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EDMC#: 0025845

SECTION: 1 of 8

DOCUMENT #: DOE/RL-92-67, DRAFT A

TITLE: Final RI/FS Report for
1100-EM-1 OU, Hanford

Final Remedial Investigation/ Feasibility Study Report for the 1100-EM-1 Operable Unit, Hanford

Date Published
November 16, 1992

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Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

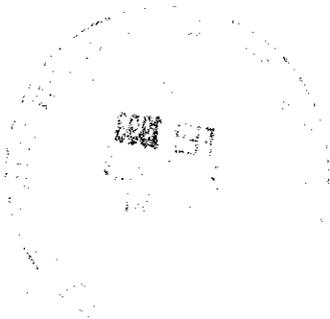


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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ACM	Asbestos Containing Materials
amsl	Above Mean Sea Level
ANF	Advanced Nuclear Fuels
ANSI	American National Standards Institute
API	American Petroleum Institute
APR	Air Purifying Respirator
ARAR	Applicable or relevant and appropriate requirements
ARAR's	Legally <u>applicable</u> , or <u>relevant</u> and <u>appropriate</u> , Federal and State environmental standards
ASR	Air supplying respirator
ASTM	American Society for Testing and Materials
AWP	Asbestos work permit
BDAT	Best demonstrated available technology
BEHP	Bis (2-ethylhexyl) phthalate
BETA-HCH	Beta-Hexachlorocyclohexane
BISRA	Baseline Industrial Scenario Risk Assessment
BRsRA	Baseline Residential Scenario Risk Assessment
BWTF	Buried Waste Test Facility
CAA	Clean Air Act
CAS	Chemical abstracts service
CBC	Complete blood count
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CFWQC	Chronic freshwater quality criterion
CGI	Combustible gas indicator
cm ³	Cubic centimeter
CNS	Central nervous system
CO ₂	Carbon dioxide
CPC	Chemical protective clothing
CPR	Cardiopulmonary resuscitation
CRC	Contamination reduction corridor
CRQL	Contract Required Quantifaction Limit
CRZ	Contamination reduction zone
CWA	Clean Water Act
dBA	Decibels on A-weighted scale
DHHS	U.S. Department of Health and Human Services
DNR	Washington State Department of Natural Resources
DOE	United States Department of Energy
DOE-RL	United States Department of Energy Field Office, Richland
DOL	Department of Labor
DOT	Department of Transportation
DOW	Washington State Department of Wildlife
Ecology	Washington Department of Ecology
EIS	Environmental impact statement

ACRONYMS
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EM	Equipment maintenance
EMI	Electromagnetic inductance
EPA	United States Environmental Protection Agency
ERDA	United States Energy Research and Development Administration
ESLI	End-of-service-life indicator
FD&CA	Food, Drug, and Cosmetic Act
FEF	Forced expiratory flow
FID	Flame ionization detector
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FRC	Functional residual capacity
FS	Feasibility Study
ft	Foot
g	Gram
GC	Gas chromatography
G/kg	Grams per kilogram
g-mole	Gram-mole
GMU	Game management unit
GPR	Ground-penetrating radar
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford Environmental Information System
HM	Hazardous material
HMS	Hanford Meteorological Station
HNF	Hanford Nuclear Facility
HNU	A photoionization detector manufactured by the HNU Co.
HOC's	Halogenated organic compounds
HQ	Hazard quotient
hr	Hour
HRL	Horn Rapids Landfill
HRS	Hazard ranking system
HSBRAM	Hanford Site baseline risk assessment methodology
HSDB	Hazardous substances data base
HSP	Health and Safety Plan
HSO	Health & Safety Officer
HSPA	Hanford Site performance assessment
HWP	Hazardous work permit
HWO&ER	Hazardous waste operations and emergency response
HWOP	Hazardous waste operating permit
HWQHC	Human water quality health criterion
HWQWC	Human water quality welfare criterion
ICR	Incremental cancer risk
IDL	Instrument detection limit
IDLH	Immediately dangerous to life and health
IP	Ionization potential
IR	Infrared

ACRONYMS
(Continued)

IRIS	Integrated Risk Information System
IU	Isolated unit
JSA	Job Safety Analysis
kg	One thousand grams
L	Liter
lb	Pound
LC	Lethal concentration
LD	Lethal dose
LDLO	Lethal dose low
LDR	Land disposal restriction
LD50	Medium lethal dose
LEL	Lower explosive limit
LFL	Lower flammable limit
LOAEL	Lowest observed adverse effect level
LOEL	Lowest observed effect level
m ³	Cubic meter
MAG	Magnetometer
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MD	Metal detector
MEFR	Maximal expiratory flow rate
Metals	Mercury, etc.
mg	Milligram
mg/kg	Milligram per kilogram
ML	Milliner
MMHG	Milliner of mercury
Mrem	Milliroentgen equivalent in man
MS	Mass Spectroscopy
MSDS	Material safety data sheet
MSHA	Mine Safety and Health Administration
msl	Mean sea level
MSWLF	Municipal and Solid Waste Landfill
MTCA	Model Toxics Control Act
MVV	Maximal voluntary ventilation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	No observed adverse effect level
NOEL	No observed effect level
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTP	National Toxicology Program
O ₂	Oxygen

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ACRONYMS
(Continued)

O&M	Operation and Maintenance
ORM	Other regulated materials
OSHA	United States Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable unit
OVA	Organic vapor analyzer
OVM	Organic vapor meter
PAH	Polycyclic aromatic hydrocarbons
PAPR	Powered air-purifying respirator
PCB	Polychlorinated biphenyl
PCE	Tetrachlorethene (perchlorethene)
PCP	Pentachlorophenol
PDS	Personnel decontamination station
PEL	Permissible exposure limit
PEST.	Pesticides
pH	Hydrogen ion concentration
PID	Photoionization detector
PNL	Pacific Northwest Laboratory
ppb	Parts per billion
ppbv	Parts per billion by volume
PPE	Personal protective equipment
ppm	Parts per million
PRC	PRC Consultants
PRG	Preliminary remediation goal
psi	Pounds per square inch
PSPL	Puget Sound Power and Light
PTL	Project team leader
PVC	Polyvinyl chloride
QAPjP	Quality Assurance Project Plan
QAPP	Quality Assurance Program Plan
QTRC	Quality Training and Resource Center
RAD	A unit for the measurement of radioactivity
RAM	Radioactive material
RAO	Remedial action objective
RBC	Red blood count
RCRA	Resource Conservation and Recovery Act
REL	Recommended exposure limit
REM	A measurement of radiation dose meaning roentgen equivalent man.
RfD	Reference dose
RHO	Rockwell Hanford Operations
Phase I RI	Phase I Remedial Investigation
Phase II RI	Phase II Remedial Investigation
RME	Reasonable maximum exposure
RV	Residual volume

ACRONYMS
(Continued)

RWP	Radiation Work Plan
SAR	Supplied-air respirator
SARA	Superfund Amendments and Reauthorization Act
SC	Specific conductance
SCBA	Self-contained breathing apparatus
SCS	United States Soil Conservation Service
SDG	Sample delivery group
SDWA	Safe Drinking Water Act
SF	Slope factor
SOP	Standard Operating Procedure
SPC	Siemens Power Corporation
SQL	Sample quantitation limit
STEL	Short-term exposure limit
SVOC	Semivolatile organic compound
ta	Ambient air temp.
ta adj	Adjusted ambient air temp.
TAL	Target analyte list
TBC	To be considered
TCA	1,1,1, trichlorethane
TCE	Trichloroethene
TCL	Target compound list
TCLo	Lowest observed toxic concentration
TDLo	Lowest observed toxic dose
TDS	Total dissolved solids
TIC	Tentatively-identified compounds
TLC	Total lung capacity
TLV	Threshold Limit Value
TLV-C	Threshold limit value - ceiling
TLV-STEL	Threshold limit value - short-term exposure limit
TOC	Total organic carbon
TORR	A unit of pressure equal to 1 mm Hg
TOX	Total organic halogen
TPA	Tri-Party Agreement
TSCA	Toxic Substance Control Act
TSD	Treatment, storage, or disposal facility
TWA	Time-weight average
UCL	Upper confidence limit
UEL	Upper explosive limit
UFL	Upper flammable limit
UN	Unplanned and unauthorized release
USC	United States Code
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USF&WS	United States Fish and Wildlife Service

**ACRONYMS
(Continued)**

USGS	United States Geological Survey
UTL	Upper tolerance limit
UV	Ultraviolet
VOC	Volatile organic compound
WAC	Washington Administrative Code
WDOE	Washington Department of Ecology
WHC	Westinghouse Hanford Company
WIDS	Waste Information Data System
WOE	Weight-of-evidence
WPPSS	Washington Public Power Supply System
WSGMA	Washington State Growth Management Act
WSU	Washington State University

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EXECUTIVE SUMMARY

The final Remedial Investigation/Feasibility Study (RI/FS) Report presents the results of field and analytical investigations conducted at the 1100-EM-1 Operable Unit at the U.S. Department of Energy (DOE) Hanford Reservation located near the city of Richland in Benton County, Washington. In addition, this report develops and evaluates a range of remedial technologies to address potential threats to human health and the environment.

This document conforms with current guidance for the conduct and preparation of RI and FS of hazardous waste sites pursuant to the National Oil and Hazard Substance Pollution Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The report fulfills DOE's agreed obligation milestone M-15-01B/C as mandated by the Hanford Federal Facility Agreement and Consent Order, commonly referred to as the Tri-Party Agreement.

The 1100-EM-1 Operable Unit is one of four within the 1100 Area. The 1100 Area was placed on the National Priorities List in July 1989. Recent efforts on the part of DOE, the Environmental Protection Agency (EPA), and others to accelerate the characterization and remediation of the entire 1100 Area have led to the initiation of an expedited investigation of the 1100-EM-2, 1100-EM-3, and 1100-IU-1 Operable Units as well. It is anticipated that results of this investigation will be available by spring of 1993 and will be incorporated into this report as an addendum. The Record of Decision developed from this final RI/FS report and addendum will then address the entire 1100 Area.

The bulk of this final RI/FS report, however, focuses on individual subunit or waste disposal areas within the 1100-EM-1. The three most significant subunits are the Discolored Soil Site, the Ephemeral Pool, and the Horn Rapids Landfill (HRL). Investigation and analysis of contamination, especially groundwater at HRL, has involved coordination with Siemens Power Corporation, who is independently investigating contaminated groundwater beneath their facility. The scope and scheduling of data collection activities for the entire RI has been subject to substantial negotiations based on concerns for and potential impacts to groundwater and the nearby North Richland well field.

This final RI/FS report summarizes and evaluates the followup analysis of both the intrusive and nonintrusive activities at the several subunits. The majority of the soil analyses and geophysical surveys were completed in early phases of this investigatory effort. Important new activities completed in the later phases of the RI include the collection of six additional rounds of groundwater samples, and excavation of several exploratory trenches at HRL. Analytical results of these efforts are presented in the appendixes.

Three main areas of concern were identified. These are: 1) approximately 340 cubic meters of contaminated soil at the Discolored Soil Site [bis (2-ethylhexyl) phthalate (BEHP) concentration up to 25,000 parts per million (ppm)]; 2) approximately 250 cubic meters of polychlorinated biphenyls (PCB's) contaminated soil at the Ephemeral Pool (PCB < 42 ppm); and 3) approximately 460 cubic meters of PCB contaminated soils (PCB \leq 101 ppm), and a 2-kilometer-long by 2-kilometer-wide groundwater plume with trichloroethene (TCE)

(up to 110 ppm) and nitrate (up to 63 ppm) contamination at HRL. Contaminants noted at these areas exceed regulatory criteria.

Potential risk to human health and the environment were assessed. Incremental cancer risks were determined to be in the range of $2E-4$ to $6E-5$, where risk management based decisions must be made in concern with regulatory agencies.

Identification and analysis of mobility and migration of contaminants was explored through the use of both unsaturated and saturated zone flow and transport models. Results from the modelling and analysis activities suggest groundwater contaminants will migrate but attenuate to levels at or below regulatory concern within 12 to 22 years.

A wide range of treatment options were reviewed. These options were screened for technical and practical applicability, and evaluated for effectiveness. Viable and practicable process technologies were then assembled into groups of alternatives to provide for remediation of those contaminants exceeding criteria. For the soil contaminants, excavation and offsite disposal and/or incineration passed screening and are considered further. For the groundwater, pumping, and treatment, along with the natural attenuation also passed the screening criteria. Additional consideration was given to costs as estimates were developed for each alternative.

Finally, each of the alternatives that survived the review, screening, and evaluation are considered against the evaluation criteria pursuant to the NCP and CERCLA. These evaluations were completed to provide objective comparison of remedial alternatives for the 1100-EM-1 Operable Unit and are available to allow for considered risk management decisions by the appropriate regulatory agencies.

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1.0 INTRODUCTION

The 1100 Area of the U.S. Department of Energy's (DOE) Hanford Reservation was placed on the National Priorities List in July 1989, pursuant to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, 42 U.S.C. 9601 *et seq.*. Based on both documented and undocumented past practices at the 1100 Area, it was determined that pollutants were released to the environment and that those contaminants might present a danger to the public health and welfare.

In anticipation of regulatory actions, the U.S. Department of Energy Field Office, Richland (DOE-RL) divided the 1100 Area into four operable units and initiated CERCLA response planning. DOE-RL, the U. S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (Ecology) jointly assigned the 1100-EM-1 Operable Unit the highest priority, within both the 1100 Area and the Hanford Site as a whole.

The Hanford Federal Facility Agreement and Consent Order, also referred to as the Tri-Party Agreement (TPA) issued in May 1989, governs all CERCLA efforts at Hanford. The Remedial Investigation (RI)/Feasibility Study (FS) work plan (DOE/RL-88-23), mandated by the TPA, led to the first phase of the RI, which was completed in the summer of 1990. The Phase I RI report (DOE/RL-90-18) was issued in August 1990, followed by the Phase I and II FS Report (DOE/RL-90-32) issued in December 1990.

The Phase II RI was initiated with the publication of the draft RI Phase II Supplemental Workplan (DOE/RL-90-37) in October 1990.

According to the TPA, the Phase II RI was due for completion in September 1991. Due to changes in the scope of remedial characterization activities, DOE, EPA, and Ecology renegotiated the Phase II RI milestone, M-15-01B, and combined it with the Phase III FS milestone M-15-01C, to become the combined RI Phase II/Phase III FS milestone M-15-01B/C with the new submittal date of December 1992. This 1100-EM-1 Operable Unit Final RI/FS Report has been prepared to meet the DOE's obligations for that combined milestone.

1.1 PURPOSE OF REPORT

The Phase I RI report concentrated on the initial site characterization for the 1100-EM-1 Operable Unit. This Final Report focuses on more complete site characterization as well as an additional investigation of problematic issues developed during Phase I. A description of the activities undertaken is found in the Phase II RI Supplemental Work Plan (Revision II) DOE/RL-90-37. It is noteworthy that some tasks originally planned in early versions of the RI Phase II Work Plan have been deleted while other tasks have been modified or added. Discussions detailing these changes are found in the introduction to the RI Phase II Supplemental Workplan (Revision II). This Final Report complements the initial characterization, providing a more definitive characterization of the nature and extent of the

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threats to human health and the environment posed by contaminant releases from the Operable Unit.

This document also presents the Phase III FS results. Included are the review of appropriate remedial technologies and analyses of several remedial options for the restoration of the 1100-EM-1 Operable Unit in accordance with pertinent regulatory criteria. This document is intended to be a self-contained report. It is important to note, however, that to avoid unnecessary duplication, this document will refer frequently to previously published reports on the 1100 Area, especially the Phase I RI and the Phase I/II FS Reports noted above.

It is the intent to provide only sufficient redevelopment of older material to allow the reader to follow the logic of the technical discussions presented in this report. Familiarity with previous investigative reports published on the 1100 Area, especially as presented in DOE/RL-90-18 and DOE/RL-90-32, is assumed for a critical review of the findings and recommendations presented in this document. As noted, this document reports primarily on those activities outlined in the Phase II RI Supplemental Work Plan, Revision II.

The TPA identifies a RI Phase II Report as a primary document. As such, regulatory agencies have the opportunity to comment, and the DOE the opportunity to respond to those comments within a certain time period. Revisions and/or modifications to this Final RI/FS Report will follow guidelines as stated in paragraph 9.2.1 of the TPA.

1.2 NATIONAL ENVIRONMENTAL POLICY ACT

This report has also been prepared to address the requirements for an environmental assessment as defined in the Council on Environmental Quality regulations for implementing the procedural requirements of the National Environmental Policy Act (NEPA) and the DOE orders for implementing NEPA. These regulations and orders require an environmental assessment to provide brief discussions of the need for the proposal, alternatives considered, the environmental impacts associated with each alternative, and a listing of agencies and persons contacted.

The regulatory authority for the proposed action is discussed above in section 1.1. The affected environment is described in detail below in sections 2, 3 and 4. The environmental and human health impacts and the rationale for requisite actions at the site are presented in sections 5 and 6. In sections 7, 8, and 9, remedial alternatives are developed, screened, and assessed. Effectiveness, implementability, and other criteria are also evaluated to determine if protection of human health and the environment are being addressed, and to meet the intent of regulatory criteria.

To date numerous agencies and persons have been contacted including: the Hanford Cultural Resources Laboratory; EPA Region 10, Hanford Project Office; Ecology, Hanford Facility Project Office; and the Department of the Interior (DOI), National Oceanic and Atmospheric Administration (NOAA). Additional agencies and

persons will be contacted through the public and regulatory review process for this document.

The DOE will use this Final RI/FS Report to determine whether the potential environmental impacts are significant enough to warrant further action. A Finding of No Significant Impact will be prepared and published by the DOE if it is determined that the potential environmental impacts are not significant.

1.2.1 Natural Resource Damage Assessments

CERCLA and the Clean Water Act (CWA), 33 U.S.C. 1251-1376, provide that natural resource trustees may assess damages to natural resources resulting from a discharge of oil or a release of a hazardous substance covered under CERCLA or the CWA and may seek to recover those damages. To this end, a Preliminary Natural Resource Survey was completed by NOAA.

According to the NCP [section 300.160 (a)(3)] the lead agency shall make available to the trustees of affected natural resources information and documentation that can assist the trustees in the determination of actual or potential natural resource injuries.

1.2.2 Trustees for Natural Resources

The trustees for Natural Resources are NOAA, DOE, and the State of Washington. Potential trustees include the following Indian Tribes: Yakima Indian Reservation, Nez Perce Tribal Executive Committee, Federated Tribes of the Umatilla, and the Tribal Council Confederated Tribes of Warm Springs Reservation. Copies of this report are to be made available to the trustees and potential trustees for Natural Resources.

1.3 REPORT ORGANIZATION

This Final RI/FS Report for the 1100-EM-1 Operable Unit is organized in a format comparable to that recommended by EPA (1988). This document does, however, combine the RI/FS portions under a single cover. The intent is to minimize the repetition of background materials without sacrificing the technical detail necessary to make an informed decision for appropriate remediation of the site. This subsection assists the reader in understanding the presentation format and in locating information of specific interest. This Final RI/FS Report, consists of eight sections in addition to this introduction, the bibliography, and associated appendices.

- Section 1: Provides a concise site description, general history, and background of the 1100-EM-1 Operable Unit.
- Section 2: Presents a summary of the physical characteristics of the 1100-EM-1 Operable Unit.

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- Section 3: Summarizes the data collection activities performed as documented in the RI/FS work plans.
- Section 4: Discusses the nature and extent of contamination at the site.
- Section 5: Presents contaminants of concern along with summaries of human health baseline risk assessments for industrial and residential scenarios and ecological risk assessments posed by hazardous substances released from 1100-EM-1 Operable Unit.
- Section 6: Analyses the environmental fate and transport of contaminants at the operable unit. Potential operable unit contaminant migration pathways are documented, contaminant characteristics relevant to migration are assessed, and transport modeling is performed to estimate current and future contaminant concentrations in each environmental medium.
- Section 7: Identifies remedial action objectives, general response actions, and screens remedial technologies and process options.
- Section 8: Develops and screens remedial alternatives.
- Section 9: Provides comparison of the alternatives against regulatory evaluation criteria.
- Section 10: Presents references cited in body of text.
- Appendixes: Presents letters, memoranda, concise summaries of validated data, and detailed technical analyses needed to confirm the findings contained within the text.

1.4 1100-EM-1 OPERABLE UNIT BACKGROUND

The 1100 Area is located in the southern-most portion of the Hanford Site, adjacent to the city of Richland in Benton County, Washington. (figure 1.1) As defined by EPA for purposes of National Priorities List (NPL) site designation, the 1100 Area includes portions of the 600, 700, and 3000 Areas. The 600 Area consists mostly of undeveloped land and some relatively remote facilities. The 700 Area is primarily comprised of administrative buildings and is located outside of the Hanford Reservation proper in downtown Richland; it is centered around the Federal Building on Jadwin Avenue in Richland. The 3000 Area is located outside of, but adjacent to, the Hanford Site; it also is comprised mostly of administrative buildings, but includes some research and development and warehouse storage facilities as well.

The 1100 Area NPL Site is currently divided into four operable units. The 1100-EM-1, 1100-EM-2, and 1100-EM-3 Operable Units, are shown in figure 1-2. The 1100-IU-1 Operable Unit is located 24 kilometers (km) west of the 1100 Area near Rattlesnake Mountain. (See figure 1-1.)

Each operable unit is designated with a three-part code. The first part indicates the NPL site affiliation, in this case the 1100 Area NPL Site. The second part provides a shorthand description of the operable unit type: EM indicates "equipment maintenance;" IU indicates "isolated unit." The final portion of the code simply provides a unique numeric designator for each operable unit.

The 1100-EM-1 and 1100-EM-2 Operable Units are comprised of different sets of waste management units that are, for the most part, located within the 1100 Area proper.

The 1100-EM-3 Operable Unit contains the 3000 Area waste management units and is physically separated from the remainder of the 1100 Area by a major thoroughfare, Stevens Drive.

Within the 1100-EM-1 Operable Unit are numerous individual sites or waste disposal areas that are identified as subunits (see figure 1.2). These subunits have been designated with descriptive names (e.g., The Discolored Soil Site) and/or a simple alphanumeric code (e.g., UN-1100-6). This nomenclature will be followed in this report.

Recent efforts on the part of DOE, EPA, and others to expedite the remediation and eventual delisting of the entire 1100 Area have led to the initiation of an expedited investigation of the 1100-EM-2, 1100-EM-3, and the 1100-IU-1 Operable Units. It is anticipated that this investigation will be completed in the spring of 1993 and the results will be presented as an addendum to this final RI/FS Report.

The Record of Decision developed from this report and addendum is intended to address the entire 1100 Area, a considerable expansion of the original focus on the 1100-EM-1 Operable Unit. This accelerated schedule is intended to provide for more effective utilization of resources.

1.4.1 Nearby Properties and Facilities

The North Richland well field has been of particular interest during the course of the 1100-EM-1 investigation. Located 0.8 km east of the 1171 building in the 1100 Area, the well field is still used to supplement city of Richland water supplies (see figure 1-2). Initial concerns focussed on the potential impact of migration of contaminants from the 1100 Area to the well field. Columbia river water is pumped to the well field and allowed to percolate through the soil. This procedure reduces turbidity and improves water quality for industrial and residential usage.

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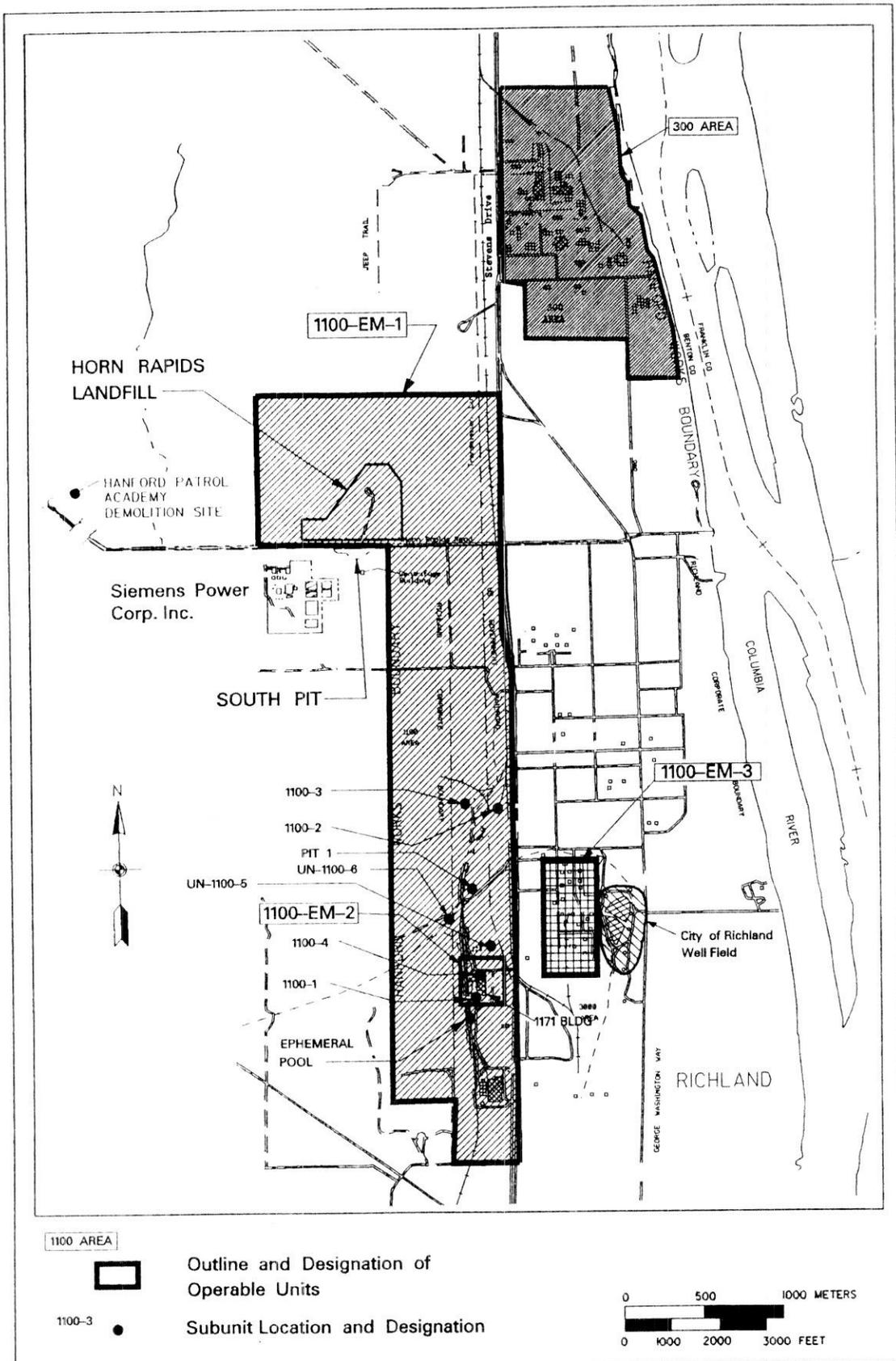
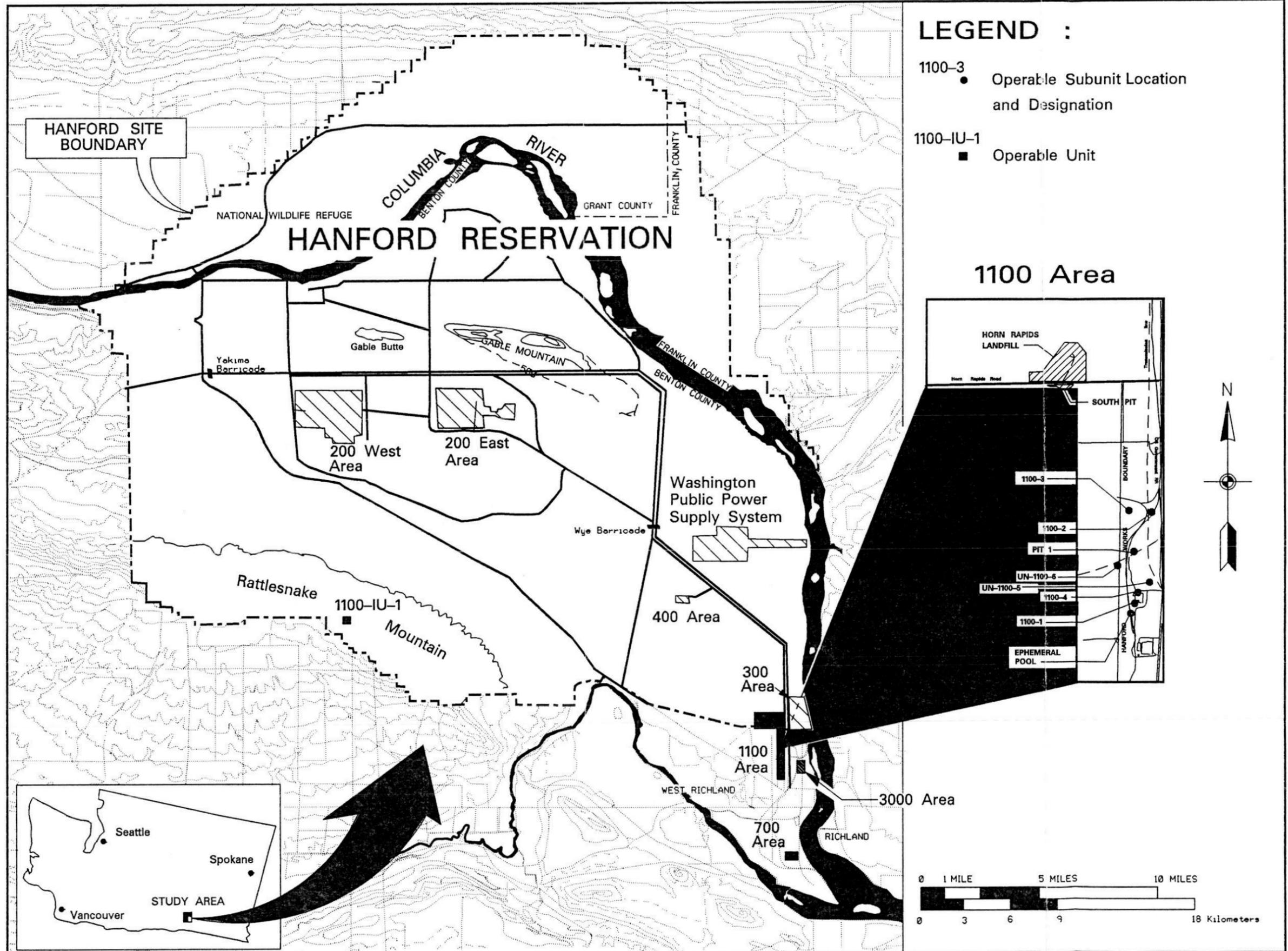


Figure 1-2. 1100 Area Operable Units

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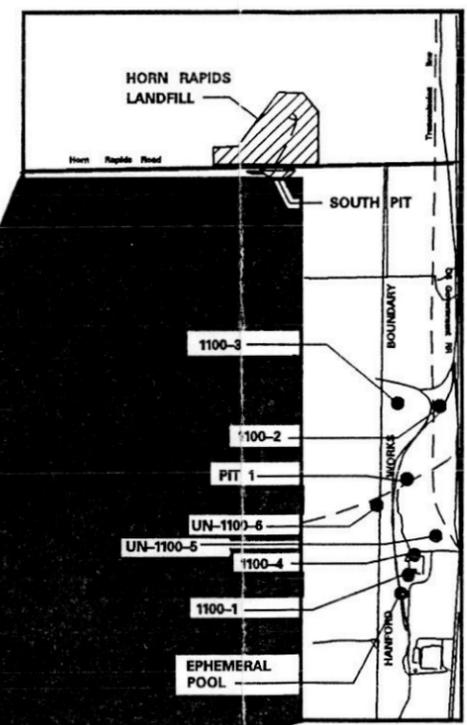
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LEGEND :

- 1100-3 ● Operable Subunit Location and Designation
- 1100-IU-1 ■ Operable Unit

1100 Area



Hanford Reservation Location Map

Fig. 1-1

During the course of the RI of the 1100-EM-1, agreements were made between DOE, EPA, Ecology, and others to investigate the groundwater at the Horn Rapids Landfill and adjacent properties. Currently, Siemens Power Corporation (SPC) owns the property which abuts the 1100 Area, specifically near the HRL. The owner and/or corporate entity charged with this property has undergone several name changes even during the course of this investigation. Previous designations include Exxon Nuclear Fuels, Advanced Nuclear Fuels, Siemens Nuclear Power and, as noted above, SPC.

The scope and scheduling of RI activities has been influenced by the participation of the SPC. Coordination with SPC on groundwater data collection and distribution has been ongoing since early 1990. In March, 1991, DOE formally briefed SPC on the DOE 1100-EM-1 Operable Unit investigation. SPC's participation in the DOE investigation has continued since this meeting. However, SPC is pursuing their own investigation of groundwater underlying their facility, as a separate investigation from DOE's investigation of the HRL and 1100-EM-1.

Both DOE and SPC will consider data generated by the other party's investigation, therefore, there has been close coordination of field activities between DOE and SPC. Data, as received from SPC, is included in this document, where appropriate.

1.4.2 1100-EM-1 Operable Unit Description

The 1100 Area is the central warehousing, vehicle maintenance, and transportation distribution center for the entire Hanford site. A wide range of materials and potential waste products were routinely used at and near the 1100 Area. Table 1-1 lists potential waste products either presumed or known to have been used at the 1100-EM-1 Operable Unit. Known toxic or chemical constituents of these products are presented as well.

The 1100-EM-1 Operable Unit has been divided into several subunits based on the nature of previous use and potential contaminants. The subunits are:

- 1100-1 (The Battery Acid Pit): An unlined dry sump, or french drain, used for disposal of waste acid from vehicle batteries. Historical documents record an estimated 57,000 liters (L) [15,000 gallons (gal)] of battery acid wastes may have been disposed of between 1954 and 1977.
- 1100-2 (The Paint and Solvent Pit): A former sand and gravel pit subsequently used for the disposal of construction debris and reportedly, waste paints, thinners and solvents.
- 1100-3 (The Antifreeze and Degreaser Pit): A former sand and gravel pit used for the disposal of construction debris along with potential disposal of antifreeze and degreasing solutions.

Table 1-1. Toxic Constituents in 1100-EM-1 Operable Unit
Potential Waste Products.

<u>Waste Product</u>	<u>Toxic Element</u>
antifreeze	ethylene glycol, propylene glycol
automotive cleaners ¹	cresol, ethylene dichloride, sodium chromate, petroleum distillates, 1,1,1-trichloroethane
battery acid ²	lead, sulfuric acid, arsenic, cadmium
contact cement ¹	toluene, hexane, methyl ethyl ketone, trichloroethene
degreasers	1,1,1-trichloroethane, trichloroethene
gasoline	C ₃ -C ₁₂ aliphatic hydrocarbons, xylene, benzene
hydraulic oils	PCB's
industrial lubricants ¹	trichloroethene, lead naphthenate
lacquer thinners ¹	ethyl acetate, butyl acetate, butyl alcohol, toluene, xylene, aliphatic hydrocarbons
metal cleaners ¹	potassium carbonate, trisodium phosphate, tetrachloroethene, trichloroethene, kerosene ^b , chromic acid
paints, latex ³	ethylene glycol, zinc
paints, oil-based ⁴	linseed oil ^c , mineral spirits ^d , lead, zinc
paints, other ^{3,4}	toluene, methyl ethyl ketone, chromium, zinc, lead
paint removers	dichloromethane, methyl ethyl ketone
paint thinners	mineral spirits ^d
penetrating oils ¹	kerosene ^b , xylene, carbon tetrachloride
roof patching sealants ¹	kerosene ^b , gasoline, mineral spirits ^d
solvents	acetone, carbon tetrachloride, gum turpentine, methanol, 1,1,1-trichloroethane, stoddard solvent ^e
stains ¹	mineral spirits ^d , aniline dyes
undercoating material ¹	aromatic hydrocarbons, aliphatic hydrocarbons, phenolic resins, methyl isobutyl ketone
vinyl adhesives ¹	benzene, toluene
waste oil ⁵	C ₁₀ -C ₁₆ alkanes, toluene, 1,1,1-trichloroethane, polycyclic aromatic hydrocarbons (PAH's)

^a Petroleum distillates are hydrocarbon fractions such as gasoline and kerosene.

^b Kerosene contains aromatic hydrocarbons and C₅-C₆ aliphatic hydrocarbons.

^c Linseed oil contains flaxseed oil and additives such as lead, manganese, and cobalt.

^d Mineral spirits contains benzene, toluene, hexane, and cyclohexane.

^e Stoddard solvent contains C₉-C₁₂ aliphatic hydrocarbons, naphthalene, and aromatic hydrocarbons.

¹ Gosselin et al. 1984.

² Eckroth 1981.

³ Ash and Ash 1978.

⁴ Myers and Long 1975.

⁵ EPA 1974.

- 1100-4 (The Antifreeze Tank Site): A former underground storage tank used for the disposal of waste vehicle antifreeze. This tank has since been emptied (1986), excavated, cleaned, and removed due to suspected leakage.
- UN-1100-5 (The Radiation Contamination Incident): On August 24, 1962, radioactive contamination was discovered on an incoming 1,452 kilograms (kg) (16-ton) shipment cask containing irradiated metal specimens from a facility at the Idaho National Engineering Laboratory. The truck trailer on which the contamination was detected, had offloaded other cargo at another building and was parked in the parking lot northwest of the 1171 Building when the contamination was detected.
- UN-1100-6 (The Discolored Soil Site): The location of an unplanned release onto the ground surface involving an unknown quantity of organic waste liquids.
- The HRL: A solid waste facility used primarily for the disposal of office and construction waste, asbestos, sewage sludge, fly ash, and reportedly, numerous drums of unidentified organic liquids. Classified documents were also incinerated at a burn cage located at the northern edge of the landfill.
- The Ephemeral Pool: An elongate, man-made depression into which parking area runoff water collects and evaporates leaving behind contaminant residues.
- Pit 1: An active gravel/borrow pit north of the 1171 building.
- The South Pit: A "disturbed" area on the south side of Horn Rapids Road, across from HRL. Scattered debris of unknown origin has been found on the ground surface.
- The Hanford Patrol Academy Demolition Site: An ash pit used for the disposal of unstable chemicals by detonation, is located approximately 2 kilometers (km) [1 mile (mi)] to the west of HRL. This demolition site is identified in WHC (1989a) as a potential Resource Conservation and Recovery Act (RCRA), 42 USC 6901 et seq., treatment, storage, or disposal (TSD) waste management unit.

In all of these areas, a number of distinct surveys and/or investigations have been performed. Several of the older surveys and analytical results have been presented in previously published work plans and/or reports and are not repeated here. During the efforts associated with this final phase of the investigation, some of the work was focussed on the particular uses and past practices of a specific subunit, while other studies concentrated on operable unit wide containment issues. Before providing a review of the investigations, surveys and studies undertaken at the entire operable unit, a brief review of the physical characteristics of the 1100 Area is presented in section 2.

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2.0 PHYSICAL CHARACTERISTICS OF THE 1100-EM-1 OPERABLE UNIT

This chapter provides a summary of important physical parameters and processes that have contributed to the conditions existing at each of the various 1100-EM-1 Operable Unit subunits. Previous reports provided detailed treatises on these subunits (DOE/RL-90-18). Only those salient items that provide immediate support to the Phase II RI presentation will be repeated in the development of the hypotheses and conclusions made in this document.

2.1 METEOROLOGY

Meteorological data is summarized in appendix D of the Phase I RI report (DOE/RL-90-18). Data was obtained from historical records gathered at the Hanford Meteorological Station (HMS), the Hanford 300 Area automated meteorological station, and the Richland, Washington Airport.

The climate of the Hanford Site has been classified as midlatitude semiarid or midlatitude desert, depending on the classification scheme employed. Summers are warm and dry with abundant sunshine. Winters are cool with occasional precipitation (Hulstrom, 1992). Average high air temperatures at the HMS reach 37°C (100°F) during the summer, and drop to lows of -5°C (23°F) in winter. Historical extremes are recorded as 46°C (115°F) and -29°C (-20°F). Annual highs are generally reached during July and lows during January.

Rain is the most common form of precipitation, but snowfalls occur regularly during the winter. Hail may fall during the summer thunderstorm season. The greatest volume of precipitation occurs in the winter, usually between the months of October and February. July is the driest month, averaging only 0.5 centimeters (cm) [0.2 inches (in)] of rainfall. The average annual precipitation falling at the Hanford Site is 15.9 cm (6.3 in) (Stone *et. al.*, 1983). This value was derived from HMS data gathered between the years 1912 through 1980.

Windblown dust is commonly associated with strong winds that regularly occur at the Hanford Site. Wind speeds average 10 to 12 km per hour (h) (6 to 7 mi/h) in winter and 13 to 17 km/h (8 to 10 mi/h) during the summer months. The strongest observed winds have speeds measuring up to 130 km/h (80 mi/h). Blowing dust originating on the site itself has been observed at wind speeds greater than 32 km/h (19 mi/h). Dust entrained offsite and carried onto Hanford has been observed at wind speeds as low as 7 km/h (4 mi/h).

The mean annual rate of potential evapotranspiration for the region has been estimated at approximately 74 cm (29 in). The estimated rate of mean annual actual evapotranspiration is approximately 18 cm (7 in) (U.S. Weather Bureau and Soil Conservation Service, 1962). The rate of annual actual evapotranspiration, then, typically approximates the rate of annual precipitation, which is not uncommon for semiarid areas.

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2.2 GEOLOGY

Regional and local geologic settings are summarized in the following paragraphs. The discussion of local geology emphasizes topics that may have direct bearing on the descriptions of contaminant transport in the environment and on the development of remedial alternatives as presented later in this document. An exhaustive presentation of the regional and local geology can be found in DOE/RL-90-18, and Gaylord and Poeter, 1991.

2.2.1 Regional Geology

The Hanford Site is located in the Pasco Basin, a topographic and structural basin situated in the northern portion of the Columbia Plateau. The plateau is divided into three general structural subprovinces: the Blue Mountains; the Palouse; and, the Yakima Fold Belt (Tolan and Reidel, 1989). The Hanford Site is located near the junction of the Yakima Fold Belt and the Palouse subprovinces. A generalized geologic structural map is included as figure 2-1.

The 1100 Area is located along the southeastern margin of the Hanford Site, adjacent to the Columbia River. This area is similar to much of the rest of the site, which consists of a two-tiered stratigraphy of basalt/basalt-related volcanic and sedimentary rocks and suprabasalt sedimentary deposits. The principal units at the Hanford Site are (from oldest to youngest): Miocene Columbia River Basalt Group (CRBG); Miocene Ellensburg formation; Miocene-Pliocene Ringold Formation; the informally defined Plio-Pleistocene clastic sedimentary unit; Pleistocene early "Palouse" soil; Pleistocene pre-Missoula gravels; the Pleistocene Hanford formation; and, Holocene eolian surficial deposits. The CRBG and Ellensburg formation are included within the basalt/basalt-related deposits while all others are included within suprabasalt deposits.

Of the regional stratigraphic units listed above, only the CRBG, the Ringold Formation, the Hanford formation, and the eolian surficial deposits have been identified within the 1100-EM-1 Operable Unit. Bedrock geology was not considered during development of remediation alternatives for this project and will not be considered further. Suprabasalt sediments present within the Operable Unit are described in the subsequent sections on Local Geology.

2.2.2 Local Geology

The interpretation and description of the geology of the 1100-EM-1 Operable Unit is based primarily on previous studies in adjacent areas and on geologic logs of monitoring wells installed during both phases of the RI. Selected geohydrologic and groundwater quality studies of the 300 Area (Lindberg and Bond, 1979; Schalla, *et al.*, 1988; Gaylord and Poeter, 1991) provide descriptions of the suprabasalt stratigraphic units within approximately 1.6 km (1 mi) of HRL. When available, geologic logs for selected previously-existing wells located near the Operable Unit (Newcomb, *et al.*, 1972; Summers and Schwab, 1977; Fecht and Lillie, 1982; CWC-HDR, Inc., 1988; Geology Section, WHC [Technical Memo 81232-90-042 to S. Clark, WHC] May 11, 1990) were also consulted.

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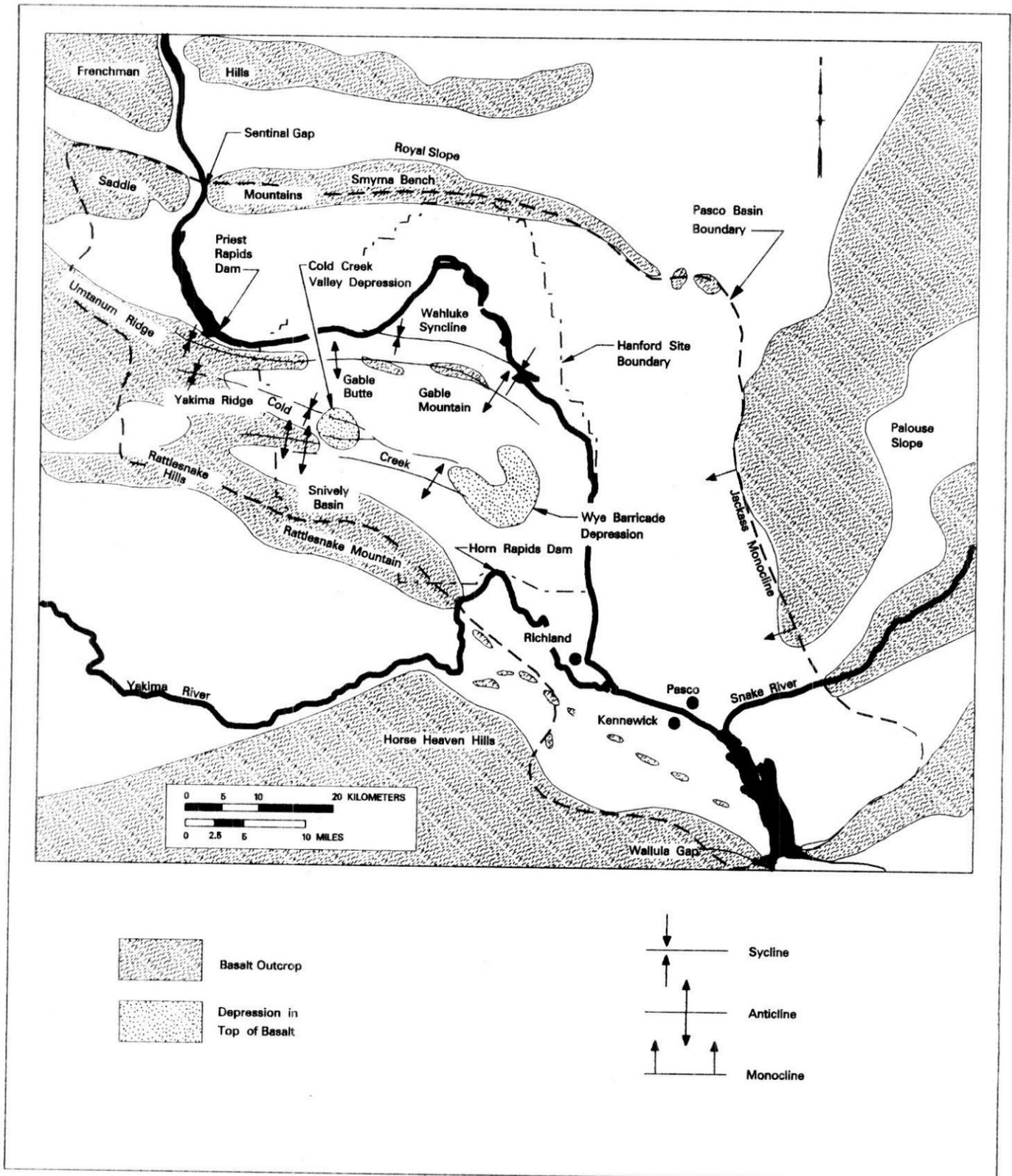


Figure 2-1. Geologic Structures of the Pasco Basin and the Hanford Site.

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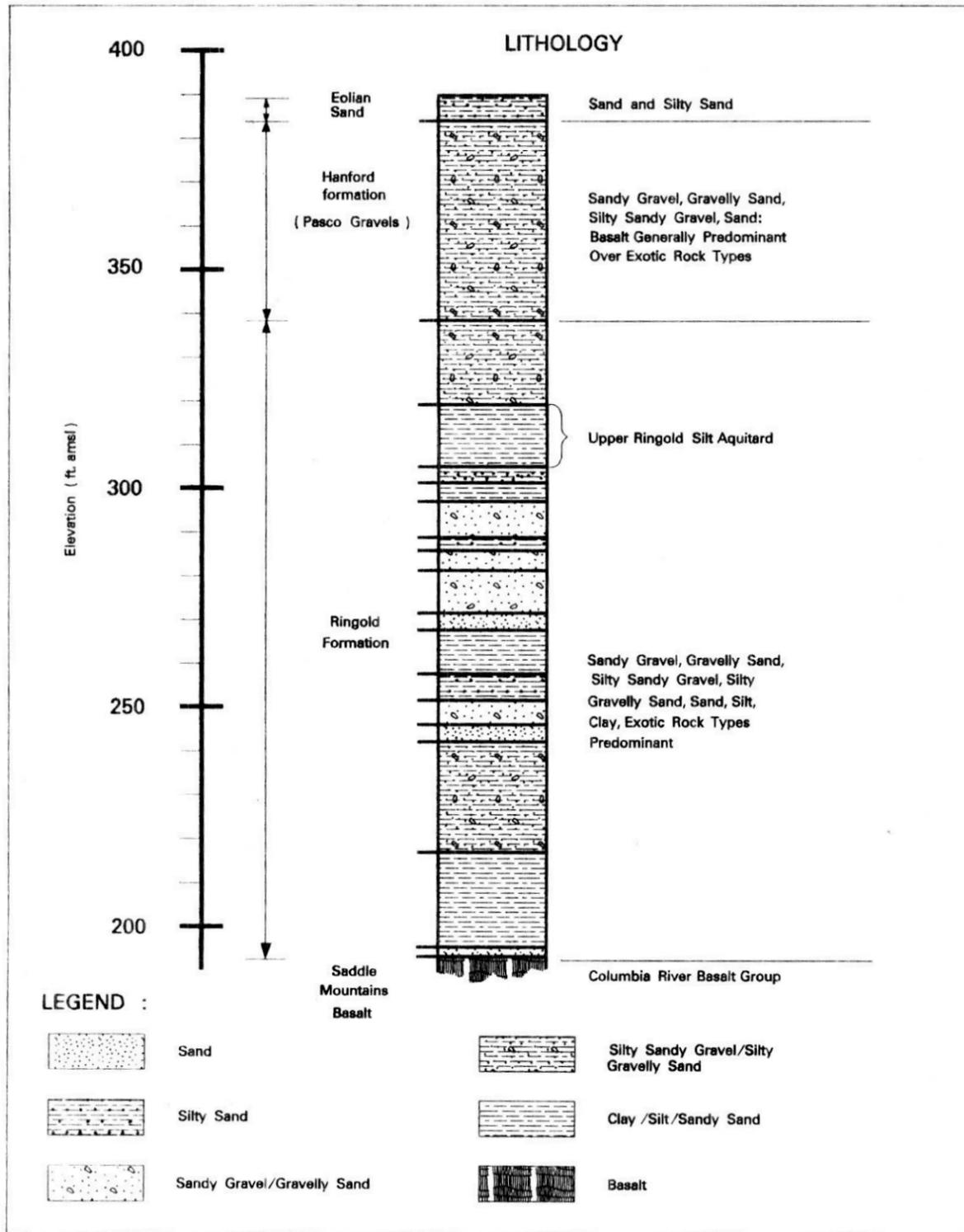


Figure 2-2. Generalized Suprabasalt Stratigraphic Column for the 1100-EM-1 Operable Unit

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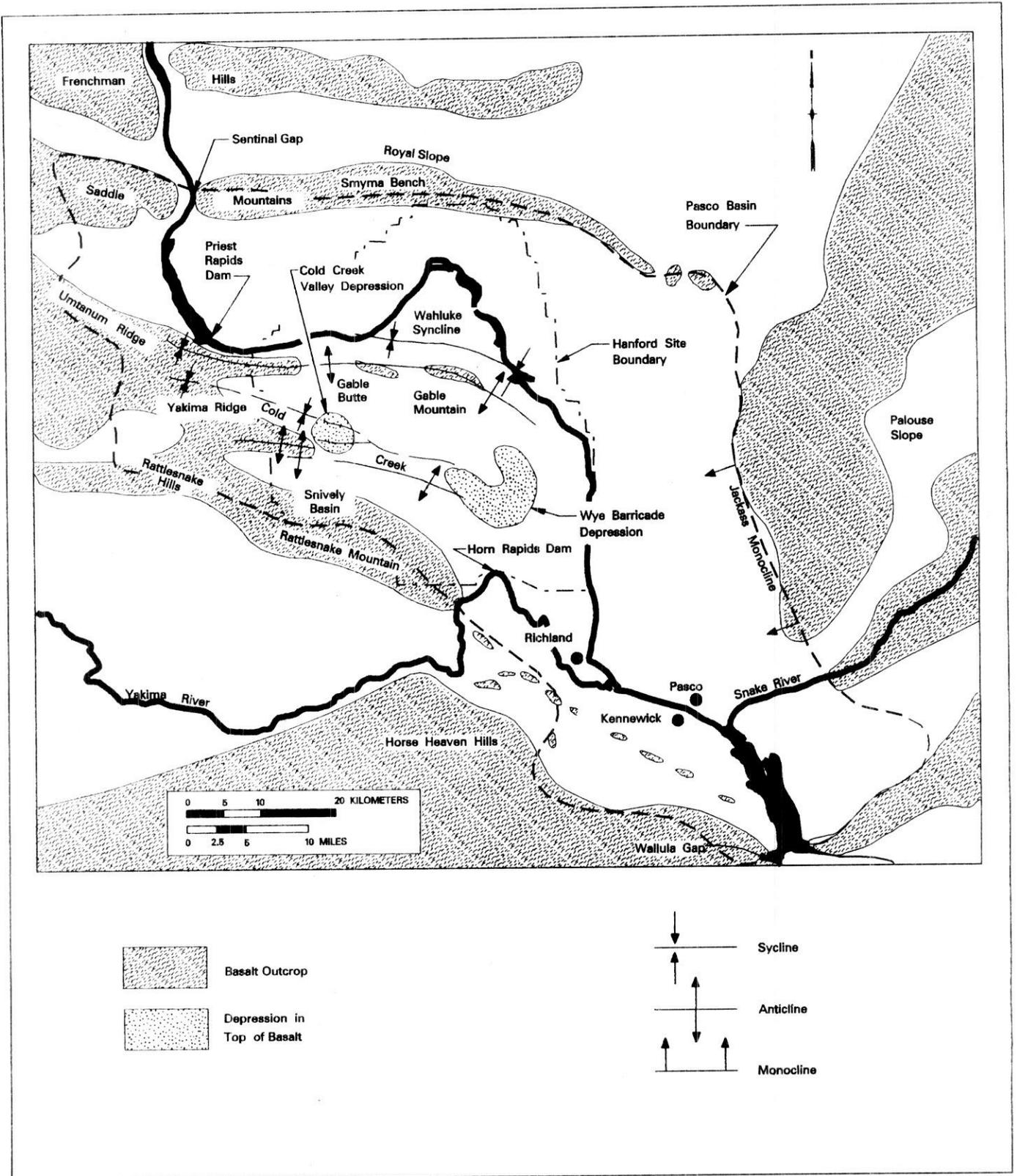


Figure 2-1. Geologic Structures of the Pasco Basin and the Hanford Site.

