INDICATES TRIP BLANK

"M" IN WATERBLANK COLUMN INDICATES METHOD BLANK

CONTRACT LABORATORY ANALYSIS

ENGLE WELL, CULEBRA, ROUND 3

PESTICIDE ANALYSIS

| PARAMETER | V | VALUE | S D | VALUE_DUP | ACIDBLANK | WATERBLANK | UNITS | DATE |
|---|---|---|---|---|---|---|---|---|
| Lindane | < | 0.0500 | NA | 0.0000 | | M< .05 | ug/l | 01-31-90 |
| Endrin | < | 0.1000 | NA | 0.0000 | | M< .10 | ug/l | 01-31-90 |
| Methoxychlor | < | 0.5000 | NA | 0.0000 | | M< .50 | ug/l | 01-31-90 |
| Toxaphene | < | 1.0000 | NA | 0.0000 | | M< 1.0 | ug/l | 01-31-90 |
| 2,4-D | < | 12.0000 | NA | 0.0000 | | M< 12 | ug/l | 01-31-90 |
| 2,4,5-TP(Silvex) | < | 1.7000 | NA | 0.0000 | | M< 1.7 | ug/l | 01-31-90 |

NOTE: "T" IN ASCID BLANK COLUMN INDICATES TRIP

"M" IN WATERBLANK COLUMN INDICATES METHO

## TABLE 5.1 Summary of surface water and sediment analysis - October 22-23, 1986

| PARAMETERS | SURFACE WATER | | | | SEDIMENT | | | |
|---|---|---|---|---|---|---|---|---|
| | HILL TANK | RED TANK | INDIAN TANK | LAGUNA GRANDE DE LA SAL | HILL TANK | RED TANK | INDIAN TANK | LAGUNA GRANDE DE LA SAL |
| **FIELD** | | | | | | | | |
| Temperature (°C) | 19 | 16 | 17 | 28 | --- | --- | --- | --- |
| pH | 7.0 | 8.2 | 7.4 | 7.8 | --- | --- | --- | --- |
| Conductivity (umhos/cm) | 140 | 230 | 250 | 30,000 | --- | --- | --- | --- |
| **GENERAL CHEMISTRY(1)** | | | | | | | | |
| Bicarbonate | 95 | 150 | 120 | 260 | 1000 | 620 | 760 | 340 |
| Carbonate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chloride | 3.1 | 5.0 | 2.5 | 25,000 | 83 | 21 | 11 | 79,000 |
| Phosphate (total) | 0.32 | 0.38 | 0.52 | 0.05 | 4 | 2 | 4 | <1 |
| Total Dissolved Solids (Filterable) | 110 | 180 | 100 | 320,000 | --- | --- | --- | --- |
| Total Suspended Solids (Nonfilterable) | 47 | 110 | 120 | 850 | --- | --- | --- | --- |
| Moisture Content (%) | --- | --- | --- | --- | 35.9 | 30.0 | 32.3 | 24.2 |
| Sulfate | 4 | 4 | 3 | 18,000 | 11 | 40 | 19 | 33,000 |
| Total Organic Carbon (TOC) | 6 | 5 | 8 | 40 | --- | --- | --- | --- |
| Total Organic Halogen (TOX) | 0.09 | 0.13 | 0.10 | 12 | --- | --- | --- | --- |
| **METALS(1)** | | | | | | | | |
| Aluminum | 0.1 | 0.2 | 0.2 | <10 | 16,000 | 3,500 | 23,000 | 670 |
| Arsenic | <0.005 | <0.005 | <0.005 | <0.005 | 11 | 2.8 | 19 | 2.7 |
| Barium | 0.10 | 0.15 | 0.12 | <0.5 | 300 | 98 | 210 | 120 |
| Calcium | 21 | 36 | 25 | 790 | (4) | (4) | (4) | (4) |
| Cesium | <0.1 | <0.1 | <0.1 | <0.1 | 18 | <10 | 18 | 18 |
| Chromium | 0.01 | 0.02 | 0.01 | 2.3 | 14 | 5.2 | 24 | 3.2 |
| Lithium | <0.01 | <0.01 | <0.01 | 1.7 | 17 | 5.0 | 37 | 13 |
| Magnesium | 4.7 | 3.2 | 5.6 | 10,000 | (4) | (4) | (4) | (4) |
| Potassium | 6 | 12 | 5.7 | 29,000 | (4) | (4) | (4) | (4) |
| Selenium | <0.005 | <0.005 | <0.005 | 0.047 | <0.5 | <0.5 | <0.5 | <0.5 |
| Sodium | 1.4 | 2.4 | 0.1 | 93,000 | (4) | (4) | (4) | (4) |
| Strontium | 0.07 | 0.09 | 0.03 | 3.6 | 57 | 30 | 12 | 2,000 |
| **ORGANICS(2)(3)** | | | | | | | | |
| Volatile Organics | | | | | | | | |
| Acetone | <10 | 96 | <10 | 14(5) | <100 | <100 | 1,000 | <100 |
| 1,2-Dicloroethane | <5.0 | 26 | <5.0 | <5.0 | <50 | <50 | <50 | <50 |
| Methylene Chloride | <10 | <10 | <10 | 16(5) | <100 | <100 | 120 | <100 |
| Toluene | <5.0 | 15 | <5.0 | <5.0 | 61 | 67 | <50 | <50 |
| Semi-Volatile Organics | | | | | | | | |
| Bis(2-ethylhexyl)phthalate | 22 | <10 | <10 | <10 | <330 | <330 | <330 | <330 |
| N-Nitrosodiphenylamine (Diphenylamine) | <10 | <10 | <10 | <10 | <330 | <330 | 1,000 | <330 |
| Pesticides/PCBs | NONE DETECTED | | | | | | | |

