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DATA SUMMARY PACKAGE FOR THE BETHEL VALLEY AREA DQO WORKSHOP

WASTE AREA GROUPING 1

VOLUME 3

SECTIONS V - VII
(Contaminated Media; Burial Grounds; and Active Facilities)

FINAL

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WASTE AREA GROUPING 1 DQO Data Package

VOLUME I

I. Introduction

1.1 Overview
- Organization of Data Package
- Major Findings Overall
- Bethel Valley RI/FS Sites
- Site Map

1.2 General WAG 1 Information

II. Tanks, Pipes and Ducts

- Introduction
- Source Information
- Data Summary
- Conceptual Site Model
- Risk Assessment
- References
- Other

III. Impoundments

- Introduction
- Source Information
- Data Summary
- Conceptual Site Model
- Risk Assessment
- References
- Other

VOLUME II

IV. D&D Buildings and Reactors

- Introduction
- Source Information
- Data Summary
- Conceptual Site Model
- Risk Assessment
- References
- Other

VOLUME III

V. Contaminated Media

- Introduction
- Source Information
- Data Summary
- Conceptual Site Model
- Risk Assessment
- References
- Other

VI. Burial Grounds

- Introduction
- Source Information
- Data Summary
- Conceptual Site Model
- Risk Assessment
- References
- Other

VII. Active Facilities (WMRAD)

- Introduction

White Oak Creek DQO Data Summary Worksheet

Form Completed by: P. Salpas
Date: 12-22-95

Document Reviewed: WAG 1 Site Characterization Summary Report Vol. 2
Doc ID: DOE/OR-1043/V2+D1
Author/Date: DOE 1992

Comments:

WAG	Description of Study	Waste Unit	Sampling Dates	Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Analytical Protocol	Questions Addressed	Quality or Confidence
1	Characterization of major sources in WAG 1		9/90 - 4/91	GW	WAG 1 wells	G, WL	I, O, R ~~I, O, R~~		2B, 3A, 4A 3B, 4B	M -> H
				SURF	WAG 1	S, G	I, O, R, P		2A, 3A, 3B, 4A, 4B	M -> H
			10/90 - 3/91	SW	WAG 1 tribs + WOC	G, SG, BG, WL	I, O, R, P		2C, 3A, 3B, 4A, 4B	M -> H
			10/90	SED	WOC, 1st Creek, 5th Creek, NWT	G	I, O, R, P		2D, 3A, 3B, 4A, 4B	

General:
NA - Not Available
NR - Not Researched
(blank) - Unknown

Confidence:
H - High
M - Medium
L - Low

Media:
SURF - surface soil
SUB - subsurface soil
SW - surface water
GW - groundwater
Seep
SED - sediment

Sampling Locations:
List specific locations if possible. Otherwise, indicate scope of sampling effort.

Sampling Protocol:
G - grab
SG - stormflow grab
BG - baseflow grab
FC - flow composite
SC - spatial composite
V - vertical profile
S - site survey
WL - water level

Analytical Fraction:
I - Inorganics
O - Organics
R - Radionuclides
P - PCBs/Pesticides/Herbicides
G - General Chemistry

Analytical Protocol:
CLP - CLP level 3 or 4
Screen - Screening level
ESD - ESD project-specific
FM - Field measurement
Gross - Gross alpha, beta, gamma
Iso - Isotopic
Sr/H3 - Strontium/Tritium

Question / Hypothesis
1 = Source characteristics
1A - design/operation
1B - leachate
1C - waste inventory
1D - waste unit hydrology/hydrogeology
1E - other FS information
2 = Nature/Extent of Current releases
2A - surface water, seeps
2B - groundwater
2C - soil around waste units
2D - sediment
2E - cummulative at integration point
3 = Current risk
4 = Modeling for future risk
3A/4A - human health risk
3B/4B - ecological risk

viii

000001

Bethel Valley RI/FS Historical Data Review

Form Completed by: Anita Parker
Date: 3/21/97

Document Reviewed: Action Memorandum for WAG-1 Corehole 8 Removal Action
Doc ID: DOE/OR/02-1317 + D2
Author/Date: Jacobs ER Team / 11/94

Comments: Plume Map

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
1	Documents approval	Corehole	Release of Sr-90	1991	GW	WAG-1		GR		M → H
	for a CERCLA	8	into 1st Creek	1994	GW	Seeps		B/G		
	non-time critical					Manhole		Discharge		
	removal action					Catch basins				

General:
NA = Not Available
NR = Not Researched
(blank) = Unknown

Sampling Media:
surface soil
subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

Sampling Protocol:
G = grab
SG = stormflow grab
BG = baseflow grab
FC = flow composite
SC = spatial composite
V = vertical profile
S = site survey

Analytical Fraction:
I = Inorganics
O = Organics
P = PCBs/Pesticides/Herbicides
GR = gross alpha/beta
ISO = isotopic rads
B/G = beta/gamma survey
FLD = field measurements

Decision Rule / Hypothesis
1 = Source characteristics
1A = design/operation
1B = leachate
1C = waste inventory
1D = waste unit hydrology
1E = other FS information
2 = Current releases
2A = shallow groundwater, seeps
2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

Source Investigation Report for WAG 1 Nov 1996

INTRODUCTION

This report describes activities and findings associated with the Task Work Agreement Waste Area Grouping (WAG) 1 Groundwater Source Investigations Work Breakdown Structure (WBS) 1.4.12.6.1.01.44.08 performed in FY 1996. The objective of the task was to identify a source(s) of groundwater radiological contamination in WAG 1 that could reasonably be related to the so-called core hole 8 ^{90}Sr plume and other potential radiological plumes.