2.2.2.1. Structural Geology and Tectonic Setting. The Columbia Plateau is a part of the North American continental plate and is situated in the back-arc east of the Cascade Range. The plateau is bounded on the north by the Okanogan Highlands, on the east by the Northern Rocky Mountains and Idaho Batholith, and on the south by the High Lava Plains and Snake River Plain.

The Columbia River Basalts within the vicinity of 1100-EM-1 as interpreted by Myers and Price (1979), are folded into a broad, gentle, northwest-trending syncline; the Pasco syncline. The 1100-EM-1 subunits are located near the axis of this syncline, on its gently-sloping western flank. The Pasco syncline slopes gently northwestward toward a flat structural low referred to as the Wye Barricade depression (DOE/RL-88-23), where it loses definition. The geologic structure of the Ringold and Hanford formations has not been identified in the area of the 1100-EM-1 Operable Unit.

2.2.2.2 Local Stratigraphy. A generalized suprabasalt stratigraphic column for the 1100-EM-1 Operable Unit is shown in figure 2-2. Information obtained from the drilling of 22 soil borings and 23 groundwater monitoring wells during the 1100-EM-1 Operable Unit RI, and five groundwater monitoring wells installed between the 1100 Area and the city of Richland well field in 1988 (Bryce and Goodwin, 1989) was used to develop the idealized stratigraphic column depicted.

The shallow depth of these borings and wells pose substantial limitations on the reliability of the estimates for the actual depth, thickness, and characteristics of the lower portion of the Ringold Formation beneath the 1100-EM-1 Operable Unit. The interpretation of the lower stratigraphic units on figure 2-2 is based primarily on a single log for a nearby, previously-existing well that extends to the basalt; 10/28-10G1. This log is published in Newcomb, *et al.*, 1972, and DOE/RL-90-18.

A cross section identification map is provided in figure 2-3. Cross section A-A" (which runs north-south from the HRL to south of the 1171 Building) is shown in figure 2-4. Three east-west cross sections are also provided: B-B" (through HRL) in figure 2-5, and C-C" (near the 1100-2 and 1100-3 subunits) and D-D" (near the 1100-1 and 1100-4 subunits) in figure 2-6.

Geologic logs for the Phase II monitoring well boreholes are included in appendix A. It should be noted that the lithologies shown in the borehole logs are based on visual field estimates of grain-size distribution using the Wentworth grain-size scale, as modified by Folk (1954). Laboratory grain size analyses were not performed during the Phase II investigations. However, comparisons of Phase II field classifications with Phase I laboratory classifications of soil types encountered during monitoring well installations revealed no unusual divergence.

Tables 2-1 through 2-4 list the depths and elevations of the stratigraphic units identified in the borings advanced and wells constructed during both phases of the 1100-EM-1 RI. Locations of Phase I and Phase II monitoring wells are presented on figures 2-7 and 2-8, respectively.

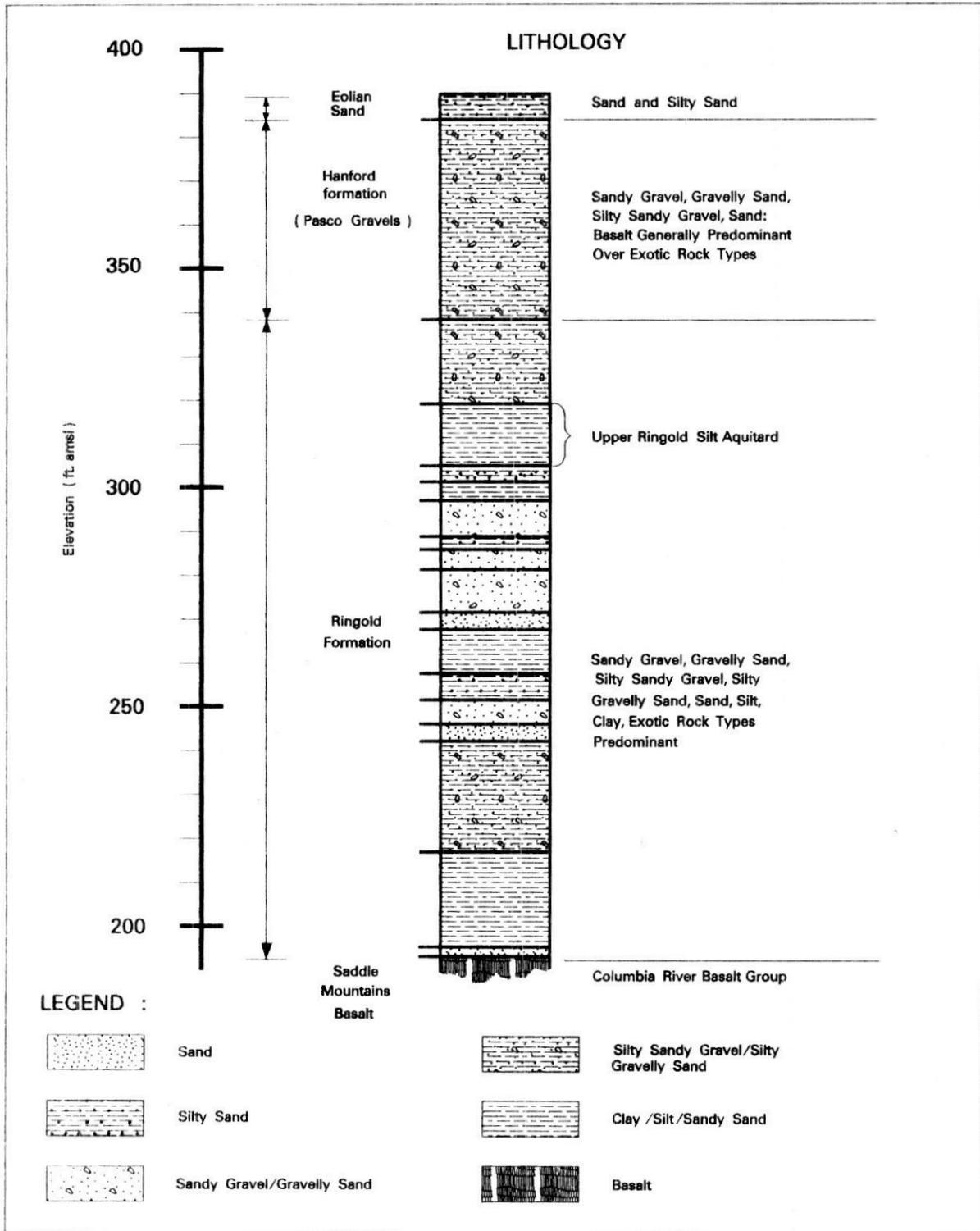


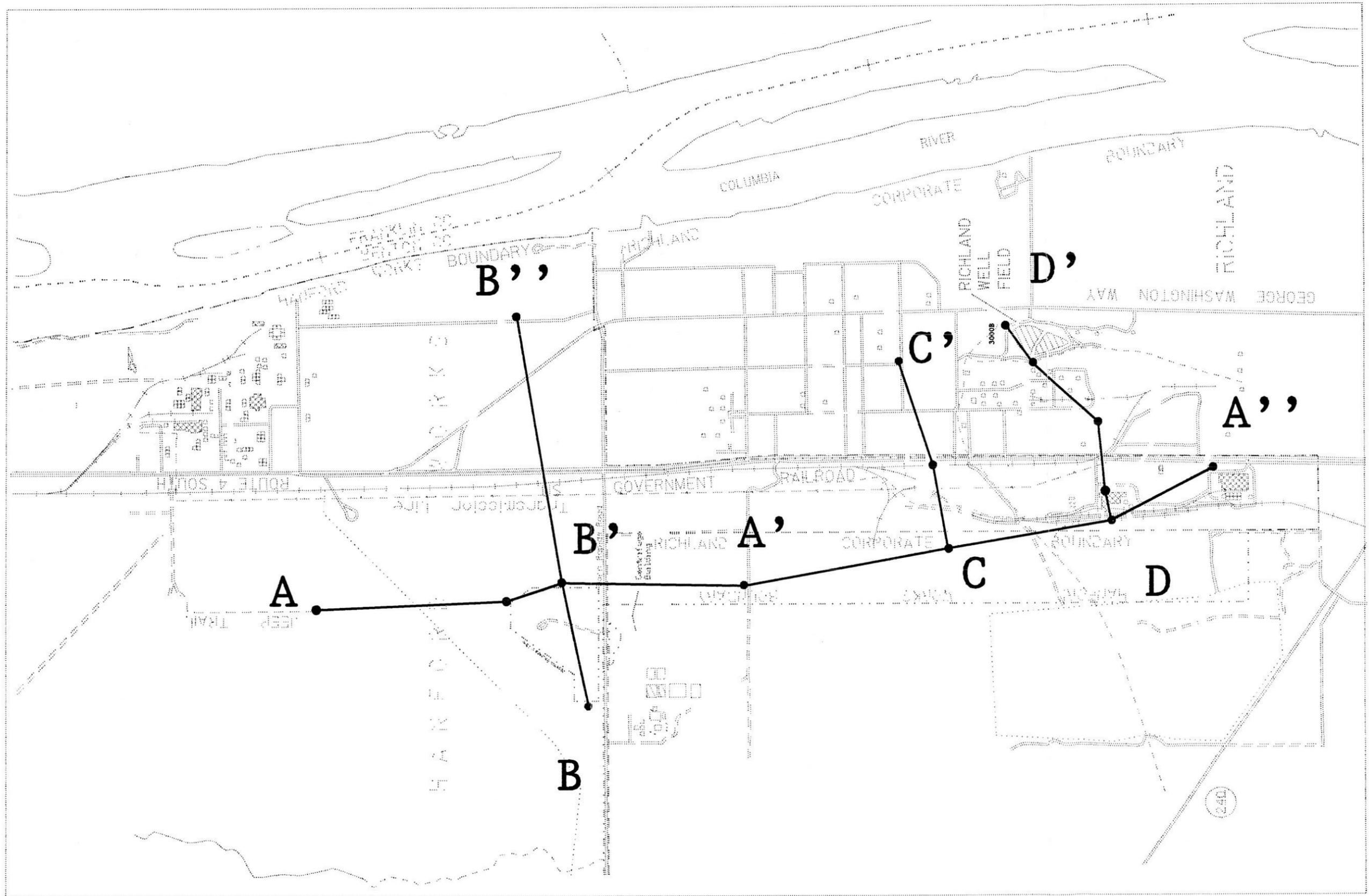
Figure 2-2. Generalized Suprabasalt Stratigraphic Column for the 1100-EM-1 Operable Unit

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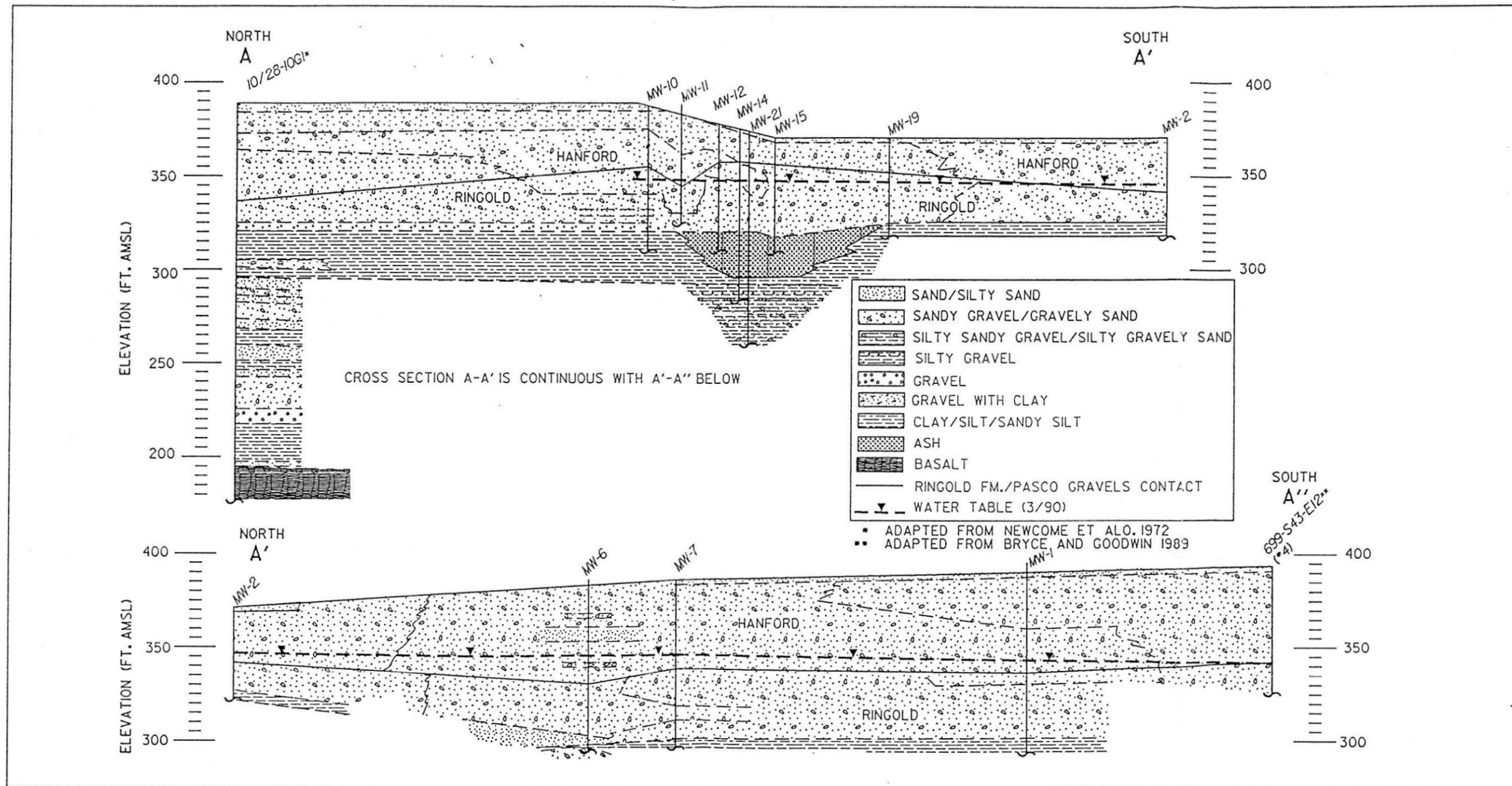
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9 3 1 2 8 2 0 2 4 6



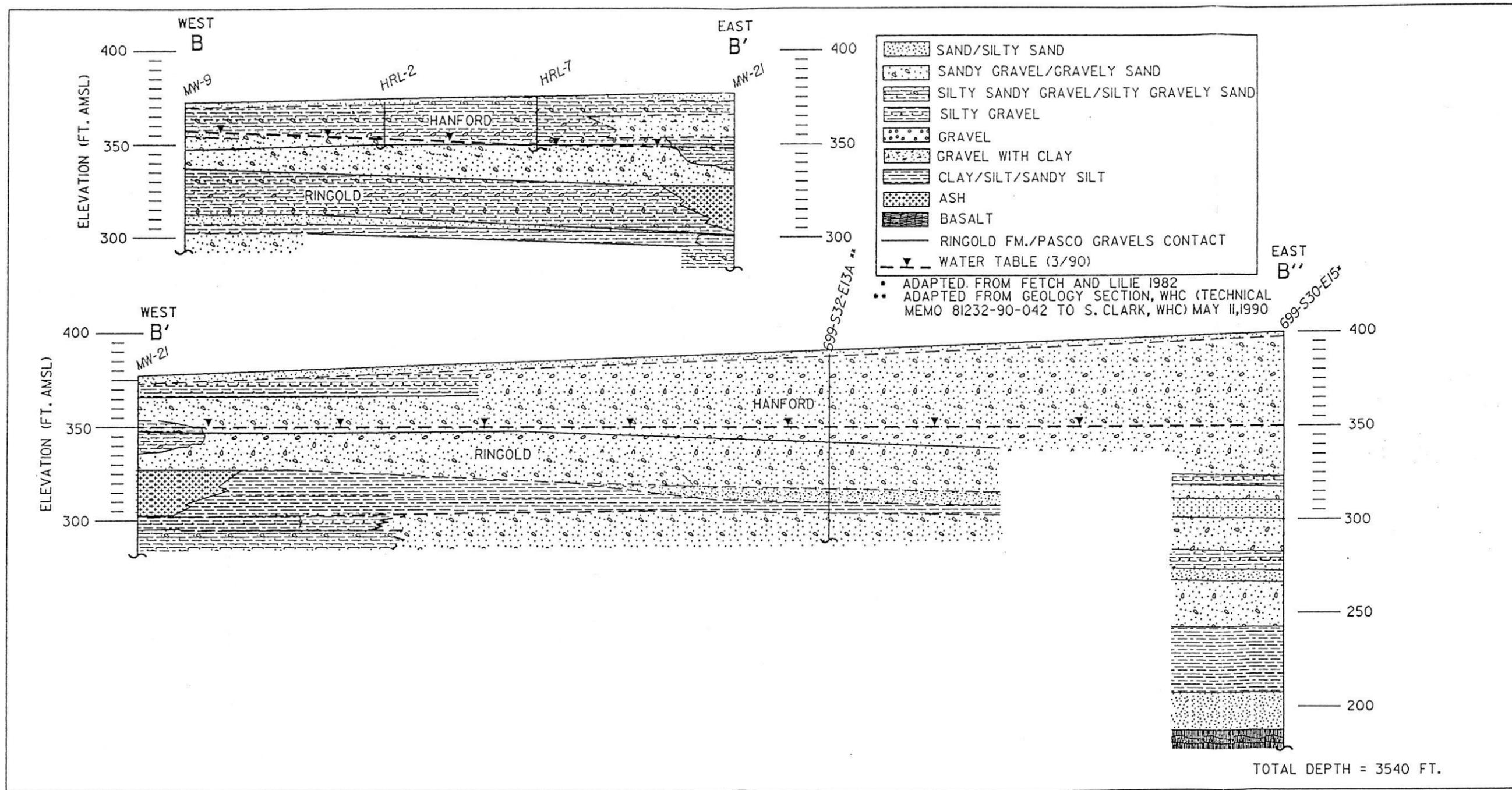
X - SECTION LOCATION MAP

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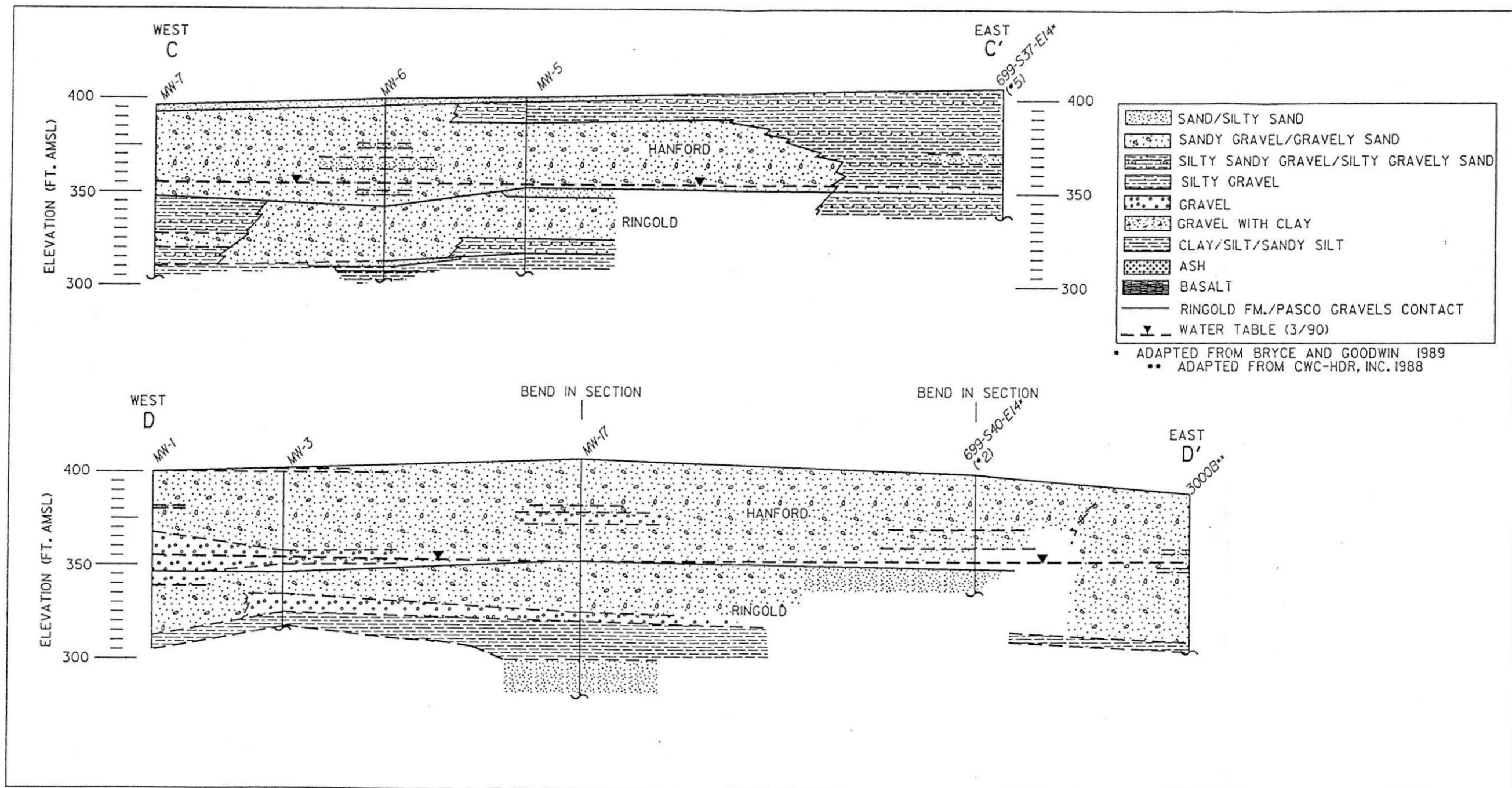
CROSS SECTION A-A''

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CROSS SECTION B-B''

Figure 2-5



CROSS SECTION C-C' AND D-D'

TABLE 2-1: Stratigraphic Data from Borehole Logs
 Battery Acid Pit (1100-1), Antifreeze Tank Site (1100-4), Discolored Soil Site (UN-1100-6), and Ephemeral Pool

BORING	TOTAL DEPTH m(ft)	BORING ELEV. m(ft)	FILL THICKNESS m(ft)	EOLIAN SAND THICKNESS m(ft)	HANFORD FORMATION THICKNESS m(ft)	DEPTH TO TOP OF RINGOLD FM. m(ft)	TOP OF RINGOLD ELEV. m(ft)	DEPTH TO TOP OF SILT AQUITARD m(ft)	TOP OF SILT AQUITARD ELEV. m(ft)
Vadose Background BAP-2	13.88 (45.55)	121.21 (397.66)	N/A	0.30 (1.0)	Base of Eolian Sand to EOH	ND	ND	ND	ND
Vadose Zone Boring BAP-1	6.10 (20.0)	122.66 (402.42)	1.83 (6.0)	none	Base of Fill to EOH	ND	ND	ND	ND
ATS-1C	6.71 (22.0)	Not Available	3.75 * (12.3*)	none	Base of Fill to EOH	ND	ND	ND	ND
Monitoring Wells MW-1	28.65 (94.0)	121.44 (398.43)	N/A	0.58 (1.9)	16.03 (52.6)	16.61 (54.5)	104.83 (343.9)	26.97 (88.5)	94.47 (309.9)
MW-3	25.52 (83.74)	122.53 (402.0)	N/A	none	18.33 (60.14)	18.44 (60.5)	104.09 (341.5)	23.96 (78.6)	98.57 (323.4)
MW-17	38.10 (125.0)	124.24 (407.62)	N/A	none	17.07 (56.0)	17.07 (56.0)	107.17 (351.6)	27.58 (90.5)	96.66 (317.1)

- NOTES:
1. EOH - End of Hole.
 2. N/A - Not Applicable.
 3. ND - No Data due to Shallow Depth of Boring.
 4. * - 0.11 m (0.35 ft) of Blacktop Asphalt at Ground Surface.

TABLE 2-2: Stratigraphic Data from Borehole Logs
Paint and Solvent Pit (1100-2)

BORING	TOTAL DEPTH m(ft)	BORING BLEV. m(ft)	FILL THICKNESS m(ft)	EOLIAN SAND THICKNESS m(ft)	HANFORD FORMATION THICKNESS m(ft)	DEPTH TO TOP OF RINGOLD FM. m(ft)	TOP OF RINGOLD ELEV. m(ft)	DEPTH TO TOP OF SILT AQUITARD m(ft)	TOP OF SILT AQUITARD ELEV. m(ft)
Vadose Background									
DP-7	12.50 (41.0)	119.65 (392.54)	N/A	0.46 (1.5)	Base of Eolian Sand to EOH	ND	ND	ND	ND
Vadose Zone Borings									
DP-4	6.10 (20.0)	120.15 (394.19)	2.16 (7.1)	none	Base of Fill to EOH	ND	ND	ND	ND
DP-5	6.10 (20.0)	120.22 (394.43)	4.88 (16.0)	none	Base of Fill to EOH	ND	ND	ND	ND
DP-6	6.10 (20.0)	120.31 (394.71)	not identified	none	To EOH	ND	ND	ND	ND
DP-9	12.13 (39.8)	119.68 (392.65)	1.22 (4.0)	none	10.82 (35.5)	12.04 (39.5)	107.64 (353.15)	ND	ND
Monitoring Wells									
MW-4	20.51 (67.29)	122.35 (401.40)	N/A	1.07 (3.5)	15.09 (49.5)	16.15 (53.0)	106.19 (348.4)	ND	ND
MW-5	27.02 (88.65)	122.40 (401.57)	N/A	0.91 (3.0)	14.94 (49.0)	15.85 (52.0)	106.55 (349.6)	26.49 (86.9)	95.91 (314.7)
MW-6	27.74 (91.0)	120.70 (396.0)	N/A	0.55 (1.8)	16.98 (55.7)	17.53 (57.5)	103.17 (338.5)	25.9 (85.0)	94.79 (311.0)
MW-7	27.22 (89.3)	120.46 (395.20)	N/A	1.14 (3.75)	13.91 (45.7)	15.06 (49.4)	105.40 (345.8)	26.06 (85.5)	94.40 (309.7)
MW-18	21.06 (69.1)	121.84 (399.74)	N/A	0.61 (2.0)	14.48 (47.5)	15.09 (49.5)	106.75 (350.24)	ND	ND

- NOTES:
1. EOH - End of Hole.
 2. N/A - Not Applicable.
 3. ND - No Data due to Shallow Depth of Boring.

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Table 2-2
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TABLE 2-3: Stratigraphic Data from Borehole Logs
Antifreeze and Degreaser Pit (1100-3)

BORING	TOTAL DEPTH m(ft)	BORING ELEV. m(ft)	FILL THICKNESS m(ft)	EOLIAN SAND THICKNESS m(ft)	HANFORD FORMATION THICKNESS m(ft)	DEPTH TO TOP OF RINGOLD FM. m(ft)	TOP OF RINGOLD ELEV. m(ft)	DEPTH TO TOP OF SILT AQUITARD m(ft)	TOP OF SILT AQUITARD ELEV. m(ft)
Vadose Background									
DP-7	12.50 (41.0)	119.65 (392.54)	N/A	0.46 (1.5)	Base of Eolian Sand to EOH	ND	ND	ND	ND
Vadose Zone Borings									
DP-1	6.10 (20.0)	117.57 (385.74)	not identified	none	To EOH	ND	ND	ND	ND
DP-2	6.10 (20.0)	116.99 (383.84)	1.6 (5.3)	none	Base of Fill to EOH	ND	ND	ND	ND
DP-3	6.10 (20.0)	118.13 (387.58)	not identified	none	To EOH	ND	ND	ND	ND
DP-8	10.36 (34.0)	117.81 (386.51)	not identified	none	To EOH	ND	ND	ND	ND
Monitoring Wells									
MW-4	20.51 (67.29)	122.35 (401.40)	N/A	1.07 (3.5)	15.09 (49.5)	16.15 (53.0)	106.19 (348.4)	ND	ND
MW-5	27.02 (88.65)	122.40 (401.57)	N/A	0.91 (3.0)	14.94 (49.0)	15.85 (52.0)	106.55 (349.6)	26.49 (86.9)	95.91 (314.7)
MW-6	27.74 (91.0)	120.70 (396.0)	N/A	0.55 (1.8)	16.98 (55.7)	17.53 (57.5)	103.17 (338.5)	25.9 (85.0)	94.79 (311.0)
MW-7	27.22 (89.3)	120.46 (395.20)	N/A	1.14 (3.75)	13.91 (45.7)	15.06 (49.4)	105.40 (345.8)	26.06 (85.5)	94.40 (309.7)

NOTES: 1. EOH - End of Hole.
2. N/A - Not Applicable
3. ND - No Data due to Shallow Depth of Boring.

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TABLE 2-4: Stratigraphic Data from Borehole Logs
Horn Rapids Landfill (1 of 3)

BORING	TOTAL DEPTH m(ft)	BORING BLEV. m(ft)	FILL THICKNESS m(ft)	EOLIAN SAND THICKNESS m(ft)	HANFORD FORMATION THICKNESS m(ft)	DEPTH TO TOP OF RINGOLD FM. m(ft)	TOP OF RINGOLD BLEV. m(ft)	DEPTH TO TOP OF SILT AQUITARD m(ft)	TOP OF SILT AQUITARD ELEV. m(ft)
Vadose Background									
HRL-1	5.67 (18.6)	112.71 (369.78)	N/A	0.30 (1.0)	Base of Eolian Sand to EOH	ND	ND	ND	ND
Vadose Zone Borings									
HRL-2	7.71 (25.9)	114.34 (375.13)	N/A	0.91 (3.0)	6.10 (20.0)	7.01 (23.0)	107.33 (352.1)	ND	ND
HRL-3	7.80 (25.6)	114.63 (376.07)	N/A	0.61 (2.0)	Base of Eolian Sand to EOH	ND	ND	ND	ND
HRL-4	7.77 (25.5)	114.48 (375.58)	not identified	none	To EOH	ND	ND	ND	ND
HRL-5	7.80 (25.6)	114.40 (375.33)	not identified	none	To EOH	ND	ND	ND	ND
HRL-6	8.47 (27.8)	114.95 (377.12)	not identified	none	To EOH	ND	ND	ND	ND
HRL-7	7.92 (26.0)	114.31 (375.04)	not identified	none	6.92 (22.7)	6.92 (22.7)	102.39 (352.3)	ND	ND
HRL-8	8.63 (28.3)	114.73 (376.40)	red brick frags. 6.31 to 6.95 (20.7 to 22.8)	none	Base of Fill to EOH	ND	ND	ND	ND
HRL-9	8.23 (27.0)	114.16 (374.54)	not identified	none	3.32 (10.9)	3.32 (10.9)	110.84 (363.6)	ND	ND

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Table 2-4
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TABLE 2-4: Stratigraphic Data from Borehole Logs
Horn Rapids Landfill (2 of 3)

BORING	TOTAL DEPTH m(ft)	BORING ELEV. m(ft)	FILL THICKNESS m(ft)	EOLIAN SAND THICKNESS m(ft)	HANFORD FORMATION THICKNESS m(ft)	DEPTH TO TOP OF RINGOLD FM. m(ft)	TOP OF RINGOLD ELEV. m(ft)	DEPTH TO TOP OF SILT AQUITARD m(ft)	TOP OF SILT AQUITARD ELEV. m(ft)
Vadose Zone Borings continued									
HRL-10	10.5 (34.5)	116.24 (381.37)	discoloration @ 5.28 (19.1)	none	Base of Fill to EOH	ND	ND	ND	ND
Monitoring Wells									
MW-8	10.99 (34.08)	113.27 (371.62)	N/A	1.07 (3.5)	6.86 (22.5)	7.92 (26.0)	105.34 (345.6)	ND	ND
MW-9	24.8 (81.4)	113.34 (371.86)	N/A	1.07 (3.5)	7.59 (24.9)	8.66 (28.4)	104.69 (343.5)	10.73 (35.3)	102.61 (336.7)
MW-10	20.57 (67.5)	118.59 (389.09)	N/A	0.61 (2.0)	10.06 (33.0)	10.67 (35.0)	107.93 (354.1)	19.51 (64.0)	99.09 (325.1)
MW-11	17.83 (58.5)	118.47 (388.69)	N/A	0.82 (2.7)	12.28 (40.3)	13.11 (43.0)	105.37 (345.7)	ND	ND
MW-12	18.04 (59.17)	116.17 (381.14)	N/A	1.22 (4.0)	6.40 (21.0)	7.62 (25.0)	108.55 (356.1)	17.37* (57.0*)	98.8* (324.1*)
MW-13	13.41 (44.0)	115.78 (379.85)	N/A	none	7.62 (25.0)	7.62 (25.0)	108.16 (354.9)	ND	ND
MW-14	18.44 (60.5)	115.83 (380.01)	N/A	0.15 (0.5)	6.55 (21.5)	6.71 (22.0)	109.12 (358.0)	16.34* (53.6*)	99.49* (326.4*)
MW-15	16.60 (54.47)	115.04 (377.43)	N/A	0.30 (1.0)	6.40 (21.0)	6.71+ (22.0+)	108.34+ (355.4+)	15.82* (51.9*)	99.22* (325.5*)
MW-19	16.46 (54.0)	117.21 (384.56)	N/A	0.61 (2.0)	7.92 (26.0)	8.53 (28.0)	108.68 (356.56)	15.85 (52.0)	101.36 (332.56)

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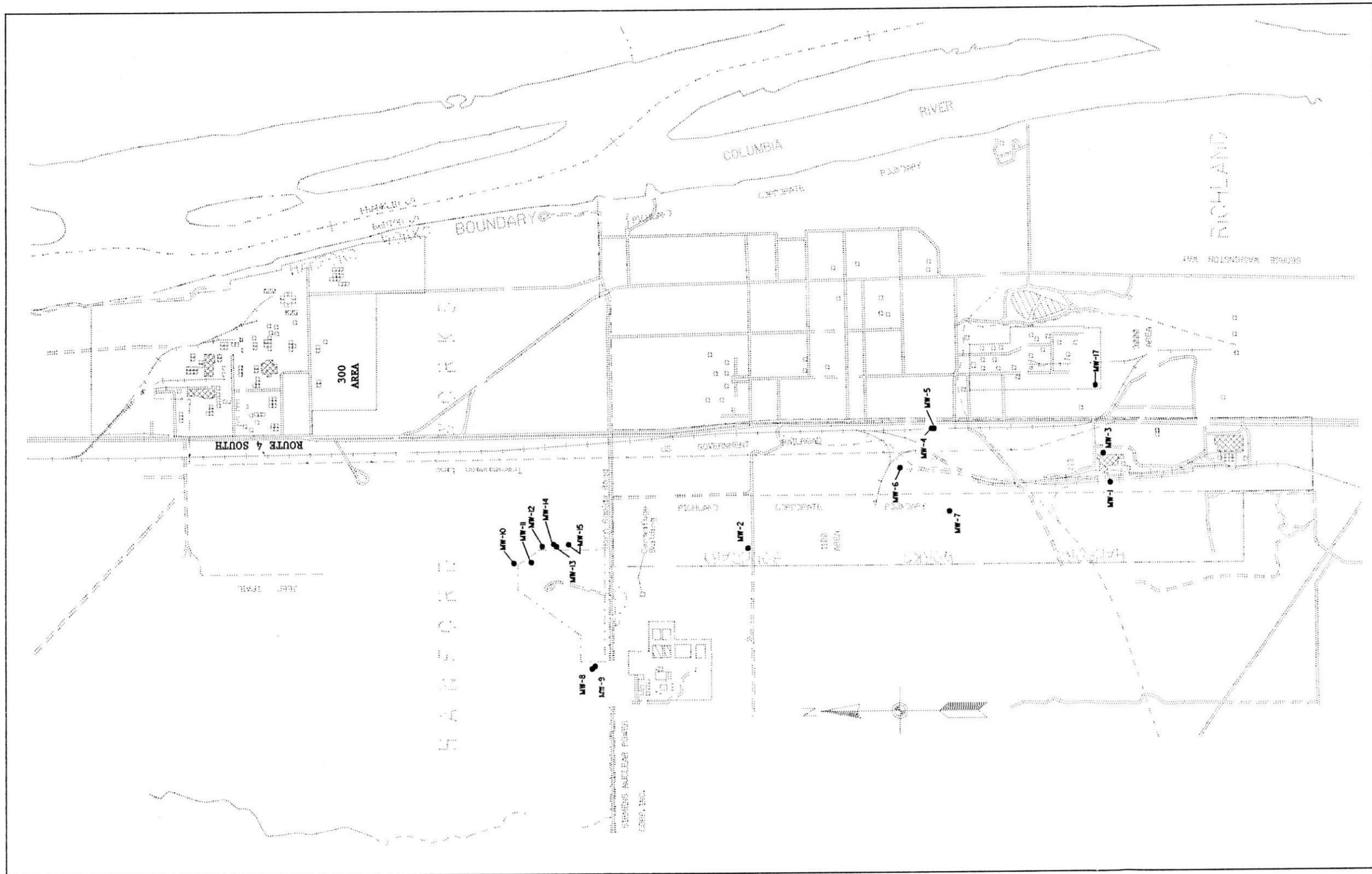
TABLE 2-4: Stratigraphic Data from Borehole Logs
Horn Rapids Landfill (3 of 3)

BORING	TOTAL DEPTH m(ft)	BORING ELEV. m(ft)	FILL THICKNESS m(ft)	EOLIAN SAND THICKNESS m(ft)	HANFORD FORMATION THICKNESS m(ft)	DEPTH TO TOP OF RINGOLD FM. m(ft)	TOP OF RINGOLD ELEV. m(ft)	DEPTH TO TOP OF SILT AQUITARD m(ft)	TOP OF SILT AQUITARD ELEV. m(ft)
Monitoring Wells									
MW-20	20.64 (67.7)	116.88 (383.45)	N/A	1.68 (5.5)	6.86 (22.5)	8.53 (28.0)	108.34 (355.45)	20.12* (66.0*)	96.76* (317.45*)
MW-21	29.26 (96.0)	115.66 (379.45)	N/A	0.91 (3.0)	9.30 (30.5)	10.21 (33.5)	105.45 (345.95)	23.62 (77.5)	92.03 (301.95)
MW-22	19.20 (63.0)	117.37 (385.07)	N/A	0.61 (2.0)	10.52 (34.5)	11.13 (36.5)	106.24 (348.57)	17.68* (58.0*)	99.69* (327.07*)
W-7A	17.77 (58.3)	118.26 (388.00)	N/A	0.61 (2.0)	9.51 (31.2)	10.12 (33.2)	108.14 (354.80)	ND	ND
W-8A	16.70 (54.8)	117.71 (386.19)	N/A	1.22 (4.0)	12.50 (41.0)	13.72 (45.0)	103.99 (341.19)	ND	ND

- NOTES:
1. EOH - End of Hole.
 2. N/A - Not Applicable.
 3. ND - Not Determined due to shallow depth of boring.
 4. + - Ringold contact based on visual examination of physical samples in the WHC Sample Library.
 5. * - Measurement on top of volcanic ash layer.

2-20

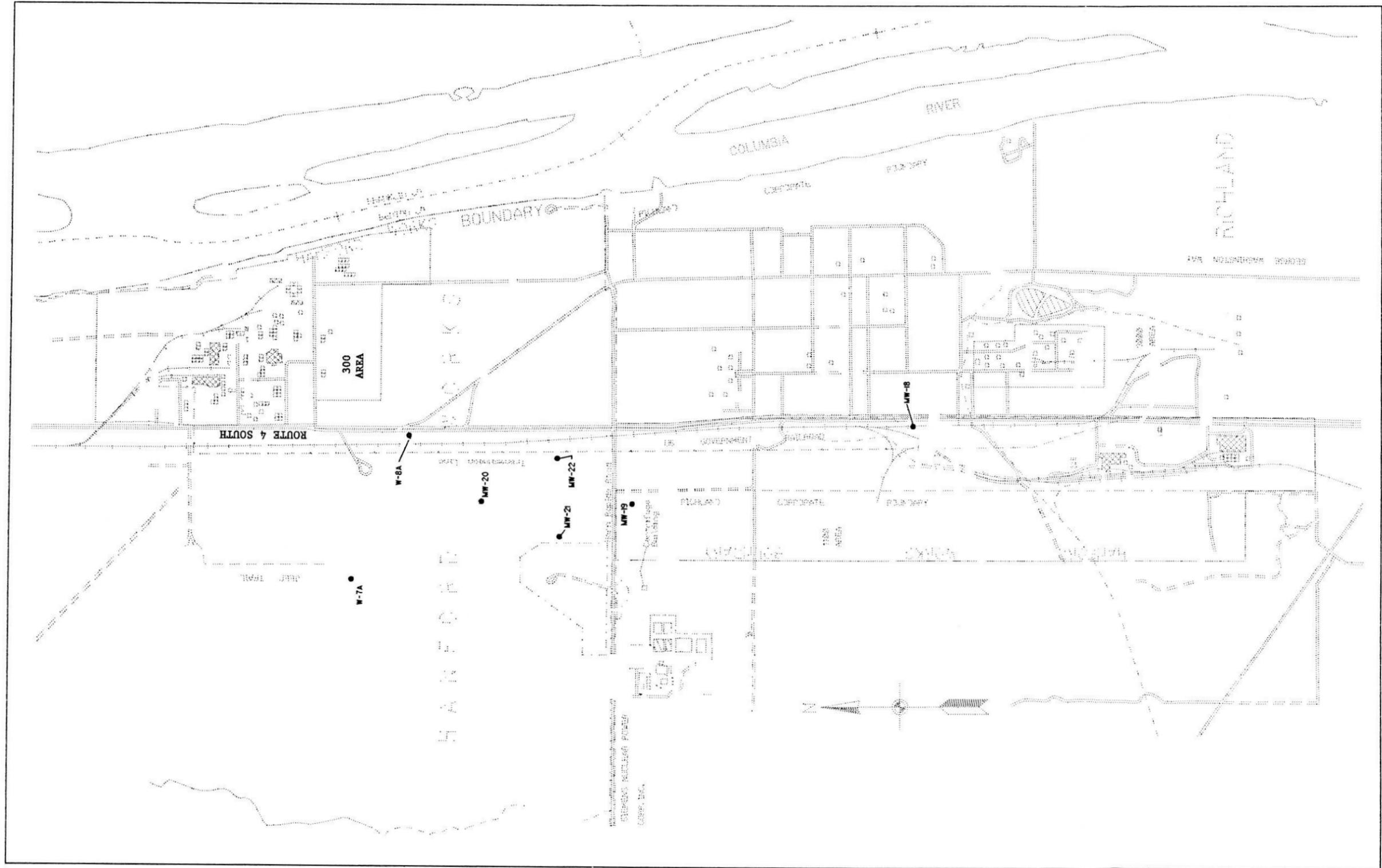
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Phase I Monitoring Wells Location Map

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Phase II Monitoring Wells Location Map

2.2.2.2.1 Ringold Formation--The Ringold Formation consists of semi-indurated clay, silt, pedogenic mud, fine- to coarse-grained sand, cobbles, and gravel that usually are divided into: (1) gravel, sand, and paleosols of the basal unit; (2) clay and silt of the lower unit; (3) gravel of the middle unit; (4) mud and lesser sand of the upper unit; and (5) basalt detritus of the fanglomerate unit (Newcomb, 1958; Newcomb, *et al.*, 1972; Myers and Price, 1979; Bjornstad, 1984; DOE/RL-88-23). Ringold strata also have been divided on the basis of facies types (Tallman, *et al.*, 1981) and fining-upwards sequences (PSPL, 1982). All of these stratigraphic divisions are of limited use as they are too generalized to account for marked local stratigraphic variations or are defined sufficiently only for small areas (Lindsey and Gaylord, 1990).

Data available for the characterization of the Ringold Formation in the vicinity of the 1100-EM-1 Operable Unit are limited. Of the monitoring wells installed and soil borings sampled during the RI, 27 penetrated the Ringold Formation to depths ranging from 7.7 to 38 meters (m) [25.3 to 125 feet (ft)] below the ground surface. The data show the upper portion of the Ringold Formation in the vicinity of the Operable Unit to consist primarily of interfingering sandy gravels, gravelly sands, silty sandy gravels, and silty gravelly sands, with discontinuous sand lenses. Data from the deeper monitoring wells show that these coarse-grained sediments are underlain by finer-grained facies comprised of silt, clay, sandy silt, and sand.

Gravels and sands in the upper portion of the Ringold Formation underlying the 1100-EM-1 Operable Unit are poorly to moderately consolidated, and are calcareous in some wells. Sorting of the gravelly horizons is generally poor, whereas the sand units are typically well sorted. Sands are commonly angular to subangular, micaceous, and quartzitic. The gravels and sands are generally brown-gray to gray-brown, with olive grays and olive browns occurring locally. The lithologies of gravel clasts indicate that they were derived from granitic and metamorphic rocks located outside the Pasco Basin. Within the gravel horizons, however, basaltic gravels and sands locally predominate, reflecting upstream erosion in basaltic terrain traversed by the Columbia River.

The fine-grained sediments underlying the coarse-grained facies are moderately consolidated, and clayey horizons are generally plastic. The uppermost fine-grained unit consists of a brown to yellow-brown to olive silt-to-clay horizon that was encountered at most of the monitoring wells installed throughout the 1100-EM-1 Operable Unit. In the few wells where the entire silty unit was penetrated, the thickness varies. In MW-9 and MW-21, at the HRL, and in MW-17, east of the 1171 Building, the silty unit is approximately 10, 1, and 5.5 m (33, 3.4, and 18 ft) thick, respectively. This silty layer acts as an aquitard within the 1100-EM-1 Operable Unit, separating the upper unconfined aquifer from the lower confined aquifer.

The elevation of the top of the uppermost fine-grained Ringold Formation facies (the silt unit of the previous paragraph) varies across the Operable Unit. As shown in north-south cross section A-A" (see figure 2-4), the fine-grained facies decreases in elevation southward, from approximately 99 to 103 m (324 to 337 ft) at HRL to approximately 94 m (310 ft) in the vicinity of monitoring well MW-1, west of the 1171 Building. There is a 7-m (23-ft) decrease in elevation of the top of the silt between MW-2, where the elevation is 101 m (333

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ft), and MW-6 and MW-7 to the south, where the elevations are approximately 94 m (310 ft). As shown in east-west cross section D-D" (see figure 2-6), there is a 4-m (13-ft) increase in elevation of the top of the silt between MW-1, west of the 1171 Building, and MW-3, located approximately 168 m (550 ft) to the east.

The clayey silt unit in the vicinity of the 1100-EM-1 Operable Unit has been tentatively identified as a paleosol, based on the absence of bedding fabric, the massive appearance, a pattern of disaggregation typical of paleosols in the Ringold Formation throughout the Hanford Site, and the mixing of silt- and clay-sized grains which suggests bioturbation. Based on current knowledge of the Ringold depositional system, this paleosol is inferred to have formed in an overbank setting where muds deposited by floods were subjected to pedogenic alteration. Similar fine-grained facies are reported in the Ringold Formation in many borehole logs for existing wells in and near the Operable Unit. In well 10/28-10G1, north of HRL, an uppermost clay horizon is approximately 5 m (17 ft) thick (Newcomb *et al.*, 1972). However, the quality of many of the existing borehole logs is such that the fine-grained sediments noted can not be definitively correlated with those present in the monitoring wells constructed for the 1100-EM-1 RI.

Available data precludes determining whether the fine grained Ringold sediments are laterally continuous over a broad area. Because of its considerable thickness in MW-9, MW-17, and 10/28-10G1, the fine grained facies is interpreted to be laterally continuous within and near the Operable Unit (see figure C-2). However, the fine-grained facies appears have been locally eroded prior to deposition of the overlying Ringold Formation gravels, creating an irregular erosional surface at the top, and the silt unit may have been completely eroded in some areas not investigated by soil borings.

The probable depositional environment of the Ringold Formation beneath the 1100-EM-1 Operable Unit is fluvial, in which the coarse-grained facies are interpreted to be high-energy, meandering river channel deposits, and the fine-grained facies are interpreted to be overbank and lacustrine floodplain deposits.

In MW-12, -14, -15, -21, and -22, east of HRL, a distinctive ash layer was encountered at an approximate elevation of 99 m (325 ft) (see figures 2-3 and 2-4). The ash was microscopically examined and shown to consist of white, angular-to-subangular, glassy, silt-sized grains showing no evidence of alteration other than mechanical breakage. Dark accessory mineral grains, probably heavy minerals and other mafic grains, constitute less than 1 percent of the ash. Some of the ash grains appear to be fragments of bubble-walls (glass containing gas bubbles entrapped during solidification). With the exception of a few very-thin layers of fine sand or of staining, bedding is indiscernible in core barrel and split spoon samples.

A thickness of 7.04 m (23.1 ft) of ash was penetrated in MW-21. Because all other wells that encountered the ash were ended prior to reaching the base of the unit, the overall geometry of the deposit is uncertain. No ash of a comparable thickness or in a similar stratigraphic position has been reported from the Ringold Formation elsewhere beneath the Hanford Site. The lateral extent of the ash appears to be very limited, in that the three closest wells to the south, west, and north (MW-2, MW-9, and MW-10, respectively)

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contained massive, brown-to-tan silt and clay comprising the silt aquitard horizon mentioned above (see figures 2-3 and 2-4, and figure C-4) at the same elevation as the ash. Ash is not reported to occur in the same stratigraphic position to the northeast in the 300 Area (Lindberg and Bond, 1979; Schalla *et al.*, 1988), and available existing borehole logs to the east and southeast do not report an ash unit in this stratigraphic position.

The depositional environment of the ash interval is unclear. The subangularity of the ash grains, the lack of abundant bubble-wall shards, and the presence of minor sand stringers or staining suggests that some reworking by fluvial processes has occurred subsequent to deposition, presumably by airfall. However, the generally massive bedding and the lack of nonvolcanic material, as well as the absence of chemically weathered grains, suggests that reworking was not extensive.

The most-favored hypothesis to interpret the relationships between the environment of deposition of the ash and the apparently laterally continuous clayey silt paleosol is that they are separated by an erosional surface (disconformity). The clayey silt is tentatively interpreted to be a paleosol formed in an overbank setting where muds deposited by floods subsequently underwent pedogenic alteration. The absence of chemical weathering in the ash precludes it from being correlative with the paleosol. The ash unit is tentatively interpreted to be an airfall ash deposit of limited extent that was subsequently reworked by a fluvial system on a local erosional surface capping the clayey silt paleosol. The ash may have been transported to its present location by a nearby drainage, possibly the ancestral Yakima River, that drained the volcanic Cascade terrain. A relatively close source could account for the purity of the ash and the lack of major mechanical erosion resulting in only minor reworking of the ash.

The shallow depth of the monitoring wells constructed during the 1100-EM-1 RI precludes determining the nature and thickness of the lower portion of Ringold Formation beneath the 1100-EM-1 Operable Unit. The overall thickness of the Ringold Formation has, therefore, been estimated, based on the assumption that the approximate elevation of the top of basalt is 59 m (195 ft) (Myers and Price, 1979), and that elevation of the top of the Ringold Formation ranges from 103 to 111 m (337 to 364 ft), figure C-1. Using these assumptions, the thickness of the Ringold Formation beneath the Operable Unit is estimated to range from approximately 43 to 52 m (142 to 169 ft). This thickness is consistent with the thickness of the Ringold Formation in the North Richland well field area, which is reported by CWC-HDR, Inc. (1988) to range from 30 to 46 m (100 to 150 ft). Total thickness of the Ringold Formation in test well 10/28-10G1, located approximately 1.3 km (0.7 mi) north of HRL, is reported by Newcomb *et al.*, (1972) to be approximately 44 m (144 ft). In the 300 Area, approximately 1.9 km (1 mi) northeast of HRL, the Ringold Formation is approximately 46 m (150 ft) thick (Lindberg and Bond, 1979).

The lithologic units in the upper portion of the Ringold Formation beneath the 1100-EM-1 Operable Unit, as recorded in the borehole logs for the groundwater monitoring wells constructed for the RI, are tentatively interpreted to be equivalent to the middle Ringold textural facies of Newcomb (1958) and Myers and Price (1979). It is also proposed that, based on the elevation of the middle and upper Ringold units exposed east of the Operable Unit along the Columbia River near White Bluffs, the upper portion of the middle

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Ringold unit and the upper Ringold unit of Newcomb (1958) and Myers and Price (1979) are not present beneath the Operable Unit, and have most likely been removed by erosion.

2.2.2.2.2 Hanford Formation--The informally defined Hanford formation is composed of uncemented pebble to boulder conglomerate and less commonly of fine- to coarse-grained sand, silt, and silty clay. The bulk of these sediments were derived during Pleistocene Missoula floods, though some are also attributed to pre-Missoula flood episodes (PSPL, 1982).

Extensive scouring associated with the Missoula flood deposits was responsible for the erosion of an approximately north-south oriented paleochannel that cuts across the western side of the 300 area; immediately northeast of the 1100-EM-1 Operable Unit (Lindberg and Bond, 1979). This channel, which was filled with coarse-grained, dominantly gravel detritus during Hanford time, merges with the modern Columbia River north of and at the extreme southern margin of the 300 Area.

The Pasco gravels are the dominant facies of the Hanford formation in the vicinity of the 1100-EM-1 Operable Unit. The distinction between the Pasco gravels and the Ringold Formation is generally made on the basis of mineralogy, grain size, weathering of basalt clasts, and cementation. Pasco gravels have a higher percentage of basaltic materials, and are generally coarser-grained and uncemented. Pasco gravel basalt clasts are commonly less weathered than basalt clasts in the Ringold Formation.