(1) All units, unless indicated otherwise, are in mg/l or parts per million (ppm) for surface water and mg/kg or ppm for sediments.
(2) All units, unless indicated otherwise, are in ug/l or parts per billion (ppb) for surface water and ug/kg or ppb for sediments.
(3) Only those organic compounds which were at or above the detection limits are included in this table.
(4) No data available due to incorrect laboratory procedure.
(5) Concentration obtained from the northern sampling location of Laguna Grande de la Sal.
--- = Not Tested.

TABLE 5.5 Surface water and sediment analytical data comparisons for metals - October 1986, June 1987, and November 1987

| DATE OF SAMPLING | SURFACE WATER[1] HILL TANK | RED TANK | INDIAN TANK | LAGUNA GRANDE. | SEDIMENT[2] HILL TANK | RED TANK | INDIAN TANK | LAGUNA GRANDE. |
|---|---|---|---|---|---|---|---|---|
| | | | | ARSENIC | | | | |
| Oct. 1986 | <0.005 | <0.005 | <0.005 | <0.005 | 11 | 2.8 | 19 | 2.7 |
| Jun. 1987 | <0.005 | <0.005 | 0.005 | <0.010 | 8.2 | 3.9 | 8.2 | 4.2 |
| Nov. 1987 | <0.005 | 0.006 | 0.005 | <0.036 | 1.6 | 1.2 | 1.1 | 1.4 |
| | | | | CALCIUM | | | | |
| Oct. 1986 | 21 | 36 | 25 | 790 | (3) | (3) | (3) | (3) |
| Jun. 1987 | 33 | 36 | 18 | 930 | 62,000 | 29,000 | 36,000 | 200,000 |
| Nov. 1987 | 34 | 32 | 32 | 270 | 58,800 | 45,000 | 20,600 | 95,000 |
| | | | | MAGNESIUM | | | | |
| Oct. 1986 | 4.7 | 3.2 | 5.6 | 10,000 | (3) | (3) | (3) | (3) |
| Jun. 1987 | 4.5 | 4.4 | 4.1 | 9,800 | 14,000 | 4,300 | 31,000 | 9,600 |
| Nov. 1987 | 5.9 | 8.2 | 7.7 | 12,500 | 13,000 | 5,600 | 18,400 | 5,700 |
| | | | | POTASSIUM | | | | |
| Oct. 1986 | 6 | 12 | 5.7 | 29,000 | (3) | (3) | (3) | (3) |
| Jun. 1987 | 13 | 11 | 9.4 | 28,000 | 4,500 | 1,200 | 2,200 | 8,300 |
| Nov. 1987 | 17 | 20 | 9.2 | 37,500 | 6,400 | 3,400 | 2,600 | 24,600 |
| | | | | SODIUM | | | | |
| Oct. 1986 | 1.4 | 2.4 | 0.1 | 93,000 | (3) | (3) | (3) | (3) |
| Jun. 1987 | 2.0 | 3.7 | 0.03 | 100,000 | 200 | 62 | 100 | 32,000 |
| Nov. 1987 | 2.4 | 8.7 | 1.2 | 101,000 | 69 | 85 | 60 | 214,000 |
| | | | | STRONTIUM | | | | |
| Oct. 1986 | 0.07 | 0.09 | 0.03 | 3.6 | 57 | 30 | 12 | 2,000 |
| Jun. 1987 | 0.09 | 0.07 | 0.02 | 41 | 110 | 29 | 40 | 850 |
| Nov. 1987 | 0.10 | 0.13 | 0.04 | 17 | 140 | 82 | 32 | 1,400 |

(1) In mg/l or parts per million.
(2) In mg/kg or parts per million.
(3) No data available due to [illegible]