The source investigations task was divided into two phases. Phase 1 involved installing and sampling drive points to the east of core hole 8 (CH-8) to identify a discrete source of contamination. Phase 2 involved installing and sampling groundwater wells to identify a more diffuse source of contamination.

DRIVE POINT INSTALLATION

Phase 1 activities began in November 1995, with the installation of five drive points in the vicinity of Tank W-1A in the northwest corner of the North Tank Farm (Fig. 1). This location was selected because it is directly east (along geologic strike) of the subcropping of the core hole 8 plume preferred flow pathway and near the inferred groundwater flow divide located in the central portion of Oak Ridge National Laboratory (ORNL). The location was also selected to be near enough to potential tank/pipeline leaks that could logically be associated with the plume but far enough away to avoid penetrating such utilities and creating an environmental and human health hazard.

Based on the radiological results obtained from the samples, it was decided that it would be cost effective, while maintaining the technical objective of the task, to install additional drive points and fewer groundwater monitoring wells than originally planned. Additional drive points were installed in February and March 1996.

About 40 drive points were planned for installation, but encountering shallow obstructions believed to be above the water table limited the number of drive points to 17. From a total of 22 drive points installed, 68% contained groundwater and 50% were able to be sampled. Drive point civil survey data are shown in Table 1. The radiological results (Table 2) indicate that significant gross beta (attributable to ^{90}Sr) and gross alpha (attributable to $^{233/234}U$) activity exists in the vicinity of Tank W-1A and decreases in concentration away from the tank. Because ^{90}Sr and ^{90}Y were in disequilibrium in the sample, the gross beta values are underreported. More accurate gross beta values can be obtained by doubling the ^{90}Sr value.

The results indicate that the highest levels of contamination and the shallowest depth to groundwater exist in closest proximity to the tank and in the deepest drive points (Fig. 2). These results are interpreted to indicate that the Tank W-1A excavation acts as a "bathtub" that maintains saturation around the tank. Continuous water elevation data from these drive points confirm this interpretation by the development of a shoulder on the ascending limb of the