The Pasco gravels unconformably overlie the Ringold Formation at the 1100-EM-1 Operable Unit and consist of a variable mixture of boulders, cobbles, pebbles, sands, and silts. Most of the Pasco gravels can be classified as moderately to poorly sorted, unconsolidated sandy gravels to gravelly sands and silty sandy gravels. Sand lenses up to 2 m (7 ft) thick are present locally. The gravels are composed primarily of subrounded to rounded, unweathered basalt clasts with lesser amounts of mixed granitic and metamorphic lithologies. Calcium carbonate rinds occur on some gravel clasts and reworked caliche clasts are locally present. The sand fraction is angular to rounded and medium to coarse grained, and contains from 20- to 90-percent basalt. The color ranges primarily from dark grays to dark browns, with lighter-brown materials locally present near the ground surface.

Within the 1100-EM-1 Operable Unit, the Pasco gravels range in thickness from approximately 7.6 m (25 ft) at HRL to 17 m (56 ft) in the vicinity of the 1171 Building. Within the groundwater monitoring wells constructed east of the 1100 Area, the thickness of the Pasco gravels was identified as approximately 15 m (50 ft) (Bryce and Goodwin, 1989).

The Pasco gravels were deposited during multiple Pleistocene glaciofluvial flood events on an irregular erosional surface of the Ringold Formation. The predominantly coarse-grained facies present beneath the 1100-EM-1 Operable Unit indicate that the area was within a main channel of these floods.

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Lindberg and Bond (1979) have identified two cycles of graded bedding within the Pasco gravels at the 300 Area. They interpret each fining-upward sequence to represent deposition of coarse sediments during initial surges of flood waters; the finer sediments were deposited later as each flood surge diminished. The finer portion of the second, or upper, cycle is not present in the 300 Area, and Lindberg and Bond (1979) suggest that it may have been removed by erosion. These fining-upward sequences in the Pasco gravels were not recognized in the vicinity of the 1100-EM-1 Operable Unit.

2.2.2.2.3 Holocene Eolian Surficial Deposits--Holocene eolian deposits locally form a thin veneer that generally overlies the Hanford formation within the 1100-EM-1 Operable Unit. This veneer ranges from less than 0.3 m (1 ft) to more than 1.8 m (6 ft) in thickness. The deposits consist of wind-transported sand that was derived from reworked Hanford formation sediments. In some portions of the 1100-EM-1 Operable Unit, these sands form dunes with amplitudes exceeding 3 m (10 ft); the dune south of 1100-6 has an amplitude of approximately 6 m (20 ft).

These sands are generally composed of brown, very fine to medium grained sand or silty sand. They are moderately to well sorted, contain from 10- to 80-percent mafic constituents, and commonly contain root hairs and plant material.

2.3 SURFACE WATER HYDROLOGY

A detailed characterization of surface water hydrology, regionally within the Pasco Basin and locally in the vicinity of the 1100-EM-1 Operable Unit, was presented in the 1100-EM-1 Phase I RI report (DOE, 1990). With few exceptions, little new information is presented in this report to change the previous findings. Of note is the description and characterization of the Ephemeral Pool (see paragraph 3.6).

The topography within the 1100-EM-1 Operable Unit is generally flat, with no obvious drainage channels or ponds. The lack of well defined drainages, and the arid to semiarid climate, lead to the infiltration and evapotranspiration of moisture from virtually all surface waters. However, manmade ponds do exist near the 1100-EM-1 Operable Unit. To the southwest of HRL is the SPC facility. The lined ponds located at SPC are used for pretreatment of waste water. East of the 1171 Building is the North Richland well field. The unlined ponds operated in the city well field are specifically intended to recharge the unconfined groundwater table with water pumped from the Columbia River. Water filtered in this manner is then extracted to satisfy seasonal and peak municipal demands.

2.4 HYDROGEOLOGY

A detailed description of the 1100-EM-1 Operable Unit hydrogeology was presented in DOE, 1990, and is summarized, with updated information, in the following paragraphs. Pertinent additional information gathered subsequent to Phase I RI report, relating to the well

inventory, observed groundwater levels, and hydraulic parameters for the saturated and unsaturated zone are discussed.

2.4.1 Monitoring Well Inventory

Twenty three groundwater monitoring wells were installed during the 1100-EM-1 RI. These wells were installed to provide additional groundwater sampling stations; to define geological and hydrogeological characteristics of the Operable Unit; and, in two instances (MW-3 and MW-8A), to further define the nature and extent of contamination in the soil column.

2.4.1.1 Phase I Monitoring Wells. A total of 16 wells were installed during the Phase I RI. Well installation occurred from November 1989 through February 1990. The cabletool method was used to advance borings designated to receive well assemblies. All wells were constructed with stainless steel screens and casing. Well construction was performed in accordance with Washington State standards for resource protection wells (WAC 173-160-500). Phase I well locations are presented on figure 2-7.

Laboratory analyses were conducted for the following soil physical parameters: grain-size distribution, moisture content of soils located above the local water table, and, in a few select cases, vertical permeability. Soil samples collected for chemical analysis were obtained only at MW-3. These samples were analyzed for Target Analyte List (TAL) and Target Compound List (TCL) parameters.

Well borings were logged by a professional geologist who noted details on stratigraphy, drilling method and characteristics, well construction, types and locations of downhole samples, and visual soil characteristics. Soil samples collected for physical analysis, and chemical analysis in the case of MW-3, were obtained at approximately 1.5-m (5-ft) intervals and at changes in soil composition. A detailed summary of the distribution of downhole soil samples; a summary of well completion information; summary borehole logs for each monitoring well installation; results of physical analyses of soil samples; and, soil chemical analytical results are contained in the appendices of DOE, 1990.

2.4.1.2 Phase II Monitoring Wells. Seven additional groundwater monitoring wells were installed during the Phase II RI. Well installation took place from January through July 1991. As during the Phase I installations, cabletool drilling was exclusively used to advance borings designated to receive well assemblies. Wells were constructed with stainless steel screens and casing. All construction was again performed according to Washington State standards for installation of resource protection wells (WAC 173-160-500). Location of the Phase II wells are provided on figure 2-8.

Laboratory analyses for the determination of physical soil parameters were not conducted during the Phase II RI. Soil samples collected for chemical analysis were obtained from well MW-8A. These samples were analyzed for Target Analyte List (TAL) and Target Compound List (TCL) parameters.

Well borings were logged by a professional geologist who noted details on stratigraphy, drilling method and characteristics, well construction, types and locations of downhole samples, and visual soil characteristics. Soil samples collected for chemical analysis were obtained at approximately 1.5-m (5-ft) intervals and at changes in soil composition. The distribution of downhole soil samples is provided on summary borehole logs provided in appendix A. A summary of well completion information is contained in Table 2-5. Soil chemical analytical results are provided in appendix D.

2.4.2 Groundwater Levels

The more detailed definition of site hydrogeology provided by the Phase II RI data and the larger well inventory, confirms the basic description of groundwater occurrence and flow found in the Phase I RI report (DOE, 1990). Monthly potentiometric surface maps for March 1991 to June 1992 are found in appendix B. Groundwater level elevations are provided in table 2-6. Additional maps for January 1990 through February 1991 were previously presented in the "Interim Groundwater Data Summary Report for the 1100-EM-1 Operable Unit for 1990," prepared for Westinghouse Hanford Company by Golder Associates, Inc., September 20, 1991, (Doc. No.903-1215) and are not included herein. All of these maps were prepared for the 1100-EM-1 Operable Unit from water level measurements taken in monitoring wells during the course of the RI. The purpose of these constructions was to refine the definition of groundwater flow directions, groundwater surface fluctuations, and relative groundwater flow velocities, proffered in the Phase I report (DOE/RL-90-18). The maps include data gathered from the 300 Area and the SPC area (see paragraph 3.7).

The potentiometric surface maps show, for the observed period, the direction of groundwater flow in the unconfined aquifer and the range of groundwater level fluctuations. The direction of flow is from high pressure (high potentiometric head) towards the adjacent lower pressure (lower potentiometric head). On the maps, this is orthogonal to the contours in the down-gradient direction. Site groundwater flow and water table fluctuations are discussed in paragraph 2.4.3.2.

2.4.3 Hydrostratigraphy

The hydrostratigraphy within the 1100-EM-1 Operable Unit consists of the unsaturated vadose zone, an unconfined (water table) aquifer, a clayey silt aquitard, a confined aquifer, and a lower clayey silt to silty clay unit which essentially overlies bedrock. This basic hydrostratigraphy was used in the development of the groundwater model described in paragraph 6.4 and in appendix H. A generalized depiction of the hydrostratigraphic column is presented in figure 2-9.

2.4.3.1 Vadose Zone. The vadose zone consists predominantly of unsaturated interlayered sandy gravel, gravelly sand, and silty sandy gravel of the Hanford formation between the ground surface and the water table. It is the zone through which natural and anthropogenic recharge waters may migrate toward the groundwater:

Table 2-5: Completion Summary for the Phase II Monitoring Wells

<u>Well ID</u>	<u>Installation Date (mo/yr)</u>	<u>Ground Surface Elevation (ft amsl)</u>	<u>Top of Screen Elevation (ft amsl)</u>	<u>Screen Length (ft)</u>	<u>Sand Pack Interval (ft amsl)</u>	<u>Screen Type</u>	<u>Aquifer</u>
MW-7A	5/91	388.00	355.50	20.00	356.20 - 331.70	a	Unconfined
MW-8A	5/91	386.19	351.19	20.30	327.79 - 354.69	a	Unconfined
MW-18	1/91	399.74	357.74	20.00	333.44 - 360.44	a	Unconfined
MW-19	6/91	388.56	354.66	20.98	330.26 - 358.76	a	Unconfined
MW-20	6/91	383.45	359.35	20.00	294.75 - 338.45	a	Unconfined
MW-21	6/91	379.45	290.95	10.10	280.95 - 298.95	a	Confined
MW-22	6/91	385.07	355.07	20.40	295.07 - 328.07	a	Unconfined

NOTES:

1. a - 0.010 slot, stainless steel, wire wound screen
2. A similar completion summary for the Phase I monitoring wells is provided in Chapter 2 of the Phase I RI report (DOE/RL 90-18).

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Table 2-6: 1100-EM-1 Operable Unit
Monitoring Well Groundwater Levels

Well ID	DATES																						
	2/90	6/90	9/90	3/91	4/91	5/91	6/91	7/91	8/91	9/91	10/91	11/91	12/91	1/92	2/92	3/92	4/92	5/92	6/92	7/92	8/92	9/92	
	Groundwater Elevations (m)																						
11-34-13	107.35	107.29	107.56	107.15	107.16	107.25	107.38	107.62	107.72	107.86	107.86	107.77	107.70	107.47	107.33	107.23	107.20	107.23	107.284	107.23	107.20	107.16	
11-41-13C	107.30	107.62	107.72	106.75	107.15	108.38	108.53	108.59	108.66	108.75	108.46	107.96	107.41	106.96	107.02	106.99	107.10	107.36	107.253	107.34	107.15	107.50	
30-45-16	105.80	106.41	106.06	105.34	105.61	106.33	106.54	NA	108.12	NA	NA	NA	NA	106.06	106.06	106.07	106.97	106.06	107.515	107.24	107.05	107.22	
30-47-18B	104.42	105.57	103.40	104.63	105.29	105.36	105.19	104.85	105.00	104.08	104.44	104.02	104.02	103.94	103.66	103.91	103.80	104.43	104.483	103.69	103.34	103.42	
S27-E14	104.67	105.52	103.88	104.79	105.36	105.61	105.35	104.58	104.43	103.98	104.12	104.14	104.52	104.17	103.92	104.05	104.39	NA	NA	NA	NA	NA	
S29-E11 (MW-20)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	105.87	105.77	105.70	NA	105.56	105.64	105.74	105.76	106.31	105.25
S29-E12	105.36	105.86	105.42	105.35	105.40	105.24	105.79	105.73	105.65	105.60	105.60	106.32	105.47	105.33	105.24	NA	105.21	105.29	105.406	105.33	105.25	NA	
S30-E10A (MW-10)	106.24	106.28	106.34	106.30	106.26	106.29	106.32	106.43	106.46	106.53	106.56	106.57	106.60	106.50	106.42	106.37	106.28	106.27	106.324	106.38	106.37	106.34	
S30-E10B (MW-11)	106.40	106.39	106.49	106.42	106.40	106.42	106.45	106.55	106.60	106.68	106.71	NA	106.73	106.66	106.60	106.50	106.45	106.43	106.485	106.54	106.54	106.52	
S30-E15A	104.67	105.65	103.84	104.76	105.21	105.39	104.88	104.83	104.96	104.17	104.34	104.26	104.39	104.26	103.96	103.97	104.22	104.62	104.729	104.14	103.65	103.64	
S31-E10A (MW-12)	106.12	106.16	106.22	106.12	106.11	106.16	106.21	106.34	106.38	106.46	106.51	106.49	106.48	106.36	106.27	106.16	106.11	106.13	106.193	106.25	106.23	106.20	
S31-E10B (MW-13)	106.34	106.34	106.43	106.34	106.31	106.35	106.38	106.51	106.56	106.56	106.70	106.70	106.69	106.59	106.51	106.41	106.36	106.35	106.415	106.47	106.46	106.44	
S31-E10C (MW-14)	106.31	106.92	107.01	106.31	106.29	106.32	106.36	106.49	106.54	106.63	106.68	106.67	106.64	106.57	106.50	106.38	106.32	106.33	106.394	106.44	106.43	106.41	
S31-E10D (MW-15)	106.28	106.28	106.37	106.28	106.26	106.29	106.34	106.46	106.51	106.60	106.65	106.65	106.64	106.52	106.43	106.34	106.29	106.30	106.354	106.41	106.40	106.37	
S31-E10E (MW-21)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.50	106.42	106.32	NA	106.16	106.19	106.269	106.33	106.32	106.31
S31-E11 (MW-22)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	105.82	105.64	105.51	NA	105.51	105.72	105.827	105.74	105.68	106.22
S31-E13	105.41	106.00	105.55	105.34	105.49	105.76	106.03	105.92	105.92	105.86	105.86	105.64	105.50	105.32	105.19	105.13	105.30	105.66	105.717	105.51	107.59	105.50	
S31-E8 (MW-8)	107.64	107.60	107.69	107.72	107.70	107.69	107.69	107.77	107.82	107.92	107.97	107.99	108.02	107.99	107.95	107.91	107.89	107.85	107.884	107.94	107.94	107.97	
S32-E11 (MW-19)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	107.01	106.89	106.71	106.61	106.51	106.59	106.695	106.73	106.69	106.70	
S32-E13B	107.15	106.08	105.75	105.46	105.59	105.84	106.12	106.08	106.06	106.06	106.06	105.83	105.70	105.52	105.41	105.27	105.55	105.88	105.879	105.71	105.65	105.73	
S32-E8 (MW-9)	NA	NA	109.44	109.40	109.39	109.39	109.39	109.44	109.49	109.59	109.63	109.66	109.76	109.83	109.73	109.59	109.67	109.67	108.786	109.75	109.75	109.80	
S34-E10 (MW-2)	107.55	107.43	107.70	107.39	107.31	107.46	107.64	107.95	108.02	108.16	108.18	107.78	108.03	107.81	107.65	107.55	107.51	107.58	107.643	107.66	107.66	107.70	
S36-E12B	107.13	107.39	107.56	106.46	106.93	108.02	105.21	108.28	108.30	108.50	108.27	107.80	107.30	106.79	106.81	106.76	106.92	107.21	107.089	107.14	106.95	107.33	
S36-E13A	107.07	107.38	107.51	106.41	106.92	107.96	108.18	108.18	108.36	108.38	108.16	107.70	107.22	106.74	106.78	106.70	106.87	107.18	107.098	107.14	106.96	107.29	
S36-E13B	107.15	NA	108.37	NA	NA	NA	107.37	106.81	106.79	106.88	106.93	107.77	107.076	107.09	106.96	107.27							
S37-E11 (MW-6)	107.32	107.42	107.71	106.74	106.99	107.95	108.27	108.40	108.53	108.60	108.40	107.99	107.61	107.11	109.43	106.99	107.11	107.31	107.265	107.29	107.15	107.45	
S37-E12 (MW-18)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	107.38	NA	106.94	NA	107.04	107.30	NA	107.34	107.09	107.43	
S37-E14	107.04	107.41	107.17	106.41	106.98	108.18	108.34	108.31	108.49	108.48	108.18	107.61	107.09	106.55	106.74	106.72	106.83	107.11	107.009	107.08	106.90	NA	
S38-E11 (MW-7)	107.60	107.56	107.89	107.20	107.27	107.90	108.20	108.45	108.52	108.69	108.54	108.26	107.97	107.61	107.48	107.40	107.46	107.57	107.585	107.57	107.50	107.69	
S38-E12A (MW-4)	107.26	107.56	107.68	106.61	107.10	108.30	108.48	108.52	108.63	108.68	108.40	107.89	107.38	106.89	106.97	106.93	107.04	107.32	107.226	107.28	107.11	107.45	
S38-E12B (MW-5)	107.26	107.56	107.68	106.61	107.10	108.30	108.48	108.53	108.69	108.69	108.40	107.89	107.39	106.90	106.97	106.92	107.04	107.31	107.232	107.28	107.11	107.46	
S40-E14	107.34	0.00	108.02	106.52	107.59	109.08	109.25	109.17	109.44	109.15	108.59	107.96	107.15	106.88	107.12	107.05	107.33	107.54	107.415	107.44	107.36	107.73	
S41-E11 (MW-1)	107.84	107.63	107.88	107.56	107.54	107.86	108.05	108.28	108.45	108.59	108.53	108.35	108.20	107.95	107.81	107.73	107.72	107.73	107.72	107.70	107.67	107.83	
S41-E12 (MW-3)	NA	107.42	107.73	107.05	NA	107.78	107.95	108.23	108.31	108.48	108.35	108.04	107.65	107.35	107.57	107.53	107.52	107.61	107.585	107.57	107.51	107.68	
S41-E13A	107.43	107.84	107.88	106.77	107.38	108.68	108.77	108.87	109.07	108.97	108.73	108.09	107.56	107.02	107.16	107.11	107.22	107.51	107.406	107.47	107.31	107.65	
S41-E13B	107.43	107.85	107.88	106.76	107.38	108.69	108.79	108.88	109.16	108.98	108.60	108.08	107.51	107.01	107.15	107.10	107.21	107.52	107.406	107.46	107.31	107.65	
S41-E13C (MW-17)	107.73	NA	NA	106.76	107.40	108.54	108.94	108.74	108.94	108.83	108.51	108.04	107.45	106.96	107.16	107.09	107.18	107.46	107.348	107.39	107.31	107.60	
S43-E12	107.73	107.58	107.83	107.48	107.45	107.73	107.91	108.14	108.25	108.47	108.40	107.60	108.10	107.84	107.72	107.62	107.59	107.60	107.595	107.59	107.56	107.62	
MW-7A	NA	NA	NA	NA	NA								106.05		106.02	106.00							
MW-8A	NA	NA	NA	NA	NA									104.99	104.96	104.85							

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BLANK - Measurements have been obtained but not yet entered into HEIS
NA - Measurements are not recorded in HEIS database

9 9 2 0 2 8 2 1 5 6

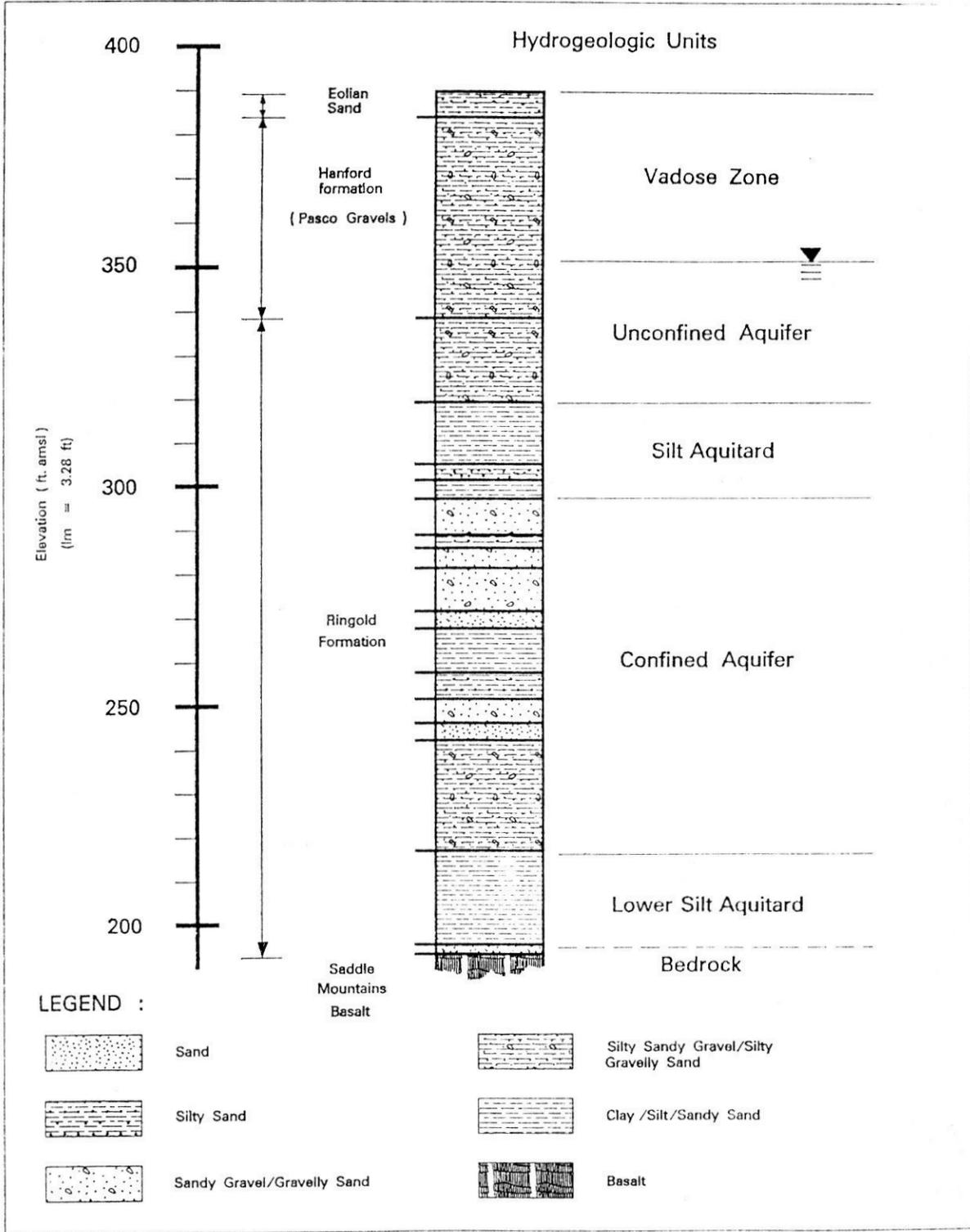


Figure 2-9. Generalized Hydrostratigraphic Column for the 1100-EM-1 Operable Unit

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Below the 1100-EM-1 Operable Unit, the thinnest portion of the vadose zone occurs on the west side of HRL, where it is only 6 m (20 ft) to the water table. East and south of the landfill, the vadose zone thickness gradually increases by 6 to 8 m (20 to 25 ft). Below the 1100-2 and 1100-3 subunits, it is about 15 m (50 ft) to groundwater, and about 14 to 15 m (45 to 50 ft) to groundwater below subunits 1100-1, 1100-4, 1100-6, and the Ephemeral Pool.

Hydraulic testing and surface mapping to evaluate vadose zone recharge to groundwater was not conducted during the 1100-EM-1 RI. The Hanford Site Performance Assessment (HSPA) project, however, has collected data at several locations on drainage and moisture in the vadose zone (Rockhold *et al.*, 1990). Two of these locations are within 16 km (10 mi) of the 1100-EM-1 Operable Unit. The information from these locations can be generally applied to the vadose zone underlying the Operable Unit.

The two HSPA sites located nearest to the 1100-EM-1 Operable Unit are the Buried Waste Test Facility (BWTF) Site and the Grass Site (Rockhold *et al.*, 1990). They are located about 16 km (10 mi) and 8 km (5 mi) north of the Operable Unit, respectively. The sites are instrumented to monitor in-situ water content of the sediments and cumulative drainage volumes. At the BWTF Site, lysimeters and caissons were installed using locally derived, repacked sieved sediments passing a 1.3 cm (0.5 in) mesh with about 3-percent silt and clay. At the Grass Site, neutron probe access tubes were installed in undisturbed sediments consisting of 74-percent sand, 21-percent silt, and about 5-percent clay. These sediments are similar to those occurring in the vadose zone of the 1100-EM-1 Operable Unit, but are lacking in the very coarse fraction which includes large gravel, cobbles, and small boulders.

Water-balance calculations, completed for the period from 1985 to 1989, have provided cumulative drainage volumes for the BWTF Site. The calculations were performed on data collected from two weighing lysimeters (north and south) and a caisson. Cumulative drainage volumes over the 4-year (yr) study ranged from 0.0 to 10.6 cm (0.0 to 4.5 in) for the vegetated south weighing lysimeter, 3.1 to 10.0 cm (1.3 to 4.0 in) at the unvegetated north weighing lysimeter, and 4.0 to 11.1 cm (1.7 to 4.5 in) at the unvegetated south caisson, which is deeper than either the north or south weighing lysimeters (Rockhold *et al.*, 1990). The south caisson extends to a depth of 7.6 m (25 ft), whereas the north and south weighing lysimeters extend to only 1.5 m (4 ft) below ground surface.

In general, the vegetated south weighing lysimeter had 3 to 6 cm (1.3 to 2.5 in) less drainage than the north weighing lysimeter and the south caisson from 1986 to 1989. The drainage rate in the south caisson was also reported to be more regular due to its greater depth, as compared to both the north and south weighing lysimeters, which were observed to show seasonal fluctuations (Rockhold *et al.*, 1990).

Fewer data are available to evaluate drainage from the Grass Site. A computed recharge rate for the Grass Site, based on the unit gradient principle and the average field-measured saturated hydraulic conductivity, was estimated at 0.44 cm/yr (0.17 in/yr)

(Rockhold *et al.*, 1990). The unit gradient was generally observed in the field moisture content data. The smaller recharge rate at the Grass Site was attributed to the finer-grained vegetated sediments.

Computer modeling of the water table aquifer recharge rate from surface infiltration was performed during the Phase II investigation. A discussion of the modeling is provided in paragraph 6.3 of this report. Groundwater recharge within the 1100-EM-1 Operable Unit, as determined through the modeling effort, was computed as averaging 1.04 cm/yr (0.41 in/yr) for vegetated areas and 3.46 cm/yr (1.36 in/yr) for unvegetated areas. Both values are well within the ranges measured by field investigations described above.

2.4.3.1.1 Vadose Zone Properties--Soil grain size distribution and moisture content were the only two physical properties determined for vadose zone sediments during the 1100-EM-1 Operable Unit Phase I investigation. Neither property was measured during the Phase II investigation. A detailed summary and discussion of vadose zone parameters are presented in paragraph 6.1. Tables presented there provide a compilation of the soil samples obtained for physical analyses, the borehole/well from which the samples were obtained, the depths of the samples, a summary of their grain-size composition, the measured soil-moisture contents, and the Wentworth Classification of the soil based on laboratory gradation analysis results.

Gradation percentages and classifications presented in these tables may differ from field data entered on the boring logs. Field data was based entirely on visual estimation of soil grain-size composition and, therefore, subject to the classifier's judgement. Based on the arithmetic averaging of 168 test results, the overall soil gradation within the vadose zone consists of 50-percent gravel sized particles, 42-percent sand, and 8-percent silt-sized or finer grains. Soil moisture averages 0.06 cm³/cm³.

2.4.3.2 Unconfined Aquifer. The unconfined aquifer below the 1100-EM-1 Operable Unit occurs between the water table and the underlying silt aquitard, approximately 95 to 107 m (310 to 350 ft) above mean sea level (msl). The aquifer occurs within the lower Hanford formation and the upper portion of the middle Ringold Formation.

2.4.3.2.1 Aquifer Thickness--Below the 1100-EM-1 Operable Unit, the unconfined aquifer thickness gradually increases south from HRL to a trough, which occurs in the vicinity of the 1100-2 and 1100-3 subunits. Directly south from these two subunits, toward the 1100-1 subunit, the thickness does not appear to change. Southeast from the 1100-2 and 1100-3 subunits and east from the 1100-1 subunit, the thickness decreases slightly. The maximum thickness observed is 13 m (44 ft), in the vicinity of the 1100-1, 1100-2, 1100-3, and UN-1100-6 subunits. The minimum observed thickness is 5 m (16 ft) and occurs on the west side of HRL.

Outside of the 1100-EM-1 Operable Unit, fewer data are available to map the unconfined aquifer thickness. In general, the thickness appears to increase toward the Columbia River.

2.4.3.2.2 Recharge--Groundwater recharge to the unconfined aquifer below the 1100-EM-1 Operable Unit results primarily from eastward groundwater inflow. The source of inflow is likely the Yakima River, which appears to discharge directly to the unconfined aquifer along the Horn Rapids Reach below Horn Rapids Dam (Freshley *et al.*, 1989). Irrigation losses from farmland west of the Operable Unit is likely a minimal contributor to the westward groundwater inflow volume.

Within the boundaries of the 1100-EM-1 Operable Unit, groundwater recharge also may occur as a result of natural precipitation. The volume of recharge from infiltrating precipitation is anticipated to be small relative to the westward groundwater inflow volume.

To the east of the 1100-EM-1 Operable Unit, the North Richland well field artificially recharges the unconfined aquifer to provide treatment of turbid Columbia River water and enhance the well field capacity. This is a major source of recharge to the aquifer and causes groundwater mounding that extends west to the vicinity of the 1100-1, 1100-4, UN-1100-6, and Ephemeral Pool subunits. However, because the well field is recharged intermittently, the mound may dissipate between periods of recharge. Monthly totals for recharge at the well field during 1988 and 1989 ranged from about 75,000,000 L (20,000,000 gal) to 1,500,000,000 L (400,000,000 gal).

2.4.3.2.3 Water Table Surface Fluctuations--Groundwater surface fluctuations near the 1100 Area occur due to Columbia River stage fluctuations and variable recharge at the Richland well field. Of the observed data sets, the June 1990 and the April 1992 water surfaces (shown in figures B-1 and B-17) have, respectively, the highest and lowest surfaces due to river fluctuations. Comparing these data sets, the influence of the major (seasonal) river stage fluctuations in the northern part of the area extends inland to about the down-gradient boundary of the HRL. In the southern part of the area, the extent of the river influence does not reach as far inland, because of the steepness of the surface gradient in this area. Its exact extent could not be determined because of the variable influence of the Richland well field recharge.

As noted, recharge from the Richland well field causes groundwater mounding in the southern part of the area as shown on the groundwater level maps. Of the observed data sets, the greatest and least amount of mounding occurred in September 1991 (figure B-10) and March 1991 (figure B-4), respectively. The maximum observed northward extent of the recharge influence was to the area approximately 1,500 m south of Horn Rapids road. The recharge mounding has not been observed to have a significant effect on groundwater levels or gradient directions within the SPC/HRL area.

2.4.3.2.4 Groundwater Flow--The groundwater flow direction was determined from groundwater potential measurements in monitoring wells within and adjacent to the 1100-EM-1 Operable Unit as reported in table 2-6 and the potentiometric surface maps discussed in paragraph 2.4.2.

The potentiometric surface maps indicate consistent northeasterly groundwater flow in the vicinity of the HRL and that groundwater passing through the SPC area flows to the

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HRL. HRL wells containing the highest concentrations of contaminants (paragraph 4.8.2) are directly down-gradient from the SPC facility.

The potentiometric maps also confirm the Phase I RI observation that local groundwater flow originating north of latitude 46°20'N (near wells MW-7 and MW-5) does not flow to the Richland well field. Therefore, based on the 1990 to 1992 observations, it is not possible for unconfined aquifer groundwater contamination originating at the SPC/HRL area to flow directly to the Richland well field.

The maps also show that groundwater passing beneath the southern portion of the 1100-EM-1 Operable Unit flows eastward toward the Richland well field when it is not obstructed by recharge mounding, and westward when mounding occurs. Examination of the 29 months of available data revealed that 13 allowed for flow from the 1100-EM-1 eastward towards the well fields while 16 indicated the presence of a recharge mound that caused the flow to be reversed. The average local surface gradients were approximately equivalent for those two conditions. Therefore, for the localized area west of the well field, the 1990 to 1992 data indicates that the recharged water dominates the direction of flow, that flow is towards the west more than towards the east, and that, if the observed recharge pattern is continued indefinitely, the natural groundwater beneath the southern portion of the 1100-EM-1 Operable Unit will not flow into the Richland well field.

In summary, however, groundwater flowing below the 1100-EM-1 Operable Unit ultimately flows to the Columbia River unless pumped from the aquifer by the city of Richland or other well owners.

2.4.3.2.5 Discharge--Groundwater discharge from the unconfined aquifer occurs primarily into the Columbia River and to wells in the city of Richland well field, depending on the well field operations. Hydraulic connection between the aquifer and the river is shown by the continuity of the formation materials toward the river, and the similarity between river stage and the observed groundwater potential in the unconfined aquifer near the river.

This hydraulic connection was further demonstrated by the response of many monitoring wells to a 0.3-m (1-ft) decline in Columbia River stage from March 2 to 5, 1990. During this period, groundwater potential measured in monitoring wells nearest the river also declined approximately 0.3 m (1 ft).

2.4.3.2.6 Hydraulic Properties--Hydraulic properties for the unconfined aquifer were determined from previous investigations at this and nearby sites, and from recent pump tests performed at the SPC facility and west of Stevens Drive at the 300-FF-5 Operable Unit. Pump tests were not performed at the HRL because of concerns expressed by regulators regarding the pumping of potentially contaminated groundwater to the surface. The SPC pump test was performed close to the area of immediate concern and mainly evaluated properties of the Hanford formation. The two 300-FF-5 Operable Unit tests, at wells 7T and 4T, were located about 1/2 and 1 mile from the HRL boundary, respectively, and reflect properties of the middle Ringold Formation (figure 2-6).

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Pump test results were used as the representative data for site hydraulic conductivity instead of the slug tests results reported in the Phase I RI report. This was determined after reviewing other hydraulic property investigations (see appendix B), discussions with the US Geological Survey (USGS) concerning unpublished hydraulic property testing in the vicinity (personal communication between M. Johansen, US Army Corps of Engineers, and Ward Staubitz, USGS), and the conventional understanding that pump test results are more representative than slug test data because a larger area of the aquifer is stressed. There were also concerns reported in the Phase I RI and in the 300-FF-5 aquifer test report about the accuracy of the slug test results for wells with small screen mesh sizes (10 to 20 slot at the 1100 Area and 30 slot at the 300-FF-5 Area) and accompanying fine sand-pack material.

The SPS pump test was conducted April 27 through 30, 1992, by pumping well PW-1 (located near SPC monitoring well GM-5 as shown in figure 6-13) at approximately 154 gpm for a period of 72 hours; a time period sufficient for test stabilization (see appendix F). The pumping rate was determined from a previously performed step-drawdown test. The driller's log for well PW-1 shows the base of the screen to be located a few feet above the silt aquitard layer with the screen extending 15 feet upward to the vicinity of the water table. The contact between the Hanford and Ringold Formations is interpreted as occurring approximately at the midpoint of the screened interval with slightly more length screened in the Pasco gravels of the Hanford formation. The pump test largely evaluated the properties of the Hanford formation since most of the pumped water was likely derived from the more permeable Pasco gravels. Based on test results, the estimated transmissivity of the unconfined aquifer in the vicinity of the pumping well was approximately 2,460 to 3,140 m³/d-m (180,000 to 230,000 gallons per day per foot). Corresponding hydraulic conductivities range from 400 to 520 meters per day (1,320 to 1,700 feet per day). The information is preliminary and is to be finalized and presented in an RI report for SPC scheduled for release by December 1992.

Aquifer testing at the 300-FF-5 sites was conducted from January to May of 1992 in 10-inch-diameter wells equipped with 30-slot, wire-wrap screens (WHC, 1992c). The two test wells were screened entirely within the middle Ringold Formation with screen lengths for wells 4T and 7T being 20.2 and 30.5 feet, respectively. Three observation wells were constructed for each test well and several different slug and pump tests were performed. The slug test results were reported as unrepresentative of aquifer properties because of the effects of the fine filter pack material required by the 30-slot size screens. The pump test results were 10 - 72 m per day(d) (33 to 236 ft/d) (K_h), 2 to 5 m/d (6.6 to 16 ft/d) (K_v), and 0.01 - 0.58 (S_y). The constant discharge tests (Neuman analysis) were reported to provide the best estimate of the unconfined aquifer properties with results of 37 to 49 m/d (121 to 161 ft/d) (K_h), 2 to 5 m/d (6.6 to 16 ft/d) (K_v), and 0.02 - 0.37 (S_y).

The SPC and 300-FF-5 pump tests provided the best estimates of aquifer properties in the HRL vicinity. However, additional information concerning the hydraulic properties of the unconfined aquifer near the river was desired for use in groundwater modeling. The water table contour maps (appendix B) show that the groundwater surface near the 300 Area is consistently and distinctly flatter than the up-gradient surface near the HRL. According to the governing principles of groundwater flow, this decrease in the slope indicates the

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presence of relatively high aquifer hydraulic conductivities in this area. The up-gradient pump tests results were, therefore, not extrapolated into this area. The best available hydraulic property information for this area were K_h measurements of 3,350 - 15,000 m/d (10,991 to 49,215 ft/d) for the local Hanford formation (RI/FS Work Plan for the 300-FF-5 Operable Unit, Hanford Site, Richland, Washington).

An earlier pumping test completed at the Richland well field provided a single hydraulic conductivity estimate of 457 m/d (1E+03 ft/d), which is more typical for the unconfined aquifer. At the well field, the unconfined aquifer occurs within both the Hanford formation and middle Ringold Formation. During this test, water was withdrawn from the aquifer at a rate of 5,070 l/min (1,340 gal/min). Although the test continued for a total of 98 hours, all observed drawdown occurred in the first 24 hours. A total drawdown of 1.2-m (4-ft) was measured in the pumping well. In an observation well 107 m (350 ft) away, the total drawdown was only 0.20 m (0.66 ft). These results are consistent with those of the SPC test.

Table 2-7 summarizes the estimated hydraulic properties for the hydrogeologic units at the site. Those values not taken from the information reported above, were estimates and observations taken from the 1100-EM-1 Operable Unit Phase I RI report (DOE, 1990) and other investigations at Hanford as reported in appendix B. Where no previous site-specific data was available, the estimated value, or range, was extrapolated from the nearest available measured value (*i.e.*, some vertical hydraulic conductivity estimates were derived from measured horizontal conductivity values by using a 1 to 10 ratio).

2.4.3.3 Silt Aquitard. A silt aquitard was identified during drilling throughout the 1100-EM-1 Operable Unit, and is also recognized in the drill logs of previous workers in the general vicinity. See appendix C for further details and maps defining stratigraphic characteristics, thicknesses, and areal extent of the silt aquitard. The aquitard was encountered within the interval from 91 to 102 m (299 to 333 ft) above msl. Wells drilled to elevations lower than 91 m (299 ft) amsl invariably intercepted the aquitard. There is, however, uncertainty regarding the continuity of this layer. A possibility exists for the aquitard to be discontinuous due to erosion that may have occurred before the overlying sediments were deposited.

2.4.3.3.1 Aquitard Thickness and Extent--The reported thickness of the silt aquitard ranges from 1.04 to 10.1 m (3.4 to 33 ft) (see table C-1). The thickness of only 1.04 m (3.4 ft) was observed in MW-21. This unit is overlain by a 7.04 m (23.1 ft) thick volcanic ash layer (see appendix C). The ash appears to have been alluvially deposited in an isolated depression on the top of the silt. On the west side of HRL, at MW-9, the silt aquitard thickness is measured to be 10.1 m (33 ft). A short distance west of the North Richland well field, in MW-17, the aquitard is 5.5 m (18 ft) thick. Within the North Richland well field, no wells extended through the silt aquitard; however, several logs indicate a silt or clay interval being intercepted at the bottom of the borehole.

The change in thickness of the aquitard is interpreted to reflect undulations in its upper surface. This surface likely was subject to erosion based on the high-energy sand and gravel deposits that overlie it and the apparent geometry of the ash deposit previously

described. The lower surface of the silt appears to be relatively flat (based on six data points), varying in elevation by less than 3 m (10 ft) over a 6-km (3-mi) north-south transect passing through the 1100-EM-1 Operable Unit. (Cross section A-A", figure 2-4.)

The uniformity and gradation in elevations of the lower silt surface, as observed, suggest the aquitard may be a continuous stratum; however, the undulating upper surface indicates the potential for complete erosion of the silt in localized areas. Below the 300 Area, a silt aquitard, which occurs at about the same elevation as that below the 1100-EM-1 Operable Unit, pinches out near the Columbia River channel, an indication of complete erosion in this area (see figure C-2). However, it is not clear that these two silt horizons are absolutely correlative.

The uppermost Ringold silt layer present within the 1100-EM-1 Operable Unit is, at least partially, discontinuous to the east, adjacent to the Columbia River. This is evident in the head differences obtained from two well clusters (MW-8 and 9 located along the western edge of HRL and wells 7A, 7B, and 7C located within the 300-FF-5 Operable Unit), which indicated upward pressure head differences of 2.0 and 0.3 m (6.6 and 1.0 ft), respectively. If the silt layer were continuous, the head differences would be approximately the same across the site or may even increase closer to the river.

Monitoring well MW-21, which penetrates the confined aquifer at the eastern edge of HRL, presents an anomaly to this trend. Water level measurements indicate that a slightly lower potentiometric surface exists in the confined aquifer versus the unconfined aquifer at this location. Water level elevation differences average 0.13 m (0.43 ft) with a maximum difference of 0.18 m (0.59 ft) and a minimum of 0.10 m (0.33 ft); the water level elevation in the lower confined aquifer being lower than that in the upper unconfined aquifer. A preliminary check of the top-of-casing elevation listed for well MW-21 suggests the anomaly may be the result of survey error. Alternately, the well seal may be compromised. An elevation survey of 1100 Area wells is underway. This anomaly will be re-evaluated when the new survey data becomes available.

2.4.3.3.2 Hydraulic Properties--Ten samples of the silt aquitard were used to measure the vertical hydraulic conductivity of this confining layer. The hydraulic conductivity results ranged from 2.5E-05 to 4.3E-02 m/d (8E-04 to 1E-01 ft/d) (DOE/RL-90-18). These values were several orders of magnitude lower than in the overlying unconfined aquifer. The laboratory test results may not, however, be representative of the true hydraulic conductivities of the sediments due to sampling disturbances.

The confining ability of the aquitard is shown by comparison of the groundwater potentials in monitoring wells MW-8 and MW-9 on the west side of HRL. Well MW-9 is screened entirely within sediments underlying the silt aquitard and has groundwater potentials approximately 1.9 m (6.3 ft) greater than those in MW-8, which is screened above the aquitard. Under these conditions, an upward hydraulic gradient across the aquitard exists.

At MW-17 the groundwater potential difference across the aquitard was essentially zero. The absence of a potential gradient at MW-17 may be attributed to the occurrence of a window through the aquitard, mounding effects caused by recharge at the well field, or poor

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well construction. In general, an easterly decline in the hydraulic gradient across the aquitard is anticipated, as the aquitard likely pinches out in this direction, thereby allowing the unconfined aquifer to equilibrate with the aquifer below.

2.4.3.4 Confined Aquifer. The upper confined aquifer occurs immediately below the silt aquitard. Information on this aquifer is limited, as the 1100-EM-1 RI hydrogeological investigation focused primarily on the vadose zone and unconfined aquifer.

The upper confined aquifer is monitored by wells MW-9, MW-17, and MW-21. The groundwater potentials measured in these wells indicate that flow is apparently toward the east. There is also flow upward into the silt aquitard of the overlying unconfined aquifer, with the possible exception of MW-21 as discussed in paragraph 2.4.3.3.1. It is presently unknown if Richland well field operations have significant effects on the flow observed in this aquifer, although minor fluctuations observed in water levels measured in well MW-17 indicate that at least some minor effect is likely.

The sediments encountered in the confined aquifer ranged from silty sand to sandy gravel of the middle Ringold Formation. Rising head slug tests conducted in MW-9 and MW-17 yielded hydraulic conductivity estimates of $3.4E-01$ m/d ($1E+00$ ft/d) and $8.6E-02$ m/d ($3E-01$ ft/d), respectively, indicating that at least in these two locations the hydraulic conductivity is generally lower than in the unconfined aquifer.

The horizontal and vertical extent of the upper confined aquifer is not well defined. Lindberg and Bond (1979) show the upper confined aquifer to merge with the unconfined aquifer near the Columbia River within the 300 Area, and Newcomb *et. al.*, (1972) report on a well drilled through the upper confined aquifer southwest of the 300 Area. During drilling for the initial phase of the 1100-EM-1 RI, the upper confined aquifer was identified at HRL at MW-9, and to the south at MW-6 and MW-17. The vertical thickness of the upper confined aquifer may vary from a few meters up to 10 m (30 ft), depending on the continuity of silt strata in the middle Ringold unit. During the RI, no explorations penetrated the full thickness of the upper confined zone below the 1100-EM-1 Operable Unit.

2.4.3.5 Lower Silt Aquitard. A clayey silt to silty clay unit is assumed to overlie the bedrock surface below the 1100-EM-1 Operable Unit. There are no wells within the Operable Unit that extend deep enough to confirm this assumption. However, the unit was intercepted by numerous deep borings located in the 300 Area to the northeast, and a silty to clayey soil unit is described by driller's logs at or near the bedrock surface for wells located along the Columbia River to the east of the 1100 Area. Geologist logs of wells drilled in the 300 Area indicate this silt layer may, in places, be separated from direct contact with bedrock by a thin sand layer (RI/FS Work Plan for the 300-FF-5 Operable Unit, DOE/RL-89-14, 1990).

This fine-grained unit serves as the major aquitard separating water-bearing units in the basalt bedrock from water-bearing strata of the suprabasalt sedimentary sequence. In the 1100-EM-1 groundwater model, the lower silt aquitard is assigned the role of lower bounding unit for the geometric block of sediments of which the model is composed.

Table 2-7: Measured and Estimated Saturated Zone Hydraulic Properties

Hydrogeologic Unit	Horizontal Hydraulic Conductivity (m/d)	Vertical Hydraulic Conductivity (m/d)	Storage Coefficient	Porosity (effective)
Unconfined Aquifer				
Hanford Formation (near HRL)	400 - 520	40 - 50*	.02 - .37*	.20 - .33*
Hanford Formation (near 300 area)	3350 - 15000	330 - 1500*	.02 - .37*	.20 - .33*
Ringold Formation	10 - 72	2 - 5	.02 - .37	.11 - .30*
Silt Aquitard	.001 - .03	.001 - .03		.20 - .33*
Confined Aquifer	10 - 72	2 - 5		.11 - .30*

* Value, or range, is based partly on general reported values at the Hanford site or extrapolated from nearest available value.

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3.0 SITE INVESTIGATIONS

Investigations completed for the 1100-EM-1 Operable Unit RI will be summarized in the following sections. Subunits will be discussed in the sequence: 1100-1, Battery Acid Pit; 1100-2, Paint and Solvent Pit; 1100-3, Antifreeze and Degreaser Pit; 1100-4, Antifreeze Tank Site; UN-1100-6, Discolored Soil Site; Ephemeral Pool; and, HRL. Subunits UN-1100-5, Radiation Contaminant Incident; Pit No. 1; and, the Hanford Patrol Academy Demolition Site were eliminated from further consideration for remediation during the Phase I portion of the RI (DOE/RL-90-18) pursuant to the CERCLA process and according to the TDA protocol. Of these three sites eliminated, the first two were deleted from further consideration due to a lack of substantive contamination detected at the sites. It is anticipated that the Hanford Patrol Academy Demolition Site will be addressed separately, if necessary, under Ecology's RCRA authority.

The discussion of site investigations will commence with a general description of each subunit. Following the site description, details of individual investigations completed at each subunit will be presented including soil sampling and analysis, soil-gas sampling efforts, and geophysical investigations. Then, a summary of all subunit soil investigations, focussing on a tabulation of screened contaminants follows. Finally, groundwater investigations will be discussed on an Operable Unit-wide basis in the last paragraph of this section.

Surface soil [0 to 0.7 m (0 to 2.0 ft)] contaminants detected within the 1100-EM-1 Operable Unit are presented in tables 3-1 and 3-2 as data derived from the analysis of surface and subsurface soil samples. Table entries include those substances detected in concentrations above local background levels (see appendix D). Phase I analytical parameters for soils consisted of EPA TAL and TCL parameters (EPA, 1989a and 1989b, respectively). Phase II analytical parameters were more restrictive in that Phase II analyses focused on contaminants of potential concern identified during the Phase I investigation (DOE, 1990).

Surface radiation surveys were conducted at all 1100-EM-1 Operable Unit subunits. All radiation surveys were negative. These will not be considered further.