Table 4.1 Average values for selected soil parameters (middle value) with asymmetrical 95% confidence limits (see text for explanation of methods)

| PARAMETER | CTR-1 | CTR-2 | SE-1 | SE-2 | NW-1 | NW-2 |
|---|---|---|---|---|---|---|
| | 16.6 | 15.9 | 37.2 | 11.8 | 11.2 | 23.4 |
| Ca (mg/kg) | 20.3 | 21.2 | 49.2 | 21.5 | 38.2 | 27.2 |
| | 24.0 | 26.3 | 61.7 | 32.4 | 74.1 | 30.9 |
| | 3.1 | 3.5 | 3.2 | 2.3 | 2.5 | 3.0 |
| Mg (mg/kg) | 3.9 | 4.1 | 4.8 | 7.7 | 5.1 | 3.5 |
| | 4.7 | 4.8 | 6.5 | 12.0 | 7.8 | 4.0 |
| | 6.5 | 4.1 | 5.1 | 4.8 | 9.8 | 5.5 |
| K (mg/kg) | 7.4 | 5.5 | 8.4 | 6.3 | 24.3 | 7.0 |
| | 8.5 | 7.1 | 11.8 | 7.9 | 38.9 | 8.3 |
| | 2.1 | 2.0 | 3.6 | 1.9 | 13.8 | 2.5 |
| Na (mg/kg) | 2.9 | 2.5 | 30.4 | 8.3 | 95.3 | 4.9 |
| | 3.7 | 3.0 | 55.0 | 15.1 | 151.4 | 14.8 |
| | | | | 3.4 | 6.2 | 4.5 |
| Cl (mg/kg) | < 5 | < 5 | < 5 | 13.0 | 64.9 | 5.4 |
| | | | | 20.4 | 102.3 | 6.2 |
| | 6.7 | 7.1 | 7.7 | 7.2 | 8.1 | 7.2 |
| pH | 6.6 | 6.9 | 7.6 | 7.1 | 7.6 | 7.1 |
| | 6.5 | 6.7 | 7.5 | 7.0 | 7.1 | 7.0 |
| | 157 | 144 | 204 | 114 | 232 | 170 |
| EC (μmhos/cm) | 182 | 174 | 406 | 175 | 749 | 196 |
| | 210 | 209 | 618 | 242 | 1186 | 224 |
| | 0.11 | 0.09 | 0.19 | 0.16 | 0.79 | 0.16 |
| SAR | 0.20 | 0.13 | 1.22 | 0.62 | 4.43 | 0.30 |
| | 0.31 | 0.18 | 2.33 | 1.08 | 8.79 | 0.45 |

# Appendix B

## Methods of Environmental Monitoring

## Groundwater, Surface Water, Sediment, Soil

TABLE 7-4

METHODS USED FOR GROUNDWATER AND SURFACE WATER ANALYSIS

| PARAMETER | REFERENCE METHOD |
|---|---|
| Alkalinity | Method 403, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 16th Ed., 1985. |
| Bromide, Titrimetric | Method 320.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Chloride, Potentiometric Method | Method 407C, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 16th Ed., 1985. |
| Cyanide Determination by Flow Injection Analysis | Quick Chem Method No. 10-204-00-1-A, Lachat Instruments-1987. |
| Fluoride (Potentiometric) Ion Selective Electrode) | Method 340.2, Method for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Nitrate/Nitrite Determination by Flow Injection Analysis | Quick Chem Method No. 10-107-04-1-A, Lachat Instruments-1987. |
| Nitrogen/Nitrate (Colorimetric, Brucine) | Method 352.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| pH (electrometric) | Method 150.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Phenol Determination by Flow Injection Analysis | Quick Chem Method No. 10-210-00-1-A, Lachat Instruments-1987. |
| Phosphorus, All Forms (Colorimetric; Ascorbic Acid; Single Reagent) | Method 365.2, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Residue, Nonfilterable | Method 160.2, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Residue, Filterable | Method 160.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |

TABLE 7-4

METHODS USED FOR GROUNDWATER AND SURFACE WATER ANALYSIS
(CONTINUED)

| PARAMETER | REFERENCE METHOD |
|---|---|
| Conductance (Specific Conductance, µmhos at 25°C) | Method 120.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Sulfate (Turbidimetric) | Method 375.4, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Total Organic Halides | Method 9020, Test Methods for Evaluating Solid Waste, USEPA SW-846 3rd Ed., 1986. |
| Total Organic Carbon | Method 9060, Test Methods for Evaluating Solid Waste, USEPA SW-846 3rd Ed., 1986. |
| Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis Of Water and Waste | Method 200.7, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Arsenic (Atomic Absorption, Furnace Technique) | Method 206.2, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Molybdenum (Atomic Absorption, Direct Aspiration) | Method 246.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Selenium (Atomic Absorption, Furnace Technique) | Method 270.2, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Titanium, Direct Aspiration | Method 283.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Mercury, Manual Cold Vapor | Method 7470, Test Methods for Evaluating Solid Waste, USEPA, SW-846 3rd Ed., 1986. |
| Strontium, Direct Aspiration | Method 303A, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 16th Ed., 1985. |
| Thallium (Atomic Absorption, Furnace Technique | Method 279.2, Methods for the Chemical Analysis of Water and Waste. United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |