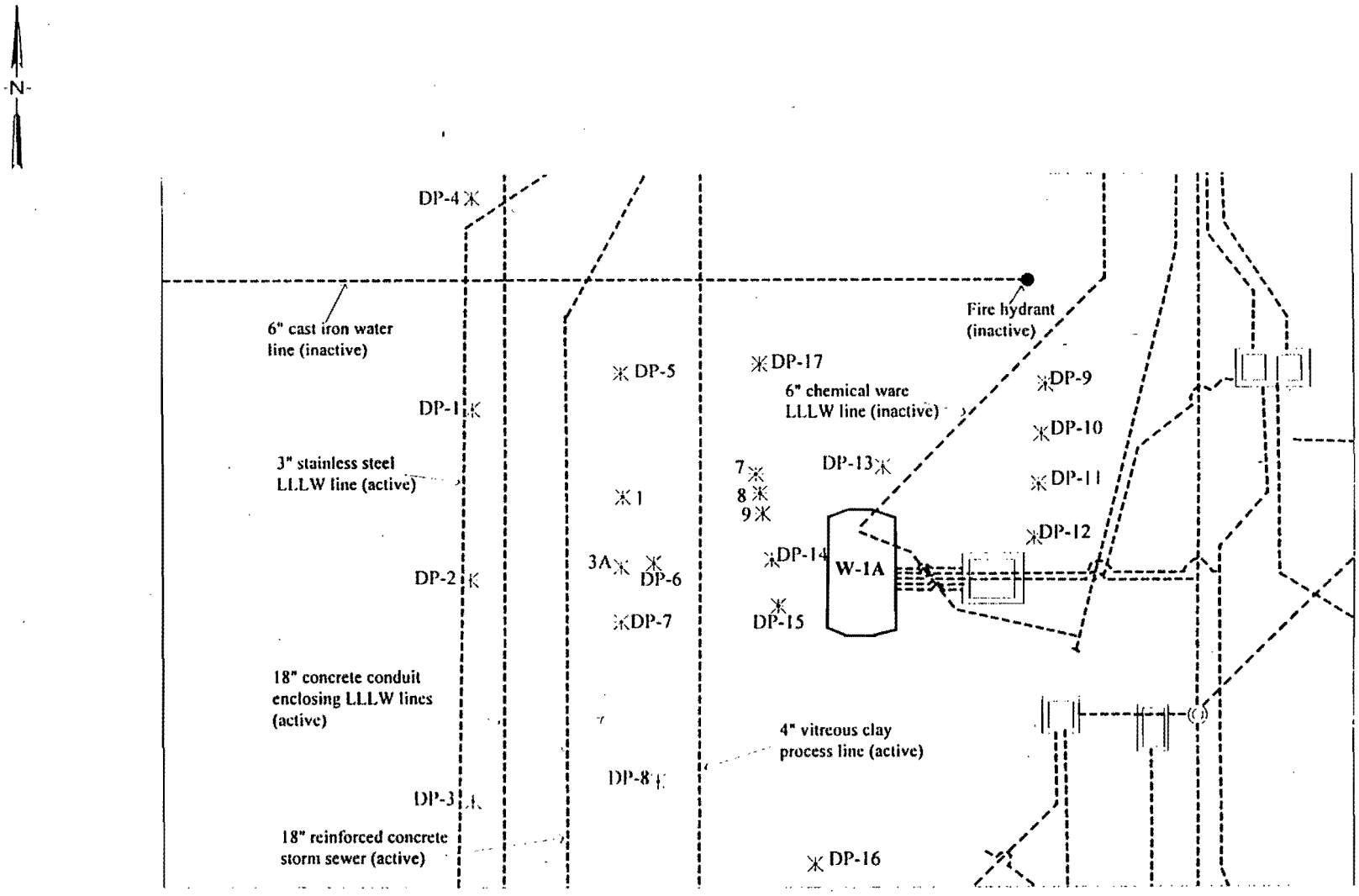

Fig. 1. Locations of Drive Points, Tank W-1A, and Underground Utilities

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Table 1. Drive point civil survey data

Drive point	Northing	Easting	Ground surface (ft MSL)	Total depth (ft bgs)	Groundwater level (ft)
DP-1	22270*	30765*	NA	14.8	0.31
DP-2	22252.2	30764.8	822.88	17.7	4.45
DP-3	22228*	30765*	NA	13.4	0.34
DP-4	22293*	30765*	NA	20.7	Dry
DP-5	22274*	30781*	NA	9.5	Dry
DP-6	22253.3	30784.7	822.93	11.9	1.15
DP-7	22247*	30781*	NA	9.4	Dry
DP-8	22230*	30785*	NA	10.7	0.34
DP-9	22272.8	30827	822.43	12.4	Dry
DP-10	22267.5	30826.5	821.7	11.7	0.42
DP-11	22262.1	30826.1	821.32	14.2	0.88
DP-12	22256.3	30825.7	820.85	9.4	1.06
DP-13	22264	30809.3	822.25	17	7.36
DP-14	22253.8	30797.3	821.84	17.8	8.37
DP-15	22248.9	30797.9	820.69	16.8	9.72
DP-16	22221.4	30802.1	817.67	17.3	3.47
DP-17	22275*	30796*	NA	12	Dry
1	22260.6	30781	823.81	15.1	0.87
3A	22253*	30781*	NA	9.3	Dry
7	22263.3	30795.8	823.37	17	NA
8	22261*	30796*	NA	16.7	Dry
9	22258.9	30796.3	822.93	17.4	NA

*Denotes estimated location.
NA = not available.
MSL = mean sea level
bgs = below ground surface

hydrograph (Fig. 3) for the rain event beginning on May 25, 1996. The presence of a similar shoulder in WAG 4 trench drive points was interpreted similarly. Hydrograph response to precipitation events ranges from 1 to 3 ft in these drive points.

The solids from one drive point sample were analyzed separately for comparison with the liquids from that sample. The results indicate that the solids contain nominally 50 times the amount of ^{90}Sr activity as the liquids. If considered on a K_d basis, this result is similar to literature reported K_d values for ^{90}Sr.

010000

Table 2. Drive point radiological data

Drive point	Sample date	Gross beta (pCi/L)	Gross alpha (pCi/L)	^{90}Sr (pCi/L)
DP-1	NS			
DP-2	3/14/96	4.32E+06	9.18E+05	3.40E+06
DP-3	NS			
DP-4	NS			
DP-5	NS			
DP-6	3/14/96	4.86E+04	6.48E+03	4.12E+04
DP-7	NS			
DP-8	NS			
DP-9	NS			
DP-10	NS			
DP-11	3/20/96	5.40E+05	3.51E+04	5.00E+05
DP-12	3/21/96	2.21E+05	3.24E+04	1.89E+05
DP-13	3/20/96	1.30E+06	8.10E+05	4.86E+05
DP-14	3/20/96	1.27E+07	5.40E+05	1.22E+07
DP-15	3/20/96	3.51E+06	2.32E+05	3.28E+06
DP-16	3/20/96	1.24E+06	7.02E+04	1.17E+06
DP-17	NS			
1	3/14/96	9.18E+04	1.19E+03	9.06E+04
3A	NS			
7	12/1/95	8.10E+06	1.59E+05	6.02E+05
7	3/14/96	6.21E+06	1.57E+05	6.05E+06
8	NS			
9	12/1/95	1.05E+07	3.78E+05	1.01E+07
9	3/14/96	7.83E+06	2.70E+05	7.56E+06

NS = not sampled.