3.1 BATTERY ACID PIT - 1100-1

The Battery Acid Pit was an unlined, sand filled sump/french drain excavated in native soil deposits approximately 30 m (100 ft) from the southwest corner of the 1171 Building (figure 3-1). During the period between 1954 to 1977, an estimated volume of 57,000 l (15,000 gal) of waste battery acid from vehicle maintenance activities was deposited in the pit. Information gathered through interviews with former site workers suggest that other substances including waste oil, waste antifreeze, and spent solvents were also deposited in the pit. No documentation exists to support these claims. Periodically, during the operation of this facility, the acid-laden sand lining was removed and deposited at an undetermined location and fresh sand fill installed. The pit dimensions during its use as a disposal facility are reported to have been roughly 1.8 m (6 ft) in diameter by 1.8 m (6 ft) in depth. The Battery Acid Pit is no longer visible at the site. When withdrawn from service,

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Table 3-1. Maximum Concentrations for Detected Compounds, Compared to UTLs for Surface Soils (0 to 2 feet) from Phase 1 and 2 Data. (sheet 1 of 3)

Parameter	Surface Soil UTL	Max Value 1100-1	Max Value 1100-2	Max Value 1100-3	Max Value 1100-4	Max Value 1100-6	Max Value HRL	Max Value EP
INORGANIC COMPOUNDS (mg/kg)								
Aluminum	9708.79	7130	8300	9770	7320	8680	15800 ^a	5810
Antimony	3.70	ND	ND	ND	ND	ND	15.6 ^a	ND
Arsenic	3.99	3.2	2.3	3.4	2.6	2.7	3.6	2.6
Barium	120.10	80.8	91.5	106	80.9	99.2	1320	72.3
Beryllium	0.74	ND	0.51	0.44	0.25	0.4	1.3	0.26
Cadmium	0.70	ND	ND	ND	ND	ND	2	ND
Calcium	5129.25	8690	6480	6810	9710	4180	86700	3030
Chromium	12.94	10.6	18.8	14	11.3	10.9	17.1	7.7
Cobalt	17.74	13.2	13.9	14.1	11.4	12.2	15.9 ^b	10.3
Copper	19.11	37.9	24.4	22.8	14.4	18.2	58.6	15.2
Iron	31110.42	21100	28600	25500	23300	23500	29800	18900
Lead	12.64	266	94.6	26.4	5	22.1	482	54.2
Magnesium	6523.58	6430	5210	6170	4650	4840	25000	4250
Manganese	552.27	484	365	436	330	383	423	354
Mercury	0.10	0.22	ND	ND	ND	ND	1.3	ND
Nickel	19.00	20.9	15	14.9	9.3	12.9	174	12.5
Potassium	1909.71	850	2080	1730	1210	1950	2230	1140
Selenium	0.39	ND	ND	ND	ND	ND	0.97 ^a	ND
Silver	2.44	ND	ND	ND	ND	ND	4.5	ND
Sodium	241.52	479	374	495	413	143	5140 ^b	216
Thallium	0.39	ND	0.48	48	ND	ND	42	ND
Vanadium	93.93	32.5	73.4	70.2	61.8	60.8	87.3	44.4
Zinc	62.20	92	58.6	59	45.9	111	408	67.5
Cyanide	0.52	ND	ND	ND	ND	ND	0.56	ND
VOLATILE ORGANIC COMPOUNDS (µg/kg)								
1,1,1-trichloroethane	5	ND	2	ND	ND	35	ND	ND
1,1-dichloroethene	5	ND	5	ND	ND	ND	ND	ND
2-butanone	11	ND	10 ^a	17 ^a	ND	69 ^a	35 ^{a,b}	ND
2-hexanone	11	ND	ND	ND	ND	53	ND	ND
Acetone	43	ND	19 ^a	92 ^a	8 ^a	190 ^a	ND	ND
Chlorobenzene	5	ND	6	ND	ND	ND	ND	ND
Methylene chloride	5	ND	42 ^a	120 ^a	ND	20 ^a	43 ^a	4 ^a
Tetrachloroethene	5	ND	35	ND	ND	ND	5	ND
Toluene	5	ND	11 ^a	6 ^a	ND	8 ^a	16 ^a	ND
Trichloroethene	5	ND	6	ND	ND	ND	ND	ND
Xylene	5	ND	6	ND	ND	ND	ND	ND

Table 3-1. Maximum Concentrations for Detected Compounds, Compared to UTLs for Surface Soils (0 to 2 feet) from Phase 1 and 2 Data. (sheet 2 of 3)

Parameter	Surface Soil UTL	Max Value 1100-1	Max Value 1100-2	Max Value 1100-3	Max Value 1100-4	Max Value 1100-6	Max Value HRL	Max Value EP
SEMI-VOLATILE ORGANIC COMPOUNDS ($\mu\text{g}/\text{kg}$)								
1,2,4-trichlorobenzene	690	ND	120	ND	ND	83	ND	ND
1,3-dichlorobenzene	690	ND	120	ND	ND	ND	ND	ND
1,4-dichlorobenzene	690	ND	120	ND	ND	86	ND	ND
2-chlorophenol	690	ND	230	ND	ND	170	ND	ND
2-methylnaphthalene	690	ND	ND	ND	ND	ND	7100	ND
2,6-dinitrotoluene	690	ND	ND	ND	ND	ND	210*	ND
4-chloro-3-methylphenol	690	ND	190	ND	ND	95	ND	ND
4-nitrophenol	3300	ND	ND	ND	ND	ND	3800	ND
Acenaphthene	690	ND	110	ND	ND	77	ND	ND
Anthracene	690	ND	ND	ND	ND	ND	70*	ND
Benzoic acid	2790	ND	ND	ND	ND	ND	220*	ND
Benzo(a)anthracene	690	ND	ND	120	ND	ND	180	ND
Benzo(a)pyrene	690	ND	110	150	ND	ND	200	ND
Benzo(b)fluoranthene	690	150	79	180	ND	ND	250	ND
Benzo(g,h,i)perylene	690	ND	330	230	ND	ND	150	ND
Benzo(k)fluoranthene	690	ND	120	180	ND	ND	190	ND
Bis(2-ethylhexyl)phthalate	690	390*	290*	940*	ND	2.5E+07	ND	ND
Butylbenzylphthalate	690	ND	ND	ND	ND	ND	99*	ND
Chrysene	690	100	ND	170	ND	ND	240	ND
Dibenzofuran	690	ND	ND	ND	ND	ND	130	ND
Dibenz(a,h)anthracene	690	ND	300	110	ND	ND	ND	ND
Di-n-butyl phthalate	690	ND	ND	ND	ND	ND	65*	ND
Di-n-octyl phthalate	690	ND	87*	ND	ND	46000	ND	ND
Fluoranthene	690	110	ND	220	ND	ND	180	ND
Indeno(1,2,3-cd)pyrene	690	ND	300	230	ND	ND	170	ND
Naphthalene	690	ND	ND	ND	ND	ND	1100	ND
N-nitroso-di-n-propylamine	690	ND	110	ND	ND	78	ND	ND
Pentachlorophenol	3300	ND	ND	99	ND	ND	980*	ND
Phenanthrene	690	ND	ND	130	ND	ND	380*	ND
Phenol	38100	ND	94	ND	ND	ND	ND	ND
Pyrene	690	97	120	250	ND	94	220	ND

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Table 3-1. Maximum Concentrations for Detected Compounds, Compared to UTLs for Surface Soils (0 to 2 feet) from Phase 1 and 2 Data. (sheet 3 of 3)

Parameter	Surface Soil UTL	Max Value 1100-1	Max Value 1100-2	Max Value 1100-3	Max Value 1100-4	Max Value 1100-8	Max Value HRL	Max Value EP
PESTICIDES/PCBs (µg/kg)								
4,4'-DDE	33	6.8	42	ND	ND	170	1200	ND
4,4'-DDD	33	ND	3.6	ND	ND	ND	260	ND
4,4'-DDT	33	ND	57	ND	ND	ND	520 ^a	ND
Aldrin	17	ND	9.8 ^a	1.1 ^a	ND	9.6 ^a	11 ^b	ND
Alpha-chlordane	170	6.5	ND	ND	ND	1000	770 ^a	1100 ^a
Total PCBs	1510	290	300	150	ND	ND	100550	42000
Aroclor 1248	170	ND	ND	ND	ND	ND	100000 ^a	ND
Aroclor 1260	330	290	300	150	ND	ND	260	42000 ^a
Aroclor-1254	330	ND	ND	ND	ND	ND	290	ND
Beta-BHC	17	ND	ND	ND	ND	ND	94 ^a	ND
Delta-BHC	14	ND	ND	ND	ND	13	ND	ND
Dieldrin	33	ND	1.3	ND	ND	2.3	1200 ^a	ND
Endosulfan II	33	ND	ND	ND	ND	ND	110 ^a	160
Endosulfan sulfate	33	ND	ND	ND	ND	ND	19	ND
Endrin	33	ND	ND	ND	ND	ND	280 ^a	39
Endrin ketone	33	ND	2	ND	ND	1.3	140 ^a	ND
Gamma-BHC(Lindane)	17	ND	ND	ND	ND	0.77	1.9	ND
Gamma-chlordane	158	6.2	ND	ND	ND	860	82	1700 ^a
Heptachlor	17	ND	1.2	ND	ND	65	ND	29
Methoxychlor	170	ND	ND	ND	ND	ND	140 ^a	ND
ND - Contaminant not detected UTL - Upper tolerance limit ^a Concentration less than detection limit after blank-adjustment ^b Phase II data								

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Table 3-2. Maximum Concentrations for Detected Compounds Compared to UTLs for Subsurface Soils (> 2 feet) from Phase 1 and Phase 2 Data. (sheet 1 of 2)

Parameter	Subsurface Soil UTL	Max Value 1100-1	Max Value 1100-2	Max Value 1100-3	Max Value 1100-4	Max Value 1100-6	Max Value HRL	Max Value EP
INORGANICS (mg/kg)								
Aluminum	6236	5860	7470	7400	6680	NS	17800 ^a	NS
Antimony	3.1	ND	3	ND	ND	NS	15.6 ^a	NS
Arsenic	2.92	3.2	1.8	1.8	5.8	NS	6.6	NS
Barium	236	85.9	96.8	85.9	98.7	NS	511 ^a	NS
Beryllium	0.27	ND	ND	ND	0.93	NS	1.1 ^a	NS
Cadmium	0.36	ND	ND	ND	ND	NS	2.4 ^a	NS
Calcium	7830	6240	13000	9080	10600	NS	44800 ^a	NS
Chromium	47.3	14.6	10.3	13.8	13.2	NS	1,250	NS
Cobalt	16.8	11.8	15.3	17.8	16.5	NS	42.5	NS
Copper	19.5	25	23.6	31.7	19.8	NS	1280 ^a	NS
Cyanide	0.51	ND	ND	ND	ND	NS	0.56	NS
Iron	29400	25800	27100	31700	26700	NS	35200	NS
Lead	5	191	45.9	4.7	5.7	NS	854 ^a	NS
Magnesium	4880	3860	4620	5290	4630	NS	7640 ^a	NS
Manganese	355	249	366	381	329	NS	501 ^a	NS
Mercury	0.1	0.39	ND	ND	ND	NS	0.44	NS
Nickel	28	9.5	13.8	11.3	10.7	NS	557	NS
Potassium	968	4880	1200	878	1030	NS	3820 ^a	NS
Selenium	0.41	ND	ND	ND	ND	NS	0.36	NS
Silver	0.54	ND	ND	ND	2	NS	7.7	NS
Sodium	419	808	458	999	726	NS	2360 ^a	NS
Thallium	0.41	ND	ND	ND	0.48	NS	0.46	NS
Vanadium	115	118	80.2	103	82.4	NS	101	NS
Zinc	50.4	100	54.9	60	63.8	NS	3,160 ^a	NS
VOLATILE ORGANIC COMPOUNDS (µg/kg)								
2-butanone	11	9 ^a	8 ^a	11 ^a	ND	NS	23 ^a	NS
Acetone	22	26 ^a	28 ^a	29 ^a	9 ^a	NS	200	NS
Benzene	5	ND	ND	ND	ND	NS	0.3 ^a	NS
Ethylbenzene	5	ND	2	ND	ND	NS	ND	NS
Methylene Chloride	5	ND	61 ^a	16 ^a	ND	NS	5 ^a	NS
Tetrachloroethene	5	ND	16 ^a	ND	ND	NS	4 ^a	NS
Toluene	5	ND	3 ^a	ND	ND	NS	ND	NS
SEMI-VOLATILE ORGANIC COMPOUNDS (µg/kg)								
1,2,4-trichlorobenzene	350	ND	ND	ND	ND	NS	230 ^a	NS
1,4-dichlorobenzene	350	ND	ND	ND	ND	NS	170	NS
2-chlorophenol	350	ND	ND	ND	ND	NS	240 ^a	NS
2,4-dinitrotoluene	350	ND	ND	ND	ND	NS	92	NS
4-chloro-3-methylphenol	350	ND	ND	ND	ND	NS	280	NS
4-nitrophenol	1700	ND	ND	ND	ND	NS	310	NS
Acenaphthene	350	ND	ND	ND	ND	NS	320 ^a	NS
Benzoic Acid	1700	ND	ND	ND	ND	NS	160 ^{a,b}	NS
Benzo(b)fluoranthene	350	74	ND	ND	ND	NS	ND	NS
Bis(2-ethylhexyl) phthalate	350	ND	3600 ^a	950 ^a	ND	NS	1,000 ^a	NS
Di-n-butylphthalate	350	ND	37	ND	ND	NS	ND	NS
Di-n-octylphthalate	350	ND	ND	ND	ND	NS	270 ^{a,b}	NS
Fluoranthene	350	110	ND	ND	ND	NS	ND	NS
N-nitro-di-n-propylamine	350	ND	ND	ND	ND	NS	170	NS
Pentachlorophenol	1700	ND	ND	ND	ND	NS	260	NS
Phenol	350	ND	ND	ND	ND	NS	330 ^a	NS
Pyrene	350	84	290	ND	ND	NS	270 ^a	NS

Table 3-2. Maximum Concentrations for Detected Compounds Compared to UTLs for Subsurface Soils (> 2 feet) from Phase 1 and Phase 2 Data. (sheet 2 of 2)

Parameter	Subsurface Soil UTL	Max Value 1100-1	Max Value 1100-2	Max Value 1100-3	Max Value 1100-4	Max Value 1100-6	Max Value HRL	Max Value EP
PESTICIDES ($\mu\text{g}/\text{kg}$)								
Aldrin	17	ND	16 ^a	ND	ND	NS	5.5 ^b	NS
Alpha-chlordane	170	1.3	ND	ND	ND	NS	13 ^b	NS
4,4'-DDE	34	ND	39	ND	ND	NS	14	NS
4,4'-DDT	34	ND	121	ND	ND	NS	ND	NS
Beta BHC	17	ND	ND	ND	ND	NS	1.2 ^b	NS
Dieldrin	34	ND	ND	ND	ND	NS	90 ^b	NS
Endrin	34	ND	ND	ND	ND	NS	120 ^b	NS
Endrin ketone	34	ND	22	ND	ND	NS	ND	NS
Heptachlor	17	ND	ND	0.58	ND	NS	ND	NS
Total PCB's	1530	ND	180	ND	ND	NS	2640	NS
Aroclor 1248	170	ND	ND	ND	ND	NS	640	NS
Aroclor 1254	340	ND	ND	ND	ND	NS	2,000 ^b	NS
Aroclor 1260	340	ND	160	ND	ND	NS	ND	NS
Notes: ND: contaminant not detected UTL: upper tolerance limit NS: no subsurface samples collected for analysis ^a Concentration less than detection limit after blank - adjustment ^b Phase 2 data								

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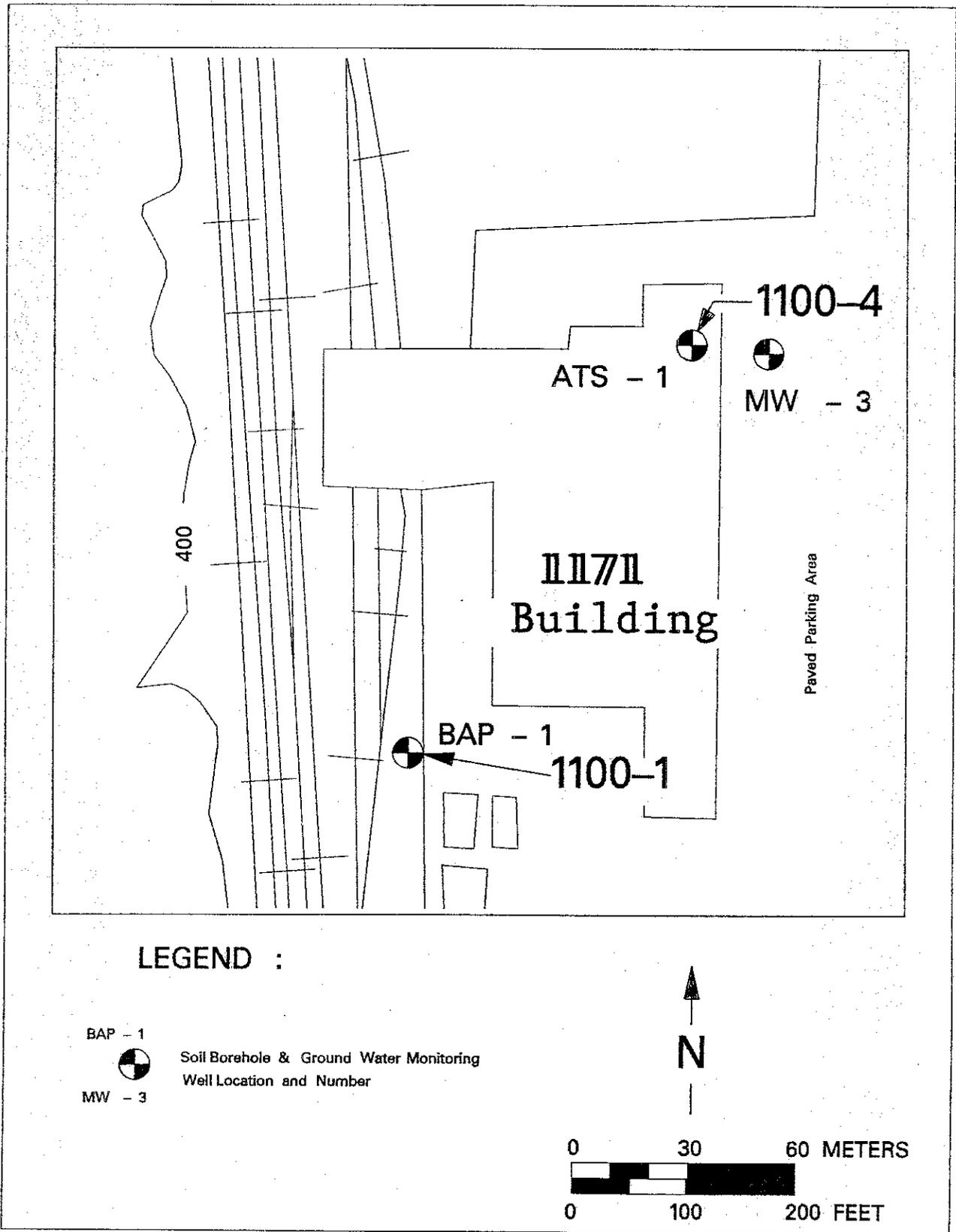


Figure 3-1. 1100-1 and 1100-4 Operable Subunits Soil Sampling Locations.

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the pit was filled with locally derived sands and gravels and graded to match the surrounding ground surface.

3.1.1 Vadose Zone Sampling

A single borehole was advanced during the Phase I RI at the 1100-1, Battery Acid Pit subunit. This borehole yielded one sample from the surface strata and seven from the subsurface. Sampling and analysis were performed as described in the Phase I RI report (DOE/RL-90-18). Inorganic contaminants were found in surface and subsurface samples. No organic contaminants were detected at this site. Contaminants identified in surface soil samples collected during the Phase I investigation included:

Inorganic Contaminants

Calcium	Copper	Lead	Magnesium
Mercury	Nickel	Sodium	Zinc

Organic Contaminants

(None encountered)

Contaminants identified in subsurface samples collected during the Phase I investigation included:

Inorganic Contaminants

Arsenic	Copper	Lead	Mercury
Potassium	Sodium	Vanadium	Zinc

Organic Contaminants

(None encountered)

Soil sampling was not performed at the 1100-1, Battery Acid Pit subunit during the Phase II RI.

3.1.2 Geophysical Investigation

A single geophysical survey was performed at the Battery Acid Pit during the Phase I investigation. Geophysical methods employed included Electromagnetic Induction (EMI), Magnetometry (MAG), Metal Detection (MD), and Ground Penetrating Radar (GPR). The geophysical investigation was conducted during the months of January through April 1989 and covered an area of approximately 390.2 square meters (4,200 square feet). Its purpose was to identify the physical location of the former waste disposal site, and to locate any underground utilities adjacent to the pit so they could be avoided during subsequent site investigations.

Survey lines were spaced at close intervals [0.76 m (2.5 ft)] because of the small size of the disposal pit (1.83 meters square [6 feet square]). GPR signal returns were complex

and difficult to interpret. As noted above, the entire site appears to have been excavated and subsequently backfilled resulting in the complex GPR returns. It was difficult to accurately locate the pit based on geophysical data because of the disturbed nature of the area. A best-guess location map was prepared based on the geophysical data and used to site soil-gas probes installed in the next phase of the initial characterization activities. A single water line was identified at a depth of 1.2 m (4 ft) extending from the 1171 Building to a shower facility located immediately north of the Battery Acid Pit. Two unidentified cables or pipelines were discovered to the west of the Battery Acid Pit (Sandness *et.al.*, 1989).

Geophysical surveys were not performed during the 1100-EM-1 Phase II investigations at the 1100-1, Battery Acid Pit subunit.

3.1.3 Soil-Gas Investigation

Five temporary soil-gas probes were installed at the Battery Acid Pit in June, 1989, as part of the Phase I investigation. One probe was placed in the approximate center of the Battery Acid Pit as located from measurements obtained through interviews with past area employees and by ground-penetrating radar surveys. One probe was placed immediately west of the pit center, and the remaining three located along a north-south line to the east of the former disposal site. No contamination was detected during the analyses of the soil-gas samples (Evans, 1989).

Soil-gas investigations were not performed during Phase II RI of the 1100-EM-1 OU at this subunit.

3.1.4 Summary of Investigations

Site investigations at the 1100-1 subunit, Battery Acid Pit, detected inorganic contaminants in soils and no contaminants in groundwater attributable to the site. Geophysical surveys detected the presence of an underground water line in the vicinity of the subunit and two questionable finds that may represent underground cables or pipelines. Soil-gas investigations failed to identify contaminants at the subunit.

3.2 PAINT AND SOLVENT PIT - 1100-2

The Paint and Solvent Pit is a semicircular depression located approximately 1.6 km (1 mile) north of the 1171 Building (figure 1-3). Originally a sand and gravel pit, the site was used during the period between 1954 through 1985 for the disposal of construction debris generated during demolition of Hanford Site facilities. Principal components of the waste include concrete rubble, asphalt, and wood debris. Undocumented disposal of waste paint, solvent, and paint thinner is also reported to have occurred at this site. The pit has an approximate diameter of 108 m (354 ft) and a depth of 1.2 to 1.8 m (4 to 6 ft).

The Paint and Solvent Pit is filled with between 1.2 and 4.9 m (4 to 16 ft) of backfill mixed with asphalt debris derived from the construction of a nearby highway. A side spur of the Hanford Rail Line traverses the pit in a southwest-northeast direction isolating the northwest third of the pit from the remainder of the disposal site.

3.2.1 Vadose Zone Sampling

Four boreholes drilled at this site during the Phase I RI yielded 4 surface samples and 29 subsurface soil samples. In addition, soil samples were obtained at 20 surface locations within the 1100-2, Paint and Solvent Pit subunit (figure 3-2). Inorganic, organic and pesticide contamination was detected in surface and subsurface samples. Sampling and analysis methodologies and results are presented in the Phase I RI report (DOE/RL-90-18). Contaminants identified in surface soil samples collected during the Phase I investigation included:

Inorganic Contaminants

Calcium	Chromium	Copper	Lead
Potassium	Sodium	Thallium	

Organic Contaminants

Chlorobenzene	Tetrachlorethene	Trichloroethene
1,1-dichloroethene	Xylene	

Contaminants identified in subsurface samples collected during the Phase I investigation included:

Inorganic Contaminants

Calcium	Copper	Lead	Magnesium
Manganese	Potassium	Sodium	Zinc

Organic Contaminants

4,4'-DDE	4,4'-DDT	Tetrachloroethene
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Soil sampling was not performed at the 1100-2, Paint and Solvent Pit subunit during the Phase II RI.

3.2.2 Geophysical Investigation

One geophysical survey was performed at the Paint and Solvent Pit during the Phase I investigation. Geophysical methods employed included EMI, MAG, MD, and GPR. The geophysical investigation covered an area of approximately 1.09 hectares (2.7 acres) during the months of January through April, 1989. The purpose was to obtain information regarding waste materials buried at the site, information regarding the location of waste disposal structures (pits and trenches), identify any underground utilities that may cross the site, and identify any other waste disposal-related features existing within the depression.

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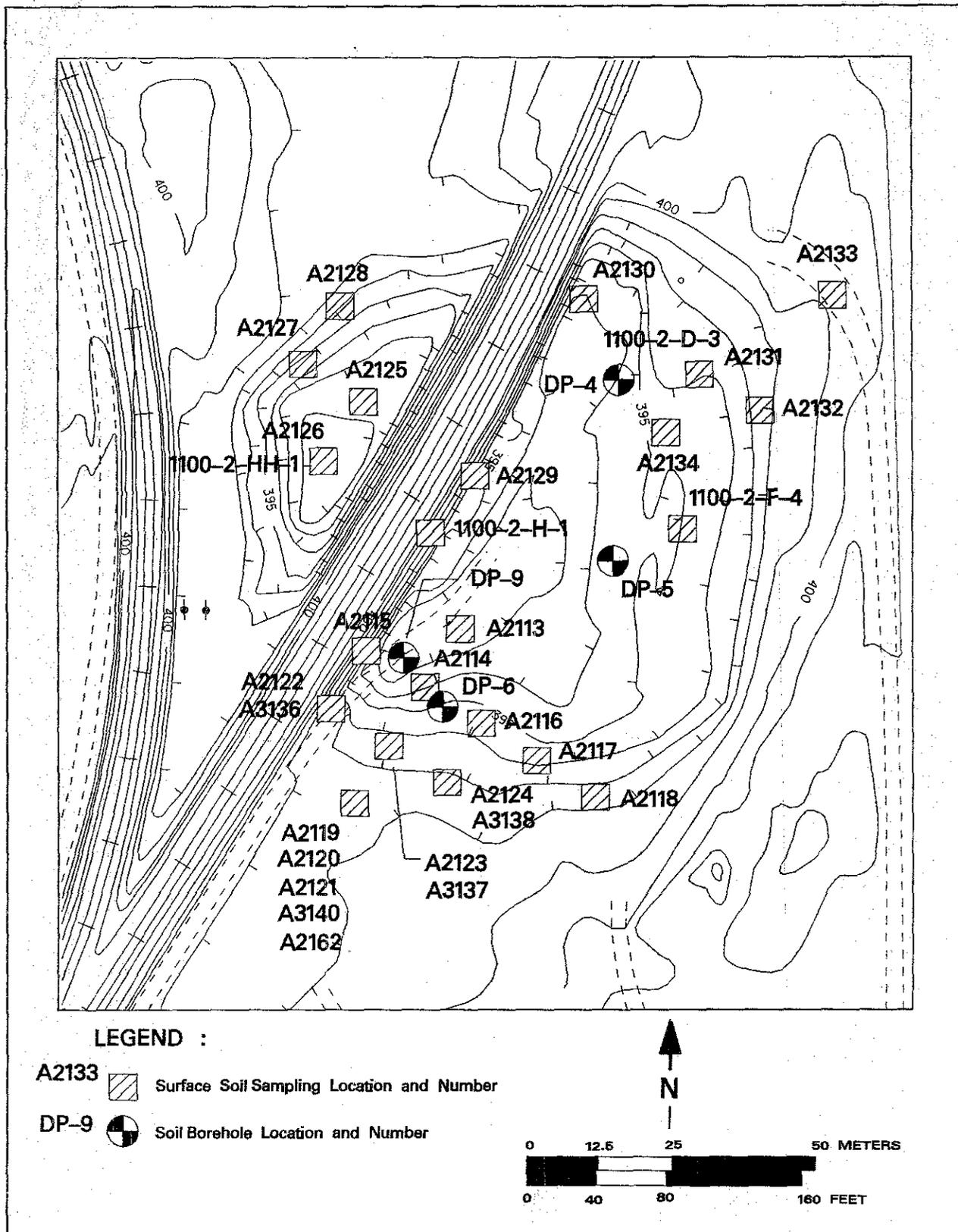


Figure 3-2. 1100-2 Paint and Solvent Pit - Operable Subunit Soil Sampling Locations.

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Waste materials identified within the Paint and Solvent Pit are concentrated in the eastern portion of the subunit. No waste deposits were evident in the portion of the pit west of the railroad tracks. A GPR reflector located at a depth of approximately 3.05 m (10 ft) appears to mark the bottom of the original pit. Based on surface observations, waste material consists predominantly of concrete and asphalt debris. Geophysical signatures indicating the presence of metals can be explained by the presence of reinforcing steel (rebar) within concrete blocks. None of the geophysical data suggest the presence of steel drums within the subunit. Waste deposits are covered by 0.61 to 1.52 m (2 to 5 feet) of soil. The only other features identified at the site were several abandoned metal irrigation pipes. Portions of these pipes are visible on the ground surface (Sandness *et. al.*, 1989).

No geophysical investigations were performed at the 1100-2, Paint and Solvent Pit during the Phase II RI.

3.2.3 Soil-Gas Investigation

Sixty-two temporary soil-gas probes were installed, sampled, and analyzed during the Phase I investigation, in February and March, 1989. One area of relatively high readings of tetrachloroethene (PCE) was found in the southwest corner of the site close to the end of a service road which extends back toward a railroad storage yard located immediately north of the Paint and Solvent Pit site. Concentration values peaked at 727 $\mu\text{g/L}$ PCE with values steeply dropping in all directions away from the high. Areal distribution of the positive soil-gas readings suggested the potential for an isolated, shallow accumulation or small surface spill of solvent within the pit. However, no PCE was identified in any soil sample for this subunit. No other volatile contaminants were detected during the soil-gas survey (Evans, 1989).

Phase II investigations did not include any additional soil-gas monitoring at the 1100-2, Paint and Solvent Pit subunit.

3.2.4 Summary of Investigations

Site investigations at the 1100-2 subunit, Paint and Solvent Pit, detected inorganic, organic, and pesticide contamination in site soils. Geophysical surveys located several abandoned waterlines within and adjacent to the Paint and Solvent Pit. Other geophysical returns can be ascribed to reinforcing steel (rebar) within concrete blocks at the site. Geophysical data did not reveal the presence of buried drums. Soil-gas investigations detected an isolated area of PCE contamination in the southwest corner of the pit.

3.3. ANTIFREEZE AND DEGREASER PIT - 1100-3

The 1100-3, Antifreeze and Degreaser Pit is a shallow, roughly circular depression located approximately 1.6 km (1 mile) north of the 1171 Building on the west side of the Hanford Rail Line (figure 1-2). Originally a sand and gravel source for construction

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activities on the Hanford Site, it was used during the period of 1979 to 1985 as a disposal site for waste construction material, principally roofing and concrete rubble. The pit is approximately 76 m (250 ft) in diameter and 1.8 to 2.4 m (6 to 8 ft) deep. Occasional disposal of waste antifreeze and degreasing solutions from the 1171 Building is suspected, but not documented, at this location.

3.3.1 Vadose Zone Sampling

Twenty-three surface samples were collected. Twenty four subsurface samples were obtained from four boreholes at the 1100-3, Antifreeze and Degreaser Pit during the Phase I RI as outlined in DOE, 1990 (figure 3-3). Inorganic contaminants were found in surface and subsurface samples. No organic contaminants were detected at the 1100-3 subunit. Contaminants identified in surface soil samples collected during the Phase I investigation included:

Inorganic Contaminants

Aluminum	Calcium	Chromium	Copper
Lead	Sodium	Thallium	

Organic Contaminants

(None encountered)

Contaminants identified in subsurface samples collected during the Phase I investigation included:

Inorganic Contaminants

Aluminum	Calcium	Cobalt	Copper
Iron	Magnesium	Manganese	Sodium
Zinc			

Organic Contaminants

(None encountered)

No Phase II soil samples were taken at the 1100-3, Antifreeze and Degreaser Pit.

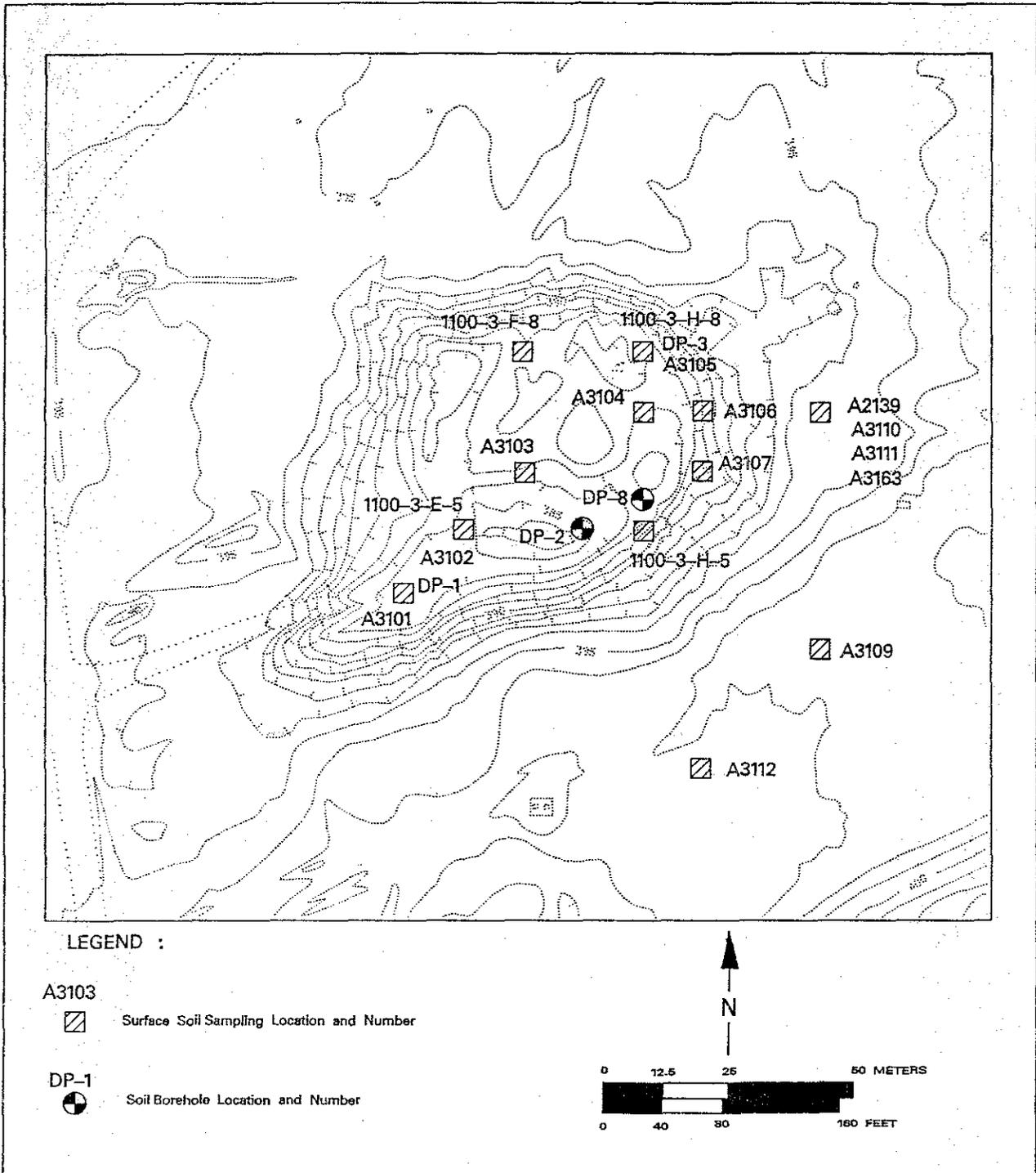


Figure 3-3 1100-3 Antifreeze and Degreaser Pit - Operable Subunit Soil Sampling Locations.

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3.3.2 Geophysical Investigation

One geophysical survey was completed at the Antifreeze and Degreaser Pit during the Phase I investigation. Geophysical methods employed included EMI, MAG, MD, and GPR. The geophysical investigation, undertaken during the months of January through April, 1989, covered an area of approximately 1.5 hectares (3.7 acres). The purpose was to obtain information regarding waste materials buried at the site, the location of waste disposal structures (pits and trenches), to identify any underground utilities that may cross the site, and to identify any other waste disposal-related features existing within the depression.

Waste materials within the Antifreeze and Degreaser Pit are concentrated in one large body and two smaller satellite bodies. The material appears to consist predominantly of concrete debris. As with the Paint and Solvent Pit, large metal signatures identified at the site likely result from reinforcing steel (rebar) within the concrete. None of the signatures indicate the presence of steel drums. Further conclusions regarding waste deposits at this site could not be made. A single abandoned tile pipe was identified in the vicinity of the pit (Sandness *et. al.*, 1989).

No geophysical investigations were performed at the 1100-3, Antifreeze and Degreaser Pit subunit during Phase II RI activities.

3.3.3 Soil-Gas Investigation

Forty-three soil-gas samples were collected during the Phase I RI from the Antifreeze and Degreaser Pit. Sample collection occurred during the months of May and June, 1989. All sampling probes were temporary and were removed after the initial round of sampling was completed. No contaminants were detected during the soil-gas investigation (Evans, 1989).

Soil-gas sampling was not undertaken during the Phase II investigations of the 1100-EM-1 Operable Unit at 1100-3, the Paint and Solvent Pit.

3.3.4 Summary of Investigations

Site investigations at the 1100-3 subunit, Paint and Solvent Pit, detected inorganic contaminants in site soils. Geophysical investigations did not provide evidence for the presence of buried drums, however, a single abandoned tile pipe was detected. Soil-gas sampling failed to detect any contaminants at the 1100-3, Antifreeze and Degreaser Pit subunit.

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3.4 ANTIFREEZE TANK SITE - 1100-4

The Antifreeze Tank Site is located beneath the concrete floor of the northern-most portion of the 1171 Building (figure 3-1). It is the former location of a 19,000 L (5,000 gal) steel, underground waste antifreeze storage tank. The tank was installed in 1976 and removed in 1986 due to suspected leakage. No evidence of leakage was detected during the removal operation.

3.4.1 Vadose Zone Sampling

During tank removal, three soil samples were collected from the base of the excavation. No detectable levels of antifreeze were identified. In November of 1989, a hole was cut through the concrete floor of stall 89 inside the 1171 Building to allow sampling of the waste site. Thirteen vadose zone samples were collected and analyzed for the full suite of chemical analyses (TCL and TAL) including ethylene glycol. Only a single sample detected ethylene glycol at a concentration of 2.6 parts per million (ppm). Only inorganic contaminants were detected at this site. Sample analysis results are reported in the Phase I RI report (DOE/RL-90-18). Contaminants identified in subsurface samples collected during the Phase I investigation included:

Inorganic Contaminants

Aluminum	Arsenic	Beryllium	Calcium
Copper	Lead	Potassium	Silver
Sodium	Thallium	Zinc	

Organic Contaminants

(None encountered)

No surface data or soil samples were collected at the 1100-4, Antifreeze Tank Site during the Phase II investigations.

3.4.2 Summary of Investigations

Site investigations at the 1100-4 subunit, Antifreeze Tank Site, detected only inorganic contaminants in subunit soils.

3.5 DISCOLORED SOIL SITE - UN-1100-6

The Discolored Soil Site was identified during the RI Phase I scoping process as a patch of oily, dark stained soil located in the eastern end of an elongate east-west oriented depression approximately 610 m (2,000 ft) northwest of the 1171 Building on the west side of the Hanford Rail Line (figure 1-2). The depression extends over an area of approximately 0.2 hectares (0.4 acres); the actual area of discolored soil covering an area of perhaps 1.8 by 3.1 m (6 by 10 ft).

The southern boundary of the triangular-shaped depression consists of a steep slope apparently excavated in a natural sand dune. The northern boundary is defined by a similar steep slope comprised of material excavated during the construction of a northeast-southwest trending, concrete lined irrigation canal located immediately to the north of the bounding slope. The short eastern boundary of the Discolored Soil Site consists of the raised bed of a native-surfaced road that parallels the western edge of the Hanford Rail Line. The discoloration is located immediately adjacent to the eastern site boundary at the base of the road fill slope.

The source of the soil discoloration is conjectured to be the isolated, unauthorized disposal of contents of one or more containers of liquid material to the ground surface. No record exists that identifies the nature or origin of the waste of the material deposited at the site.

3.5.1 Vadose Zone Sampling

Fifteen surface samples were obtained from this site during the Phase I RI (figure 3-4). Analyses were for TAL and TCL parameters as described and reported in the Phase I RI report (DOE/RL-90-18). No subsurface sampling was performed. Inorganic, organic, and pesticide contamination was detected at this site. Contaminants identified in surface soil samples collected during the Phase I investigation included:

Inorganic Contaminants

Lead Potassium Zinc

Organic Contaminants

Alpha-chlordane	Gamma-chlordane	4,4'-DDE	BEHP
Heptachlor	2-hexanone	di-n-octyl phthalate	
1,1,1-trichloroethane			

Soil sampling of the UN-1100-6, Discolored Soil Site was not performed during the Phase II investigations.

3.5.2 Soil-Gas Investigation

Soil-gas sampling was not performed during the RI Phase I investigation of the UN-1100-6, Discolored Soil Site subunit.

Fourteen temporary soil-gas probes were installed at the Discolored Soil Site to depths ranging between 0.46 and 1.22 m (1.5 and 4 ft) during the Phase II investigation. The purpose was to investigate the possibility of a vadose zone source for contaminants identified during surface soil sampling/analysis. The installations occurred in November and

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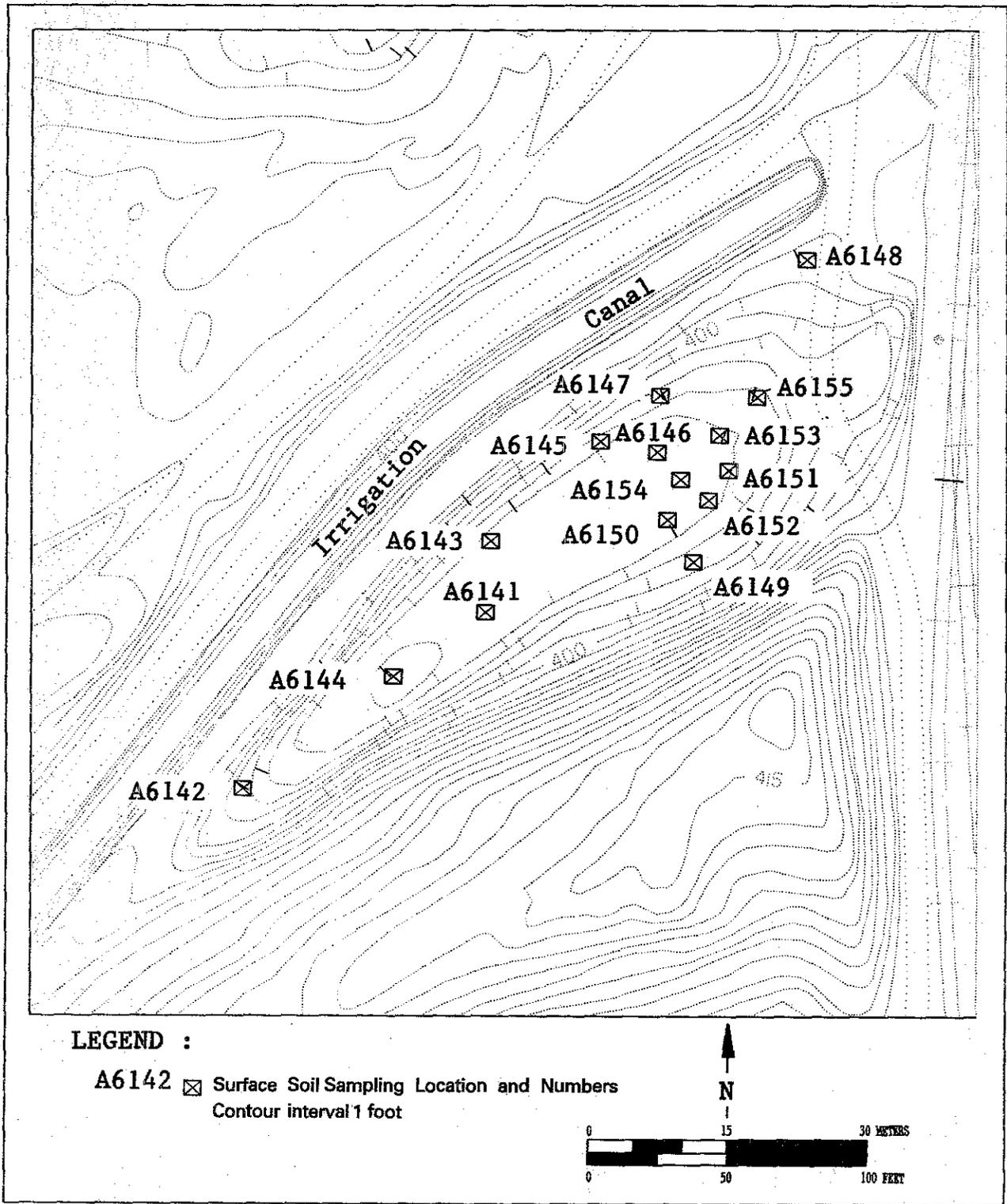


Figure 3-4. 1100-6 Operable Subunit Soil Sampling Locations

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December, 1990. Target compounds were not detected in any of the soil-gas samples (WHC, 1991b).

3.5.3 Summary of Investigations

Inorganic, organic, and pesticide contaminants were detected in soils of the UN-1100-6, Discolored Soil Site subunit at concentrations above background values.

Target compounds were not detected during the soil-gas investigation.

3.6 EPHEMERAL POOL

The Ephemeral Pool is a long, narrow, manmade depression located along the western edge of the asphalt paved 1171 Building parking area (figure 1-3). The depression was constructed to serve as a drainage collection point for precipitation runoff flowing from the parking area surface. It is bounded on the east by the parking facility and on the west by ballast of the Hanford Rail Line. On the north and south, the Ephemeral Pool boundaries are not as distinct. The bottom of the depression gradually rises toward both the north and south to near the elevation of surrounding land. Overall dimensions are approximately 6.1 m (20 ft) wide (east-west direction) by 183 to 213 m (600 to 700 ft) in length (north-south direction).

The Ephemeral Pool was designed to collect runoff from the parking area and direct it to a central culvert located approximately at the lengthwise mid-point of the depression. Settlement and/or poor grading of the depression floor results in the formation of a series of linked pools after rainfall events that temporarily hold a portion of the collected moisture within the drainage way until it evaporates or infiltrates into the ground. A pervious gravel lining encourages infiltration of the collected runoff into the vadose zone beneath this site.

3.6.1 Vadose Zone Sampling

3.6.1.1 Phase I Soil Sampling. The Phase I RI report describes the sampling and analytical results for two surface samples taken within the Ephemeral Pool. Results of the analyses indicated the presence of PCB's in low to moderate concentrations (300 to 4700 $\mu\text{g}/\text{kg}$). Contaminants identified in surface soil samples collected during the Phase I investigation included:

Inorganic Contaminants

Lead Zinc

Organic Contaminants

Aroclor-1260	Alpha-Chlordane	Gamma-Chlordane
Endosulfan II	Endrin	Heptachlor

3.6.1.2 Phase II Soil Sampling. Six surface samples and one duplicate were obtained for the Phase II RI in order to delineate the lateral extent of organic contamination at the Ephemeral Pool (figure 3-5). The soil samples collected during the Phase II RI were submitted for PCB and pesticide analyses. Laboratory results confirm the presence of alpha and gamma chlordane in concentrations of 210 to 1100 $\mu\text{g}/\text{kg}$ and 330 to 1700 $\mu\text{g}/\text{kg}$, respectively. Positive results for PCB's (Aroclor 1260) were obtained from two of the seven samples with concentrations of 11,000 and 42,000 $\mu\text{g}/\text{kg}$. Contaminants identified in surface soil samples collected during the Phase II investigation included:

Inorganic Contaminants

(Not analyzed)

Organic Contaminants

Chlordane¹

Endosulfan II

Endrin

PCB's²

¹ alpha and gamma isomers combined for evaluation as total chlordane.

² all polychlorinated biphenyls combined for evaluation as total PCB's.

Analytical results are included in appendix D.

3.6.2 Summary of Investigations

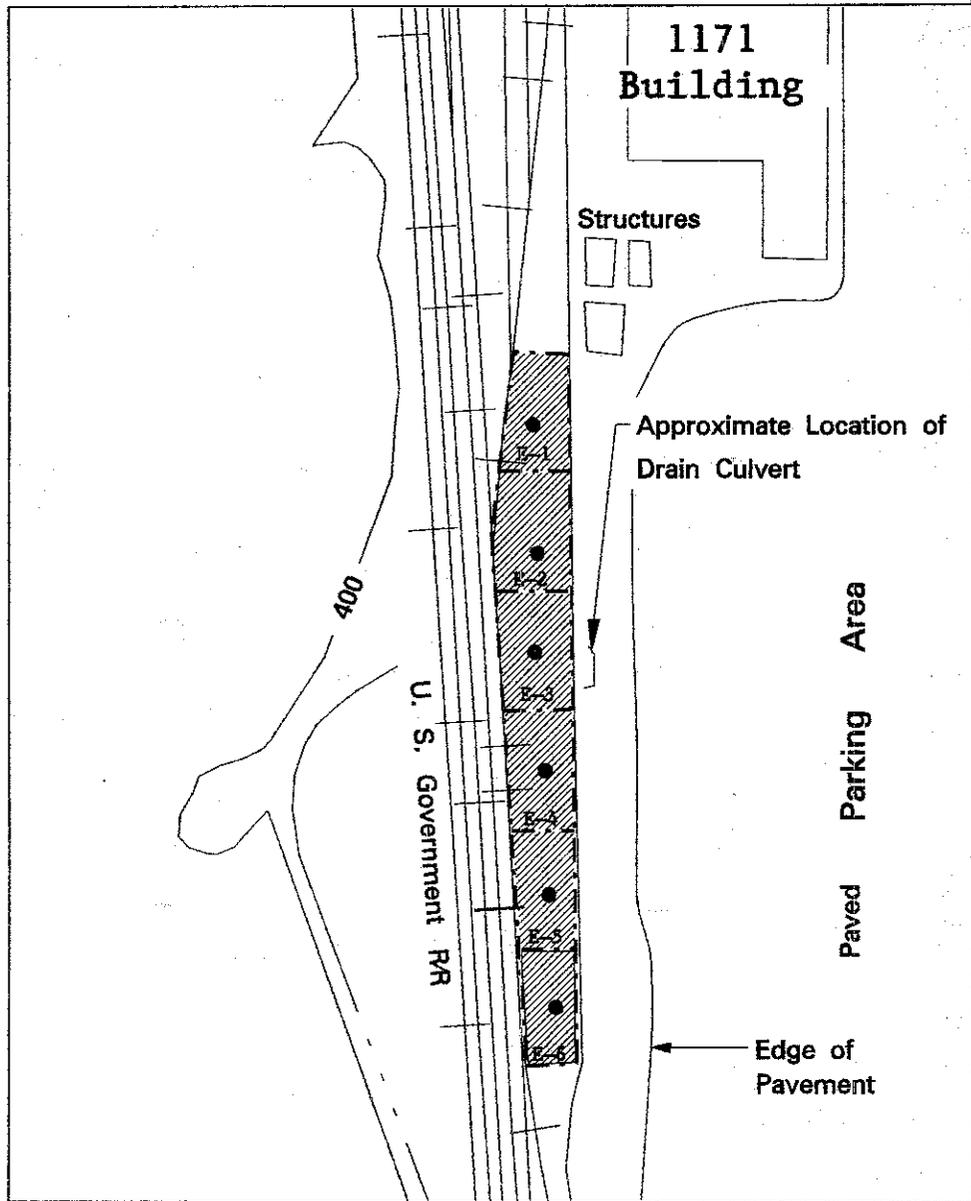
Organic and pesticide contamination of soils within the Ephemeral Pool subunit were detected at concentrations above background levels.

3.7 HRL

The HRL, which is located northeast of the SPC facility and north of Horn Rapids Road, extends over approximately 20 hectares (50 acres) of the 600 Area (figure 1-2). It was operated from the late 1940's into the 1970's as an uncontrolled landfill for Hanford Site contractors, and was used for unauthorized dumping by non-Hanford staff and area residents throughout its lifetime. Records indicate the predominant debris types deposited in disposal trenches excavated on the site were office construction refuse and demolition-derived materials, *e.g.*, broken concrete, waste metals and wood, metal piping, and insulation. HRL was not a hazardous waste landfill. The vast majority of materials deposited were solid waste.

The landfill is sited in generally flat terrain. Five partially to completely filled disposal trenches have been identified at the site through a study of historic aerial photographs, onsite investigations, and geophysical surveys. Surface debris consisting of auto and truck tires, wood, metal shavings, soft drink cans and bottles, and other small

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LEGEND :

E-1 ● Surface Soil Sampling Location and Number

▨ Estimated Boundary of Ephemeral Pool

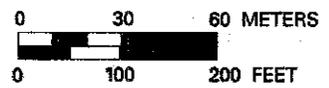


Figure 3-5. Ephemeral Pool Subunit Phase II Soil Sampling Locations

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pieces of refuse are scattered across the site. A single trench, the western-most of the identified waste disposal trenches, was posted with signs warning that the feature contained asbestos.

3.7.1 Vadose Zone Sampling

3.7.1.1 Phase I Soil Sampling. Soil sampling at HRL was performed as described in the Phase I RI report (DOE/RL-90-18). Fourteen boreholes were advanced during the Phase I RI at HRL. These boreholes yielded 63 discrete soil samples; 8 samples from the surface strata and 55 were obtained from the subsurface. Forty-two additional surface samples were taken from the landfill (figure 3-6). It should be noted that during the Phase I RI, boreholes were intentionally sited to avoid drilling through known and suspected waste deposits, the locations of which were determined during scoping, and implementation of the landfill geophysical and soil-gas surveys. This decision was made for reasons of safety and health concerns and places substantial limitations on the representativeness of the soil quality results of the Phase I data.

Numerous inorganic, organic, pesticide, and PCB contaminants were encountered in the surface and subsurface soils of the HRL during the Phase I investigation. Contaminants identified in surface soil samples collected during the Phase I investigation included:

Inorganic Contaminants

Aluminum	Arsenic	Barium	Beryllium
Cadmium	Calcium	Chromium	Cobalt
Copper	Cyanide	Iron	Lead
Magnesium	Mercury	Nickel	Potassium
Silver	Sodium	Thallium	Zinc

Organic Contaminants

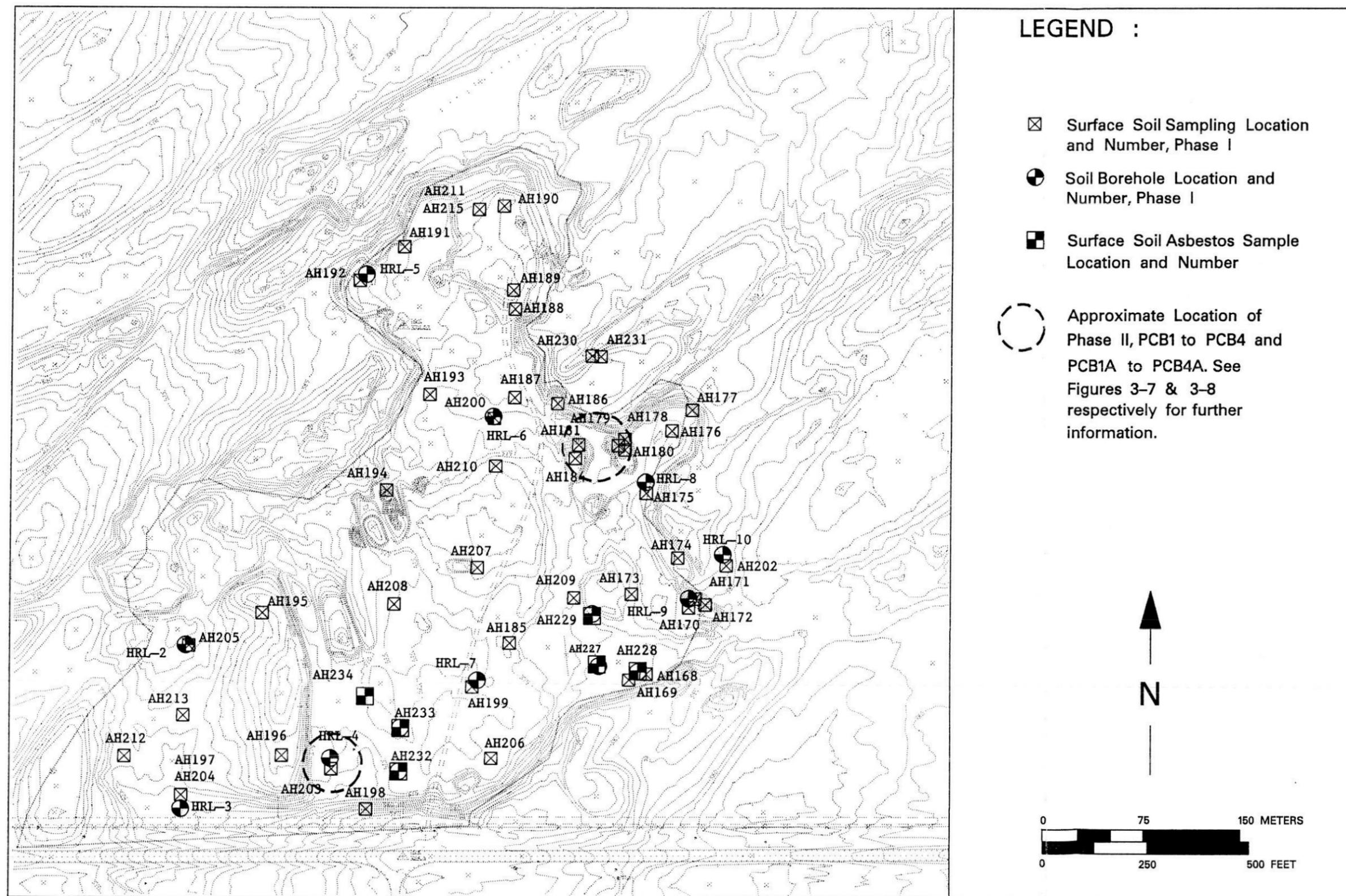
Aroclor-1248	Aroclor-1254	Alpha-Chlordane	4,4'-DDD
4,4'-DDE	4,4'-DDT	Heptachlor	2-methylnaphthalene
Naphthalene	Tetrachloroethene		

Contaminants identified in subsurface soil samples collected during the Phase I investigation at the HRL subunit included:

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Horn Rapids Landfill Subunit
Soil Sampling Locations

Inorganic Contaminants

Aluminum	Antimony	Arsenic	Barium
Beryllium	Cadmium	Calcium	Chromium
Cobalt	Copper	Cyanide	Iron
Lead	Magnesium	Mercury	Nickel
Potassium	Silver	Sodium	Thallium
Zinc			

Organic Contaminants

Aroclor-1248

3.7.1.2 Phase II Soil Sampling. Phase II sampling was performed in an attempt to further delineate pesticide and PCB contamination at HRL. Eight surface samples were taken from the vicinity of borehole HRL-4; PCB-1 to PCB-4 and PCB-1A to PCB-4A (figure 3-7). Fifteen samples were taken from the surface stratum between depths of 0 and 0.6 m (0 and 2 ft) at pits 4 and 5; B4-1, B5-1, B5-2 and B5-3 (figure 3-8). Thirteen subsurface samples were taken during disposal trench characterization activities (see paragraph 3.7.4). Contaminants identified during Phase II soil analyses that were not detected above background during the Phase I investigation include:

Surface	Subsurface
<u>Inorganic Contaminants</u>	<u>Inorganic Contaminants</u>
None encountered	Manganese
<u>Organic Contaminants</u>	<u>Organic Contaminants</u>
Endosulfan II	Dieldrin
Endrin	Total PCB's

3.7.2 Geophysical Investigations

Two separate geophysical surveys were performed at HRL as part of the Phase I and II RI. Phase I RI geophysics employed EMI, MAG, MD, and GPR methods. The geophysical investigation for the Phase II RI employed EMI, MAG, and GPR surveys.