TABLE 7-4

METHODS USED FOR GROUNDWATER AND SURFACE WATER ANALYSIS
(CONTINUED)

| PARAMETER | REFERENCE METHOD |
|---|---|
| Lithium, Aspiration | Method 317B, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 16th Ed., 1985. |
| Cesium, Direct Aspiration | Method 303A, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 16th Ed., 1985. |
| Base-Neutral and Acid Extractables | Method 625, Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, U.S. Environmental Protection Agency, 600/4-82-057, 1982. |
| Gas Chromatography/Mass Spectrometry for Volatile Organics | Method 8240, Test Method for Evaluating Solid Waste, U.S. Environmental Protection Agency, SW-846 3rd Ed., 1986. |
| Gas Chromatography/Mass Spectrometry for Volatile Organics | Method 8270, Test Methods for Evaluating Solid Waste, U.S. Environmental Protection Agency, SW-846, 3rd Ed., 1986. |
| ITWC 007 Silica | Quick Chem Method No. 10-114-27-1A, Lachat Instruments - 1988. |
| Iodide, Titrimetric | Method 345.1, Method for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Pesticides and PCBs | Method 608, Method for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA - 600/4-82-057, July 1982. |
| | Method 8080, Test Methods for Evaluating Solid Waste, USEPA SW-846, 3rd Ed., 1986. |
| Cesium 137, Cobalt 60 | Procedure number A-524, WAESD. |
| Radium 226, Thorium 228 | Procedure OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix E, WAESD. |
| Strontium 90 | Procedure number A-516, Rev. 1, Determination of Sr 89 and Sr 90 in Waste Water and Environmental Samples, WAESD. |

TABLE 7-4

METHODS USED FOR GROUNDWATER AND SURFACE WATER ANALYSIS
(CONTINUED)

| PARAMETER | REFERENCE METHOD |
|---|---|
| Neptunium 237 | Procedure number A-508, WAESD. |
| Thorium 232, Thorium 230 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix B, WAESD. |
| Uranium 238, Uranium 234, Uranium 233 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix A, WAESD. |
| Plutonium 238, Plutonium 241, Plutonium 239/240 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix C, WAESD. |
| Americium 241, Curium 244 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix D, WAESD. |
| Hydrogen 3 (Tritium) | Procedure number A-531, Rev. 0, Determination of Beta Emitting Radionuclides by Liquid Scintillation Counting, WAESD. |

TABLE 7-3

METHODS OF SOIL ANALYSIS

| PARAMETER | REFERENCE METHOD |
|---|---|
| Cesium 137, Cobalt 60, Radium 226, Thorium 228 | Procedure number A-524, WAESD. |
| Strontium 90 | Procedure number A-516, Rev. 1, Determination of Sr 89 and Sr 90 in Wastewater and Environmental Samples, WAESD. |
| Neptunium 237 | Procedure number A-508, WAESD. |
| Thorium 232, Thorium 230 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix B, WAESD. |
| Plutonium 238, Plutonium 241, Plutonium 239-240 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix H, WAESD. |
| Uranium 238, Uranium 234-233 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix G, WAESD. |
| Americium 241, Curium 244 | Procedure number OI-86-4, Rev. 2, Full Radionuclide Analysis of WIPP Samples, Appendix D, WAESD. |
| Water Soluble Extraction of Anions | Soil Extraction for Common Anions, ITAS-Pittsburgh Laboratory Methodology, 1985. |
| Chloride, Titrimetric | Method 325.3 Method for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| pH on Saturation Paste, Conductivity on Extract, Sodium Absorption Ratio | Sobeck, A., W. Schuller, J. Freeman, and R. Smith, Field and Laboratory Methods Applicable to Overburdens and Minesoils, United States Environmental Protection Agency - 600/2-78-054, p. 95, March 1978. |
| Calcium, Direct Aspiration | Method 215.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Magnesium, Direct Aspiration | Method 242.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |

TABLE 7-3

METHODS OF SOIL ANALYSIS
(CONTINUED)

| PARAMETER | REFERENCE METHOD |
|---|---|
| Potassium Direct Aspiration | Method 258.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |
| Sodium, Direct Aspiration | Method 273.1, Methods for the Chemical Analysis of Water and Waste, United States Environmental Protection Agency - 600/4-79-020, 1983 Revision. |