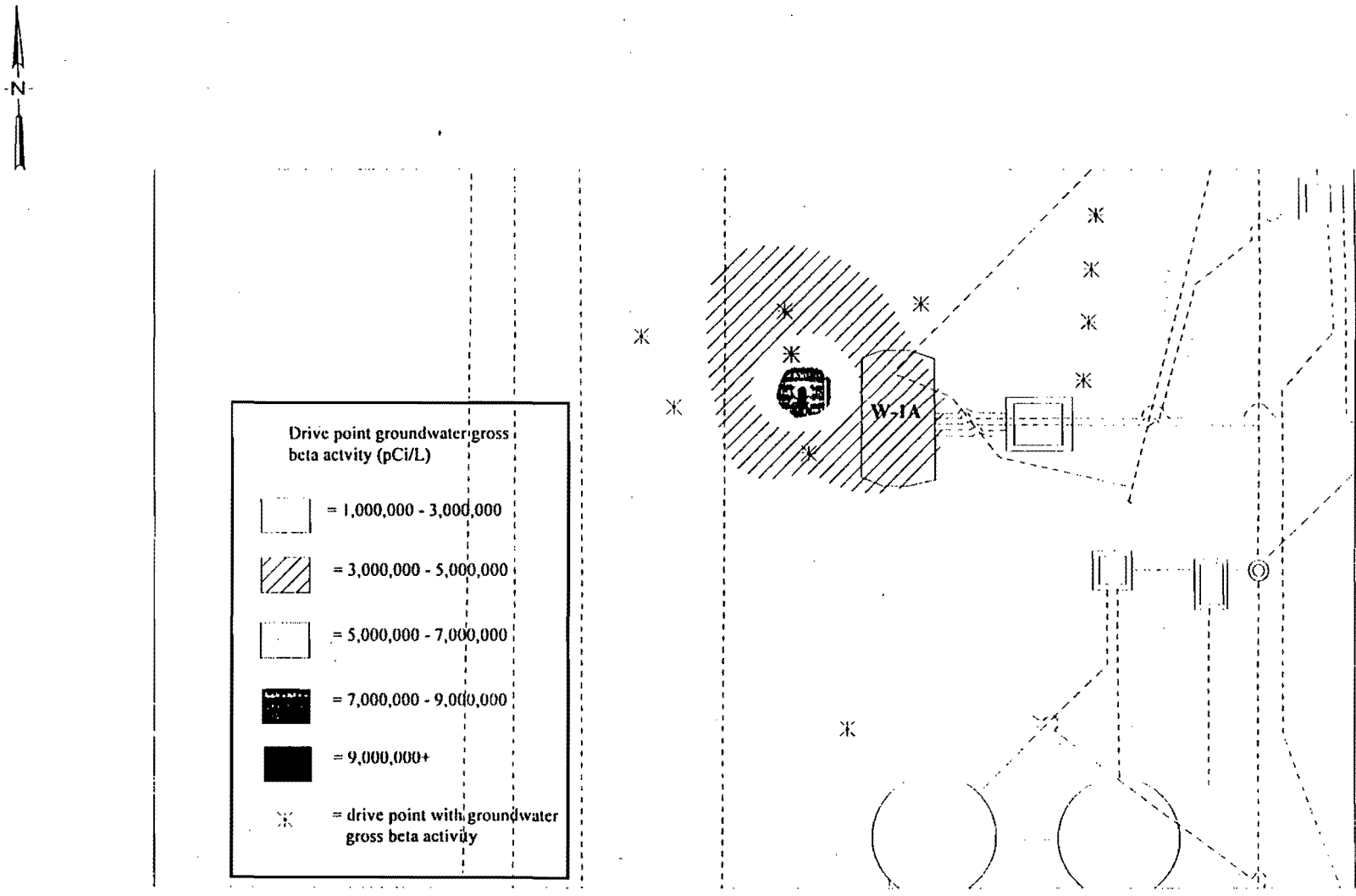

Fig. 2. Drive Point Groundwater Gross Beta Activities

000013

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occurring. Analysis of groundwater sample results from the monitoring wells and tank dry wells (to the east and from Fifth Creek obtained from WAG 1 monitoring) support that interpretation.

CONCLUSIONS AND RECOMMENDATIONS

As stated earlier, the purposes of this exploratory drilling activity were (1) to identify the source for the so-called core hole 8 contaminant plume, (2) to determine the extent of contamination, and (3) make recommendations regarding potential early actions or remediation strategies for the problem. The approach sought to determine whether the source was of a diffuse or more localized extent through a process of hypothesis testing.

The results of the activity conclusively show that the source of the core hole 8 plume is localized in the immediate area surrounding Tank W-1A located in the northwestern corner of the North Tank Farm. While diffuse contamination exists in the bedrock aquifer in the area of Buildings 3001 and 3019, it is significantly lower than the highest levels in core hole 8 and thus cannot reasonably be considered to be the source of the plume.

In addition, results from wells 4410 and 4411 support the preferred flow and transport pathway conceptual model, which is generally considered to explain the configuration of the core hole 8 plume. In addition to migration to the west, results of this activity support data from WAG 1 monitoring and demonstrate that migration also is occurring to the east and discharging to Fifth Creek. The unanticipated down dip migration to nominal depths of 90 ft in well 4411 indicates that the extent of migration and magnitude of the problem are greater than previously thought. That concentrations in well 4411 are essentially the same as those in drive points at the bedrock weathering interface suggests that little mixing occurs into and out of the pathway at depth. Lower levels of contamination at shallow depth to the east and west likely occurs as a result of dilution by infiltrating precipitation.

The depth to which contamination migrates down dip could not be addressed because of health and safety concerns resulting from the unacceptably high potential for inadvertently encountering an underground or overhead utility in the area where drilling could feasibly occur. However, because groundwater brine exists at a nominal depth of 300 ft throughout the Oak Ridge Reservation, it is unlikely that contaminants would migrate to depths greater than about 300 ft.