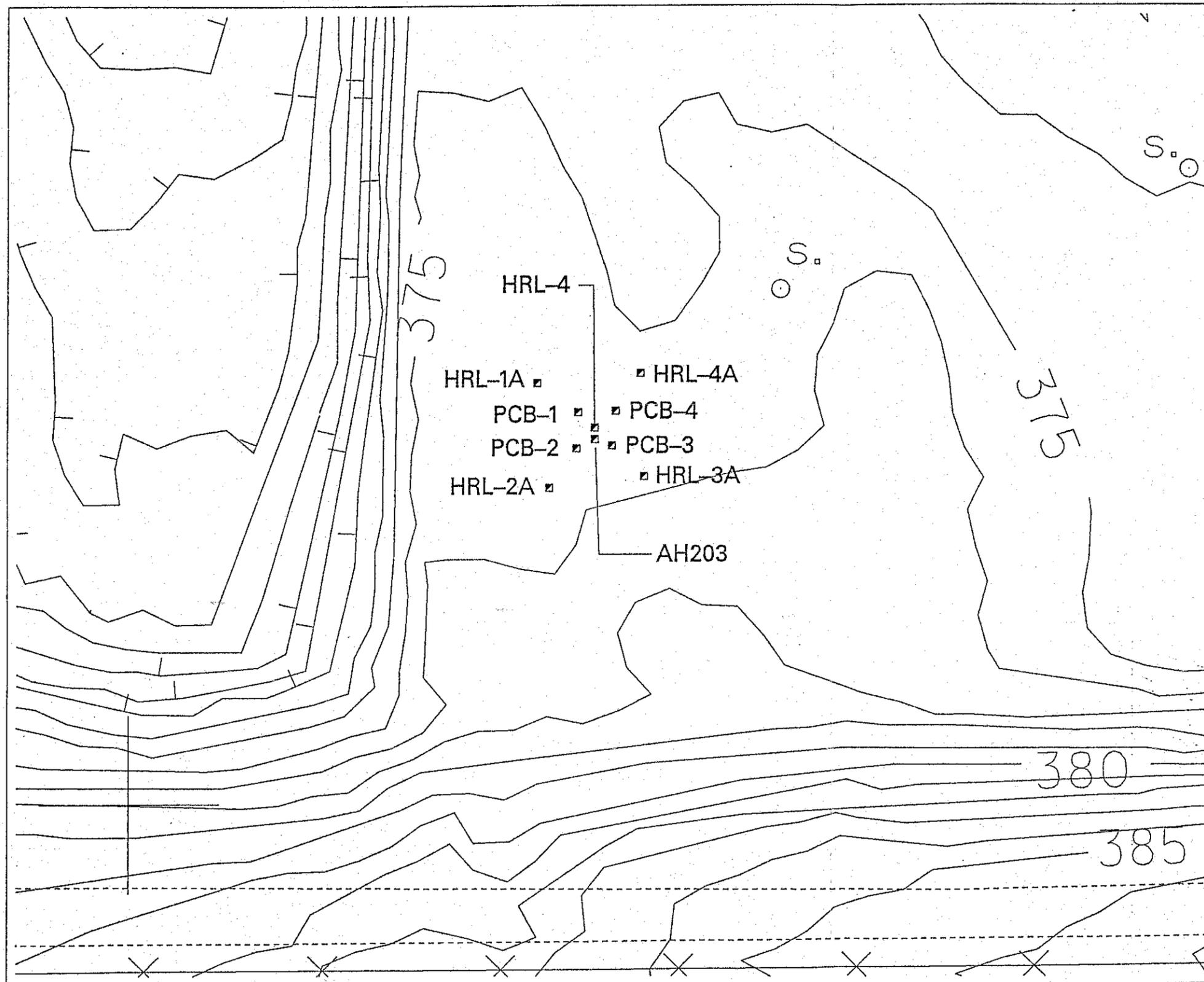
3.7.2.1 Phase I RI. The Phase I geophysical investigation covered an area of approximately 24.7 hectares (61 acres) during the months of January through April, 1989. The purpose was to obtain information regarding waste materials buried at the site and the location of waste disposal structures (pits and trenches), to identify any underground utilities which may cross the site, and to identify any other waste disposal-related features existing within the landfill. Survey lines were laid out with a 30.5 m (100 ft) spacing.

Due to the wide spacing of survey lines, little in the way of detailed data concerning the disposal trench contents was obtained. Based on GPR results, disposal trenches were interpreted as containing abundant waste metals to at least depths approaching 5.5 m (18 ft). Waste deposits were found to be concentrated in an approximately 6.9 hectare (17 acre) area in the south-central portion of the landfill. Outside of the five identified waste disposal

trenches, no other major waste accumulations were detected, although the entire surface of the site is littered with miscellaneous debris. The landfill had apparently been a large sand and gravel pit prior to its use as a disposal facility. This conclusion was reached due to the absence of eolian dune sand throughout the surveyed area and the exposure of normally buried natural deposits of sand and gravels at the ground surface (Sandness, *et. al.*, 1989).

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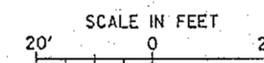
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LEGEND :

- Soil Sampling Location and Number

Contour interval 5 feet



Horn Rapids Landfill Phase II
Soil Sample Locations

Figure 3-7.

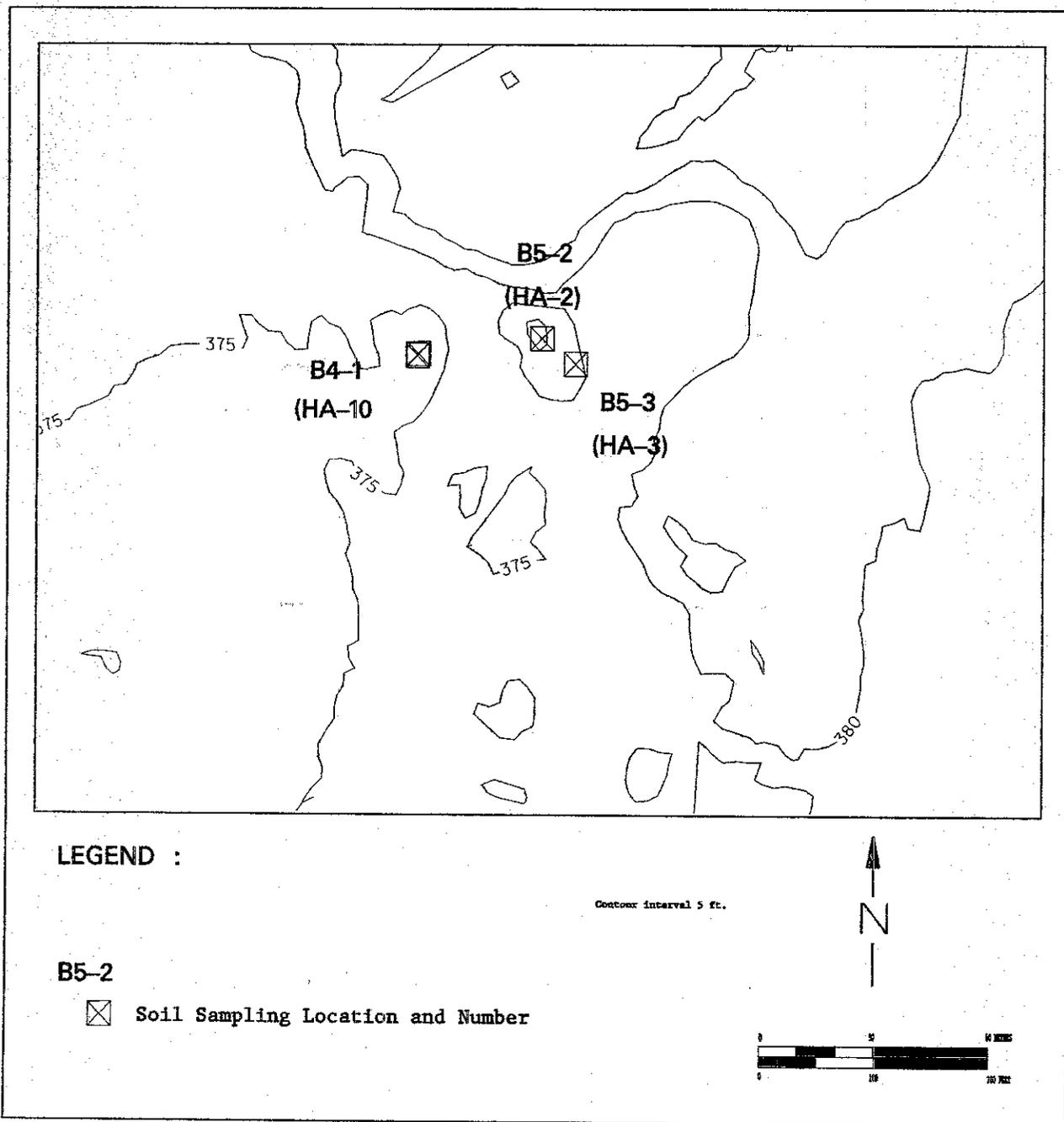


Figure 3-8. Horn Rapids Landfill Phase II Soil Sampling Locations.

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3.7.2.2 Phase II RI. The Phase II RI geophysical investigation at HRL was performed to further delineate disposal trench boundaries identified during the first geophysical surveys of the site and to search for an accumulation of drums containing organic solvents said to have been buried at this facility. During May 1991, EMI and MAG surveys were performed to delineate the trenches fully and to perform the initial search for drums. GPR was used to define the spacial extent, both vertically and laterally, of anomalies identified by the initial two geophysical methods.

A total of 4.7 hectares (11.7 acres) were surveyed. The EMI survey grid was performed along lines spaced 3.1 m (10 ft) east-west and 6.1 m (20 ft) north-south. The grid for MAG measurements was laid out on lines spaced 3.1 m by 3.1 m (10 ft by 10 ft). The GPR survey was run over east-west lines spaced at 3.1 m (10 ft) intervals; each line 24.4 m (80 ft) to 121.9 m (400 ft) in length.

Anomalies identified by the EMI survey were located in the immediate vicinity of disposal trenches, adjacent to the burn cage located at the northern edge of the landfill and, finally, the burn cage itself was identified as an anomaly. MAG anomalies were generally coincident with those identified by EMI. Results obtained near the disposal trenches were interpreted as being caused by an abundance of shallow deposits of metallic debris buried within the features. The quantities of metallic debris was such that each disposal trench effectively registered as a single buried metal object. GPR survey results were less specific. Signal penetration outside the disposal trenches reached to the depths of 4.9 to 6.1 m (16 to 20 ft). Fairly continuous stratigraphic boundaries were found to exist in these areas. In contrast, signals directly over the disposal trenches were generally chaotic. Penetration into the subsurface was severely limited and irregular. A total of 253 targets were identified during the GPR survey, most at depths of between 1.5 and 3.1 m (5 to 10 ft).

The overall interpretation of the Phase II RI geophysical investigation at HRL was that there are extensive shallow deposits of metallic debris buried within the identified disposal trenches. There were no geophysical signatures obtained from any area investigated consistent with a concentration of 10 or more drums being present in the subsurface. Of the five trenches of concern, the asbestos trench, (the western-most and longest disposal trench which was posted with signs identifying the presence of asbestos-containing materials), was the least likely candidate to contain buried drums based on geophysical survey results (Golder, 1991).

3.7.3 Soil-Gas Investigations

Soil-gas studies were performed at HRL and in surrounding areas during both the Phase I and Phase II RI utilizing permanent and temporary soil-gas extraction points. All permanent soil-gas probes were installed during the Phase I investigation. Monitoring of permanent probes continued through the Phase II investigations at HRL. Purposes of the soil-gas monitoring included the preliminary delineation of the groundwater contaminant plume located beneath the Horn Rapids area to assist in siting permanent groundwater monitoring wells; a survey of the vadose zone for a possible contaminant source contributing

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to groundwater quality degradation; and, evaluate of the sensitivity of soil-gas monitoring and its usefulness to accurately define the extent and rate of growth of a groundwater contaminant plume. A summary of the results of each is presented in the following paragraphs. Detailed results of soil-gas sampling activities performed at HRL can be found in Evans, 1989 and Golder Associates, 1992.

3.7.3.1 Delineation of Groundwater Contaminant Plume. The first stage of preliminary soil-gas sampling performed at HRL was for the purpose of scoping work for future RI sampling activities. Two hundred and eleven temporary soil-gas extraction points were installed in the landfill area to depths between 1.1 and 1.2 m (3.5 and 4.0 ft) during the period of March through May, 1989. Evidence of contamination by several chlorinated species including trichloroethene (TCE); 1,1,1 trichloroethane (TCA); and tetrachloroethene (PCE) were found within the HRL. TCE was widespread on the east side of the landfill and was found in a narrow plume extending from the southern boundary northwards toward the center of the facility. A small area giving rise to positive TCA indications is coincident with the TCE plume which extends from the landfill's southern boundary. A region of PCE positive results is located approximately 152 m (500 ft) east of the TCE maximum (Evans, 1989). Results of this preliminary scoping study were used to determine the siting of subsequent groundwater monitoring wells installed near HRL during the Phase I RI.

During the second stage of initial sampling, a total of 53 additional sampling probes were installed, sampled, and analyzed to delineate the TCE plume previously identified in the vicinity of HRL. The probes were temporary and were removed immediately after sampling had been completed. They extended from an area near the SPC pretreatment ponds to approximately 610 m (2,000 ft) northeast of the landfill center. TCE was detected at concentrations from 2 to 255 parts per billion by volume (ppbv) in 36 of the 53 probes. The highest TCE concentrations were obtained just outside the disturbed portions at the eastern limits of HRL. Results obtained from this stage of soil-gas monitoring were used in the siting of groundwater monitoring well Nos. 19, 20, 21, and 22 installed during the Phase II investigation.

3.7.3.2 Vadose Zone Contaminant Source Investigation. A total of 36 permanent soil-gas extraction points were installed within the limits of HRL during the period between December, 1990 and February, 1991. Forty temporary extraction points were placed within the South Pit, immediately south of the landfill across Horn Rapids Road, between November and December, 1990. The purpose of these installations was to investigate the possibility that a vadose zone contaminant source exists that is contributing to the degradation of the underlying groundwater. South Pit is a satellite disposal facility to HRL (figure 1-2). Disposal trenches within the South Pit area have been observed on aerial photographs taken throughout the operating history of the Hanford Site. Like HRL, waste disposal at South Pit was unregulated and undocumented. Waste material, (as evidenced by surface observations, the study of aerial photographs, and geophysical surveys), is similar to that found in the Horn Rapids facility. Since the groundwater contaminant plume skirts South Pit, it was included in the investigation as containing a possible vadose zone source for the groundwater contaminants.

TCE was detected in 38 of the 40 soil-gas extraction points sampled in South Pit. Concentrations ranged from 5 to 394 ppbv. Of the 36 permanent soil-gas probes installed within HRL, TCE was detected at 17 locations with concentrations ranging from 3 to 233 ppbv. These results strongly suggest that a vadose zone source for TCE or other volatile organic compound is not present within HRL or South Pit. A vadose zone contaminant source would have resulted in soil-gas measured values many orders of magnitude greater than those actually observed. An approximate concentration for TCE in the vadose zone soil-gas, if present as a free source, can be estimated from its vapor pressure (EPA, 1987). The concentration immediately above the source would be expected to be 7 percent, or 70,000,000 ppbv. This is determined by taking the vapor pressure of TCE divided by the sum of the vapor pressure and atmospheric pressure:

$$7 \text{ percent TCE per liter of air} = (60/(60+760))*100$$

where 60 is the TCE vapor pressure (in mm Hg at 25°C) and 760 is atmospheric pressure (in mm Hg at sea level and 25°C). Sample results at HRL indicate TCE levels from nondetect to 394 ppbv as compared to an estimated maximum of 70,000,000 ppbv if a liquid TCE source were present near any of the sampling locations (Golder, 1992).

3.7.4 Disposal Trench Characterization

Anecdotal information gathered during the Phase I RI, suggested a quantity of up to 200 drums of carbon tetrachloride (CCl₄) may have been buried in one of the disposal trenches located within HRL. Golder Associates, Inc., performed a suite of geophysical surveys at the landfill including EMI, GPR, and MAG during May, 1991. Survey results discounted the anecdotal reports and did not present evidence for the presence of a large accumulation of drums (greater than 10) within the landfill facility. However, EPA and Ecology directed that the largest of the geophysical anomalies be investigated and the known disposal trenches at the landfill be characterized. Eight exploration trenches were excavated within the landfill debris trenches during September and October, 1991 to complete these tasks (figure 3-9). Exploration trenches were sited based on the location of the largest anomalies discovered during the geophysical survey and trench depths were planned to intercept the particular anomaly in question. Geologic logs of the test pits are provided in appendix A.

3.7.4.1 Soils. The soil matrix within all trench excavations consisted of sandy gravel having a fairly uniform composition averaging 53-percent gravel, 44-percent sand, and less than 4-percent silt. Soil structure was lacking in the gravel deposits as they likely have been repeatedly reworked by heavy equipment during debris burial operations throughout the life of the landfill facility. A deposit of 100-percent fine to medium sand was encountered below a depth of 13 feet within Trench No. 3A. The material appeared to be in an undisturbed state. Structural details of the sand deposit were indiscernible due to the depth of the trench. The excessive sloughing of the excavation sidewalls prohibited safe trench entry of site

personnel for visual inspection of the deposit. All soil material is interpreted as belonging to the Hanford formation. Trench depths, soil gradations and classification, and the percentage of soil versus debris encountered in each trench is presented in table 3-3.

3.7.4.2 Debris. Debris encountered during trench excavation can be roughly grouped into four categories; automotive debris, shop debris, construction debris, and miscellaneous debris.

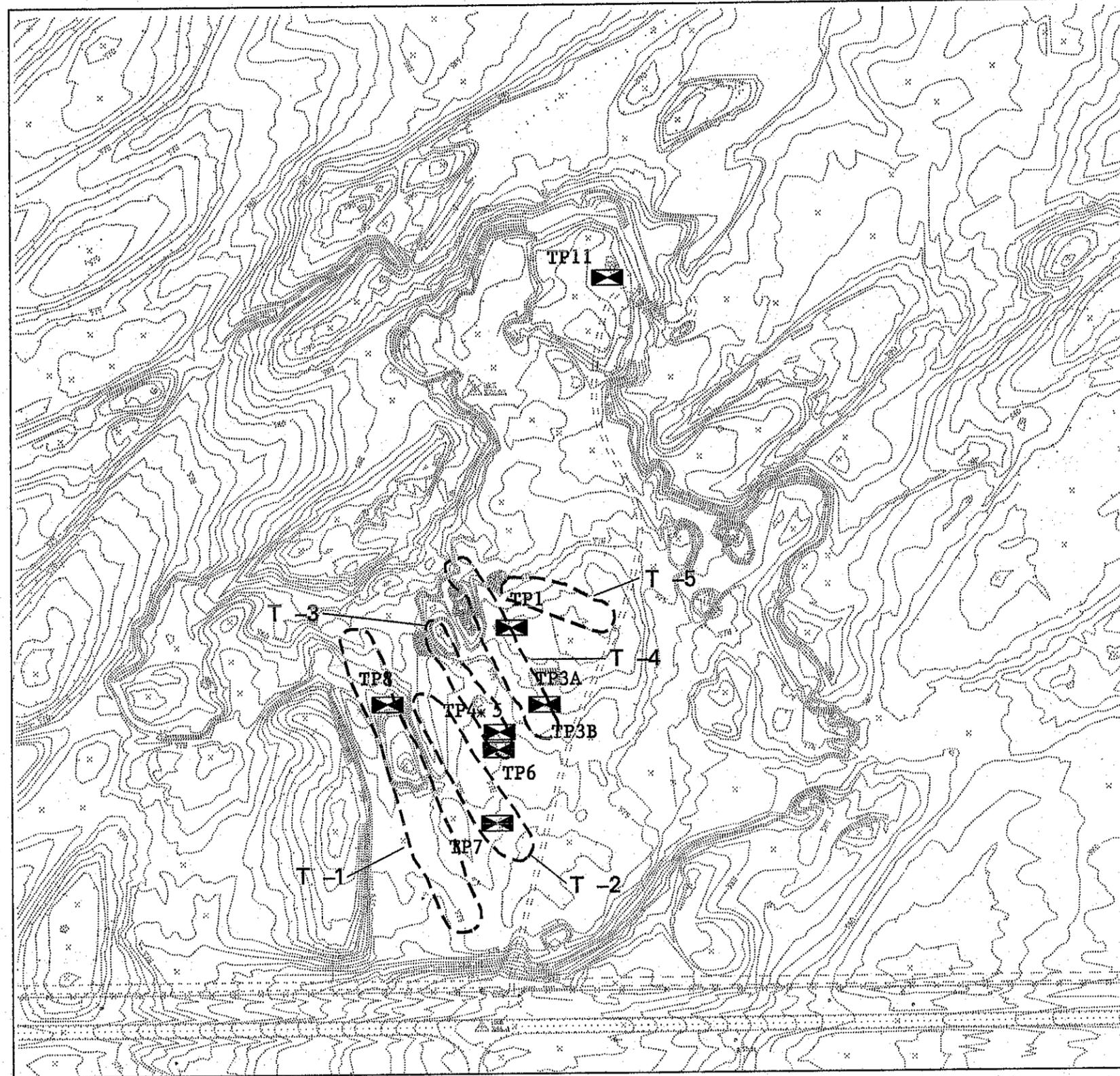
3.7.4.2.1 Automotive Debris--Automotive debris consisting of car and truck tires, mufflers, lengths of tail pipe, and inner tubes was found in all areas of the landfill. However, the highest concentration of automotive debris relative to other debris types seemed to be in the central portion of the landfill area. Most of the automotive debris appeared to have been randomly dumped into the debris trenches. Tires may have occasionally been laced prior to burial, *i.e.*, carefully stacked to conserve space when large quantities were involved.

3.7.4.2.2 Shop Debris--Shop debris is characterized by accumulations of stainless steel lathe shavings, again concentrated in the central area of the landfill property. Large quantities of the material seem to have been haphazardly dumped into the debris trenches while smaller quantities appear to have been spread into distinct layers. The metal has a fresh appearance, with little or no deterioration apparent.

3.7.4.2.3 Construction Debris--Construction debris consisted of a variety of material including: metal flashing strips of various lengths, pieces of gypsum wallboard, roofing material, metal culverts, concrete, reinforcing steel (rebar), piping, steel cable, electrical wiring, asbestos and fiberglass insulation, and timbers. This material was uncovered in varying amounts in all eight of the characterization trenches. There was no apparent preferential disposal location for this material although construction debris seemed to occur in associations. Metal flashing, gypsum wallboard, and fiberglass insulation were usually in close proximity to each other as were piping, cable, and asbestos insulation. Metal culvert lengths were found with concrete slabs and asphalt debris. Asphalt debris was usually present with roofing paper. All the materials were apparently collected during demolition activities and brought directly to the landfill for disposal.

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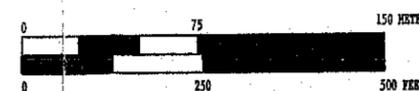


LEGEND :

TP3B  Test Pit Location and Number

 Approximate Boundary of Disposal Trenches

Contour interval 5 ft.



HRL Disposal Trench Characterization
Exploration Trench Locations

Figure 3-9.

TABLE 3-3: DEBRIS TRENCH COMPOSITION
 HORN RAPIDS LANDFILL CHARACTERIZATION
 1100-EM-1 OPERABLE UNIT

	DEPTH (FT)	SAND (%)	GRAVEL (%)	SILT (%)	SOIL (%)	DEBRIS (%)	SOIL CLASSIFICATION (after Folk, 1954)
Trench #1	0-11	43	52	5	90	10	Sandy Gravel
Trench #3A	1-13	40	55	<5	97	3	Sandy Gravel
	13-21	100	0	0	100	0	Sand
Trench #3B	0-8	52	44	4	97	3	Sandy Gravel
Trench #4/5	0-0.5	35	60	5	100	0	Silty Sandy Gravel
	0.5-12	45	55	<3	99.5	0.5	Sandy Gravel
Trench #6	0-6.5	35	65	<2	95	5	Sandy Gravel
Trench #7	0-6	52	43	0	85	15	Sandy Gravel
Trench #8	0-5	30	65	<5	98	2	Sandy Gravel
Trench #11	0-5	54	40	6	N/R	N/R	Sandy Gravel

Notes: 1. N/R - Results not reported in boring logs.

3.7.4.2.4 Miscellaneous Debris--Miscellaneous debris includes all other types of material: soda bottles, paint containers, trash cans, coffee cans, cigarette butts, cloth, ash, and other items. The greatest abundance of this material was observed in the northern portion of the landfill, adjacent to the burn cage. Paint containers seemed to be concentrated in the central portion of the landfill area.

3.7.4.2.5 Medical Debris--One unique association of debris was encountered during the excavation of Trench No. 6. Medical waste consisting of between 30 and 40 multi-injection vials containing a milky white substance, a single plastic intravenous-dispenser bag, an "eye-dropper" bottle containing a clear liquid, one multi-injection vial containing a clear liquid, and one 1.8- to 2.0-cm long by 1.0-cm diameter (7- to 8-inch long by 4-inch diameter) cylindrical bottle containing a clear liquid were uncovered at a depth of approximately 2.0 m (6.5 feet). No intact labels were present on any of the bottles or vials.

The majority of the material went undiscovered until backfilling operations had commenced and site workers were specifically alerted to watch for the presence of medical waste in the spoils pile. The medical waste was initially discovered when multi-injection vials were observed to fall from the backhoe bucket while it was being swung to the spoils pile. Trench excavation was immediately stopped when the medical waste was noticed due to the unknown hazards associated with the material. Based on visual inspection by Pacific Northwest Laboratories personnel, the milky white liquid material was very tentatively identified as some form of penicillin; likely surplus stock from a hospital or other medical facility. No identification was made for the clear liquids.

None of the medical waste was submitted for laboratory identification because no onsite laboratory could be located that was willing or capable of accepting medical waste for analysis. Offsite laboratories were inaccessible for analysis of the medical waste because the contents of the containers could not be certified by the Health Physics staff as being radiation-free and thus could not be released for offsite shipment. As excavation was stopped immediately after the discovery of the waste, the total extent of other medical products which may be present was not determined. Regulators were notified of the discovery and ultimately directed that all medical waste, chemical soil samples, and soil screening samples collected from this excavation be placed in the bottom of the trench and reburied. Only a very small volume of medical debris was discovered.

3.7.4.2.6 Unknown Debris--Two unknown waste substances were uncovered during the excavation of Trench #3A; a white crystalline powder, and an isolated pocket of bright purple, stained soil.

3.7.4.2.6.1 White Crystalline Powder--The white crystalline powder appeared to have been originally contained in plastic-lined paper bags, resembling concrete bags in size and shape. Labelling on the bags was illegible. The material was placed in the debris trench in layers. Field screening of the substance proved negative for radiation and volatile organics. A suggestion was made by site workers that the material had the appearance of commercial fertilizer.

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Chemical analysis performed during field screening of the sample using a HAZCAT® kit tentatively identified the substance as sodium bisulfate. The identification was based on the following:

- The substance is water soluble.
- Water pH after dissolution of the substance was <2.0 .
- When a wire coated with the substance is introduced into a flame, the flame color turns yellow.
- When the substance is heated, it liberates sulfur dioxide.

A sample was then analyzed at the Corps of Engineers, North Pacific Division Laboratory in Troutdale, Oregon. Laboratory analysis confirmed the field screening results (see appendix D). Laboratory results must be qualified, however, due to the fact that the sample chain-of-custody was broken. No additional sampling is anticipated as available results provide sufficient assurance that no significant health and environmental threat is posed by this substance.

3.7.4.2.6.2 Stained Soil--Soil excavated from a depth of approximately 3.1 m (10 ft) in Trench No. 3A was stained bright purple. The stained soil was first noted in materials removed from the excavation by the backhoe bucket. Approximately 0.06 to 0.08 m³ (2 to 3 ft³) of stained soil was observed. Subsequent scoops failed to remove additional similar material and no staining was observed within the exploration trench. Field screening of the stained soil was negative for radiation and volatile organics. No source for the staining substance was observed. The Site Safety Officer on duty during the discovery suggested the staining may have occurred due to the disposal of a permanganate compound.

Chemical analysis performed during field screening using a HAZCAT® kit provided a preliminary identification of the substance as potassium permanganate. The identification was based on the following:

- The substance is water soluble.
- The substance dissolves in alcohol.
- The sample provided a positive char test for the presence of manganese.
- The flame test for the presence of potassium was inconclusive due to difficulties in discerning changes in the flame color.
- The purple color is a characteristic of permanganate.

The sample was then analyzed at the Corps of Engineers, North Pacific Division Laboratory in Troutdale, Oregon (see appendix D). Laboratory analysis confirmed the field screening results. Laboratory results must be qualified, however, due to the fact that the sample chain-of-custody was compromised. As with the white powder, available results provide sufficient assurance that no significant health or environmental threat is posed by the stained soil.

3.7.4.3 Field Screening. Field screening was performed throughout the excavation of exploration trenches within the HRL. Soils were screened for organic vapors and for the presence of asbestos-containing materials. Air was monitored for the presence of asbestos

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fibers. Splits of soil samples collected for laboratory analysis were screened for the presence of heavy metals with a portable X-ray fluorescence (XRF) analyzer.

3.7.4.3.1 Organic Vapors--Soil and debris were continuously monitored with an oxygen/explosive level indicator and an organic vapor monitor (OVM) throughout the excavation process. A single positive OVM reading occurred in Trench No. 1 associated with a paint can and paint residue. The can and residue were collected, drummed, moved offsite, and disposed. At all other times, readings were negative.

3.7.4.3.2 Air Monitoring--Air monitoring for asbestos was implemented due to known past disposal of asbestos containing materials (ACM) at HRL and the discovery of asbestos waste during excavation of exploration Trench No. 1. Site-wide monitoring equipment was located at the edge of each control zone, downwind from the excavation. Personal air monitors were worn by personnel required to enter the control zones. Both types of monitors were checked daily. Asbestos collected by the monitors was below action levels in all cases.

3.7.4.3.3 Asbestos Debris Monitoring--Field personnel were constantly monitoring excavations and spoil piles for the presence of ACM. Suspect material was collected by the site geologist and/or the site safety officer and forwarded to the Hanford Environmental Health Foundation (HEHF) laboratories for analysis. All suspect material collected and analyzed proved to contain asbestos although only a single debris trench was signed as containing asbestos. There seemed no pattern to the location of ACM within the landfill. Virtually all of the material seemed to have been piping insulation. Much of the asbestos material collected and analyzed was in a friable state.

3.7.4.3.4 XRF Monitoring--As noted above, soil samples collected for laboratory analysis were also subjected to screening by an XRF device. An X-Met 880 portable XRF analyzer was used to evaluate the samples for the presence of heavy metal contamination. Anomalous concentrations of iron were identified in many of the samples submitted for analysis. However, it was not determined whether the anomalies were the result of outside contamination or the result of natural variations in the iron content of HRL soils. Two samples revealed anomalous concentrations of copper and zinc. Laboratory analyses confirmed the field screening results, but concentrations were at levels below regulatory cleanup levels. XRF screening was performed as part of a Hanford Site-wide study to determine the utility of XRF screening techniques to environmental projects. Data collected by XRF screening were not utilized in the 1100-EM-1 Operable Unit analyses for the identification of potential site contamination.

3.7.4.4 Conclusions. Excavations at HRL confirmed the geophysical survey interpretation that a large accumulation of buried drums does not exist within the facility. Geophysical magnetic anomalies were found to represent accumulations of metallic objects including automotive debris, sheet metal, and metallic lathe shavings. Ground penetrating radar reflections could be explained by large, flat-lying pieces of sheet metal and automotive debris such as large truck mufflers. Asbestos-containing pipe insulation was the single hazardous material identified at the site. CCl_4 was not detected in any of the soil samples obtained from HRL during the Phase II investigation.

Medical waste discovered in Trench No. 6 will remain buried. Identification of two unknown substances, a white crystalline powder and soil stained a bright purple color, were confirmed by laboratory testing to contain sodium bisulfate and potassium permanganate, respectively. The medical waste, sodium bisulfate, and the potassium permanganate are not believed to represent an environmental or personal health threat.

3.7.4.5 Summary of Subunit Soil Investigations. Inorganic, organic, and pesticide contamination was detected in soils at HRL subunit. Geophysical surveys conducted at HRL detected numerous anomalous readings in the vicinity of waste disposal trenches. None of the anomalies, however, were consistent with the presence of buried drums. Soil-gas readings detected TCE, TCA, and PCE vapors. Concentrations were far below those to be expected if a free source of the contaminants existed within the vadose zone. Waste disposal trench explorations failed to reveal the presence of drums containing organic liquids. Debris within the waste disposal trenches fit into four broad categories including automotive debris, shop debris, construction debris, and miscellaneous debris. Asbestos was the single hazardous substance positively identified during waste disposal trench characterization.

3.8 SPC AND 300 AREA SITE INVESTIGATIONS

Various data derived from adjacent areas were considered in the 1100-EM-1 RI analyses. Groundwater level measurements taken in the 1100 Area were coordinated with measurements being taken for ongoing investigations at the SPC facility and within the Hanford 300 Area. All groundwater level measurements were taken at the three areas on the same dates to make possible an accurate comparison of the data. SPC and 300 Area water level data were included in the 1100 Area analysis of groundwater flow direction beneath the Operable Unit; specifically, data were used in refining groundwater flow paths in the area encompassed by the groundwater model (see paragraph 6.2). Table 3-4 lists groundwater level measurements obtained from investigations performed in the 300 Area by Westinghouse Hanford Company (WHC). Table 3-5 presents groundwater elevations measured at the SPC facility by Geraghty and Miller, Inc.

Analytical data from groundwater samples obtained from SPC wells were included in the development and analysis of the 1100 Area groundwater modeling effort. Chemical data, including groundwater nitrate and TCE data, obtained from samples collected at the SPC facility is presented in appendix F.

Aquifer pump testing was performed at both the SPC facility and within the 300 Area. Results of these efforts were used to confirm the validity of aquifer properties used in the 1100 Area groundwater model. Pump tests implemented in both the 300 Area and at the SPC facility are further described in paragraph 2.4.3.2.6, and in appendixes G and H.

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Table 3-4: 1100-EM-1 Operable Unit
300 Area Monitoring Well Groundwater Levels

Well ID	DATES																																	
	2/92	5/92	9/92	3/93	4/93	5/93	6/93	7/93	8/93	9/93	10/93	11/93	12/93	1/94	2/94	3/94	4/94	5/94	6/94	7/94	8/94	9/94	10/94	11/94	12/94	1/95	2/95	3/95	4/95					
	Groundwater Elevations (m)																																	
399-1-3	104.63	105.67	103.99	104.91	105.45	105.73	105.53	104.78	104.61	104.00	104.28	104.29	104.38	104.25	104.01	104.16	104.44																	
399-1-4	105.08	106.08	104.54	105.45	105.74	106.02	105.91	105.20	104.98	104.45	104.58	104.70	104.87	104.63	104.39	104.48	104.72																	
399-1-5	104.77	105.79	104.13	105.14	105.50	105.79	105.58	104.86	104.72	104.22	104.37	104.42	104.67	104.35	104.10	104.39	104.50																	
399-1-7	104.61	105.67	103.99	104.97	105.44	105.71	105.52	104.77	104.60	104.12	104.28	104.28	104.56	104.24	104.00	104.17	104.43																	
399-1-8	NA	NA	NA	104.99	105.44	105.71	105.53	104.78	104.61	104.12	104.28	104.30	104.58	104.26	104.02	104.16	104.36																	
399-1-10	104.77	105.80	104.15	105.20	105.73	106.03	105.79	104.92	104.90	NA	104.45	104.38	104.83	104.46	104.07	104.28	104.58																	
399-1-11	104.92	105.92	104.40	105.32	105.61	105.89	105.70	105.01	104.79	104.30	104.42	104.50	104.74	104.46	104.21	104.30	104.59																	
399-1-12	104.77	105.79	104.11	105.12	105.48	105.76	105.63	104.87	104.73	104.22	104.35	104.44	104.65	104.35	104.12	104.48	104.59																	
399-1-13	104.79	105.80	104.14	105.13	105.47	105.75	105.66	104.90	104.76	104.24	104.37	104.48	104.64	104.38	104.16	104.24	104.48																	
399-1-14	104.92	105.91	104.36	105.27	105.55	105.82	105.76	105.06	104.87	NA	104.46	104.58	104.74	104.50	104.28	104.57	104.57																	
399-1-15	104.96	105.96	104.42	105.33	105.62	105.86	105.80	105.10	104.98	104.41	104.49	104.60	104.78	104.54	104.32	104.34	104.63																	
399-1-16A	104.61	105.67	103.99	104.97	105.45	105.71	105.52	104.76	104.60	104.10	104.26	104.23	104.55	104.23	103.98	104.16	104.46																	
399-1-17A	104.69	105.73	104.05	105.03	105.43	105.71	105.56	104.78	104.67	104.19	104.31	104.39	104.61	104.31	104.07	104.20	104.46																	
399-1-19	104.73	105.78	104.09	105.09	105.47	105.75	105.55	NA	NA	NA	105.03	105.08	105.29	104.98	104.74	104.82	105.27																	
399-2-1	104.58	105.59	103.93	104.77	105.45	105.74	105.50	104.57	104.61	104.04	104.21	104.16	104.52	104.23	103.94	104.12	104.44																	
399-2-2	104.60	105.65	103.98	104.91	105.45	105.72	105.52	104.75	104.62	104.09	104.25	104.19	104.55	104.22	103.99	104.13	104.46																	
399-2-3	104.59	105.65	103.97	104.89	105.45	105.71	105.50	104.73	104.58	104.08	104.25	104.17	104.51	104.20	104.05	104.12	104.44																	
399-3-1	104.54	105.56	103.91	104.76	105.42	105.70	105.45	104.56	104.59	104.01	104.19	104.28	104.57	104.20	103.93	104.09	NA																	
399-3-6	104.64	105.68	103.98	104.98	105.39	105.64	105.53	104.72	104.61	104.11	104.25	104.31	104.58	104.28	104.06	104.14	104.39																	
399-3-7	104.62	105.66	103.97	105.26	105.40	105.66	105.50	104.71	104.59	104.10	104.24	104.29	104.59	104.25	104.04	104.13	104.42																	
399-3-9	104.53	105.58	103.89	104.81	105.42	105.68	105.44	104.65	104.53	103.99	104.16	104.27	104.49	103.96	103.72	103.85	103.25																	
399-3-10	104.51	105.54	103.86	104.77	105.40	105.67	105.40	104.62	104.51	103.96	104.13	104.27	104.57	104.19	103.95	104.08	104.38																	
399-3-12	104.56	105.61	103.93	104.88	105.40	105.66	105.46	104.67	104.53	104.03	104.19	104.17	104.53	104.23	103.45	103.57	103.79																	
399-4-1	104.49	105.53	103.87	104.79	105.37	105.63	105.37	104.59	104.46	103.98	104.30	104.14	104.50	104.16	103.73	103.85	104.19																	
399-4-9	104.51	105.53	103.85	104.72	105.41	105.67	105.41	104.61	104.52	103.96	104.13	104.28	104.48	103.95	103.71	103.85	104.15																	
399-4-10	104.50	105.51	103.83	104.67	105.40	105.66	105.38	104.58	104.51	103.89	104.09	104.27	104.43	104.18	103.91	104.07	104.38																	
399-4-11	104.56	105.59	103.93	104.88	105.38	105.63	105.45	104.65	104.53	104.04	104.19	104.25	104.54	104.21	103.98	104.09	104.40																	
399-5-1	104.68	105.66	104.03	104.97	105.36	105.60	105.51	104.74	104.67	104.15	104.28	104.40	104.53	104.62	104.11	104.15	104.39																	
399-6-1	104.76	105.77	104.13	105.28	105.36	105.61	105.63	104.87	104.78	104.26	104.37	104.49	NA	103.84	103.66	103.82	104.32																	
399-8-1	104.79	105.81	104.14	105.12	105.44	105.67	105.66	104.90	104.78	104.26	104.39	104.50	104.58	104.42	104.20	104.30	104.05																	
399-8-2	104.96	105.93	104.43	105.22	105.42	105.64	105.78	105.14	104.99	104.56	104.53	104.64	104.59	104.65	104.46	104.46	103.89																	
399-8-3	104.89	105.89	104.28	105.22	105.49	105.72	105.75	105.00	104.89	104.38	104.48	104.59	104.63	104.51	104.30	103.82	103.99																	

BLANK - Measurements have been obtained but not yet entered into HEIS
NA - Measurements are not recorded in HEIS database

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Table 3-5: 1100-EM-1 Operable Unit
 Siemens Power Co. Monitoring Well Groundwater Levels

Well ID	DATES																						
	2/99	5/99	9/99	3/01	4/01	5/01	6/01	7/01	8/01	9/01	10/01	11/01	12/01	1/02	2/02	3/02	4/02	5/02	6/02	7/02	8/02	9/02	
GM-1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.35	106.31	106.27	106.20	106.15	106.10	106.12	106.18	106.189	106.204		
GM-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.34	106.31	106.28	106.23	106.18	106.13	106.13	106.18	106.216	106.219		
GM-3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.30	106.26	106.23	106.19	106.14	106.09	106.08	106.128	107.866	108.171		
GM-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.22	106.20	106.17	106.12	106.08	106.03	106.02	106.067	108.116	108.116		
GM-5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.16	106.17	106.14	106.10	106.05	106.00	107.99	108.052	108.094	108.091		
GM-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.18	106.18	106.15	106.10	106.06	106.01	107.99	108.043	108.079	108.082		
GM-7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.12	106.14	106.11	106.07	106.02	107.97	107.96	108.006	108.04	108.049		
GM-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.10	106.09	106.09	106.05	106.02	107.97	107.95	107.991	108.03	108.037		
GM-9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.09	106.07	106.05	106.03	107.99	107.94	107.92	107.954	107.994	108.003		
GM-10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.09	106.07	106.05	106.01	107.98	107.92	107.90	107.665	107.707	107.713		
GM-11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	107.98	106.00	107.98	107.94	107.91	107.85	107.83	107.869	107.607	107.918		
GM-12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	107.89	107.90	107.86	107.83	107.80	107.75	107.72	107.765	107.805	107.805		
TW-1	NA	NA	107.92	NA	NA	NA	NA	107.96	106.04	NA	NA	106.20	106.21	106.19	106.14	106.10	106.05	106.04	106.085	106.113	106.128		
TW-2	NA	NA	107.91	NA	NA	NA	NA	107.96	106.04	NA	NA	106.20	106.21	106.18	106.13	106.09	106.04	106.03	106.079	106.11	106.122		
TW-3	NA	NA	107.94	NA	NA	NA	NA	107.99	106.11	NA	NA	106.27	106.24	106.21	106.16	106.11	106.06	106.03	106.11	106.131	106.146		
TW-4	NA	NA	107.96	NA	NA	NA	NA	108.00	106.09	NA	NA	106.24	106.25	106.22	106.16	106.12	106.07	106.06	106.116	106.146	106.155		
TW-5	NA	NA	107.96	NA	NA	NA	NA	108.01	106.10	NA	NA	106.25	106.26	106.23	106.17	106.12	106.07	106.07	106.128	106.152	106.162		
TW-6	NA	NA	107.97	NA	NA	NA	NA	108.03	106.12	NA	NA	106.27	106.27	106.24	106.18	106.13	106.08	106.08	106.152	106.158	106.174		
TW-7	NA	NA	107.98	NA	NA	NA	NA	108.04	106.17	NA	NA	106.33	106.29	106.25	106.20	106.14	106.09	106.09	106.152	106.177	106.189		
TW-9	NA	NA	107.91	NA	NA	NA	NA	107.95	106.11	NA	NA	106.18	106.20	106.17	106.12	106.08	106.04	106.04	106.049	106.091	106.116		
TW-11	NA	NA	107.99	NA	NA	NA	NA	108.03	106.03	NA	NA	106.28	106.28	106.25	106.19	106.14	106.09	106.09	106.149	106.174	106.183		
TW-12	NA	NA	108.00	NA	NA	NA	NA	108.04	106.04	NA	NA	106.29	106.29	106.25	106.20	106.15	106.09	106.09	106.152	106.183	106.189		
TW-13	NA	NA	108.00	NA	NA	NA	NA	108.07	106.17	NA	NA	106.29	106.31	106.27	106.21	106.15	106.10	106.12	106.158	106.192	106.204		
TW-14	NA	NA	107.84	NA	NA	NA	NA	107.83	106.13	NA	NA	106.10	106.08	106.06	106.02	107.98	107.93	107.91	107.948	107.997	108.003		
TW-15	NA	NA	108.10	NA	NA	NA	NA	107.82	106.16	NA	NA	106.06	106.08	106.05	106.02	107.98	107.93	107.91	107.945	107.973	107.994		
TW-16	NA	NA	108.16	NA	NA	NA	NA	107.88	107.98	NA	NA	106.12	106.13	106.12	106.08	107.83	107.93	107.97	107.942	107.968	108.052		
TW-19	NA	NA	107.93	NA	NA	NA	NA	107.97	108.00	NA	NA	106.21	106.22	106.19	106.15	106.10	106.05	106.04	106.091	106.122	106.128		
TW-20	NA	NA	107.94	NA	NA	NA	NA	108.00	107.98	NA	NA	106.23	106.24	106.21	106.16	106.12	106.06	106.05	106.104	106.14	106.149		
TW-21	NA	NA	107.96	NA	NA	NA	NA	108.01	NA	NA	NA	106.27	106.27	106.24	106.18	106.12	106.09	106.08	106.134	106.165	106.171		
TW-22	NA	NA	107.99	NA	NA	NA	NA	108.04	NA	NA	NA	106.28	106.28	106.23	106.18	106.12	106.07	106.09	106.146	106.158	106.113		
TW-23	NA	NA	108.02	NA	NA	NA	NA	108.07	106.06	NA	NA	106.35	106.33	106.29	106.24	106.20	106.14	106.11	106.189	NA	106.259		
TW-24	NA	NA	108.00	NA	NA	NA	NA	106.05	106.08	NA	NA	106.31	106.30	106.27	106.22	106.17	106.13	106.08	106.158	NA	NA		
TW-25	NA	NA	108.01	NA	NA	NA	NA	108.08	106.12	NA	NA	106.30	106.32	106.29	106.25	106.21	106.17	106.12	106.177	106.219	106.268		
TW-26	NA	NA	107.91	NA	NA	NA	NA	107.96	106.13	NA	NA	106.19	106.20	106.18	106.13	106.09	106.04	107.99	106.034	106.061	106.116		

BLANK -- Measurements have been obtained but not yet entered into HEIS
 NA -- Measurements are not recorded in HEIS database

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3.9 GROUNDWATER INVESTIGATIONS

Eleven full rounds of groundwater sampling have been completed at the 1100-EM-1 Operable Unit between January, 1990 and present. Groundwater contaminants detected in concentrations exceeding background values for sampling rounds 1 and 2 were identified the 1100-EM-1 Phase I RI report (DOE/RL-90-18) and for sampling rounds 1 through 4 in WHC 1990. Groundwater contaminants detected during the Phase I investigation are presented in the appendixes of the Phase I RI report (DOE/RL-90-18). Analyses for groundwater contaminants during the first two sampling rounds included TAL, TCL, primary and relevant secondary drinking water, WAC 173-304, and RCRA groundwater monitoring parameters. Results from sampling rounds 5 through 9 are included in this report (appendix E) per negotiations with the regulatory agencies.

Further characterization of groundwater in the 1100-EM-1 Operable Unit was performed during Phase II investigations. The scope of the additional characterization was negotiated between DOE, Ecology, and EPA, and was finalized on July 24, 1991. DOE and the regulatory agencies agreed that: further hydrogeological investigations would include SPC property; that pump testing proposed by the U.S. Army Corps of Engineers, Walla Walla District, determine parameters for the unconfined aquifer in the vicinity of HRL for entry into the groundwater flow and transport model would not be performed; that monitoring well Nos. MW-8 and MW-9, located along the western HRL boundary, would be used to establish background water quality for HRL; and, no new monitoring wells would be constructed within the Operable Unit for the purposes of this final RI/FS report. Documentation provided to EPA and Ecology during the 1992 Revisions to Milestones Dispute outlined concerns that implementation of the aforementioned agreements would depreciate the quality and quantity of data available for input in the groundwater flow and transport modeling effort. The EPA and Ecology acknowledged these concerns but believed that a "bias-for-action" needed to be emphasized for the Phase II groundwater investigations at the 1100-EM-1 Operable Unit.

DOE-RL has accepted responsibility for the onsite characterization of a groundwater contaminant plume suspected of originating from process waste lagoons on property owned by SPC. Groundwater sampled from monitoring wells on SPC property intercepting the plume contains dissolved ammonia, sulphate, fluoride, elevated beta activity, trichloroethene TCE, and nitrate. As noted previously, these analytical results are presented in appendix F.

Groundwater contaminants detected at DOE monitoring wells during Phase II investigations are included in appendix E of this document. All groundwater contaminants detected in concentrations above background during Phase II investigations (sampling rounds 5 through 9) were compared with published maximum contaminant levels (MCL's) and site-wide background (see tables 3-7 through 3-11). Contaminants detected in the groundwater samples that have no published MCL value or exceed MCL's include:

Inorganics

Aluminum	Calcium	Iron	Magnesium
Nickel	Potassium	Sodium	Zinc

Organics

Ammonia	Nitrate	Phosphate	Methylene Chloride
Acetone	Chloroform	Trichloroethene	Toluene
C ₁₂ hydrocarbon	Diethylphthalate		

Radionuclides

Gross Beta

The above list of contaminants was further screened to remove micronutrients (aluminum, calcium, iron, magnesium, potassium, sodium, and zinc) and contaminants having an anomalous concentration during one round of sampling while all other rounds either did not detect the contaminant or detected the contaminant at the analyte's Sample Quantitation Limit (SQL) (nickel, methylene chloride, acetone, chloroform, toluene, C₁₂ hydrocarbon, and diethylphthalate). Ammonia was not considered further because of the low concentrations at which it was detected, and because it degrades to nitrate. Nitrate does have an MCL and was considered in subsequent analyses for 1100-EM-1 contaminants through the risk assessment phase of the investigation.

The current MCL for gross alpha activity (excluding radon and uranium) is 15 pCi/L. An MCL for specific beta activity has not been developed. However, compliance with individual MCL's for beta emitters may be assumed, without further analysis, if the average annual concentration of gross beta activity is less than 50 pCi/L. Since the gross beta activity exceeded this concentration, specific analyses of the potential beta-contributing radionuclides were conducted. Technetium-99 (Tc-99) appears to account for most, if not all, of this beta activity. No other significant contributors to the total beta activity have been detected (Prentice *et al.*, 1992). Other analyses searched for the presence of tritium and strontium-90 in the groundwater using liquid scintillation and gamma spectrometry analysis techniques. Neither analyte was detected. Tc-99 is a fission product derived mainly from the recycling of nuclear fuels. It is very persistent in the environment, having a half-life of 2.1E+05 years; however, it poses a relatively small internal health hazard. This minimal health hazard is evidenced by the high proposed MCL for Tc-99 (3.8E+03 pCi/L) and its relatively small ingestion slope factor (1.3E-12/pCi). The average Tc-99 concentration measured in HRL/SPC groundwater samples was 120 pCi/L. Since this concentration is below proposed MCL's, the gross beta activity was eliminated from further evaluation as a contaminant of potential concern.

Analytes remaining as contaminants of potential concern for the 1100-EM-1 Operable Unit groundwater are TCE and nitrate. Both are present in fairly well-defined plumes apparently emanating from SPC property and extending beneath the HRL subunit. These two contaminants are consistent with the list of contaminants of potential concern to be considered as directed by EPA (see section 5.0).

3.9 SUMMARY OF SITE INVESTIGATIONS

Site investigations of the 1100-EM-1 Operable Unit included geophysical surveys, soil-gas surveys, intrusive trenching activities to visually inspect subsurface conditions, surface and subsurface soil sampling and laboratory analyses, groundwater level monitoring, and groundwater sampling and laboratory analyses. Soil contaminants detected at subunits located within the Operable Unit at levels exceeding background concentrations are presented in tables 3-1 and 3-2. The list of detected contaminants was screened to remove essential micronutrients (see appendix D) to develop table 3-6, contaminants of potential concern (COPC) in the soil.

Groundwater contaminants identified during field investigations are presented in appendix E. Tables 3-7 through 3-10 list groundwater contaminants measured at concentrations above MCL or site background. As with the soil sample results, groundwater contaminants were further screened to remove micronutrients and analytes occurring at concentrations below published regulatory criteria. Anomalous measurements, confirmed by subsequent measurements to be below regulatory criteria, were also screened at this stage. TCE and nitrate remain as the contaminants of potential concern for the groundwater at and near the HRL subunit. Groundwater contamination is not an issue at the remaining six subunits of the 1100-EM-1 Operable Unit.

The distribution of the contaminants of potential concern for both soil and groundwater will be discussed in additional detail in section 4.0.

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**Table 3-6: 1100-EM-1 Operable Unit Groundwater Sampling Schedule
for Calendar Year 1991**

<u>Well</u>	<u>First Quarter</u>	<u>Second Quarter</u>	<u>Third Quarter</u>	<u>Fourth Quarter</u>
MW-1	None	Complete Suite	None	TAL, gross alpha, alkalinity, SC
MW-2	None	Complete Suite	None	None
MW-3	None	Complete Suite	None	TAL, TCL, volatile organics, semi-volatiles, gross alpha & beta, radium, alkalinity, SC, turbidity, SO ₄ , TDS
MW-4	None	Complete Suite	None	Volatile organics
MW-5	None	Complete Suite	None	TAL, TCL, volatile organics
MW-6	None	Complete Suite	None	TAL, TCL volatile organics
MW-7 MW-8 MW-9	None	Complete Suite	None	None
MW-10 MW-11 MW-12 MW-13 MW-14 MW-15	TCL volatile organics, gross alpha & beta, radium, anions, TDS, pH, SC, alkalinity, SO ₄ , NH ₄ , COD, nitrate, nitrite, alpha & beta spectroscopy	Complete Suite, alpha & beta spectroscopy	TCL volatile organics, TDS, pH, SC, alkalinity, SO ₄ , NH ₄ , COD, nitrate, nitrite	TCL volatile organics, gross alpha & beta, radium, anions, TDS, pH, SC, alkalinity, SO ₄ , NH ₄ , COD, nitrate, nitrite, beta emitter analyses
MW-17	None	Complete Suite	None	Complete Suite
MW-18	Complete Suite	Complete Suite	Complete Suite	Complete Suite
MW-19 MW-20 MW-21 MW-22	Complete Suite	Complete Suite	Complete Suite	Complete Suite

Complete Suite - TCL, TAL, primary and relevant secondary drinking water, WAC 173-304, and RCRA groundwater monitoring parameters.