Remediation/early action options must first focus on the soils around Tank W-1A. With nominally 50 times the contaminant levels as groundwater, the soils act as a secondary source that continually releases contaminants to groundwater upon saturation from rain events. An integral part of any action must include the removal or stabilization in place of potential sources of groundwater and soil recontamination (e.g., pipelines, Tank W-1A, contaminated soil). If contaminated soils are removed and replaced with clean fill and suspected primary contaminant sources are stabilized/removed, it is possible that the clean fill could be recontaminated by unforeseen events. In addition, soil removal has inherent personnel exposure, atmospheric dispersion, and waste management issues that must be addressed. Stabilization in place of contaminated soils with an acrylamide grout, for example, could minimize future contaminant releases while avoiding potential problems associated with soil removal.

Soil remediation without addressing remediation of contaminated groundwater is considered to be only a partial action. WAG 1 monitoring results suggest that contaminant concentrations are increasing in the vicinity of the core hole 8 plume intercept system. Because groundwater contaminant concentrations at depth are so high, and a larger than anticipated volume of groundwater is highly contaminated. concentrations are likely to continue increasing at the periphery of the plume for the foreseeable future. Additional early actions. similar to the core hole 8 intercept system. are likely to be needed as contaminant discharges to First and Fifth Creeks increase to unacceptably high levels as more small contaminant seeps develop.

Groundwater remediation options could incorporate pump-and-treat or chemical fixation in place. While generally considered to be an undesirable option. pump-and-treat, in this case, would not need to continue indefinitely because a finite mass of contaminant exists within the preferred flow pathway that could be readily removed. Alternatively, chemical fixation could provide the opportunity to demonstrate a new technology. The current configuration of new well locations (namely wells 4410 and 4411 and CH-8) are anticipated to be useful in implementing a groundwater remediation action.

Site Characterization Plan for Groundwater in WAG 1 DOE/OR/01-1194 + D2 7/94

EXECUTIVE SUMMARY

The Waste Area Grouping (WAG) 1 Groundwater Operable Unit (OU) at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee, is undergoing a Remedial Investigation in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Oak Ridge is in Anderson and Roane counties, Tennessee, and ORNL is about 7 miles south of the city of Oak Ridge. ORNL was constructed in the early 1940s as part of the efforts during World War II to construct an atomic bomb. The research, production, fabrication, maintenance, and decontamination facilities that were constructed and operated as part of that effort have resulted in various sorts of environmental contamination throughout the Oak Ridge area.

The 150-acre WAG 1 is contained within the ORNL security area. It includes all of the former ORNL radioisotope research, production, and maintenance facilities; former waste management areas; and some former administrative facilities. This document, *Waste Area Grouping 1 Groundwater Phase II Remedial Investigation Work Plan*, identifies areas of concern with respect to WAG 1 groundwater and presents the rationale, justification, and objectives for conducting this Remedial Investigation.

Volume 1 of this report summarizes the operations that have taken place at each of the areas of concern in WAG 1, summarizes previous characterization studies that have been performed, presents interpretations of previously collected data and information, identifies contaminants of concern, and presents an action plan for further site investigations and early actions that will lead to identification of contaminant sources, their major groundwater pathways, and reduced off-site migration of contaminated groundwater to surface water. These investigations will lead to a baseline risk assessment and aid in remediation option selection decision making following a feasibility study for site remediation.

Site characterization activities performed to date at WAG 1 have indicated that groundwater contamination, principally radiological contamination, is widespread. An extensive network of underground pipelines and utilities have contributed to the dispersal of contaminants to an unknown extent. In addition, numerous spills and pipeline leaks and the long and varied history of activities at specific facilities at ORNL complicates contaminant migration pathways analysis and source identification. The general absence of radiological contamination in surface water at the perimeter of WAG 1 is attributed to the presence of pipelines and underground waste storage tank sumps and dry wells distributed throughout WAG 1 which remove more than about 40 million gal of contaminated groundwater per year.

One contaminant plume is currently known to be directly discharging off-WAG to surface water and indirectly discharging via plume inleakage to storm drains. These are the largest known groundwater contaminant discharges to surface water at WAG 1. An early action is described which is designed to immediately terminate those discharges and intercept the plume at several locations along its length. This early action, however, is not part of this

Remedial Investigation but is described to add clarity and completeness to the presentation. Identifying the source for the plume is one of the primary objectives of the activities described in this report. Other areas of concern will undergo either exploratory investigation or monitoring to more fully describe the nature and extent of contamination and migration pathways which are also important report objectives. The approximate locations, numbers, target analytes, and sampling frequency of samples to be collected are described for each area of concern.

In addition to groundwater elevation and quality data acquisition from new wells, the rationale and justification for a monitoring and sampling program to provide a minimum data record are described. The monitoring and sampling program will be an ongoing, long-term effort to determine changing conditions over time.

The Field Sampling Plan, the Field Quality Assurance Project Plan, and the Laboratory Quality Assurance Plan are also included. The Field Sampling Plan describes the objectives of data collection and the quality assurance documentation required to meet those objectives. The Quality Assurance Project Plans include the procedures that will be followed by the field samplers and laboratory to obtain reliable and defensible data. They also provide for surveillances and audits and establish corrective actions to be employed in the event that activities are not consistent with quality assurance objectives.

Volume 2 of this report, to be provided, is the Health and Safety Plan and Waste Management Plan for the WAG 1 Groundwater Phase II Remedial Investigation. It will be prepared in accordance with 29 CFR 1910.120 and will contain an evaluation of potential hazards associated with the wastes disposed of from exploration, sampling, and monitoring. It will also describe personnel decontamination procedures designed to ensure that hazardous and/or radioactive material encountered in the investigated area does not leave that area.

Site Charac Pla for GW in WAG 1 DOE/OR/01-1194+ D2

6. NATURE AND EXTENT OF CONTAMINATION AND SITE DATA NEEDS

This section describes the nature and extent of contamination at WAG 1 as it is currently understood. Data gaps and additional data needed to describe groundwater contamination more completely are also noted. The description relies upon data reported by BNI (1992) and other limited historical data, and it focuses on groundwater and soils contamination which may serve as secondary sources of groundwater contamination. Accounts of additional historical contamination are based on information presented in Grimsby (1986) and known or suspected historical operations that took place in buildings and facilities, pipeline leaks, and accidental spills. Additional data needs and proposed actions follow the description of the nature and extent of contamination.

BNI (1992) provides a detailed accounting of WAG 1 groundwater, soils, and surface water contamination. Radionuclides are the major groundwater contaminants at WAG 1 both in terms of areal distribution and contaminant levels. Hazardous constituents typically occur in more limited areas (e.g., adjacent to underground fuel tanks). Underground pipelines, sumps, and tank dry wells affect the distribution of contaminants.

Because activities contributing to groundwater contamination at WAG 1 have been numerous and varied over a long period of time, a presentation of the overall condition of groundwater contamination is confusing at best. As a result, major areas of contamination are treated as individual areas of concern, and points of overlap between areas are identified. To further simplify the presentation and facilitate comparison among areas, the indicator radiological analytes gross alpha, gross beta, and tritium are emphasized. Specific radionuclides are discussed when they contribute to the description of the nature and extent of contamination. Similarly, only those nonradiological analytes that contribute to an understanding of the nature and extent of contamination are discussed. In groundwater these analytes include the volatile organic compound (VOC) TCE and its degradation products [1,2-dichloroethene (1,2-DCE) and vinyl chloride] and the metals cadmium, chromium, beryllium, mercury, and lead. The occurrence of nonradiological soil contaminants is variable and addressed on a case-by-case basis. Tables 6.1 and 6.2* contain RCRA action levels for soil and SDWA MCLs for groundwater respectively for contaminants of concern in WAG 1.

Only those areas with comparatively more significant or widespread contamination are described. This work plan is not intended as a full accounting of contamination at WAG 1 but is intended to identify and prioritize areas for interim remedial actions, and resources will be directed at those areas on a priority basis. Numerous isolated locations that are considerably less contaminated would receive a low priority ranking beyond monitoring, but should analysis of such monitoring data determine more significant or widespread contamination than presently understood, modifications can be made to the work plan in

*Because of the length and number of the tables in Chap. 6, they appear at the end of the chapter.

subsequent phase RIs. In addition, because of overlap between areas, early actions will undoubtedly affect conditions in areas peripheral to the initiating area. The extent of this effect on peripheral areas cannot be realistically predicted at present.

In general, gross alpha and gross beta groundwater contamination in any piezometer or well is inversely related to groundwater elevation. This relationship suggests that increased volumes of water during high base conditions serve to dilute contaminant levels. In contrast, tritium concentrations are commonly directly related to groundwater elevations, which suggests that tritium is mobilized during the rainy season. In both cases, the flux of contaminants through groundwater will be shown to be greater during high base than low base conditions because of accompanying increased groundwater movement.

WAG 1 groundwater is a part of the much larger Groundwater OU, and agreements have been reached as to which groundwater responsibilities lie with WAG 1 and which are part of more general issues to be addressed by the Groundwater OU. Because most WAG 1 groundwater contamination is considered to be contained within the upper portions of the aquifer, the nominal upper 100 ft of the aquifer is the responsibility of WAG 1. Deeper groundwater flow issues (e.g., long off-site flow paths, depth of active flow) lie with the Groundwater OU. Exceptions will be the instrumentation of core holes CH-2 and CH-7A in WAG 1 discussed in Sects. 6.4.10 and 6.5.1.

Because surface water in and around WAG 1 leads to WAG 2 (WOC south of the Haw Ridge water gap) the Groundwater OU will assume responsibility for WAG 1 surface water. Issues related to groundwater underflow of surface water in WAG 1 will remain the responsibility of WAG 1.

6.1 SOILS

In general, soils are most highly contaminated in the vicinity of the NTF and STF, the 3513 and 3524 impoundments, and Building 3019 (BNI 1992). Lesser contaminant levels occur in the Isotopes Area and near the thorium tank farm. Relatively localized areas of contamination are commonly related to pipeline leaks or spills.

Background radiological contaminant levels from reference soil sampling reported in BNI (1992) indicate as much as 34 pCi/g gross beta, 56 pCi/g gross alpha, and 0.22 pCi/g tritium. ^{137}Cs, ^{99}Te, and total radioactive strontium (^{89}Sr plus ^{90}Sr) were detected in small amounts. Metals and hazardous constituents were detected in varying amounts. Because the list of those analytes is long, the amount that a WAG 1 sample value exceeded the reference value is described in the sections below. Table 6.1 contains reference and RCRA action level soil contaminant values.