COD - Chemical Oxygen Demand

NH₄ - Ammonium

SC - Specific Conductance

SO₄ - Sulphate

TAL - Target Analyte List

TCL - Target Compound List

TDS - Total Dissolved Solids

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Table 3-7: Monitoring Well Sampling Schedule for Calendar Year 1992

Well	Nearest Operable Unit	Frequency of Monitoring
MW-1	1100-1 & Ephemeral Pool	Annual
MW-3	1100-4 & UN-1100-5	Annual
MW-4	1100-2	Annual
MW-6	1100-3	Annual
MW-7	None, samples used as blanks	Whenever needed
MW-8	HRL	Quarterly*
MW-10	HRL	Quarterly*
MW-11	HRL	Quarterly*
MW-12	HRL	Quarterly*
MW-14	HRL	Quarterly*
MW-15	HRL	Quarterly*
MW-19	downgradient from HRL	Quarterly*
MW-20	downgradient from HRL	Quarterly*
MW-22	downgradient from HRL	Quarterly*
6-S29-E12	downgradient from HRL	Quarterly*

Measurement Parameters for Monitoring Rounds**Annual Monitoring Rounds:**

TCL volatile organics, TCL organochlorine pesticides/polychlorinated biphenyls, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, thallium.

Quarterly Monitoring Rounds:

TCE (trichloroethene), 1,1,1-trichloroethane, nitrate, nitrite, ortho-phosphate, fluoride, chloride, sulfate, ammonia, barium, calcium, iron, magnesium, manganese, potassium, sodium, alkalinity, specific conductance, temperature, pH.

* The May quarterly sampling effort requires measurement of all analytes listed above (annual plus quarterly parameters). For further information see Phase II RI Supplemental Work Plan (DOE/RL-90-37).

Table 3-8. Summary of 1100-EM-1 Operable Unit Soil Contaminants of Potential Concern and Maximum Contaminant Concentrations. (Page 1 of 1)

Contaminant	1100-1 (mg/kg)	1100-2 (mg/kg)	1100-3 (mg/kg)	1100-4 (mg/kg)	UN-1100-6 (mg/kg)	Horn Rapids Landfill (mg/kg)	Ephemeral Pool (mg/kg)
Antimony	-	-	-	-	-	15.6	-
Arsenic	3.2	-	-	5.8	-	6.6	-
Barium	-	-	-	-	-	1,320	-
Beryllium	-	-	-	0.93	-	1.3	-
Cadmium	-	-	-	-	-	2.4	-
Chromium	-	16.8	14	-	-	1,250	-
Cobalt	-	-	17.8	-	-	42.5	-
Copper	37.9	24.4	31.7	19.8	-	1,280	-
Cyanide	-	-	-	-	-	0.58	-
Lead	268	94.6	26.4	5.7	22.1	854	54.2
Manganese	-	366	436	-	-	501	-
Mercury	0.39	-	-	-	-	1.3	-
Nickel	20.9	-	-	-	-	557	-
Selenium	-	-	-	-	-	0.97	-
Silver	-	-	-	2	-	7.7	-
Thallium	-	0.48	0.4	0.48	-	3.1	-
Vanadium	118	-	-	-	-	101	-
Zinc	100	56.6	60	63.8	111	3,160	67.5
BEHP	-	-	-	-	25,000	-	-
Beta-HCH	-	-	-	-	-	0.094	-
Chlordane	-	-	-	-	1.86	-	2.8
Chlorobenzene	-	0.006	-	-	-	-	-
DDT	-	0.16	-	-	0.17	1.98	-
Endosulfan II	-	-	-	-	-	0.11	0.16
Endrin	-	-	-	-	-	0.42	0.039
Heptachlor	-	-	-	-	0.065	0.02	0.029
2-Hexanone	-	-	-	-	0.053	-	-
Naphthalene	-	-	-	-	-	8.2	-
PCBs	-	-	-	-	-	102	42
Tetrachloroethene	-	0.035	-	-	-	0.006	-
Trichloroethene	-	0.006	-	-	-	-	-
1,1,1-Trichloroethane	-	-	-	-	0.035	-	-

- Indicates not a contaminant at this subunit
Note: This table includes data from the Phase 1 RI and Phase 2 RI.

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TABLE 3-9. Maximum Concentration of Groundwater Constituents Exceeding Background or MCL's for Metals, Sampling Rounds 5 Through 9.

MONITORING WELL			MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12					
			S41-E11	S34-E10	S41-E12	S38-E12A	S38-E12B	S37-E11	S38-E11	S31-E08	S32-E08	S30-E10A	S30-E10B	S31-E10A					
METALS (ppb)	MCL's	Background Level																	
Aluminum	50-200 (2)	152																	
Calcium		74600	88700											197000					
Chromium	100 (1)	7.8	48.4	40.1	170	10.4	21.5	11.6	24	19.4	22.5	98300	111000	115000					
Iron	300 (2)	820	2050																
Lead	50 (4)	13.7																	
Magnesium		20200	42100																
Nickel	100 (3)	15	134											140	22600	23300			
Potassium		7140	8180											13900	8070	7800	8710	9830	9190
Sodium		29500	56900																
Zinc		8.3			34	22.6	21	21.2	223	21.4	25.3	30500	35600	31600					

MONITORING WELL			MW-13	MW-14	MW-15	MW-17	MW-18	MW-19	MW-20	MW-21	MW-22				
			S31-E10B	S31-E10C	S31-E10D	S31-E13C	S37-E12	S32-E11	S29-E11	S31-E10E	S31-E11	S29-E12	S30-E15A	S32-E13A	
METALS (ppb)	MCL's	Background Level													
Aluminum	50-200 (2)	152													
Calcium		74600	105000	109000	93300	487	629			746	621				
Chromium	100 (1)	7.8	18.7	15	10.9	57.5	43.6	10.3	53.3	55.7	19.8			80800	123000
Iron	300 (2)	820	901												
Lead	50 (4)	13.7													
Magnesium		20200	21300	22400											
Nickel	100 (3)	15													
Potassium		7140	8560	9010	8420			9410	7770						
Sodium		29500	29700	31100											
Zinc		8.3			79.6	31.5	21.6	28.1			91.4	56.2	22.8		

- (1) National Revised Primary Drinking Water Regulations - Maximum Contaminant Levels (MCL's)
- (2) National Secondary Drinking Water Regulations - Secondary Maximum Contaminant Levels
- (3) Proposed National Primary Drinking Water Regulations - Maximum Contaminant Levels
- (4) Primary Drinking Water Regulations - Maximum Contaminant Levels (effective through December 7, 1992)

NOTES:

1. Monitoring well MW-3 concentrations are disregarded because of problems with well development and high levels of turbidity observed in the samples.

2. MCL's = Maximum Contaminant Levels

TABLE 3-10. Maximum Concentration of Groundwater Constituents Exceeding Background or MCL's for Wet Chemistry, Sampling Rounds 5 Through 9.

MONITORING WELL			MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12
			S41-E11	S34-E10	S41-E12	S38-E12A	S38-E12B	S37-E11	S38-E11	S31-E08	S32-E08	S30-E10A	S30-E10B	S31-E10A
WET CHEMISTRY (ppm)	MCL's	Background Level												
Ammonia		0.15									0.17		0.21	0.87
Fluoride (F)	4 (1)	0.5		0.7	0.8	0.6	0.6	0.6	0.9	0.8		0.9	1.5	1
Chloride (Cl)	250 (2)	22.1			110				25			26	26.2	
Phosphate (PO4-P)		1.0												
Sulfate (SO4)	250 (2)	42.5		45.5					49	68		75	81	78

MONITORING WELL			MW-13	MW-14	MW-15	MW-17	MW-18	MW-19	MW-20	MW-21	MW-22			
			S31-E10B	S31-E10C	S31-E10D	S31-E13C	S37-E12	S32-E11	S29-E11	S31-E10E	S31-E11	S29-E12	S30-E15A	S32-E13A
WET CHEMISTRY (ppm)	MCL's	Background Level												
Ammonia		0.15	0.32	1	0.22		0.3		0.23		0.16			
Fluoride (F)	4 (1)	0.5	1.1	1	1		0.7	0.8	1	1.1	1	0.7		0.6
Chloride (Cl)	250 (2)	22.1												
Phosphate (PO4-P)		1.0								1.9	1.1			
Sulfate (SO4)	250 (2)	42.5	68	7.6	58				89.6					

(1) National Revised Primary Drinking Water Regulations - Maximum Contaminant Levels
 (2) National Secondary Drinking Water Regulations - Secondary Maximum Contaminant Levels

TABLE 3-11. Maximum Concentration of Groundwater Constituents Exceeding Background or MCL's for VOA's, Semi-VOA's, and Pesticides, Sampling Rounds 5 Through 9.

MONITORING WELL	MW-1 MW-2 MW-3 MW-4 MW-5 MW-6 MW-7 MW-8 MW-9 MW-10 MW-11 MW-12											
	S41-E11	S34-E10	S41-E12	S38-E12A	S38-E12B	S37-E11	S38-E11	S31-E08	S32-E08	S30-E10A	S30-E10B	S31-E10A
VOAs, Semi, Pest (ppb)	MCL's	Background Level										
Methylene Chloride		1										
Acetone		10										
Chloroform		1										
1,1,1-Trichloroethane	200 (1)	1.2										
Trichloroethene	5 (1)	1										
Tetrachloroethene	5 (1)	1										
Toluene		1										
C12 Hydrocarbon		NA										
Diethylphthalate		10										

MONITORING WELL	MW-13 MW-14 MW-15 MW-17 MW-18 MW-19 MW-20 MW-21 MW-22											
	S31-E10B	S31-E10C	S31-E10D	S31-E13C	S37-E12	S32-E11	S29-E11	S31-E10E	S31-E11	S29-E12	S30-E15A	S32-E13A
VOAs, Semi, Pest (ppb)	MCL's	Background Level										
Methylene Chloride		1										
Acetone		10										
Chloroform		1										
1,1,1-Trichloroethane	200 (1)	1.2										
Trichloroethene	5 (1)	1										
Tetrachloroethene	5 (1)	1										
Toluene		1										
C12 Hydrocarbon		NA										
Diethylphthalate		10										

(1) National Revised Primary Drinking Water Regulations - Maximum Contaminant Levels

J = Estimated Value

TABLE 3-12. Maximum Concentration of Groundwater Constituents Exceeding Background or MCL's for Radionuclides, Sampling Rounds 5 Through 9.

MONITORING WELLS			MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12
			S41-E11	S34-E10	S41-E12	S36-E12A	S38-E12B	S37-E11	S38-E11	S31-E08	S32-E08	S30-E10A	S30-E10B	S31-E10A
RADIONUCLIDES (pCi/L)	MCL's	Background Level												
Gross Alpha	15 (1)	8.4	11±5										9.6±7.1	
Gross Beta	50 (2)	18	24±2.0		18±2.0							63	61±6.0	66±6.0

MONITORING WELLS			MW-13	MW-14	MW-15	MW-17	MW-18	MW-19	MW-20	MW-21	MW-22			
			S31-E10B	S31-E10C	S31-E10D	S31-E13C	S37-E12	S32-E11	S29-E11	S31-E10E	S31-E11	S29-E12	S30-E15A	S32-E13A
RADIONUCLIDES (pCi/L)	MCL's	Background Level												
Gross Alpha	15 (1)	8.4	8.4±4.4											
Gross Beta	50 (2)	18	61	70	50±5							87±7		

(1) National Primary Drinking Water Regulations - Maximum Contaminant Levels
 (2) Washington Administrative Code 246-290-310 - Maximum Contaminant Levels

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4.0 NATURE AND EXTENT OF CONTAMINATION

Section 4.0 presents the nature and extent of contamination detected within the 1100-EM-1 Operable Unit. The focus is on the significant contaminants and their distribution throughout the Operable Unit. All contaminants detected in concentrations exceeding background levels were identified in section 3.0. This extensive list was further screened to include only those contaminants exceeding published criteria, or where anomalies were measured (table 3-6). In this section, the screened list is reviewed and risk-based screening criteria is applied. Contaminants remaining after the risk-based evaluation will constitute the contaminants of concern for the Operable Unit. Further development and discussion of the risk-based screening and risk assessment process are presented in section 5.0 and appendix K.

Of the soil contaminants identified within the 1100-EM-1 Operable Unit in concentrations exceeding background levels, aluminum, calcium, iron, magnesium, potassium, and sodium are eliminated from further consideration. These are non-toxic, essential micronutrients that do not pose an environmental or human health threat at the concentration measured.

Groundwater contaminants are limited to trichloroethene and nitrate contaminated plumes emanating from SPC property and extending beneath the HRL subunit. All other contaminants detected during the Phase I and Phase II groundwater sampling rounds were eliminated from further consideration due to their concentrations being below MCL values. Groundwater contamination will not be discussed for subunits other than Horn Rapids Landfill.

The distribution of surface soil contamination present in concentrations above upper tolerance levels (UTL) are illustrated in figures 4-1 through 4-24. All maps were developed by locating soil sampling sites having the elevated analyte values, estimating the horizontal extent of contamination based on surface topographic features, and by postulating the most plausible explanation for the existence of the concentration at that point. For example, a single soil sample collected from the floor of a surface depression was assumed to be representative of the total area of the depression floor. The mode of contaminants accumulation was interpreted as runoff flowing into the depression and depositing contaminated soil or, alternatively, wind deposition of contaminated sediments. A single positive soil analysis from the floor of a depression where more than a single soil sample was obtained was interpreted as being representative of the depression floor immediately adjacent to the sampling location, possibly indicating the presence of a localized low within the depression. Contaminant concentrations located on flat terrain were shown to have a lateral extent large enough to be obvious at the map scale used; the mode of contaminant accumulation not being as easily theorized as elevated concentrations present within surface depressions. Surface soil contamination maps are not to be construed as absolutes, but only as indications of the general distribution of the contaminants within the boundaries of each subunit.

4.1 BATTERY ACID PIT - 1100-1

Elevated concentrations of contaminants detected within the surface and subsurface soils at the 1100-1, Battery Acid Pit subunit are listed in paragraph 3.1.1. Results of preliminary risk-based screening for the remaining soil contaminants present at this subunit are summarized in table 4-1. The only contaminants of potential concern at the 1100-1, Battery Acid Pit subunit are vanadium and arsenic. Both were observed in a single soil sample, A1004S, obtained from the depth interval of 1.6 to 1.9 m (5.3 to 6.1 ft) below the ground surface at borehole BAP-1 (see figure 3-1). Neither contaminant was detected in surface soil samples. The remaining contaminants (such as copper, mercury, nickel, and zinc) pose no environmental or health risks at the measured concentrations. Lead concentration is below published cleanup criteria.

4.2 PAINT AND SOLVENT PIT - 1100-2

Contaminants detected in soil samples at the 1100-2, Paint and Solvent Pit subunit are listed in paragraph 3.2.1. As insufficient data are available to ascertain speciation, chromium is conservatively assumed to be in the hexavalent (most toxic) state for the purposes of this report. Results of preliminary risk-based screening for soil contaminants at the 1100-2, Paint and Solvent Pit subunit are summarized in table 4-2. The only contaminant of potential concern for the 1100-2 subunit is chromium. Elevated chromium is found within only a single surface soil sample obtained immediately prior to the drilling of borehole DP-9 (figure 4-1). The remaining contaminants (copper, manganese, thallium, zinc, chlorobenzene, DDT, PCE, and TCE) pose no environmental or health risks at the measured concentrations. Lead levels are below the published cleanup criteria.

4.3 ANTIFREEZE AND DEGREASER PIT - 1100-3

Soil contaminants detected at concentrations above background levels at the 1100-3, Antifreeze and Degreaser Pit subunit are listed in paragraph 3.3.1. Table 4-3 summarizes the results of the preliminary risk-based screening for the subunit. Chromium exceeds its screening criteria and is thus regarded as the only contaminant of potential concern at the 1100-3 subunit.

Chromium was encountered in concentrations exceeding background levels at only one surface location in the extreme northeast portion of the Antifreeze and Degreaser Pit (figure 4-2). This substance was not encountered at elevated levels in the subsurface stratum of the 1100-3 subunit soils. Other contaminants (cobalt, copper, manganese, and zinc) occur at levels that pose no substantive threat to the environment or public health. Lead occurs at levels well below published cleanup criteria.

Table 4-1. Preliminary Risk-Based Screening for Soil Contaminants at the 1100-1 Subunit.

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ¹	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Arsenic	32	3.0E-04 ^a	2.4	--	--	1.7E+00 ^a	0.038	5.0E+01 ^{a,b}	4.3	--
Copper	37.9	4.0E-02 ^d	320	--	--	--	--	--	--	--
Lead	286	ND	--	ND	--	ND	--	ND	--	500-1,000 ^e
Mercury	0.38	3.0E-04 ^b	2.4	8.5E-05 ^b	1,100	--	--	--	--	--
Nickel	20.9	2.0E-02 ^a	160	--	--	--	--	8.4E-01 ^a	78	--
Vanadium	118	7.0E-03 ^b	56	--	--	--	--	--	--	--
Zinc	100	2.0E-01 ^b	1,600	--	--	--	--	--	--	--

¹Integrated Risk Information System (IRIS, EPA 1992a)
²Health Effects Assessment Summary Tables (HEAST, EPA 1992b)
³Based on 30% absorption of inhaled arsenic (EPA 1992b)
⁴EPA 1998b
⁵Surrogate based on proposed arsenic unit of risk of 5E-05 µg/L (EPA 1991).
⁶EPA Region-10 (see Appendix A)
 -- Indicates not available
 ND Not Determined
 Note: Shaded areas indicate screening criterion exceeded

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Table 4-2. Preliminary Risk-Based Screening for Soil Contaminants at the 1100-2 Subunit.

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ²	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Chromium	16.6	5.0E-03*	40	--	--	--	--	4.1E+01*	1.8	--
Copper	24.4	4.0E-02	320	--	--	--	--	--	--	--
Lead	94.6	ND	--	ND	--	ND	--	ND	--	500-1000*
Manganese	366	1.0E-01*	800	1.1E-04*	1,400	--	--	--	--	--
Thallium	0.48	7.0E-05 ³	0.58	--	--	--	--	--	--	--
Zinc	58.8	2.0E-01 ¹	1,800	--	--	--	--	--	--	--
Chlorobenzene	0.006	2.0E-02*	180	5E-03*	65,000	--	--	--	--	--
DDT	0.18	5.0E-04*	4.0	--	--	3.4E-01*	0.19	3.4E-01*	190	--
Tetrachloroethene	0.035	1.0E-02*	80	--	--	5.2E-02 ⁴	1.2	2E-03 ⁴	33,000	--
Trichloroethene	0.006	--	--	--	--	1.1E-02	5.8	6.0E-03	11,000	--

¹Integrated Risk Information System (IRIS, EPA 1992a)
²Health Effects Assessment Summary Tables (HEAST, EPA 1992b)
³EPA 1989b
⁴EPA-Region 10 (see Appendix A)
 -- indicates not available
 ND Not Determined
 Note: Shaded areas indicate screening criterion exceeded

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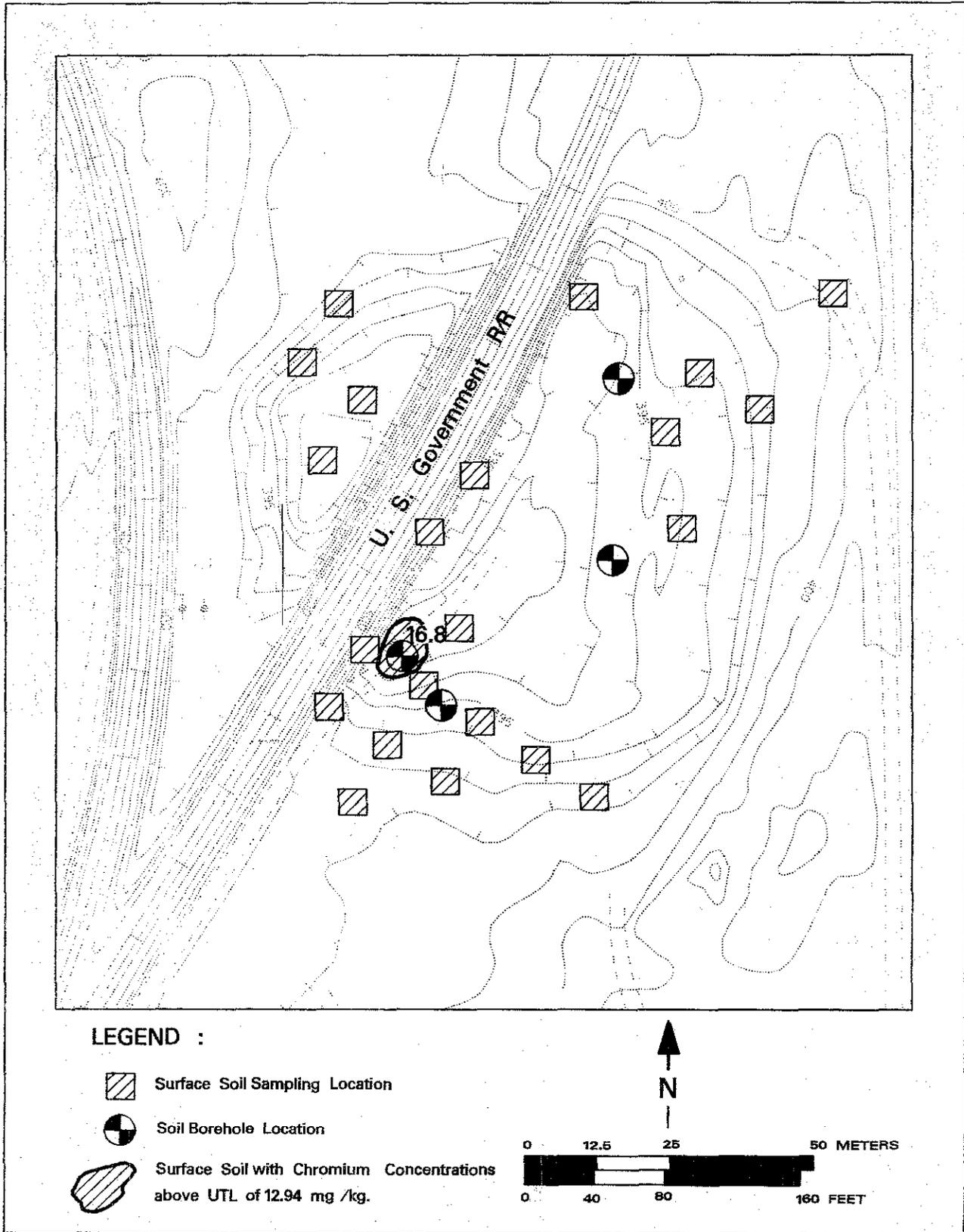


Figure 4-1. 1100-2, Paint and Solvent Pit – Chromium Distribution in Surface Soils

Table 4-3. Preliminary Risk-Based Screening for Soil Contaminants at the 1100-3 Subunit.

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ¹	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Chromium	14	5.0E-03*	40	--	--	--	--	4.1E+01*	1.0	--
Cobalt	17.8	6.0E-02 ^c	480	--	--	--	--	--	--	--
Copper	31.7	4.0E-02 ^c	320	--	--	--	--	--	--	--
Lead	28.4	ND	--	ND	--	ND	--	ND	--	500-1,000 ^d
Manganese	436	1.0E-01*	800	1.1E-04*	1,400	--	--	--	--	--
Zinc	60	2.0E-01 ^a	1,600	--	--	--	--	--	--	--

¹Integrated Risk Information System (IRIS, EPA 1992a)
²Health Effects Assessment Summary Tables (HEAST, EPA 1992b)
³Based on 30% absorption of inhaled arsenic (EPA 1992b)
⁴EPA 1989b
⁵Surrogate based on proposed arsenic unit of risk of 5E-05 µg/L (EPA 1991)
⁶EPA Region-10 (see Appendix A)
 -- Indicates not available
 ND Not Determined
 Note: Shaded areas indicate screening criterion exceeded

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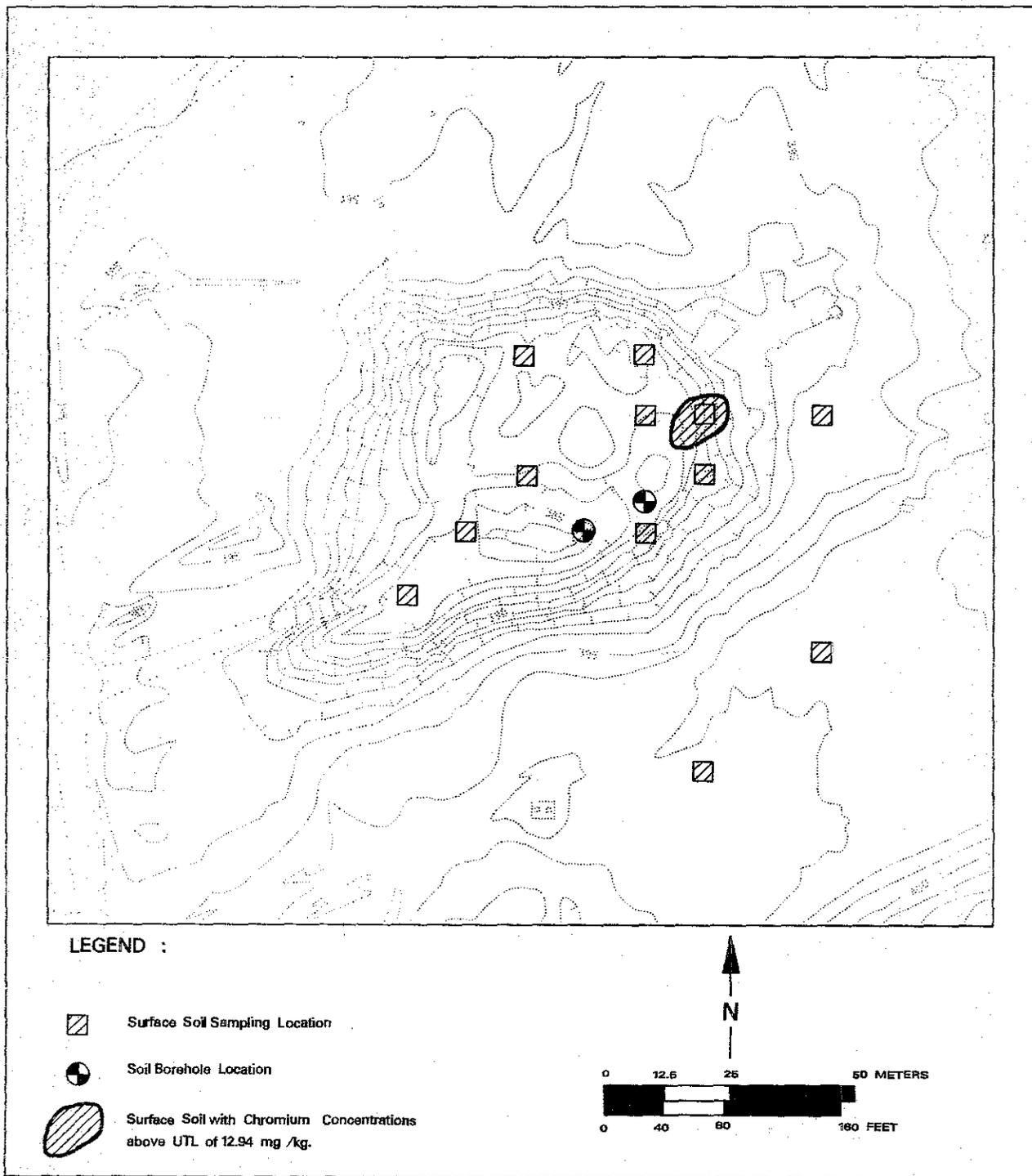


Figure 4-2. 1100-3, Antifreeze and Degreaser Pit - Chromium Distribution in Surface Soils.

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4.4 ANTIFREEZE TANK SITE - 1100-4

Elevated contaminant parameters detected in the subsurface soils at and near the 1100-4, Antifreeze Tank Site subunit are listed in paragraph 3.4.1. Aluminum and potassium, the only two contaminants associated with the actual location of the former antifreeze disposal tank, were eliminated from further consideration for reasons previously stated in section 4.0. No organic compounds were detected at elevated levels within this subunit. The remaining parameters were detected at elevated concentrations only at the location of a nearby groundwater monitoring well, MW-3, to be discussed in the following paragraph.

Preliminary risk-based screening of contaminants detected near the Antifreeze Tank Site in soil samples obtained during the installation of monitoring well MW-3 (see figure 3-1) indicates that arsenic and beryllium are the only parameters that exceed screening criteria (table 4-4). Arsenic was encountered at an elevated concentration in only a single sample obtained from below the water table, approximately 15 m (50 ft) below the ground surface. Beryllium was detected at elevated concentrations throughout the soil column penetrated during the installation of well MW-3. Concentrations detected varied from a low of 0.51 milligrams (mg)/kg to a high of 0.93 mg/kg. The maximum concentration was detected at a depth of approximately 7.9 m (26 ft) below the ground surface. There was no apparent pattern to the distribution of beryllium within the soil column.

Other contaminants (copper, silver, thallium, and zinc) are present at levels posing no substantive risk to public health or the environment. Lead is measured at levels below cleanup criteria.

4.5 DISCOLORED SOIL SITE - UN-1100-6

Inorganic and organic contaminants present in the surface soils of the UN-1100-6, Discolored Soil Site subunit are listed in paragraph 3.5.1. Table 4-5 summarizes the preliminary risk-based screening for the UN-1100-6 subunit.

Because there are insufficient data to develop an RfD for di-n-octyl phthalate, and the substance is not a known carcinogen, this compound is combined and evaluated with the carcinogen, BEHP. Insignificant concentrations of di-n-octyl phthalate, as compared with BEHP, provide further justification for combining these two substances for the purposes of further evaluation.

The potential contaminants of concern for the UN-1100-6, Discolored Soil Site subunit - BEHP, chlordane, and heptachlor - were each encountered in several samples. Figure 4-3 shows the areal distribution of BEHP at the subunit. Figures 4-4 and 4-5 illustrate the distribution of alpha- and gamma-chlordane within the UN-1100-6 subunit. Figure 4-6 presents the areal extent of heptachlor contamination at the Discolored Soil Site. All surface contamination is limited to the eastern end of the depression; coincident with the actual area of stained soil. Subsurface sampling was not performed at this subunit, but the soil staining appears to be limited to the top 20.3 to 25.4 cm (8 to 10 inches) of soil.

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Table 4-4. Preliminary Risk-Based Screening for Soil Contaminants at the 1100-4 Subunit.

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ⁻¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ⁻¹	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Arsenic	5.8	3.0E-04*	2.4	--	--	1.7E+00*	0.038	5.0E+01*	4.3*	--
Beryllium	0.93	5.0E-03*	40	--	--	4.3E+00*	0.015	6.4E+00*	7.8	--
Copper	19.8	4.0E-02†	320	--	--	--	--	--	--	--
Lead	5.7	ND	--	ND	--	ND	--	ND	--	500-1000‡
Silver	2	5.0E-03*	40	--	--	--	--	--	--	--
Thallium	0.48	7.0E-05‡	0.56	--	--	--	--	--	--	--
Zinc	83.8	2.0E-01‡	1,600	--	--	--	--	--	--	--

*Integrated Risk Information System (IRIS, EPA 1992a)
 †Health Effects Assessment Summary Tables (HEAST, EPA 1992b)
 ‡Based on 30% absorption of inhaled arsenic (EPA 1992b)
 §EPA 1989b
 ¶Surrogate based on proposed arsenic unit of risk of 6E-05 µm/L (EPA 1991)
 ††EPA Region-10 (see Appendix A)
 -- Indicates not available
 ND Not Determined
 Note: Shaded area indicate screening criterion exceeded

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Table 4-5. Preliminary Risk-Based Screening for Soil Contaminants at the UN-1100-6 Subunit.

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ¹	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Lead	22.1	ND	--	ND	--	ND	--	ND	--	500-1,000 ²
Zinc	111	2.0E-01 ³	1,800	--	--	--	--	--	--	--
BEHP	25,000	2.0E-02 ⁴	180	--	--	1.4E-02 ⁵	4.5	1.4E-02 ⁴	4,600	--
Chlordane	1.86	6.0E-05 ⁶	0.49	--	--	1.3E+00 ⁷	0.049	1.3E+00 ⁷	51	--
DDT	0.17	5.0E-04 ⁸	4.0	--	--	3.4E-01 ⁹	0.19	3.4E-01 ⁹	190	--
Haptachlor	0.085	5.0E-04 ⁸	4.0	--	--	4.5E+00 ⁷	0.014	4.5E+00 ⁷	14	--
2-hexanone	0.053	5.0E-02 ⁴	400	9.0E-02 ¹⁰	1,000,000	--	--	--	--	--
1,1,1-trichloroethane	0.035	9.0E-02	720	3E-01	4,000,000	--	--	--	--	--

¹Integrated Risk Information System (IRIS, EPA 1992a)
²Health Effects Assessment Summary Tables (HEAST, EPA 1992b)
³EPA 1989b
⁴Surrogate inhalation SF assumed to equal BEHP oral SF
⁵Surrogate based on proposed arsenic unit of risk of 5E-05 µm/L (EPA 1991)
⁶Surrogate based on 2-butanone (HEAST, EPA 1992b)
-- Indicates not available
ND Not Determined
Note: Shaded areas indicate screening criterion exceeded

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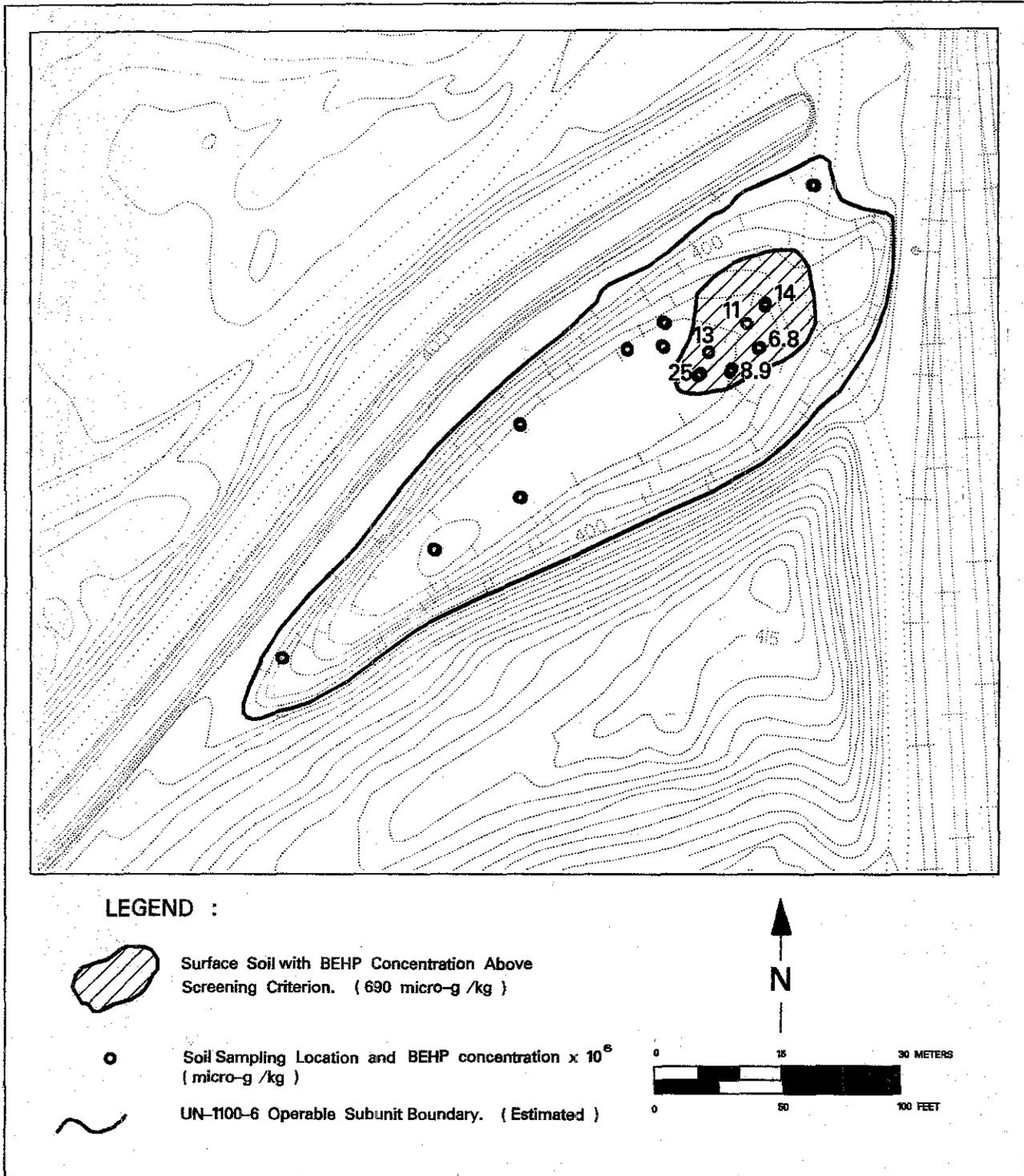


Figure 4-3. UN-1100-6, Discolored Soil Site – BEHP Distribution in Surface Soils at Concentrations above a UTL of 690 micro-g /kg.

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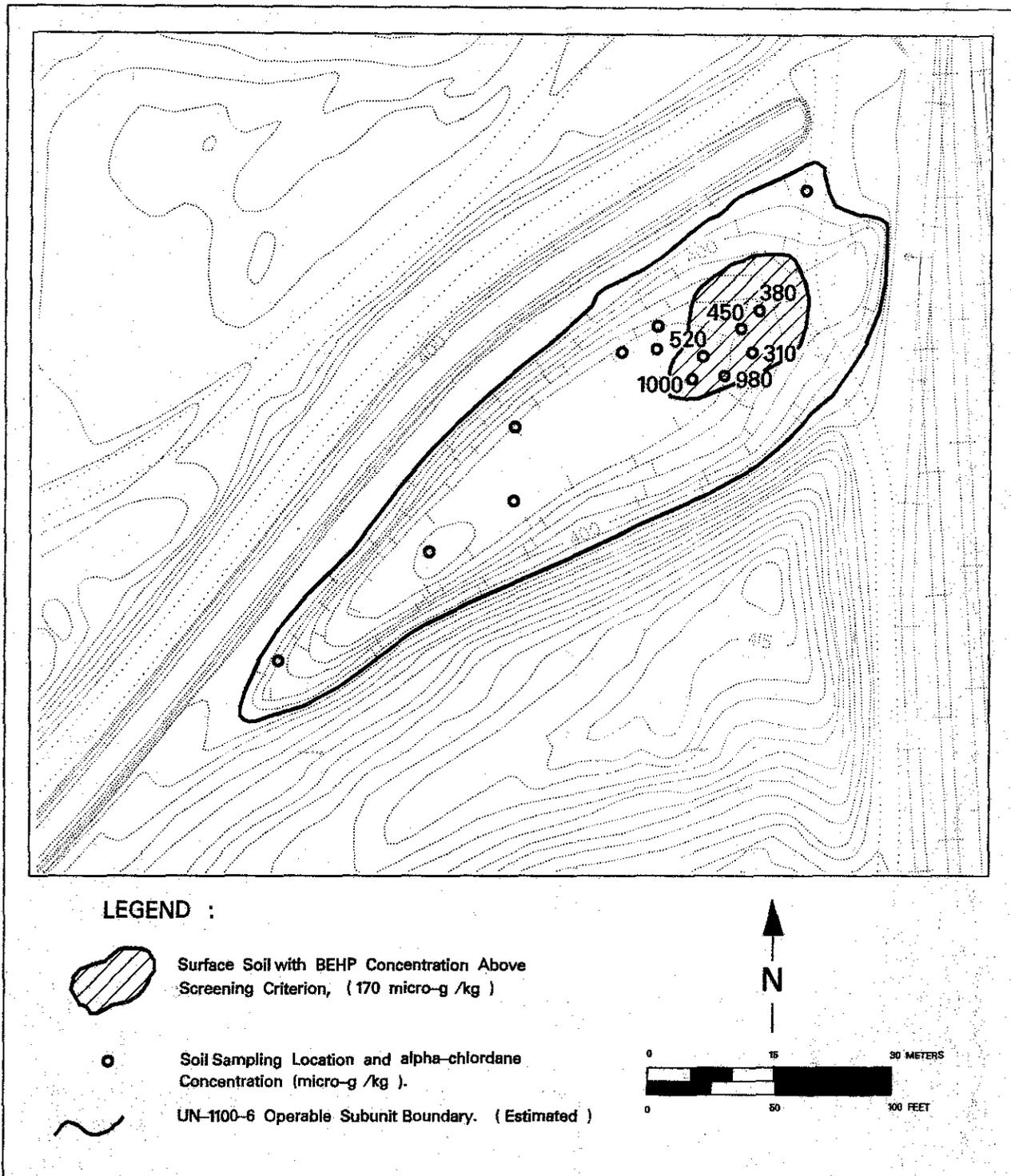


Figure 4-4. UN-1100-6, Discolored Soil Site - alpha - Chlordane Distribution in Surface Soils at Concentrations above a UTL 170 micro-g /kg.

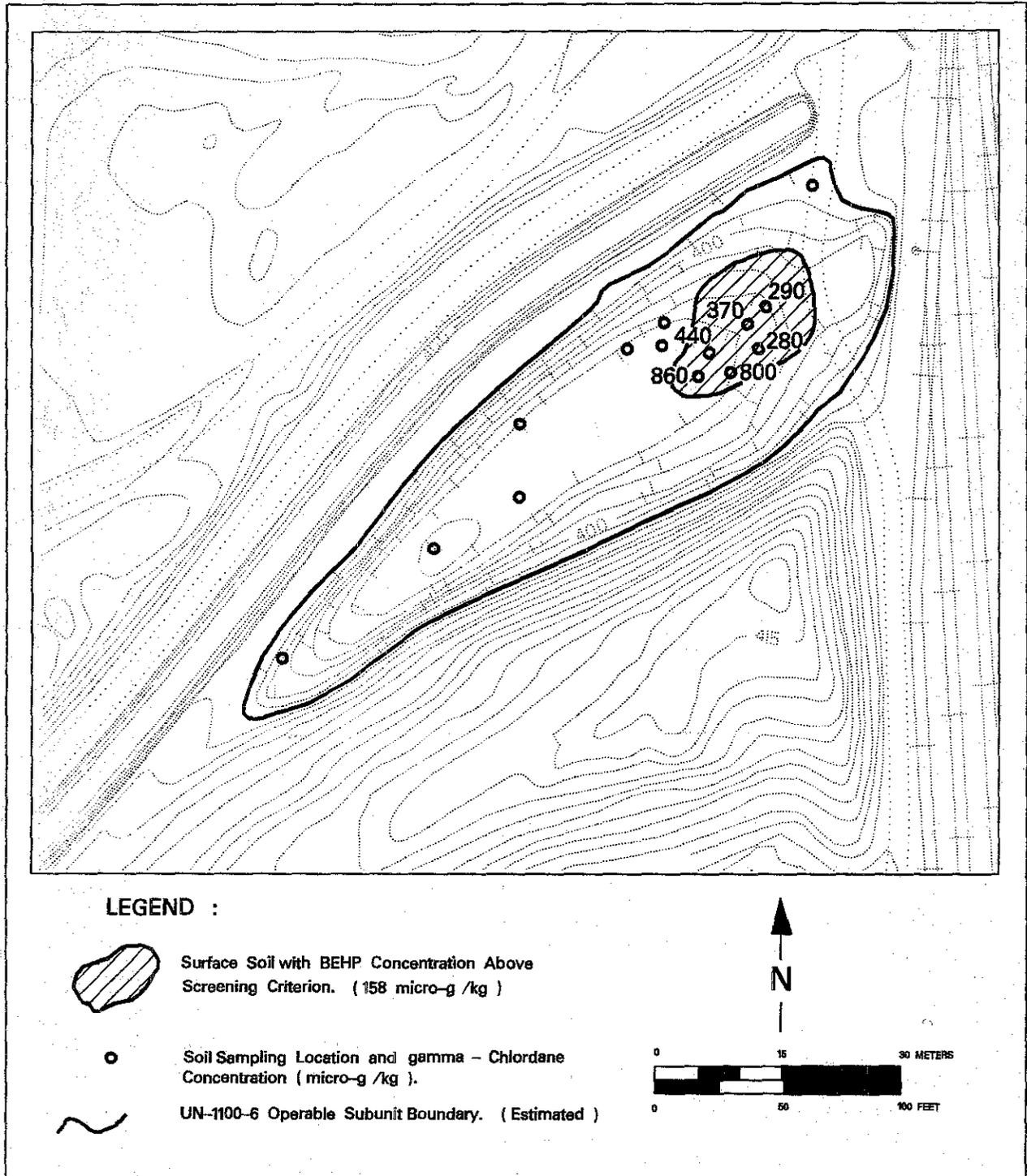


Figure 4-5. UN-1100-6, Discolored Soil Site - gamma - Chlordane Distribution in Surface Soils at Concentrations above a UTL of 158 micro-g /kg.

9 3 1 2 8 6 2 0 3 5 6

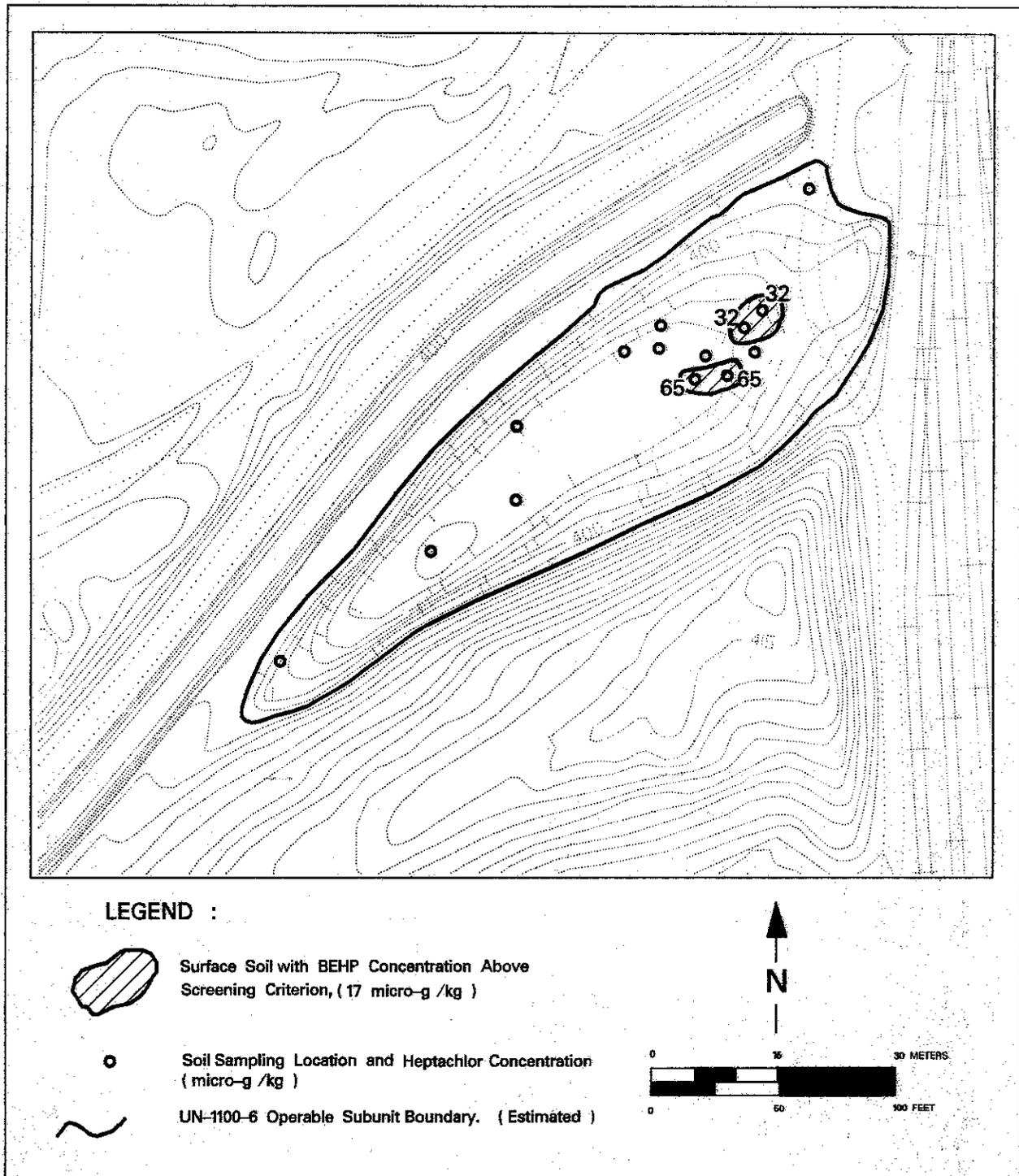


Figure 4-6. UN-1100-6, Discolored Soil Site - Heptachlor Distribution in Surface Soils at Concentrations above a UTL of 17 micro-g /kg.

Other contaminants (zinc; DDT; 2-hexanone; and 1,1,1-trichloroethane) occur at levels that do not pose substantive risks to public health or the environment. Lead is present at levels below regulatory cleanup criteria.

4.6 EPHEMERAL POOL

The contaminants detected at the Ephemeral Pool subunit are listed in paragraph 3.6.1. The preliminary risk-based screening for the identified contaminants is presented in table 4-6. Chlordane, heptachlor, and PCB's are the contaminants of potential concern at this subunit. Heptachlor was detected in one of two soil samples collected within the subunit during the Phase I investigation. The exact position of the sample site within the subunit is uncertain due to the lack of a sample location survey at the time the sample was collected. During Phase II soil sampling, heptachlor was not detected. Chlordane was identified at all sampling locations during the Phase II investigation with relatively high concentrations detected at either end of the Ephemeral Pool feature; sample sites E-1, E-5, and E-6. Elevated PCB concentrations were identified at sample locations E-2 and E-3 (figure 4-7). Sampling of subsurface soils was not performed during either the Phase I or Phase II investigations. It is assumed that both the PCB and chlordane contaminants are restricted to near-surface soils due to their relative immobility in soil/water systems.

Other contaminants (zinc, Endosulfan II, and Endrin) are measured at levels that pose no substantive risk to the environment or public health. Lead is measured at levels below cleanup criteria.

4.7 HORN RAPIDS LANDFILL

As listed in paragraph 3.7.1, numerous inorganic contaminants were encountered in the surface and subsurface soils of HRL. The only subsurface organic contaminants detected were PCB's in borehole HRL-4 and in exploration trench test pit (TP) -1.

Table 4-7 summarizes the results of the preliminary risk-based screening for soil contaminants at HRL. The contaminants of potential concern for HRL subunit are:

- | | | |
|-------------|------------|---------------------|
| ● Antimony | ● Copper | ● Beta-HCH |
| ● Arsenic | ● Nickel | ● DDT |
| ● Barium | ● Thallium | ● Heptachlor |
| ● Beryllium | ● Vanadium | ● PCB's |
| ● Cadmium | ● Zinc | ● Chlordane |
| ● Chromium | ● Cyanide | ● Endrin |
| ● Cobalt | ● Lead | ● Endosulfan II |
| | ● Mercury | ● Napthalene |
| | ● Selenium | ● Tetrachloroethene |
| | ● Silver | |

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Table 4-6. Preliminary Risk-Based Screening for Soil Contaminants at the Ephemeral Pool.