Beryllium concentrations in both WAG 1 and reference soils often greatly exceed RCRA action levels, and it is difficult to judge what actually constitutes manmade beryllium contamination in WAG 1. Klaassen et al. (1986) report that beryllium in the environment

largely results from coal combustion, but it is also used in nuclear reactions. The relative contribution of these two mechanisms to beryllium soil contamination is not known, but since coal combustion has and does occur both regionally and locally, that mechanism is considered to be the principal cause for the contamination. Deposits from vehicle brake linings may also contribute.

6.2 GROUNDWATER

Extensive areas of WAG 1 groundwater are contaminated with radiological and nonradiological constituents. Radionuclides are the principal groundwater contaminant. Contamination generally appears to be confined to the upper portions of the aquitard. Evidence to support the potential for contaminant migration to greater depths is discussed below, as is the potential for off-WAG migration by groundwater underflow of surface water.

Background radiological contaminant levels from reference sampling (BNI 1992) indicate about 4 pCi/L gross alpha, 5 pCi/L gross beta, and between about 1000 and 2000 pCi/L tritium. SDWA MCLs are 15 pCi/L (gross alpha), 4 mrem/year (gross beta) and 20,000 pCi/L (tritium). Table 6.2 compares these levels. Although different geologic units in WAG 1 may have slightly different amounts of naturally occurring radionuclides, gross alpha and beta maximum reference values are useful for evaluating contaminant levels. BNI (1992) describes the difficulties in accurately determining what constitutes radiological contamination at WAG 1, and the maximum reference values and MCLs were used only as guides. VOCs, base/neutral/acid-extractables, metals, and pesticides and herbicides were either not detected or were detected in relatively low concentrations at isolated locations.

6.3 SURFACE WATER

Historical surface water radiological contamination data for First Creek, Fifth Creek, Northwest Tributary, and WOC surrounding WAG 1 indicate negligible to low levels of contamination. Contaminant discharges to WOC downstream of the PWTP outfall are obscured by plant discharges. Assuming that groundwater at WAG 1 discharges to adjacent surface water bodies, the generally low surface water contaminant levels compared to groundwater within the WAG supports the concept that contaminated groundwater is being effectively captured by pipelines, sumps, and underground tank dry wells. Adsorption, radioactive decay, travel distance, and dilution in surface water also contribute to apparent differences between groundwater and surface water contaminant concentrations.

6.4 AREA-SPECIFIC CONTAMINATION

This section describes known areas of contamination in WAG 1 based on analysis of site data and/or historical activities. In most cases, these areas comprise the most significant or widespread contamination, and some are considered to contain contaminant sources.

6.4.1 Building 3001/3019 Area

This area includes Buildings 3001 and 3019, the 3001/3019 storage canal, and the "3019 Hot Bank," which is the slope located north of Building 3019 (Fig. 6.1*). Building 3001 is one of the oldest buildings at ORNL and houses the Graphite Reactor. Building 3019 includes the main portion of the Radiochemical Processing Plant and houses a High Radiation Level Analytical Facility.

Buildings 3001 and 3019 are connected by the 3001/3019 storage canal. The canal is a belowground concrete structure which is 7 ft wide, 11.5 ft deep, and 101 ft long. It is covered with a concrete lid and soil and has a capacity of 62,000 gal. The canal was used for underwater transfer of spent fuel from the graphite reactor and was in operation from 1943 to 1963. The canal was then used for storage of radioisotopes until 1990 when a leak was discovered and removal of the stored material was initiated (ORNL 1990). Remediation of the canal under RCRA has been accelerated. As part of the remedial process, sludge containing cobalt crystals was removed from the canal. As a result of the sludge removal, the rate of leakage from the canal is reported to have increased.

Also included in this area is the 3019 Hot Bank which is the slope located north of Building 3019. The slope has been contaminated by a combination of emissions from the Building 3019 stack and LLLW line leaks in the area. Most of the contamination at the Hot Bank is believed to be limited to surface or near-surface soils, but some contamination may have infiltrated to groundwater or been transported along pipelines that cross the area.

In addition to the facilities described above, there are other potential sources of contamination in the area. These include filter houses, underground ductwork, tanks, and pipelines.

Environmental sample data for the 3001/3019 potential source area are limited mostly to surface and near surface soil samples. No water quality wells and only a limited number of piezometers are located within the area. The piezometers are completed at the top of the bedrock, and during most of the year do not provide sufficient quantities of water for sampling. Some groundwater data from wells located outside the immediate vicinity may indicate contamination from Building 3001/3019 sources. Screening level water samples have been collected from one temporary pipeline trench piezometer located at a former pipeline leak site. These data are discussed briefly below.

Table 6.3 summarizes indicator radiological data from groundwater and soil samples collected from the 3001/3019 area. The data indicate that three areas of contamination exist: (1) site of an past pipeline leak southwest of Building 3019, (2) site of past pipeline leak north of Building 3019, and (3) the 3019 Hot Bank.

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*The legend for Figs. 6.1–6.4 and 6.6–6.12 appears on p. 6-5.

Soil boring SB132 is located at the site of a series of historic LLLW pipeline leaks that occurred southwest of Building 3019. Samples from this boring contained up to 16,005 pCi/g gross beta and 1043 pCi/g gross alpha. In addition, samples from this location contained elevated concentrations of several other radionuclides including ^{137}Cs, total radioactive strontium, ^{60}Co, ^{238}Pu, $^{239/240}Pu$, and ^{147}Pm. Concentrations were greatest in samples collected from the 10–12-ft interval, which is nominally 5 ft below the estimated pipeline invert elevation.