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ¹	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Lead	54.2	ND	--	ND	--	ND	--	ND	--	500-1,000*
Zinc	67.5	2.0E-01*	1,600	--	--	--	--	--	--	--
Chlordane	2.8	6.0E-05*	0.48	--	--	1.3E+00*	0.049	1.3E+00*	50	--
Endosulfan II	0.16	5E-05*	0.4	--	--	--	--	--	--	--
Endrin	0.039	3E-04*	2.4	--	--	--	--	--	--	--
Heptachlor	0.029	5.0E-04*	4.0	--	--	4.5E+00*	0.014	4.5E+00*	14	--
PCBs	42	--	--	--	--	7.7E+00*	0.008	7.7E+00*	8.5	1-25 ⁴

*Integrated Risk Information System (IRIS, EPA 1992a)
¹Health Effects Assessment Summary Tables (HEAST, EPA 1991)
²Surrogate inhalation SF assumed to be equal to PCB oral SF
³40 CFR 761
⁴EPA 1989b
 -- Indicates not available
 ND - Not determined
 Note: Shaded areas indicate screening criterion exceeded

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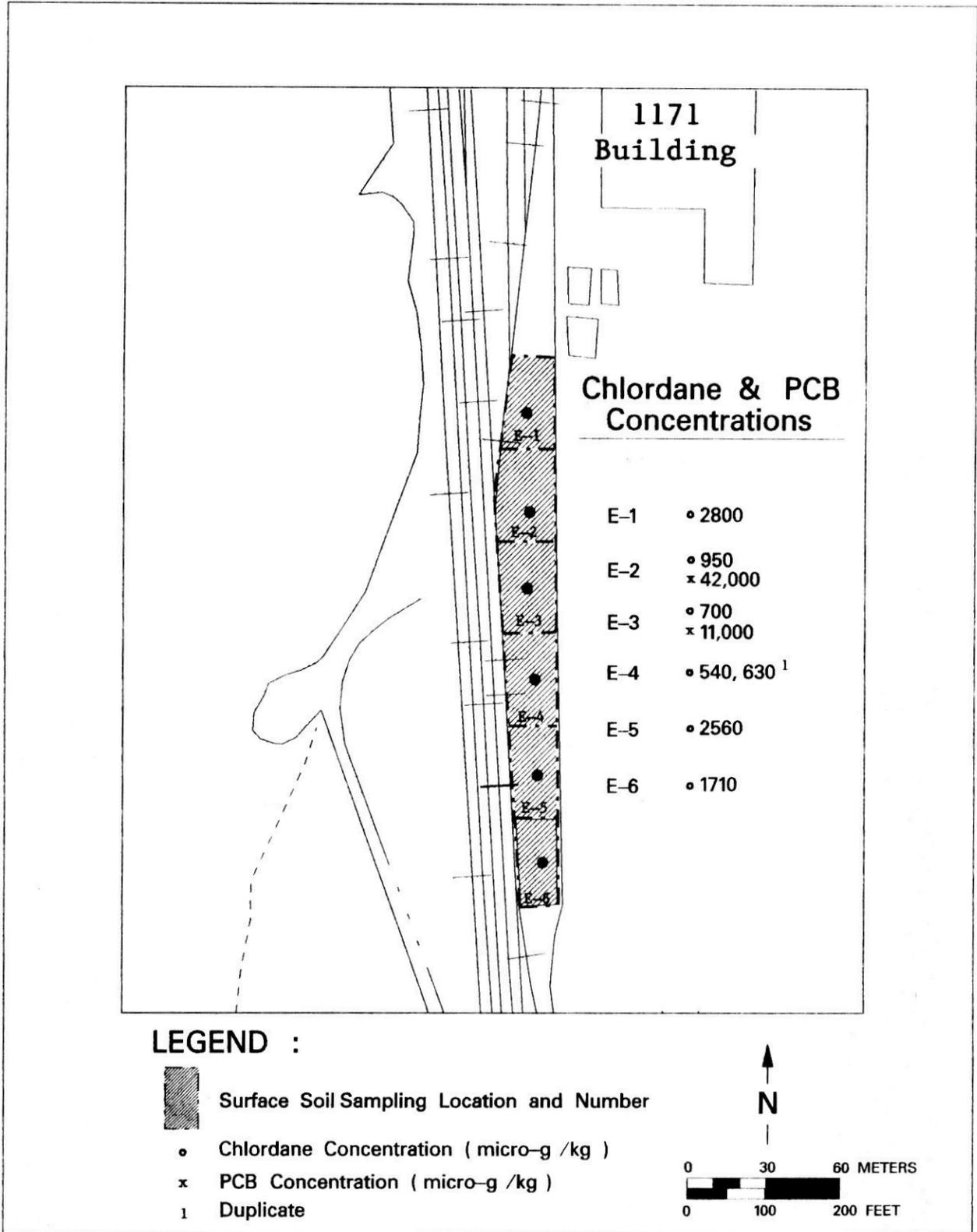


Figure 4-7. Ephemeral Pool - Chlordane and PCB Distribution in Surface Soils

Table 4-7. Preliminary Risk-Based Screening for Soil Contaminants at the Horn Rapids Landfill. (sheet 1 of 2)

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ¹	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Antimony	15.8	4.0E-04 ^a	3.2	--	--	--	--	--	--	--
Arsenic	6.8	3.0E-04 ^a	2.4	--	--	1.7E+00 ^a	0.038	5.0E+01 ^a	4.3 ^a	--
Barium	1320	7.0E-02 ^a	560	1.0E-04 ^b	1,300	--	--	--	--	--
Beryllium	1.3	5.0E-03	41	--	--	4.3E+00 ^a	0.015	8.4E+00 ^a	7.8	--
Cadmium	2.4	1.0E-03 ^a	8.0	--	--	--	--	6.1E+00 ^a	10	--
Chromium	1250	5.0E-03 ^a	40	--	--	--	--	4.1E+01 ^a	1.8	--
Cobalt	42.5	8.0E-02 ^c	480	--	--	--	--	--	--	--
Copper	1280	4.0E-02 ^c	320	--	--	--	--	--	--	--
Cyanide	0.56	2.0E-02 ^a	160	--	--	--	--	--	--	--
Lead	854	ND	--	ND	--	ND	--	ND	--	500-1,000 ^d
Manganese	501	1.0E-01 ^a	800	1.1E-04 ^a	1400	--	--	--	--	--
Mercury	1.3	3.0E-04 ^b	2.4	8.6E-05 ^b	1,100	--	--	--	--	--
Nickel	557	2.0E-02 ^a	160	--	--	--	--	8.4E-01 ^b	78	--
Selenium	0.97	5.0E-03 ^b	44	--	--	--	--	--	--	--
Silver	7.7	5.0E-03 ^a	40	--	--	--	--	--	--	--
Thallium	3.1	7.0E-05 ^a	0.56	--	--	--	--	--	--	--
Vanadium	101	7.0E-03 ^b	56	--	--	--	--	--	--	--
Zinc	3180	2.0E-01 ^b	1,600	--	--	--	--	--	--	--
Beta-HCH	0.094	--	--	--	--	1.8E+00 ^a	0.038	1.8E+00 ^a	36	--
DDT	1.98	5.0E-04 ^a	4.0	--	--	3.4E-01 ^a	0.18	3.4E-01 ^a	190	--
Endosulfan II	0.11	5.0E-05 ^a	0.4	--	--	--	--	--	--	--

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Table 4-7. Preliminary Risk-Based Screening for Soil Contaminants at the Horn Rapids Landfill. (sheet 2 of 2)

Parameter	Maximum Detected Soil Concentration (mg/kg)	Oral RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Inhalation RfD (mg/kg-d)	Soil Concentration at HQ=0.1 (mg/kg)	Oral SF (mg/kg-d) ¹	Soil Concentration at Oral ICR = 1E-07 (mg/kg)	Inhalation SF (mg/kg-d) ¹	Soil Concentration at Inhalation ICR = 1E-07 (mg/kg)	Regulatory Soil Cleanup Guidelines (mg/kg)
Endrin	0.42	3.0E-04*	2.4	--	--	--	--	--	--	--
Heptachlor	0.02	5.0E-04*	4.0	--	--	4.5E+00*	0.014	4.5E+00*	14	--
Naphthalene	8.2	4.0E-02 ^b	320	--	--	--	--	--	--	--
PCBs	102	--	--	--	--	7.7E+00*	0.008	7.7E+00 ^b	8.5	1-25 ^c
Tetrachloroethene	0.006	1.0E-02*	80	--	--	5.2E-02 ^d	1.2	2.0E-03 ^d	33,000	--

*Integrated Risk Information System (IRIS, EPA 1992a)
¹Health Effects Assessment Summary Tables (HEAST, EPA 1991 or EPA 1992b)
^bBased on 30% absorption of inhaled arsenic (EPA 1992b)
^cEPA 1989b
^dSurrogate inhalation SF assumed to equal BEHP oral SF
^eEPA-Region 10 (see Appendix A)
^fSurrogate oral and inhalation RfDs based on 2-butanone (HEAST, EPA 1992b)
^gSurrogate inhalation SF assumed to be equal to PCB oral SF
^h40 CFR 761
ⁱSurrogate based on proposed arsenic, unit of risk of 5E-05 µg/L (EPA 1991)
 -- Indicates not available
 ND = Not Determined
 Note: Shaded areas indicate screening criterion exceeded

4.8.1 Horn Rapids Landfill Soil Contaminants

The distribution of each contaminant within HRL subunit are discussed in the following paragraphs. UTL's for surface and subsurface soil contaminants were presented in tables 3-1 and 3-2, respectively. Maps providing the locations and designations of all surface sampling and borehole locations within the HRL subunit were included in figures 3-6 and 3-9.

4.8.1.1 Antimony. Antimony was detected in surface soil samples at concentrations above the UTL levels at three locations in the east-central portion of the landfill. Figure 4-8 shows the distribution of this analyte in the surface soils. Antimony was detected in only a single subsurface sampling location; borehole HRL-2 within the depth interval of 1.6 to 2.2 m (5.1 to 7.1 ft).

4.8.1.2 Arsenic. Arsenic was not detected in surface soils at concentrations above the UTL for this substance. Subsurface distribution was sporadic. It was detected in exploration trenches 7, 8, and 11 at depths between 1.2 and 1.5 m (4 and 5 ft), in borehole HRL-3 at a depth of 7.3 m (24 ft), and in borehole HRL-7 at an approximate depth of 1.0 m (10 ft).

4.8.1.3 Barium. The distribution of barium in the surface soils at HRL in concentrations above a UTL of 120.1 mg/kg is presented in figure 4-9. Only one subsurface sample yielded an elevated barium concentration; B00Z59, obtained from a depth of 1.2 m (4.0 ft) in exploration trench TP-11 (see figures 3-6 and 3-9).

4.8.1.4 Beryllium. Figure 4-10 presents the beryllium distribution at concentrations above UTL levels in surface soils at the HRL subunit. Beryllium was widespread in subsurface samples obtained from borings HRL-2 through -10. Concentrations above the subsurface UTL were detected throughout the length of the soil column penetrated [*i.e.*, depths of 4.6 to 8.5 m (15 to 28 ft)]. As discussed in section 2.0, these boreholes were sited to intentionally avoid penetrating assumed locations where waste had been buried during landfill operation. They, therefore, are assumed to penetrate undisturbed soil deposits for much of their depth. Only a single soil sample collected from a known disturbed area contained an elevated concentration of beryllium. Sample B00ZV3, gathered from a depth of 1.5 m (5.0 ft) in exploration trench TP-8, contained beryllium at a level exceeding the UTL.

4.8.1.5 Chromium. Chromium distribution in surface soils is illustrated in figure 4-11. It appears to be generally isolated to the eastern edge of the landfill; appearing in samples obtained from shallow depressions in the ground surface. Subsurface chromium contamination is scattered throughout the subunit. Boreholes HRL-4, -5, -6, and -8 show concentrations above UTL values at depths of approximately 4.6 m (15 feet). One soil sample from HRL-6 at a depth of 7.6 m (25 feet) also showed elevated chromium. Samples obtained during Phase II characterization of the landfill's waste disposal trenches contained elevated concentrations of chromium in exploration trenches TP-3A, -4, -5, and -11 at depths of 5.8, 3.7, and 1.2 m (19, 12, and 4 ft), respectively.

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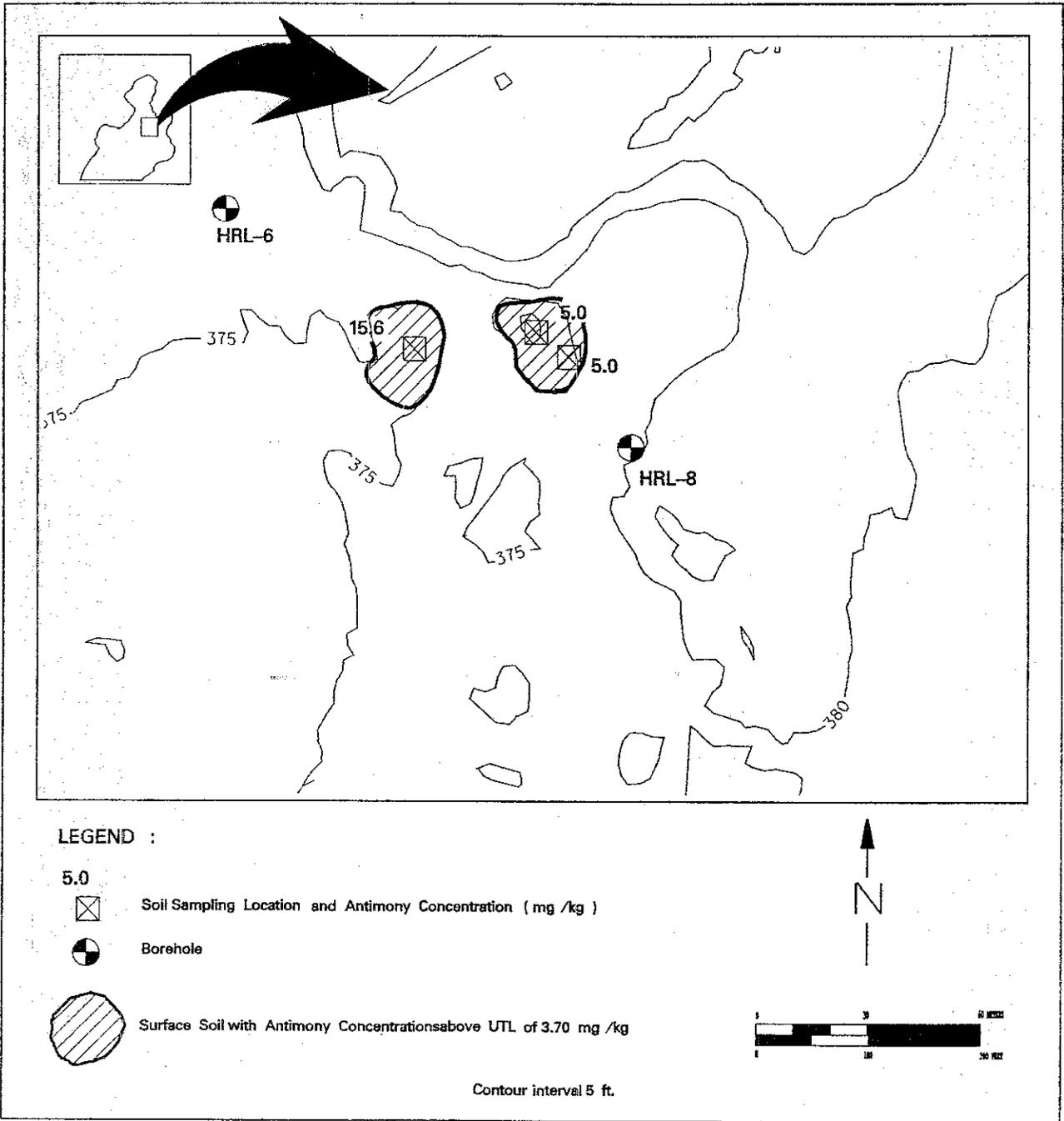
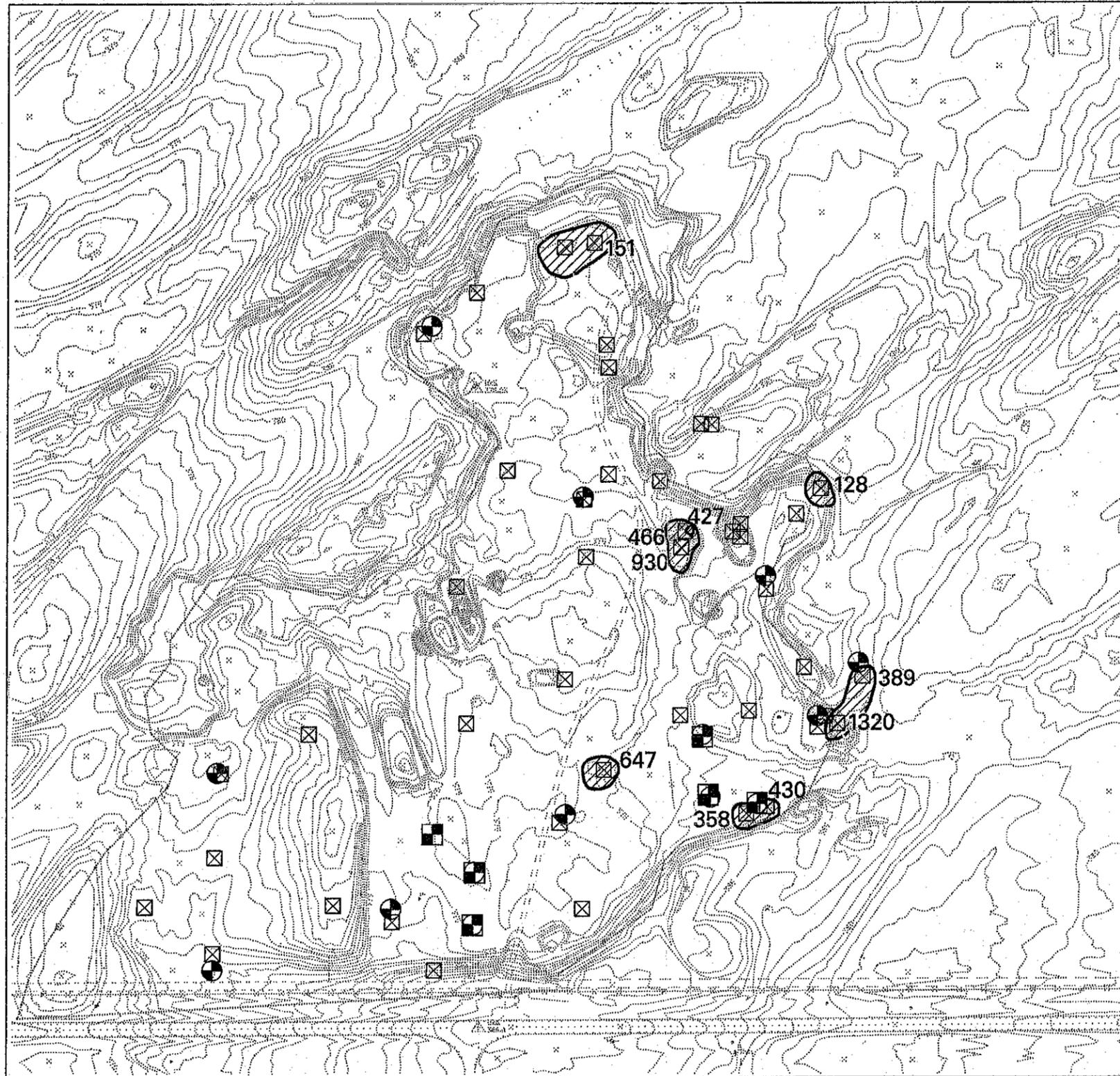


Figure 4-8. Horn Rapids Landfill - Antimony Distribution in Surface Soils

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LEGEND :

PHASE I SAMPLING;

- ☒ Surface Soil Sampling, Phase I
- ⊙ Soil Borehole Location, Phase I
- ⊞ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;

- Surface Soil Sampling Location Phase II

Barium Concentrations (mg /kg)
provided for values exceeding UTL
of 120.1 mg /kg

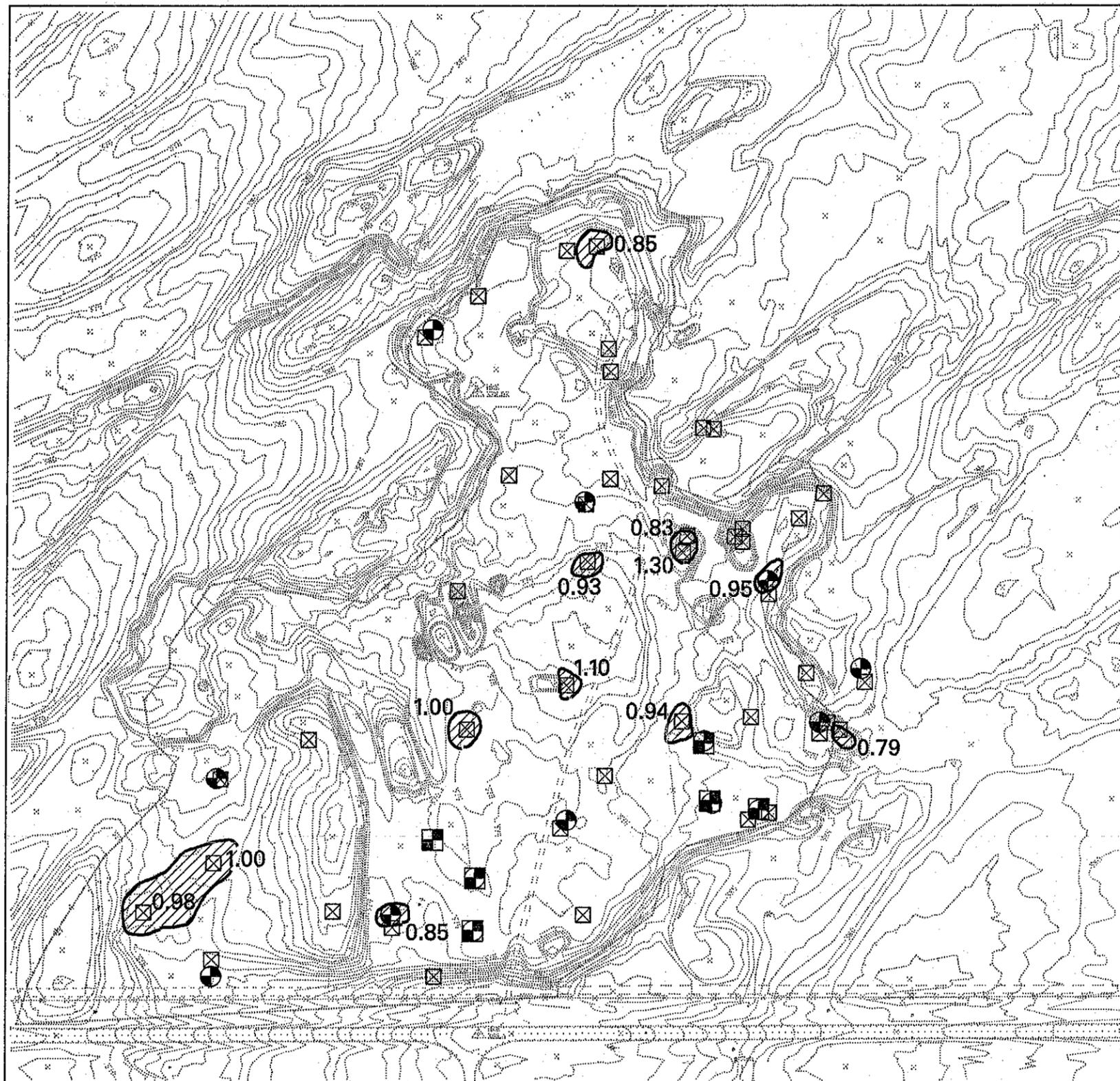
☐ Surface Soil with Barium
Concentrations above UTL of
120.1 mg /kg

▲
|
N
|

0 75 150 METERS
0 250 500 FEET

Horn Rapids Landfill – Barium Distribution in Surface Soils.

Fig. 4-9

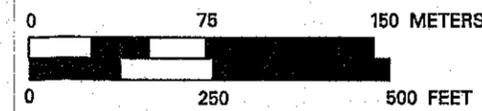


LEGEND :
PHASE I SAMPLING;
 ☒ Surface Soil Sampling, Phase I
 ⊕ Soil Borehole Location, Phase I
 ⊞ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;
 ○ Surface Soil Sampling Location Phase II

Beryllium Concentrations (mg /kg)
 provided for values exceeding UTL
 of 0.74 mg /kg

⊞ Surface Soil with Beryllium
 Concentrations above UTL of
 0.74 mg /kg

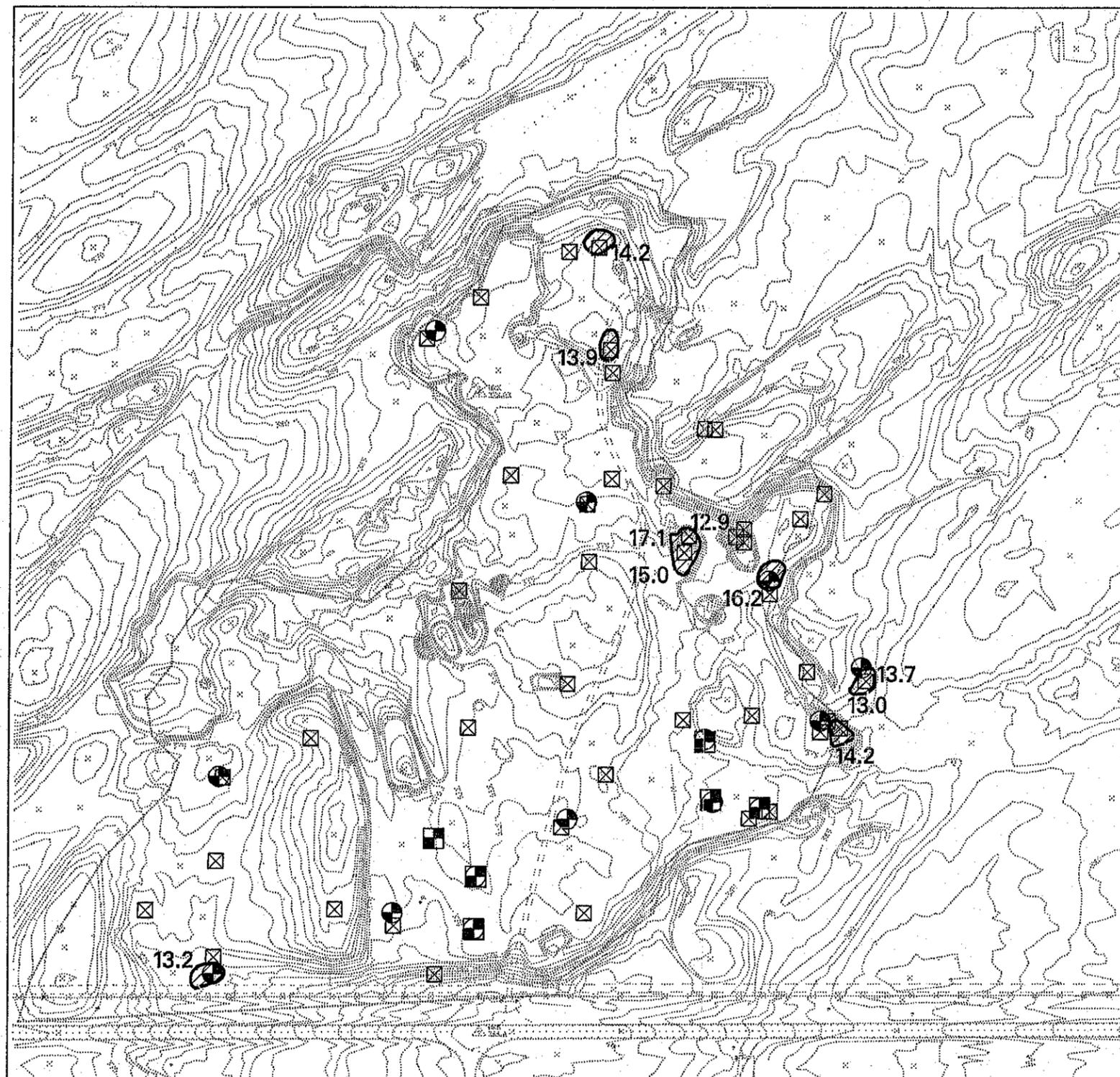


Horn Rapids Landfill – Beryllium
 Distribution in Surface Soils

Fig. 4-10

9 3 1 2 8 2 0 3 6 8

9 3 1 2 8 2 0 3 6 9



LEGEND :

PHASE I SAMPLING;

- ☒ Surface Soil Sampling, Phase I
- ⊕ Soil Borehole Location, Phase I
- ⊞ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;

- Surface Soil Sampling Location Phase II

Chromium Concentrations (mg /kg)
provided for values exceeding UTL
of 12.94 mg /kg

◌ Surface Soil with Chromium
Concentrations above UTL of
12.94 mg /kg

▲
N

0 75 150 METERS
0 250 500 FEET

Horn Rapids Landfill - Chromium
Distribution in Surface Soils

Fig. 4-11

4.8.1.6 Copper. The distribution of copper in the surface soils of HRL at concentrations above the UTL value is depicted in figure 4-12. Areas of high copper concentrations are generally restricted to depressions in the ground surface or to the base of relatively steep soil slopes. Copper was also a common contaminant detected above UTL values in soil samples obtained from the subsurface. Elevated levels of copper were detected in boreholes HRL-4, -5, -6, -8, -9, and -10 and appeared to be randomly distributed throughout the depth of natural soil deposits sampled. Elevated levels of copper were also detected in soil samples obtained from exploration trenches TP-3A, -4, -5, -8, and -11. Again, copper appeared to be randomly distributed within these disturbed deposits.

4.8.1.7 Lead. Figure 4-13 illustrates the distribution of lead present at concentrations above UTL levels in the surface soil of HRL. With few exceptions, the locations of elevated lead levels are within surface depressions of the subunit. Elevated levels of lead in the subsurface were detected in soil samples obtained from boreholes HRL-6 and HRL-10. Both boreholes showed elevated lead concentrations at a depth of approximately 6.1 to 7.6 m (20 to 25 feet). In addition, HRL-10 had elevated values at a depth of approximately 1.2 m (4.0 ft). Exploration trenches TP-3A, -4, -5, -7, -8, and -11 encountered elevated lead concentrations at depths ranging from 1.2 to 5.8 m (4 to 19 ft). There was no pattern to the lead distribution in the subsurface at these locations..

4.8.1.8 Nickel. Nickel was detected at HRL subunit at concentrations above UTL values in a single surface sample located in the extreme northern portion of the facility. Figure 4-14 presents the location of elevated nickel concentrations in the HRL surface soils. The distribution of nickel in the subsurface is scattered, as there appeared to be no consistency in the depths of elevated nickel concentrations from borehole-to-borehole. Boreholes HRL-4, -5, -6, -8, and -10 showed elevated nickel in soil samples collected from varying depths. As with the boring samples, nickel was found randomly distributed in exploration trenches at levels above UTL levels. Soil samples collected from trenches TP-3A, -4, -5, -7, and -11 had elevated nickel at depths of 5.8, 3.7, 1.5, and 1.2 m (19, 12, 5, and 4 ft), respectively.

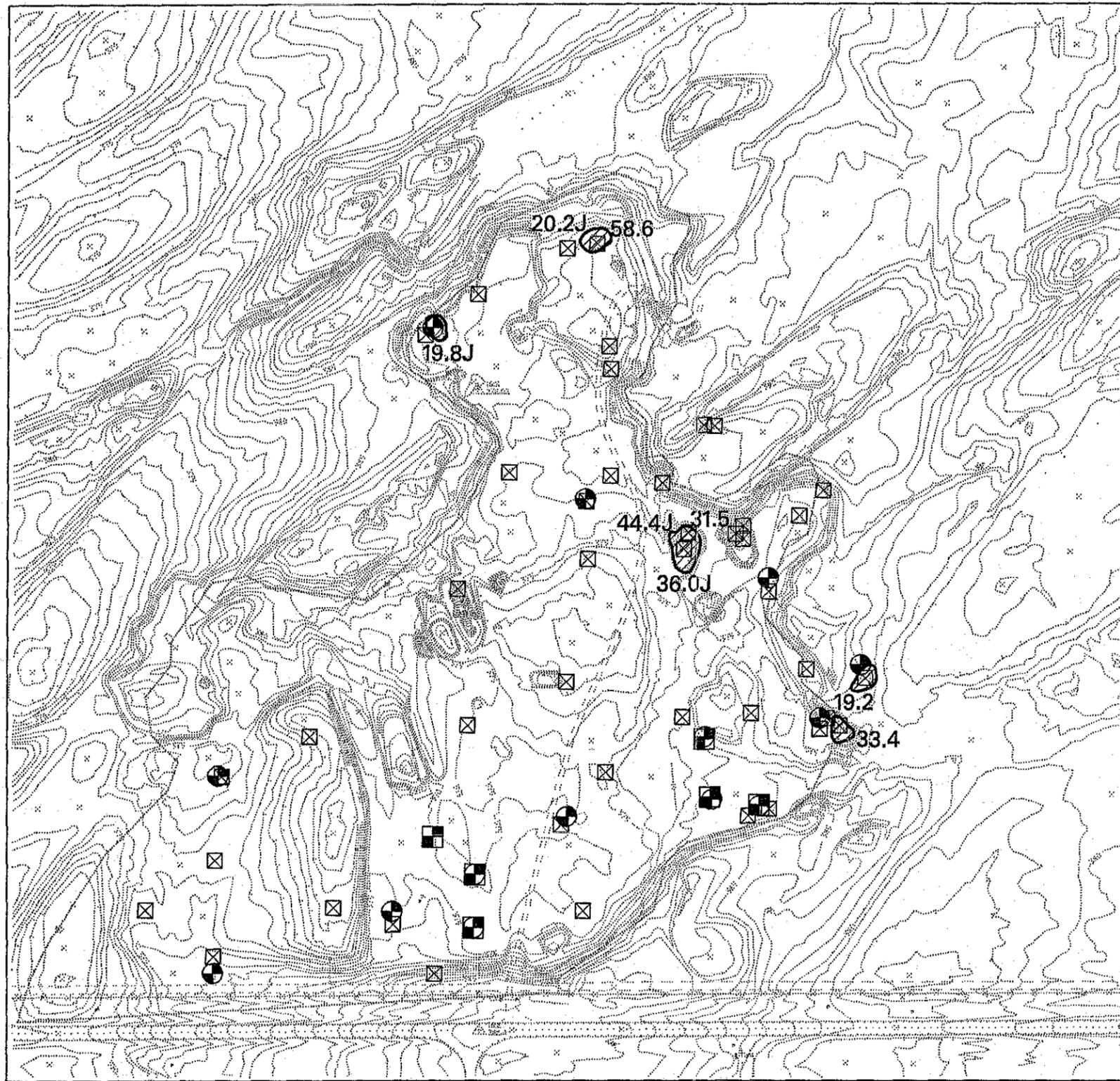
4.8.1.9 Thallium. A single surface soil sample in the extreme southeast corner of the subunit yielded thallium concentrations above UTL levels. Figure 4-15 shows the location of the elevated thallium within HRL. Borehole HRL-7 was the only location having elevated thallium in the subsurface. Soil samples obtained at the depth intervals of 3.9 to 4.6 m and 6.9 to 7.6 m (12.7 to 15.1 ft and 22.7 to 25.0 ft) during drilling of the borehole tested positive for thallium at concentrations exceeding UTL levels.

4.8.1.10 Vanadium. Vanadium was detected in two surface samples at concentrations exceeding UTL values; AH188 in the northern portion of the landfill, and AH203 in the southern portion. The location of these sampling locations is presented in figure 4-16. Elevated concentrations of vanadium were not detected in subsurface soil samples collected from HRL.

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9 3 1 2 8 6 2 0 3 7 1

9312620372



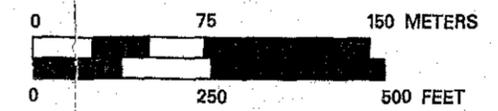
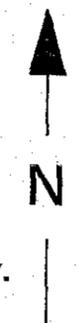
- LEGEND :**
- PHASE I SAMPLING;**
- ☒ Surface Soil Sampling, Phase I
 - Soil Borehole Location, Phase I
 - Surface Soil Asbestos Sampling Location Phase I

- PHASE II SAMPLING;**
- Surface Soil Sampling Location Phase II

Copper Concentrations (mg /kg) provided for values exceeding UTL of 19.11 mg /kg

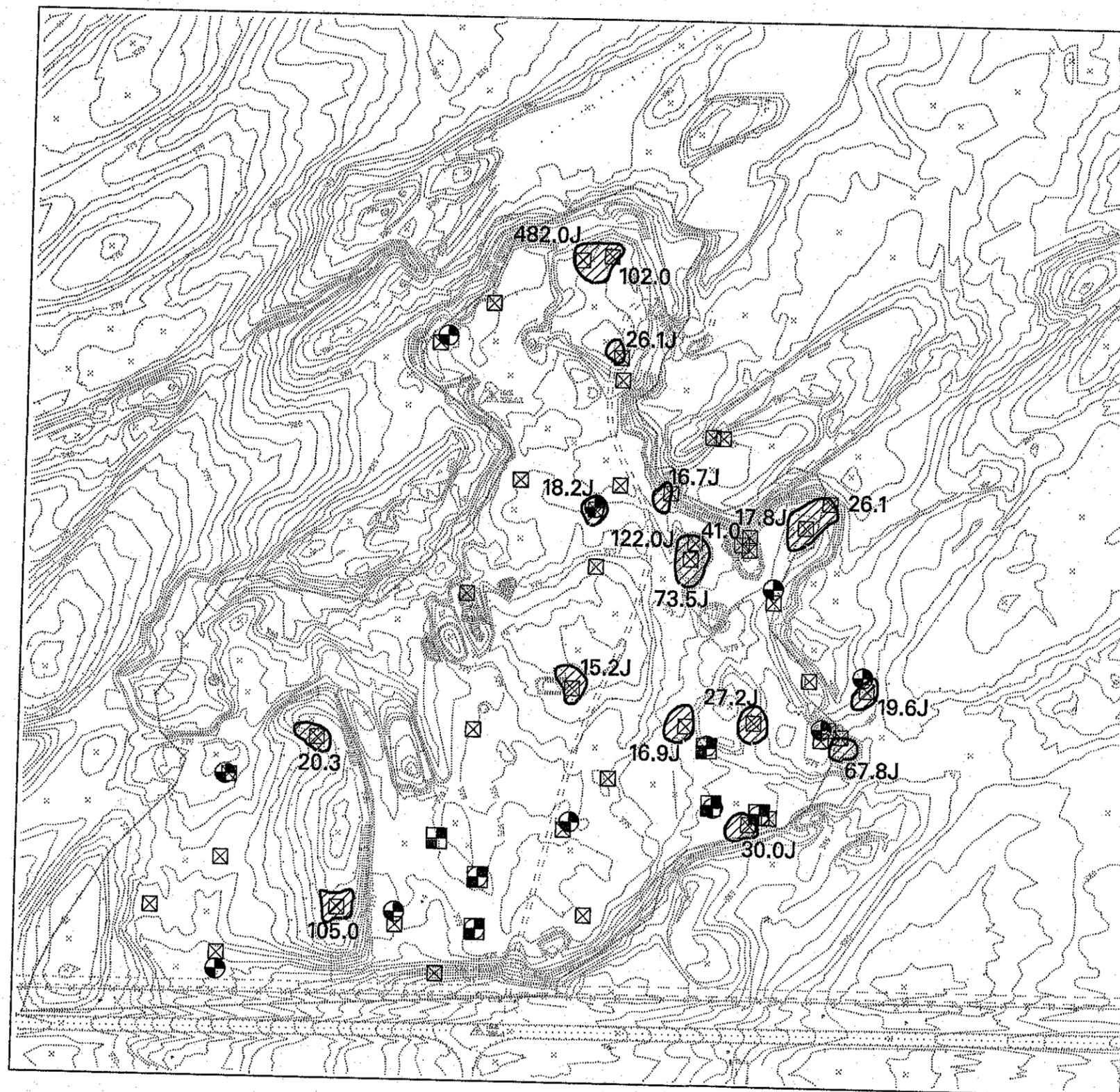
☐ Surface Soil with Copper Concentrations above UTL of 19.11 mg /kg

NOTE:
 19.6J - J is a Laboratory Analysis Qualifier indicating an estimated quantity.



Horn Rapids Landfill - Copper Distribution in Surface Soils

93128 20373



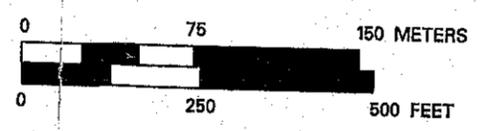
LEGEND :
PHASE I SAMPLING;
 ☒ Surface Soil Sampling, Phase I
 ● Soil Borehole Location, Phase I
 ■ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;
 ○ Surface Soil Sampling Location Phase II

Lead Concentrations (mg /kg)
 provided for values exceeding UTL
 of 12.64 mg /kg

☐ Surface Soil with Lead
 Concentrations above UTL of
 12.64 mg /kg

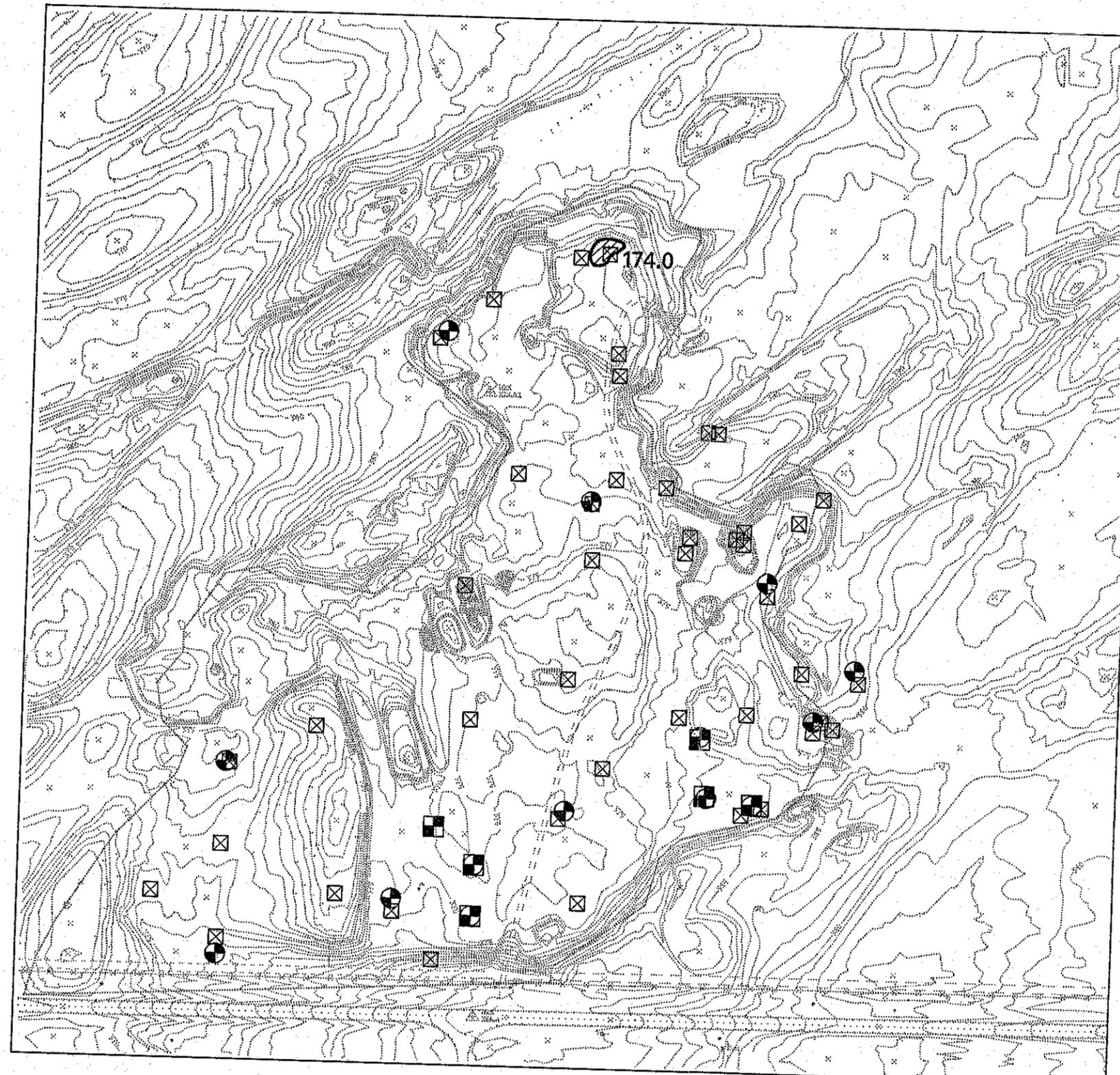
NOTE:
 19.6J - J is a
 Laboratory
 Analysis Qualifier
 indicating an
 estimated quantity.



Horn Rapids Landfill - Lead
 Distribution in Surface Soils

Fig. 4-13

93128 20374



LEGEND :

PHASE I SAMPLING;

- ☒ Surface Soil Sampling, Phase I
- ⊕ Soil Borehole Location, Phase I
- ⊞ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;

- Surface Soil Sampling Location Phase II

Nickel Concentrations (mg /kg)
provided for values exceeding UTL
of 19.0 mg /kg

▨ Surface Soil with Nickel
Concentrations above UTL of
19.0 mg /kg

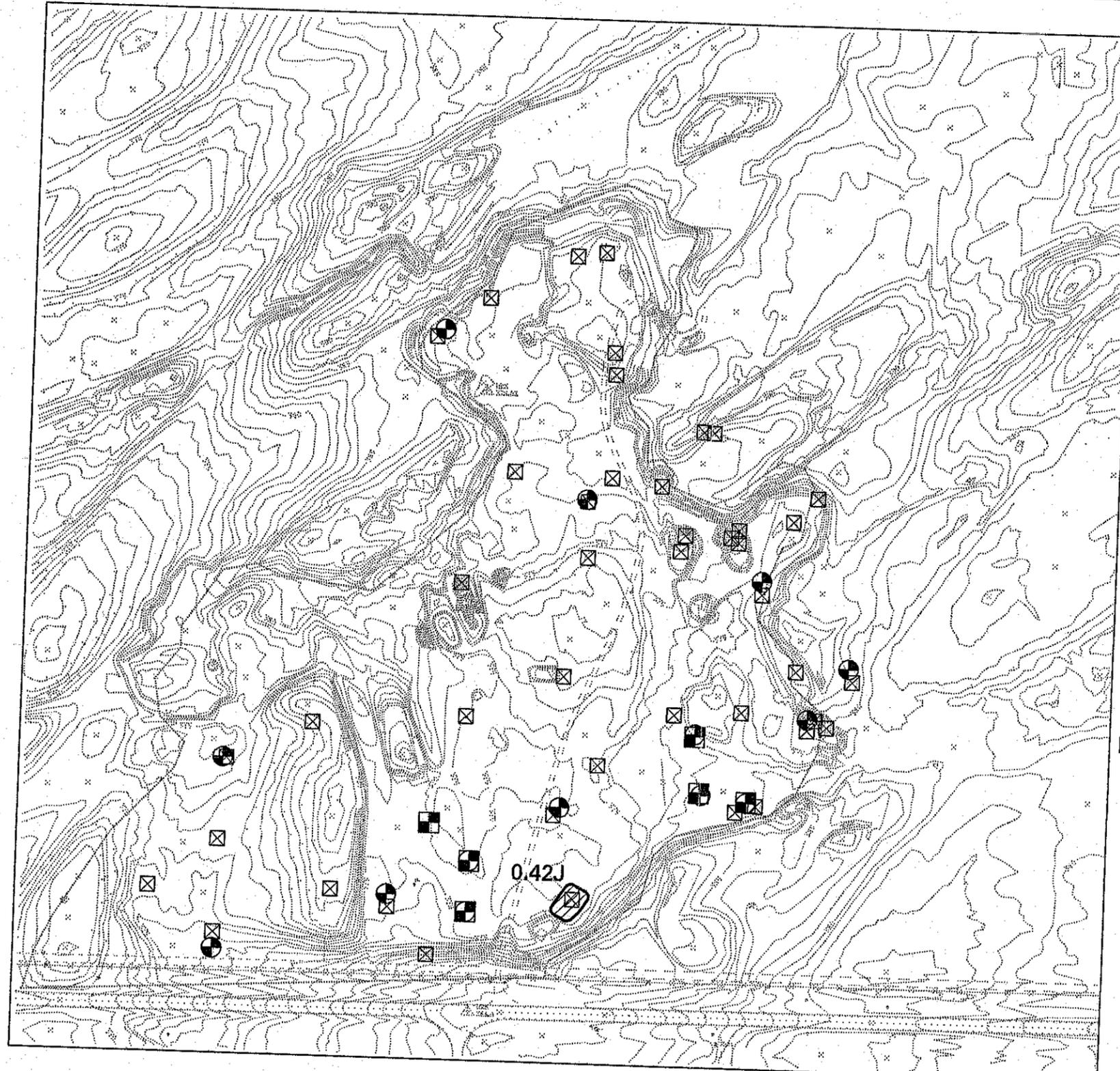
▲
N

0 75 150 METERS
0 250 500 FEET

Horn Rapids Landfill - Nickel Distribution in Surface Soils

Fig. 4-14

93128 20375



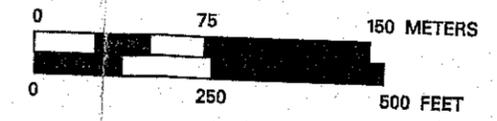
- LEGEND :**
- PHASE I SAMPLING;**
- ☒ Surface Soil Sampling, Phase I
 - ⊙ Soil Borehole Location, Phase I
 - ⊠ Surface Soil Asbestos Sampling Location Phase I

- PHASE II SAMPLING;**
- Surface Soil Sampling Location Phase II

Thallium Concentrations (mg /kg)
provided for values exceeding UTL
of 0,39 mg /kg

 Surface Soil with Thallium
Concentrations above UTL of
0.39 mg /kg

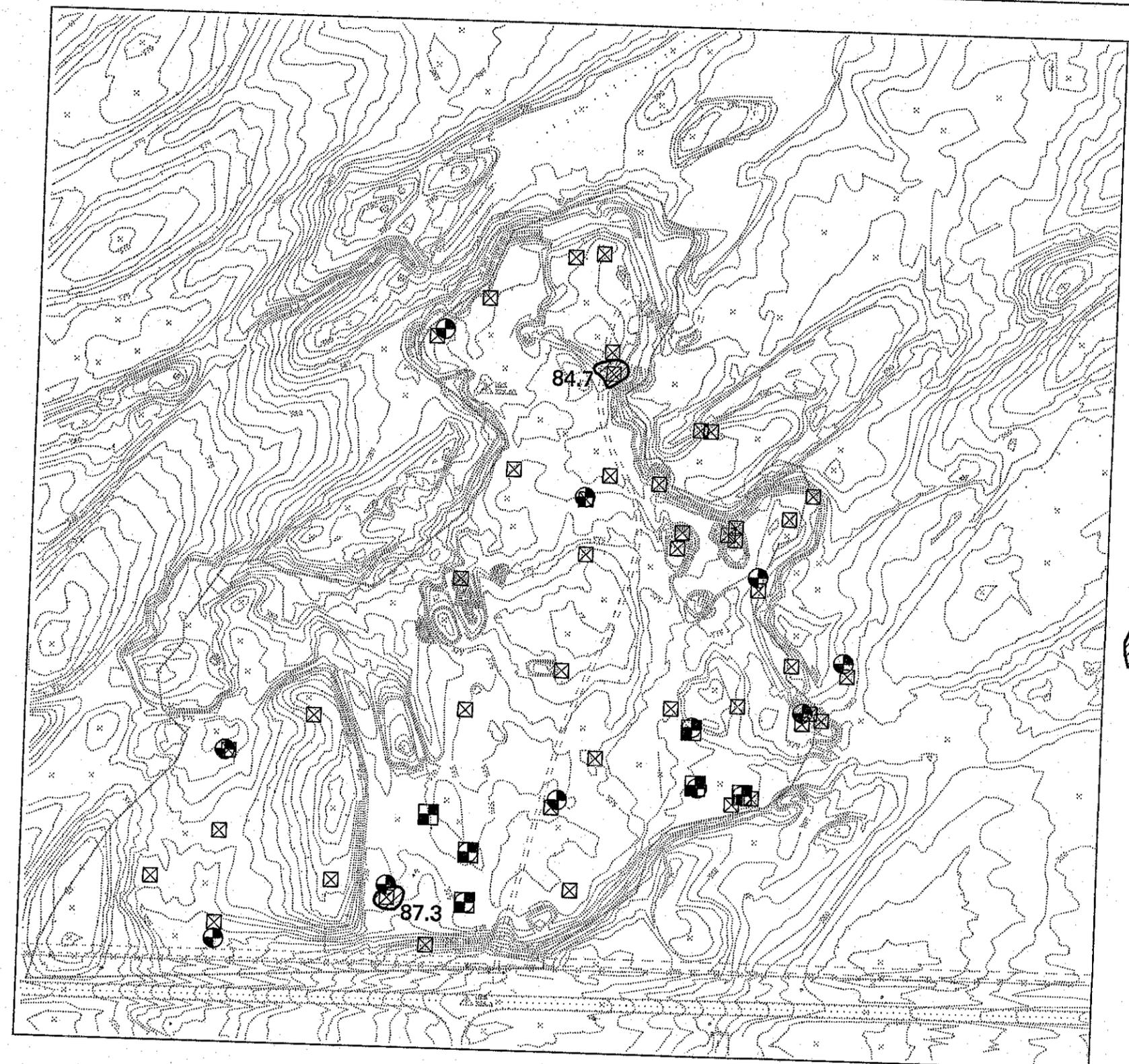
NOTE:
19.6J - J is a
Laboratory
Analysis Qualifier
indicating an
estimated quantity.



Horn Rapids Landfill - Thallium
Distribution in Surface Soils

Fig. 4-15

23128 20376



LEGEND :

PHASE I SAMPLING;

- ☒ Surface Soil Sampling, Phase I
- ⊙ Soil Borehole Location, Phase I
- ⊞ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;

- Surface Soil Sampling Location Phase II

Vanadium Concentrations (mg /kg)
provided for values exceeding UTL
of 83.93 mg /kg

⊞ Surface Soil with Vanadium
Concentrations above UTL of
83.93 mg /kg

▲
|
N
|

0 75 150 METERS
0 250 500 FEET

Horn Rapids Landfill - Vanadium Distribution in Surface Soils

Fig. 4-16

4.8.1.11 Zinc. Concentrations of zinc in the surface soil at HRL exceeding UTL values were limited to samples collected from the bottoms of depressions located Figure adjacent to the landfill's eastern and northern boundary slopes. These areas are shown on figure 4-17. Elevated concentrations of zinc were detected in subsurface soils sampled during the drilling of boreholes HRL-5, -6, and -10 at depths of approximately 3.0, 3.7, and 5.8 m (10, 12, and 19 ft.), respectively. Zinc was also detected in soils excavated from exploration trenches TP-3A, -4, -5, -8, and -11 at depths varying from 1.2 to 5.8 m (4 to 19 ft).

4.8.1.12 beta-HCH. Concentrations of beta-HCH above UTL values were only detected in surface samples collected during the Phase II investigation. Three sample locations adjacent to borehole HRL-4 contained elevated beta-HCH; HRL-1A, -2A, and 4A. Sampling locations are presented in figure 4-18.

4.8.1.13 DDT. The insecticides 4,4'DDD, 4,4'DDE, and 4,4'DDT were found in surface soils at concentrations above UTL values in isolated locations within HRL (see figures 4-19, 4-20, and 4-21 and 4-22, respectively). No subsurface concentrations of insecticides/pesticides were detected within the HRL subunit.

4.8.1.14 Heptachlor. A single heptachlor concentration obtained from surface soil samples exceeded UTL values for the HRL subunit. The heptachlor concentration in sample AH203, located along the south central boundary of the landfill (figure 4-23), only slightly exceeded the UTL. No elevated concentrations of heptachlor were detected in soil samples collected from subsurface strata.

4.8.1.15 PCB's. PCB contamination at concentrations exceeding UTL levels were detected in two surface samples collected during the Phase I investigation and in eight surface samples collected during the Phase II investigation. All 10 samples were collected in the same, very limited, area of the landfill; adjacent to borehole HRL-4. Figure 4-24 shows the locations of Phase II samples having elevated PCB values. All PCB's detected in the surface soil were identified as aroclor-1248. One subsurface sample (sample A2205S from a depth interval of 1.6 to 2.4 m (5.4 to 8.0 ft) in borehole HRL-4) contained aroclor-1248 at a concentration exceeding the UTL limit. Aroclor-1254 was detected in one subsurface soil sample, collected from a depth of 2.7 m (9 ft) in exploration trench TP-1, at a concentration above the UTL.

4.8.2 Groundwater

The extent of the TCE and nitrate plumes, identified in the Phase I RI, were further defined by new information concerning TCE and nitrate use at the Siemens Power Corporation facilities and from additional data generated during the installation of new groundwater monitoring wells in the SPC/HRL area.

9312820377

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9 3 1 2 8 6 2 0 3 7 8

1312820379



LEGEND :

- PHASE I SAMPLING;**
- ☒ Surface Soil Sampling, Phase I
 - ⊙ Soil Borehole Location, Phase I
 - Surface Soil Asbestos Sampling Location Phase I

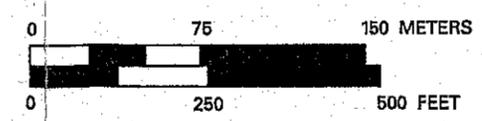
- PHASE II SAMPLING;**
- Surface Soil Sampling Location Phase II

Zinc Concentrations (mg /kg)
provided for values exceeding UTL
of 62.2 mg /kg

 Surface Soil with Zinc
Concentrations above UTL of
62.2 mg /kg

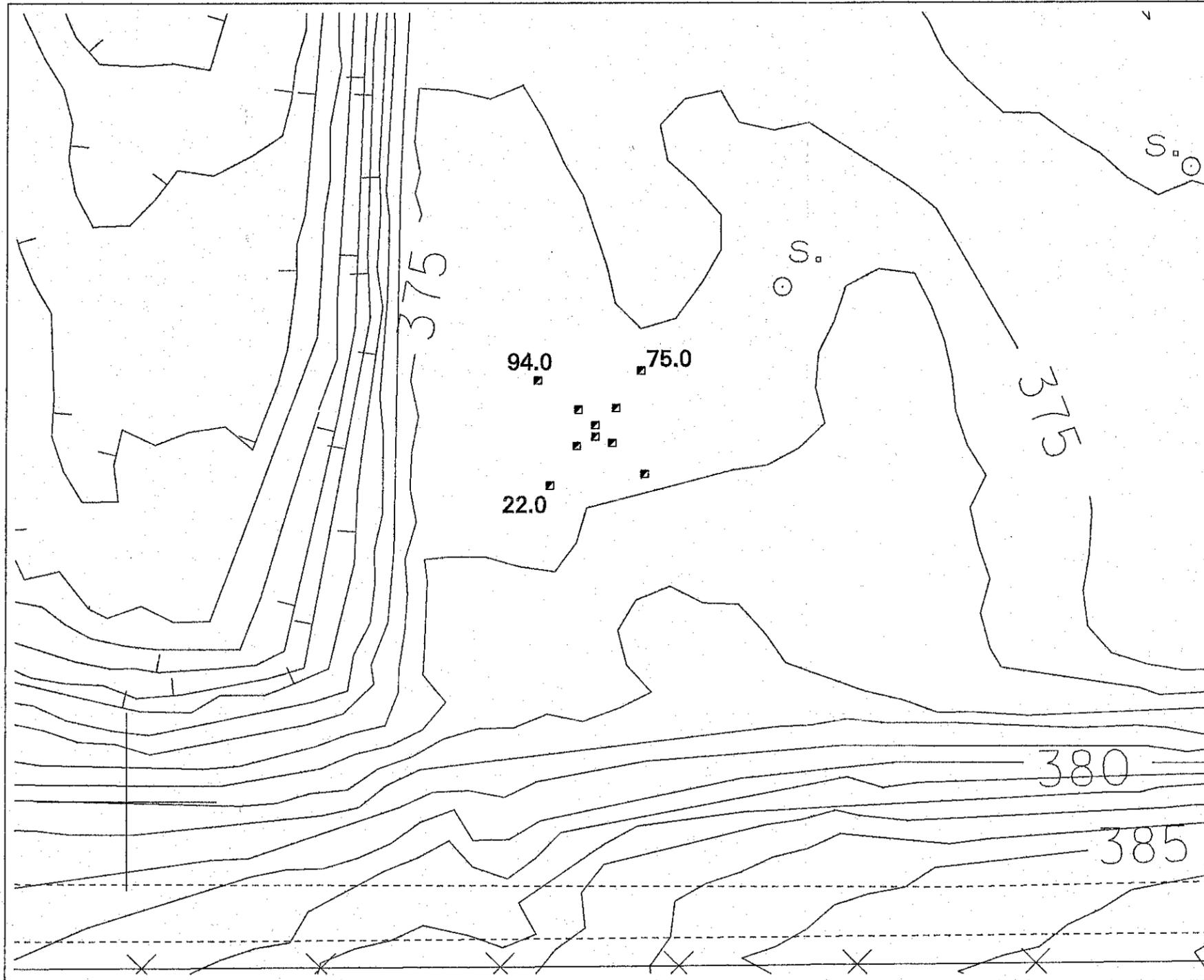
NOTE:

68.8J - J is a
Laboratory
Analysis Qualifier
indicating an
estimated quantity.



Horn Rapids Landfill - Zinc
Distribution in Surface Soils

Fig. 4-17

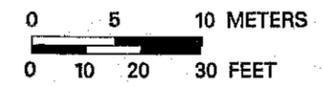


LEGEND :

■ Soil Sampling Location

beta - HCH concentrations (micro-g /kg) for values exceeding UTL of 17 micro-g /kg. Maximum value is recorded for the depth interval 0 - 1.5 ft.

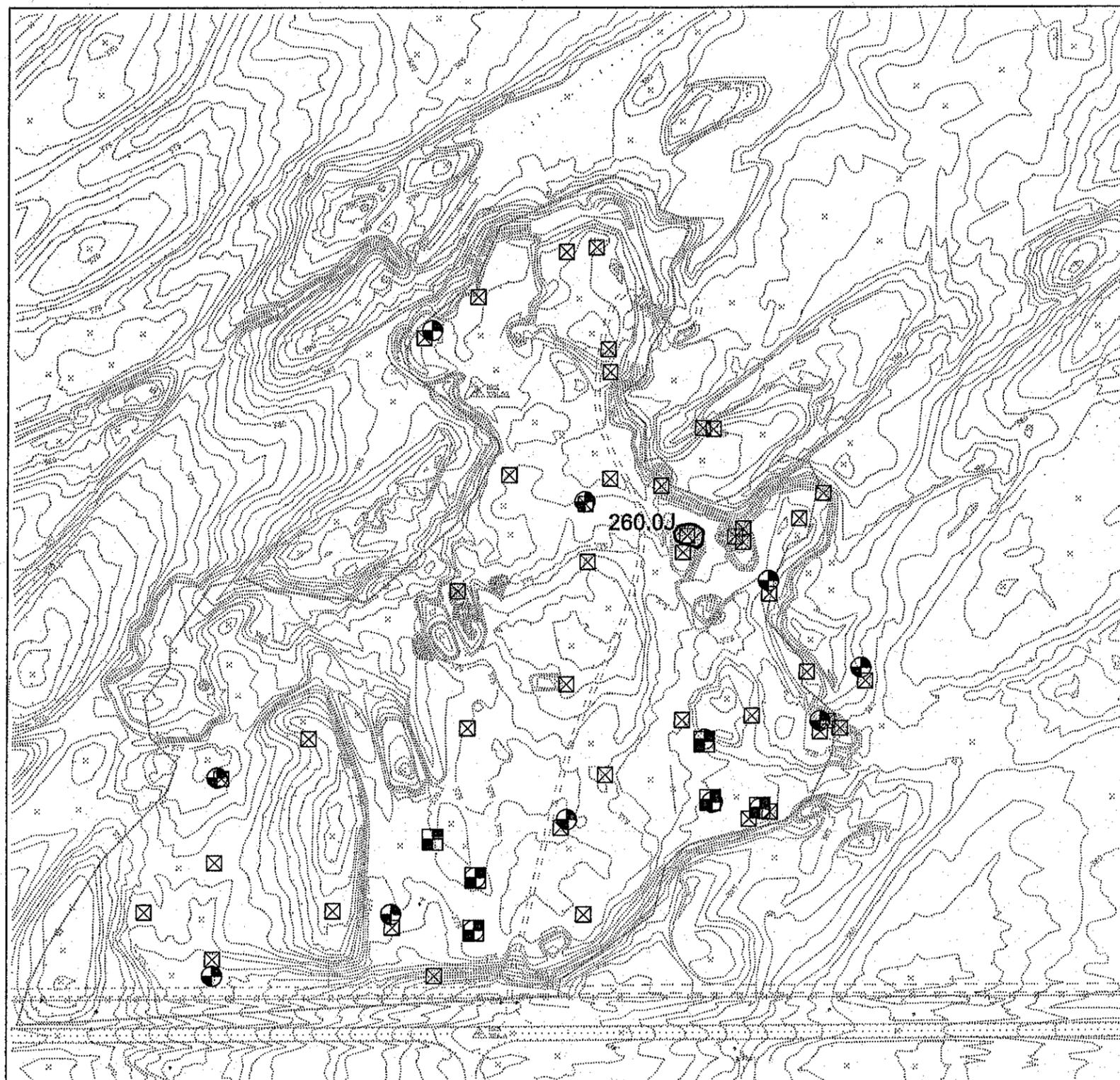
Contour interval 5 feet



Horn Rapids Landfill - beta-HCH Distribution in Surface Soil

Fig. 4-18

1312820380



LEGEND :

PHASE I SAMPLING;

☒ Surface Soil Sampling, Phase I

⊕ Soil Borehole Location, Phase I

⊞ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;

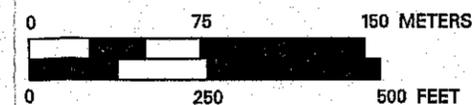
○ Surface Soil Sampling Location Phase II

4,4' DDD Concentrations (micro-g /kg) provided for values exceeding UTL 33 micro-g /kg

▨ Surface Soil with 4,4' DDD Concentrations above UTL of 33 micro-g /kg

NOTE:

260.0J - J is a Laboratory Analysis Qualifier indicating an estimated quantity.

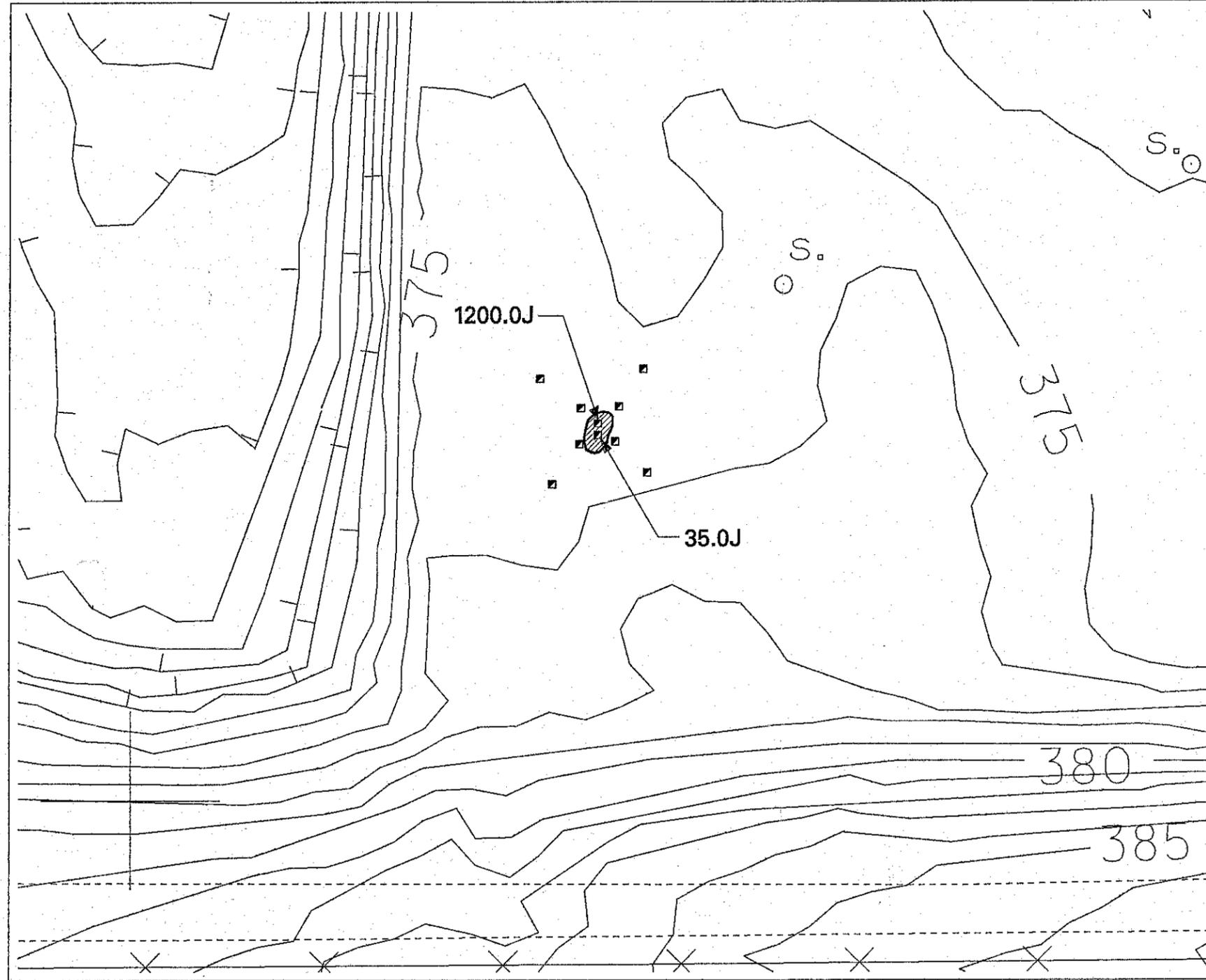


Horn Rapids Landfill - 4,4' DDD Distribution in Surface Soils

Fig. 4-19

20381

7312820382

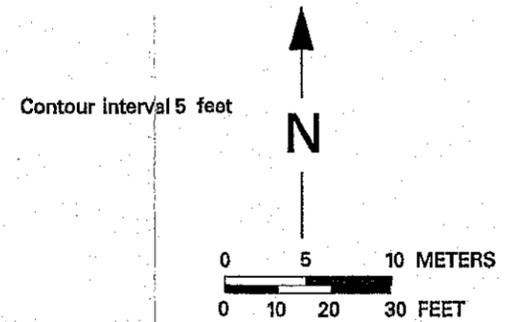


LEGEND :

- ▣ Soil Sampling Location
- 4,4' DDE Concentration (micro-g /kg)
for values exceeding UTL of 33
micro-g /kg.
-  Surface Soil with 4,4' DDE
Concentrations above UTL of
33 micro-g /kg.

NOTE :

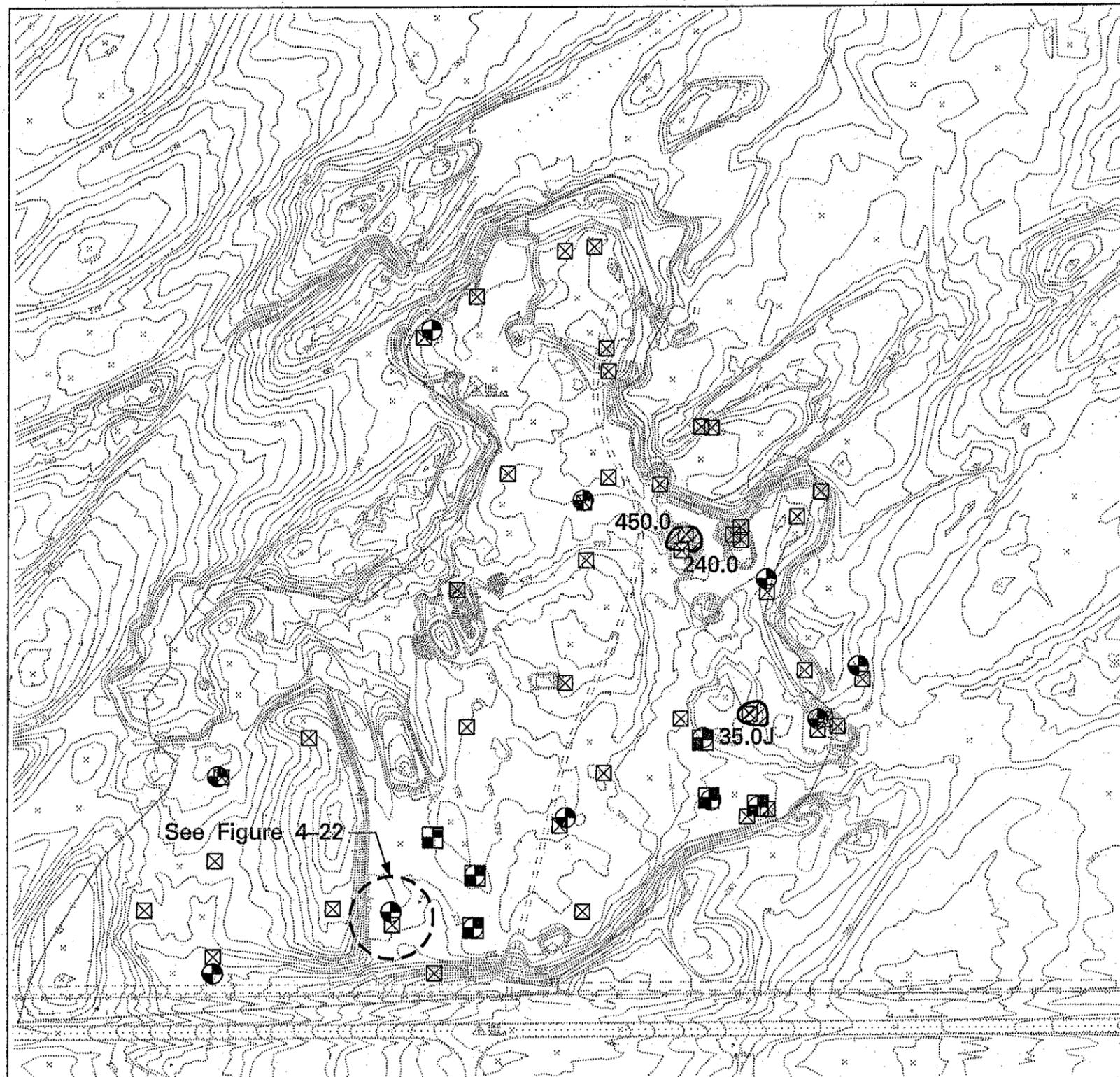
35.0J - J is a laboratory analysis
qualifier indicating an estimated
quantity.



**Horn Rapids Landfill - 4,4' DDE
Distribution in Surface Soils**

Fig. 4-20

73129 20383



LEGEND :

PHASE I SAMPLING;

- ☒ Surface Soil Sampling, Phase I
- ⊗ Soil Borehole Location, Phase I
- ⊠ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;

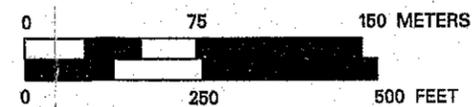
- Surface Soil Sampling Location Phase II

4,4' DDT Concentrations (micro-g /kg)
provided for values exceeding UTL
33 micro-g /kg

 Surface Soil with 4,4' DDT
Concentrations above UTL of
33 micro-g /kg

NOTE:

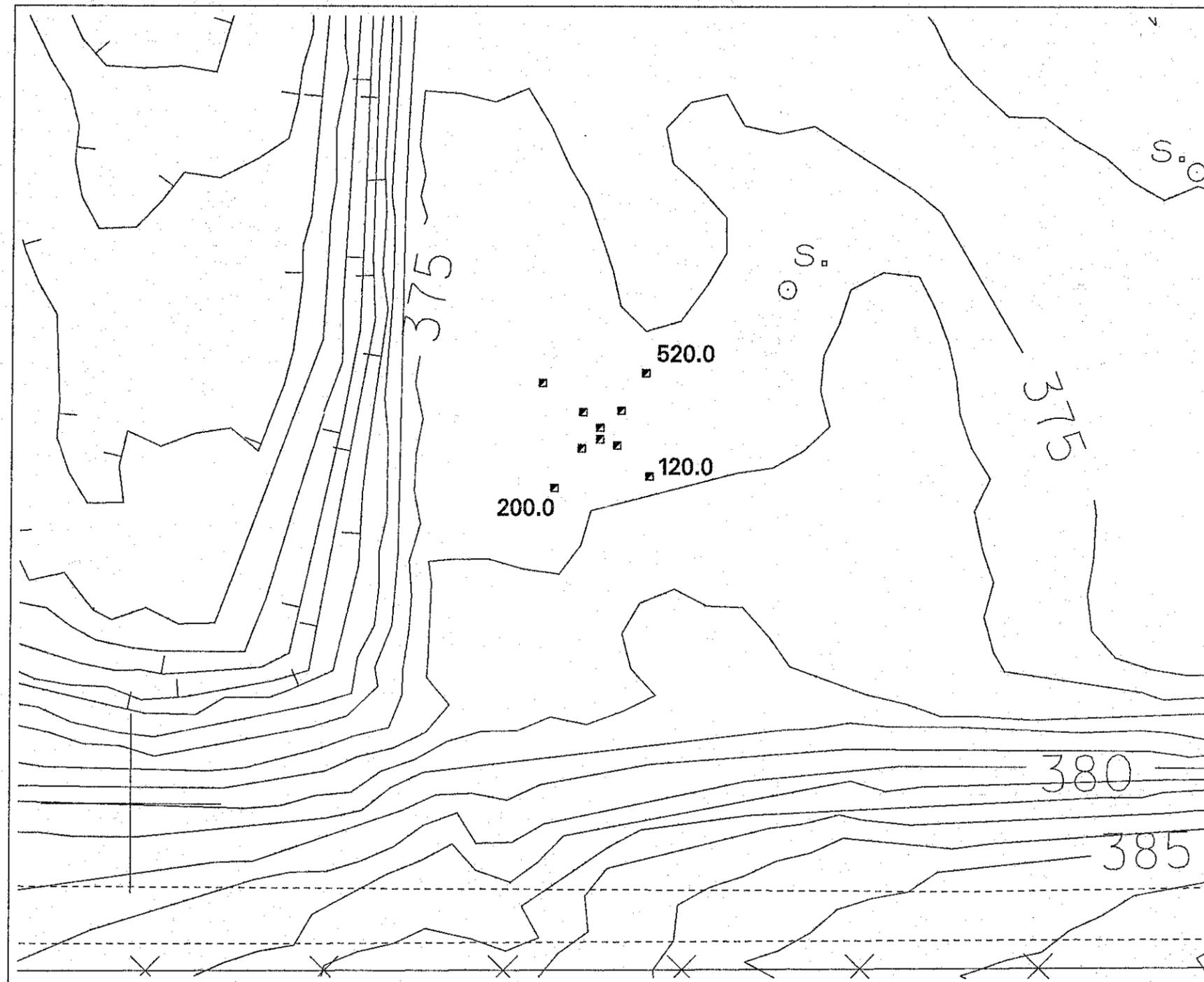
35.0J - J is a
Laboratory
Analysis Qualifier
indicating an
estimated quantity.



Horn Rapids Landfill - 4,4' DDT
Distribution in Surface Soils

Fig. 4-21

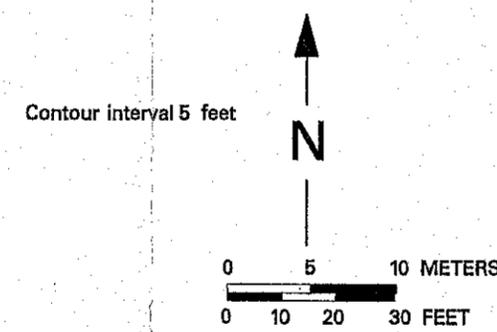
93128 20384



LEGEND :

■ Soil Sampling Location

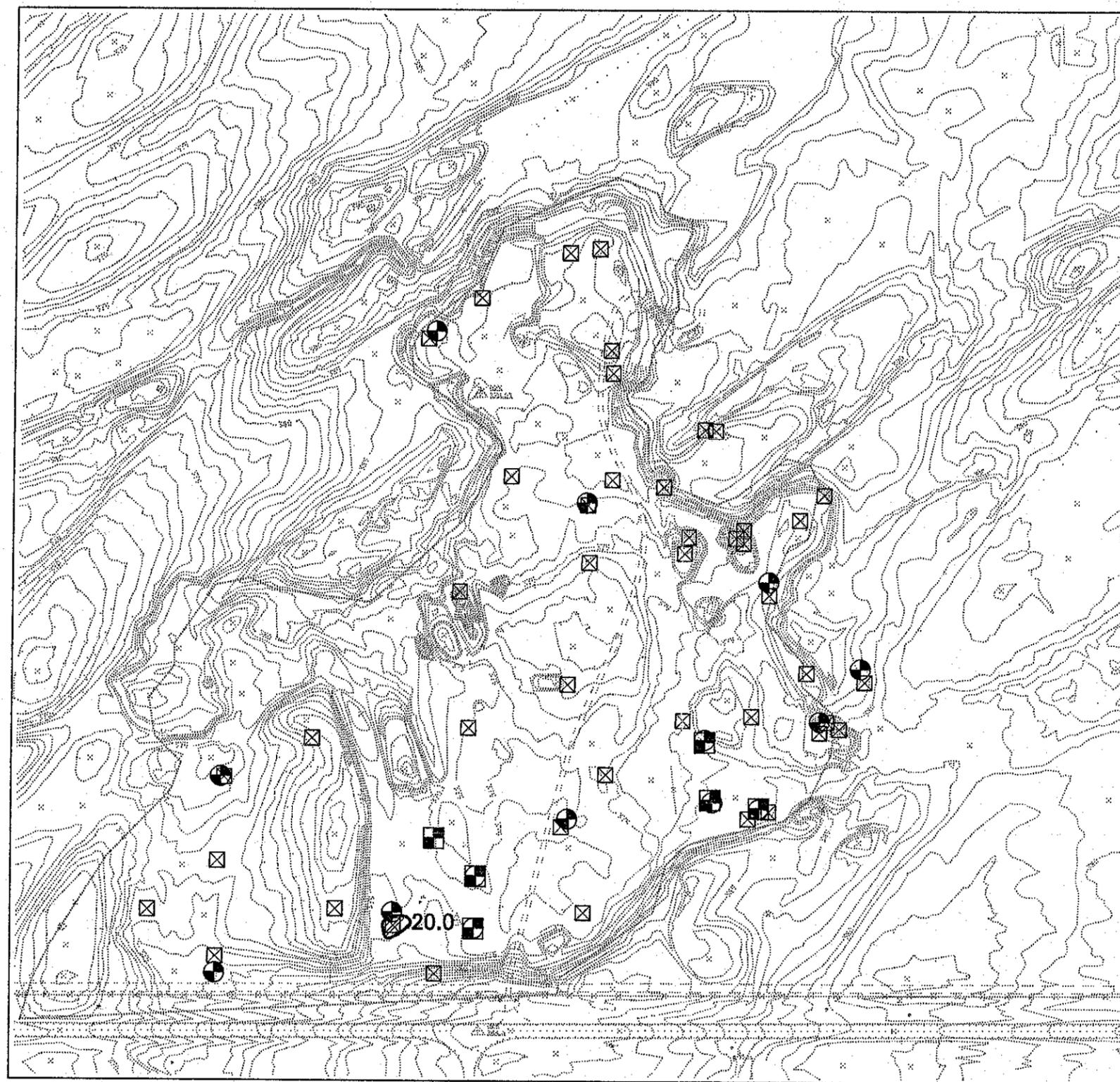
4, 4' DDT Concentrations (micro-g /kg)
for values exceeding UTL of 33
micro-g /kg. Maximum concentration
shown for depth interval of 0 - 1.5 ft.



Horn Rapids Landfill - 4, 4' DDT
Distribution in Surface Soils

Fig. 4-22

7312020385



LEGEND :

PHASE I SAMPLING;

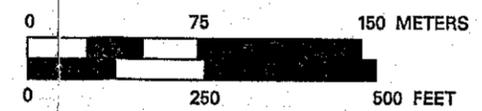
- ☒ Surface Soil Sampling, Phase I
- ⊙ Soil Borehole Location, Phase I
- ⊞ Surface Soil Asbestos Sampling Location Phase I

PHASE II SAMPLING;

- Surface Soil Sampling Location Phase II

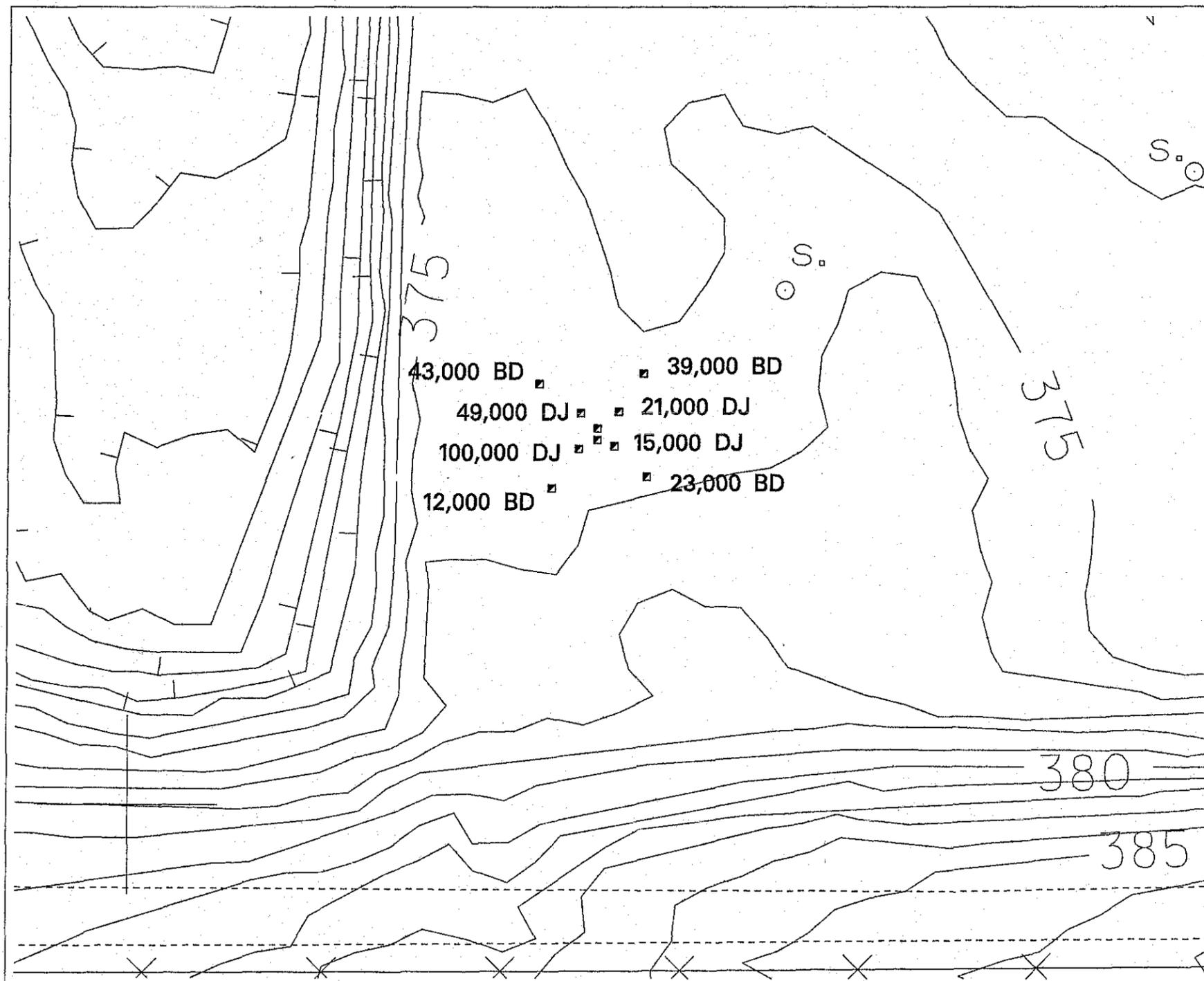
Heptachlor Concentrations (micro-g /kg) provided for values exceeding UTL of 17 micro-g /kg

- ▨ Surface Soil with Heptachlor Concentrations above UTL of 17 micro-g /kg



Horn Rapids Landfill - Heptachlor Distribution in Surface Soils

Fig. 4-23

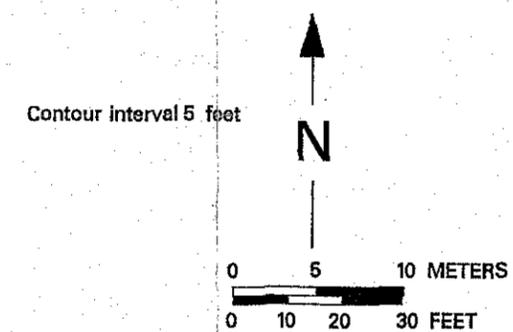


LEGEND :

- ▣ Soil Sampling Location
- PCB Isomer Anchor 1248 only one detected.
- Aroclor 1248 Concentrations (micro-g /kg) for values exceeding UTL of 170 micro-g /kg.
- Maximum concentration shown for the depth interval 0 - 1.5 ft.

NOTE :

- B - Laboratory analysis qualifier indicating analyte was found in associated blank as well as in sample.
- D - Laboratory analysis qualifier indicating compound identified at a secondary dilution factor.
- J - Laboratory analysis qualifier indicating an estimated quantity.



Horn Rapids Landfill - PCB Distribution in Surface Soils

Fig. 4-24

9312820386

4.8.2.1 Source Information--TCE Plume. Information concerning the source of the TCE plume at the HRL/SPC area was provided by: (1) soil sampling, trenching investigations, geophysical surveys, and soil-gas investigations performed at the HRL and vicinity; (2) documents and reports provided by SPC; (3) groundwater sampling at SPC property; once in the fall of 1987, four times in 1990, three times in 1991, and quarterly in 1992; and (4) quarterly groundwater sampling, 1990 to present, of the 1100-EM-1 monitoring wells.

The soil sampling, trenching investigations, geophysical surveys, and soil-gas investigations revealed no evidence of a TCE source in the vadose zone at HRL or the South Pit. The soil-gas measurements revealed the presence of TCE in the vadose zone at HRL and the South Pit, but at concentrations inconsistent with a significant TCE source in the vadose zone at those locations (see paragraph 3.7).

The only documented record of the occurrence or use of TCE near the present-day contaminant plume is at the SPC lagoon area. The work plan for the hazardous substance source evaluation performed at SPC by Geraghty & Miller, Inc., identifies the use of TCE at SPC during the installation of Hypalon™ lagoon liners (page 12, SNP, 1992). TCE was used to clean the liner in preparation for bonding overlapping liner sections together (meeting minutes, October 15 1990, meeting at the SPC, formerly Advanced Nuclear Fuels (ANF), facility). SPC also provided a liner installation, cleaning, and repair history that indicated that these activities started, for the Hypalon™ liners, in 1978 and continued through 1988 (as shown in figure 6-24). The most numerous liner installation and repair efforts occurred during three time periods around the years 1979, 1983, and 1987 and 1988. The average depth to the water table at the SPC facility is about 4.6 m (15 ft).

Construction drawings for the SPC lagoons and the observed groundwater levels indicate that minimum distances from lagoon liners to the water table vary from 2.6 to 4.2 m (8.5 to 13.8 ft). Construction drawings indicate the material below the liners consists of a sand layer underlain by compacted fill material. The transport capacity of sand and fill material is relatively high, indicating that TCE, spilled or excessed during lagoon liner installation, cleaning, or repair would have a short and unobstructed pathway to the groundwater table.

Groundwater data, presented in section 3.0, provides additional information about the TCE source. Analysis of TCE groundwater sample concentrations over time indicate that the plume is attenuating relatively quickly and that the contaminant is currently present at relatively low concentrations. Samples from SPC well TW-9, located just down-gradient of the SPC lagoons, demonstrate this. A December, 1987, sample from this well had a TCE concentration of 420 ppb while the average of two samples taken in 1991 was 12 ppb. This attenuation indicates that the TCE source is not continuous. Concentrations at another SPC well, TW-1, showed similar attenuation from a December 1987 spike of 230 ppb to a 1991 level of 11 ppb. The rapid attenuation of TCE is consistent with a low volume spike source rather than a continuous source.

Similar attenuation is seen in down-gradient wells located within the HRL. Well MW-12 had a concentration of 110 ppb in the spring of 1990 but was about one-half of that in the summer of 1992. This reduction is also consistent with that of an attenuating plume.

that originated from an up-gradient slug or spike source. However, groundwater velocities are not sufficient to carry the 1987 spike to MW-12 by 1990 (see groundwater contaminant transport section) suggesting earlier, up-gradient releases consistent with the time-frame of TCE use at SPC. Simplistic, single-event releases do not appear to account for observed values. Detailed evaluation and modeling (see section 6.0) was undertaken to carefully analyze post-usage and current conditions.

The amount of TCE in the groundwater, as indicated by measured monitoring well TCE concentrations and approximate plume dimensions, is about 75 to 110 liters (20 to 30 gallons). Although an additional unknown amount is adsorbed onto the host soil, volatilized, biodegraded, or attenuated by other processes, the data indicates the total original amount of TCE source released to the ground was on the order of one to three drums.

The shape and extent of the current plume are consistent with a single source area located at the SPC facility. If another source existed, the shape and concentration levels of the observed plume would likely appear markedly different, except for the unlikely case where the second source was located directly down-gradient of the SPC source. In addition, aquifer groundwater velocities (average of 0.4-0.5 m/d with up to about 1.0 m/d in the upper Hanford formation strata) are such that if TCE had been dumped at the HRL in the 1960's or early 1970's, then TCE would be found in well 699-S29-E12, which is directly down-gradient of the current observed plume (about 760 meters from MW-12 and about 1220 m (4,003 ft) from the HRL/SPC boundary within the plume). TCE has not been identified in this well since it was first sampled in 1990.

In summary, the occurrence of elevated TCE levels in groundwater samples collected near the SPC lagoons in 1987, the noncontinuous nature of the source, the estimated volume of TCE present, and the shape and extent of the plume are consistent with releases of TCE associated with lagoon liner installation, cleaning, and repair activities at SPC. Data from soil-gas surveys and geophysical investigations do not support the existence of a TCE source within the HRL.

4.8.2.2 Source Information - Nitrate Plume. Information on potential nitrate sources was provided by groundwater sampling results from the SPC and HRL areas, and from SPC documents. The earliest data from the 1970's indicate maximum total nitrogen ($\text{NH}_3 + \text{NO}_3$) levels of 400 ppm, 1800 ppm, 300 ppm, and 300 ppm in SPC wells TW-1, TW-2, TW-3, and TW-9, respectively (see appendix F). The nitrate-to-total-nitrogen ratio for this data is not known; but even at low ratios, the nitrogen levels would be much higher than the 10 ppm MCL. Nitrogen was specifically included as a measurement parameter in groundwater sample analyses beginning in 1981, with detected levels consistently between 20 and 100 ppm in the SPC area down-gradient of the lagoons and facilities. Nitrate values upgradient of the SPC facilities and lagoons have been below 10 ppm (measured at TW-23, TW-24, GM-1, and GM-2). The work plan referred to in paragraph 4.8.2.1 identifies at least eight areas of potential nitrate releases from the SPC facility including the lagoons, the Ammonia Recovery Facility (ARF), former tank farms, storage areas, etc. The inconsistent nature of nitrate peaks observed in the SPC well concentration data suggests multiple sources or, at a minimum, multiple releases within the SPC area.

4.8.2.3 Plume Delineations. The approximate horizontal distributions of TCE at the HRL/SPC for the 1987 to 1992 period are shown in figure 4-25. The TCE plume extends in the direction consistent with groundwater flow, with its up-gradient end identifying the approximate source area. The earliest TCE data available is from the fall of 1987 and consists of three measurements taken near the SPC lagoons. The highest of these, 420 ppb at well TW-9, is about 40 times higher than concentrations at that same well in 1992, and is over 8 times higher than the highest concentration observed in the plume in 1992. This indicates considerable natural attenuation at the site and is consistent with a low-volume, non-continuous source.

The first groundwater samples to be analyzed for TCE at the HRL were taken in 1990 and revealed maximum concentrations of 110 ppb (at MW-12). Continued quarterly sampling showed concentrations to be steadily decreasing through the latest sampling rounds, which occurred in 1992. Concentration levels detected in 1992 at MW-12 are nearly half that of the 1990 levels. If this "attenuation" rate were to continue, using a half life of 2 years and a target level of 5 ppb, the TCE concentrations would be reduced to MCL's by the year 2000. This simple extrapolation does not account for plume movement or other necessary factors (see paragraph 6.2). This attenuation may be due to dispersion (*i.e.*, mixing and spreading) that is a result of the high hydraulic conductivities in the upper soil strata at the site. Biodegradation and volatilization also account for some of the attenuation. Further, more detailed discussion on contaminant fate and transport are found in the contaminant transport and modeling section (paragraph 6.2).

Existing data did not allow determination by direct observation of the rate of movement of the plume front because of the lack of sampling wells between the MW-12 well cluster and well 699-S29-E12, located near Stevens Drive.

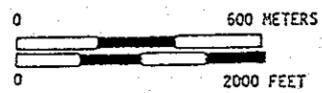
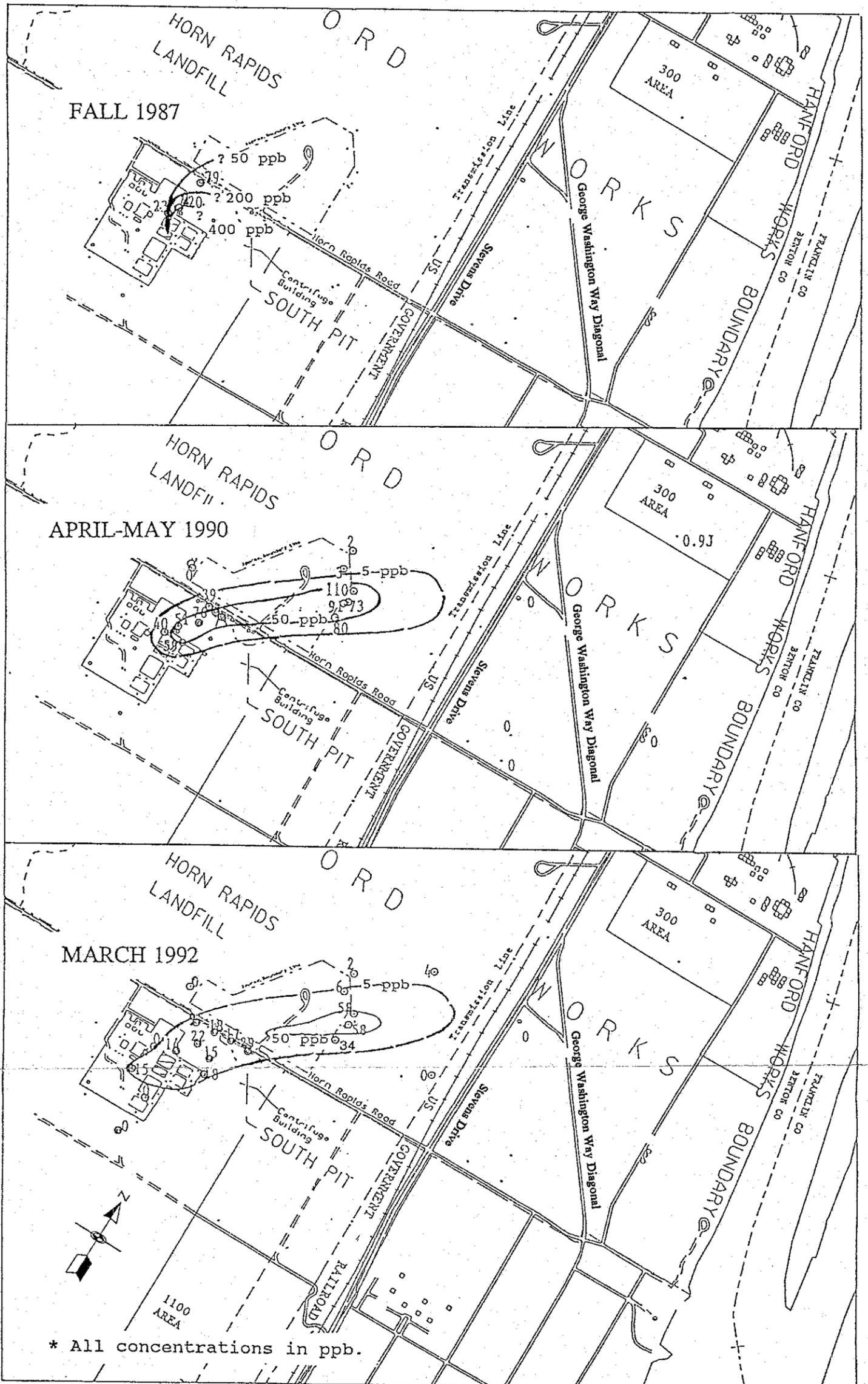
The approximate horizontal distribution of nitrate is shown in figure 4-26. The direction of plume elongation is consistent with the direction of groundwater flow, with the up-gradient end indicating the approximate source area. A comparison of the 1990 and 1992 data sets indicates that nitrate levels in the SPC area have generally decreased by about one-half, while levels near the MW-12 well cluster have stayed about the same over this short time period. The highest concentration levels, observed in the 1970's at well TW-2, were near the SPC facilities and were in the hundreds, and potentially thousands, of ppm. The concentrations observed at the MW-12 area are in the 50 ppm range. Nitrate concentrations in the Stevens Drive area are in the 5 ppm range. This data indicates a trend of lesser concentrations with increasing distance from the SPC area suggesting considerable attenuation over distance.

The vertical distribution of contaminants within the unconfined aquifer is not definable, because the sampling wells are consistently screened over the same interval. Without discreet screens set at different elevations within the upper aquifer, no data is available for determining a vertical distribution. However, research on the migration of chlorinated hydrocarbons in porous media indicate that, at low concentrations (the HRL concentrations would be considered very low), differences in densities between the contaminant and the host water do not cause the plume to sink and the influence of the kinetic forces (water momentum forces) will be far greater than the gravitational forces

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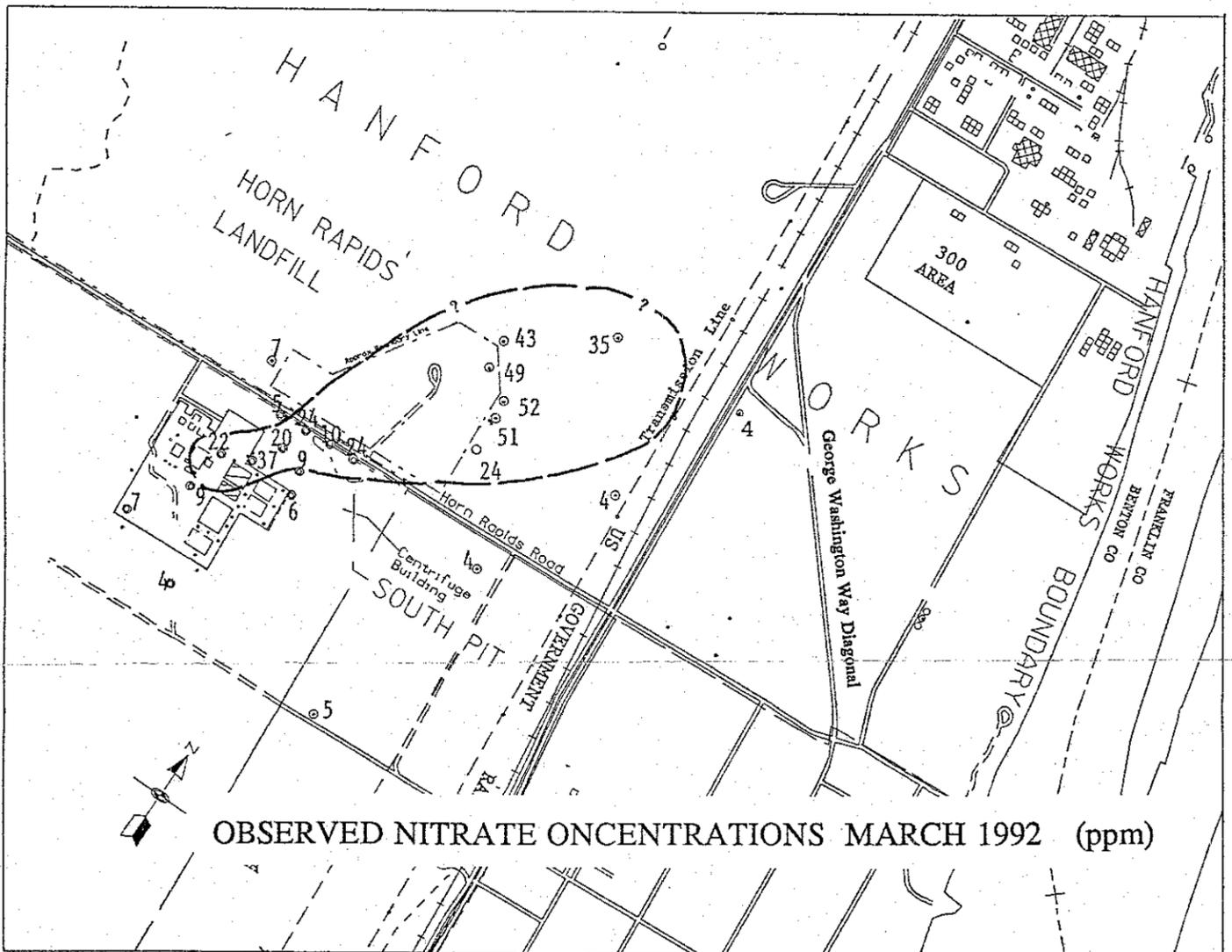
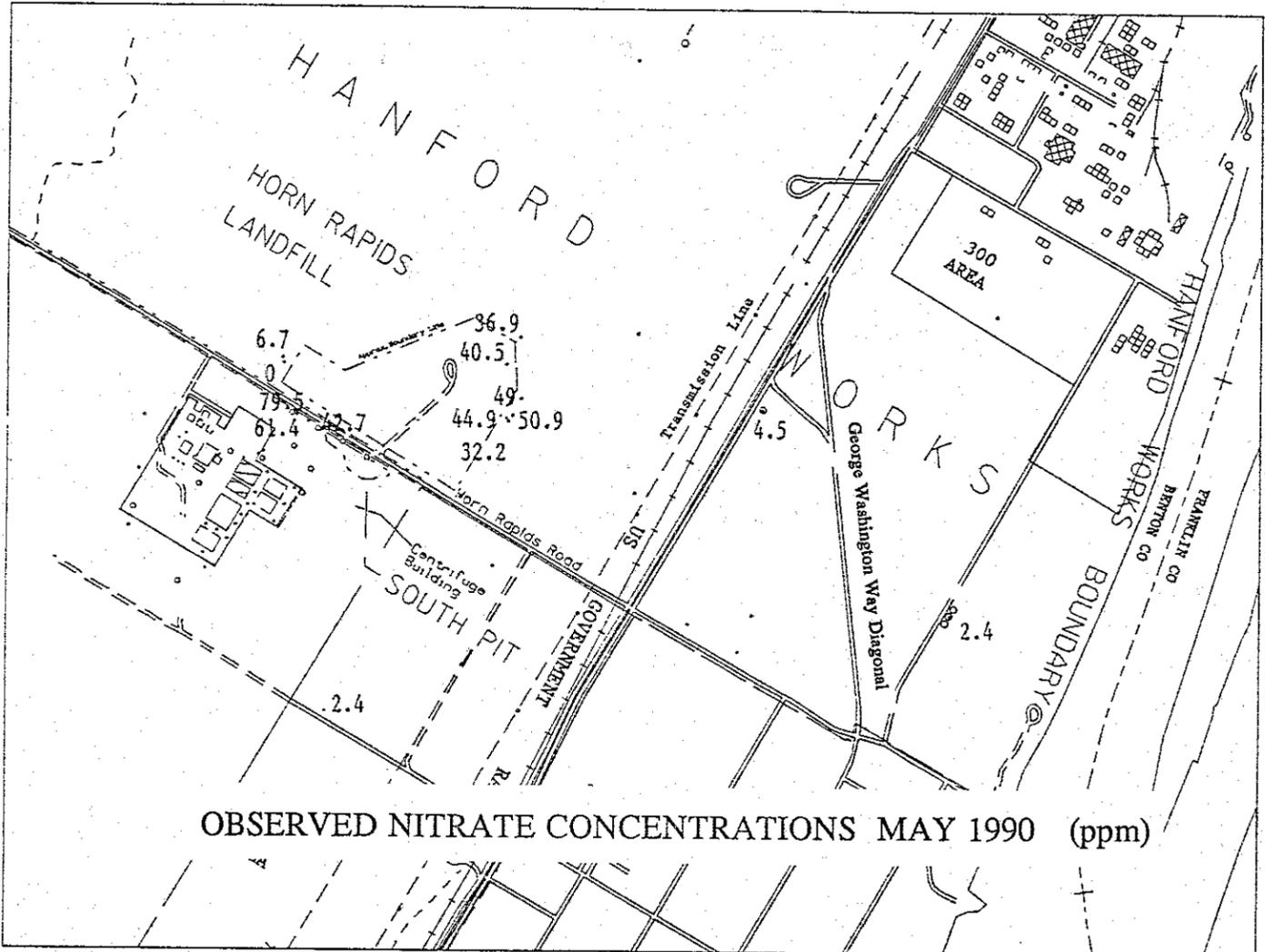
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9 3 1 2 8 6 2 0 3 9 0



Observed TCE Concentration Levels from 1987 to 1992 and Approximate Plume Delineations.

Figure 4-25



Observed Nitrate Concentration Levels in 1990 and 1992.

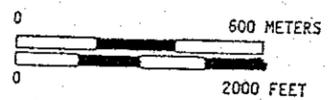


Figure 4-26

(differences in densities) (Schwille, 1988). The exception occurs when a free, dense, non-aqueous phase of the contaminant exists. Such an occurrence would be indicated by groundwater concentrations in the 1000's or 10,000's ppm, which is three orders of magnitude higher than concentrations measured within the HRL/SPC area. Based on published research and observed concentration levels, the TCE plume in the HRL/SPC area is expected to be distributed evenly in the vertical direction throughout the unconfined aquifer.

4.9 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION

Seven subunits within the 1100-EM-1 Operable Unit have detectable soil contamination at concentrations above preliminary risk-based screening levels. These contaminants are summarized in table 4-9. Contaminants above preliminary risk-based screening levels in groundwater to be considered during the risk assessment for the 1100-EM-1 Operable Unit include TCE and nitrate. In section 5.0, these contaminants, in both the soil and the groundwater, will be further evaluated in a more rigorous and extensive risk assessment process to identify a list of contaminants of concern to be addressed in the remediation of the 1100-EM-1 Operable Unit.

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Table 4-9. Summary of Contaminants of Potential Concern for the 1100-EM-1 Operable Unit.

Contaminant	1100-1	1100-2	1100-3	1100-4	UN-1100-6	Horn Rapids Landfill	Ephemeral Pool
Antimony						X	
Arsenic	X			X		X	
Barium						X	
Beryllium				X		X	
Chromium		X	X			X	
Copper						X	
Lead*						X	
Nickel						X	
Thallium						X	
Vanadium	X					X	
Zinc						X	
BEHP					X		
Beta-HCH						X	
Chlordane					X		X
DDT						X	
Heptachlor					X	X	X
PCBs						X	X
*Contaminant of interest							

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