The historical pipeline leak site north of Building 3019 was sampled at borings SB130. Samples from this location contained elevated activities of gross beta (up to 1855.8 pCi/g) and gross alpha (up to 3104 pCi/g). Radionuclides found in these samples include ^{241}Am, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{238}Pu, $^{239/240}Pu$, and ^{244}Cm. Highest concentrations were found in samples collected in the 10–12-ft depth interval, also below estimated pipeline invert elevations.

Soil samples collected at the 3019 Hot Bank also contain contamination. For example, gross beta activities in samples from boring SB126 were as high as 6171 pCi/g, and gross alpha activities from the same location were as high as 1904 pCi/g. The most predominant radionuclides detected in Hot Bank soils were ^{137}Cs and total radioactive strontium. Most of the contamination on the Hot Bank appears to be limited to the upper 6 ft of soil.

Soil samples were collected from other areas near 3001/3019, including the storage canal, pipelines, and buried tanks sites. With the exception of one boring, gross beta and gross alpha activities in samples from these borings were generally at or near background levels. However, because some of the borings (e.g., the storage canal borings) could not be advanced deep enough to allow sampling below the probable contaminant depth, it is possible that contaminants could have been missed. The location where contamination was detected is boring SB258, where soils in the 2–4-ft depth range contained elevated activities of gross beta and strontium. The source of this contamination is not known, but may be associated with buried pipelines in the area.

Very little groundwater quality data are available for the 3001/3019 area. The only groundwater sampling locations in the area are piezometers 573 and 582. During the recent RI (BNI 1992), screening-level groundwater samples were collected from these locations. Results from these analyses indicate that groundwater at piezometer 582, located south of 3019, contains elevated gross beta activities. However, it is important to note that samples from these locations are not considered to provide a complete or reliable representation of groundwater quality at the 3001/3019 area.

Other incidental data provide additional indications that groundwater contamination may exist at the site. For example, soil samples collected from the two historic pipeline leak sites (SB132 and SB130) were wet at depths greater than about 10 ft BGS. This depth interval is greater than the depth at which the formerly leaking pipelines are believed to be buried, and is also the interval at which soil samples containing the greatest amounts of contamination were found. Based on available data from nearby piezometers, depths to groundwater in the area are typically >25 ft. Therefore, the wet soils encountered in the soil borings may indicate

perched water table conditions, possible associated with leaky pipelines or with water moving along relatively permeable pipeline trench backfill material.

A temporary piezometer was installed in borehole SB132 to provide information on water quality in the perched zone. Screening-level water samples collected from the piezometer contained elevated activities of gross beta (up to 20,000 pCi/L) and gross alpha (up to 110 pCi/L). Water levels in the piezometer have been quite variable (ranging from 11.65 to 15.2 ft BGS), suggesting that periodic, fairly rapid, pulses of flow may occur. These pulses are probably responsible for most of the flow in the trenches. Concentration data for the SB132 piezometer indicate that as the pulses occur, contaminant concentrations decrease, probably as a result of dilution. This indicates that there is some direct communication between the trench and infiltrating water; the infiltration may occur directly on the ground, or from secondary sources such as building gutter discharges or leaking storm drains.

Potential contaminant source areas in the 3001/3019 area include known historic pipeline leaks (mostly north and southwest of Building 3019), unknown historic leaks (floor drains, tanks, etc.), the historical canal leak, and leaching from hot bank soils. There are several potential mechanisms by which contamination may migrate from the 3001/3019 area to other parts of the WAG. Because of its position near the northern, upslope, upgradient portion of WAG 1 and its operational history, the 3001/3019 area is recognized as a potential source area for much of the contamination found in WAG 1 groundwater, including contamination in core hole CH-8, the NTF, the Isotopes Area, and other areas of the WAG.

Most historical leaks at 3001/3019 are believed to have occurred in unsaturated soil. In this situation, the clayey soils retard the downward migration of contamination. Contamination may be retarded for long periods of time, with periodic releases occurring when contaminants are periodically mobilized either because of a rising water table or downward infiltration. The net result is that there are areas of unsaturated soil in the 3001/3019 area that would continue to be constant or periodic sources of groundwater contamination.

One area in which a direct release to groundwater may have occurred is north of Building 3019 where a cavity was discovered during excavation of the leaking pipeline. Waste is believed to have migrated into the cavity where it interacted directly with groundwater. The potential for contaminant migration along pipelines was clearly demonstrated by the results of a dye tracer test conducted following discovery of the pipeline leak (Huff 1985). The test results demonstrated that a hydraulic connection exists between the cavity and the Building 3042 sump and underground pipelines in the area.

The pipeline network at 3001/3019 is believed to have a large impact on the transport of contaminated groundwater. There is a large, complex array of buried pipelines leading from the 3001/3019 area. These lines extend to much of the WAG, including the areas south of 3001/3019 (e.g., NTF, Isotopes Area), First Creek, and Fifth Creek. As a result, the pipeline system may conceivably transport contaminants from the 3001/3019 area to virtually any other part of WAG 1.

The predominant groundwater gradient direction at 3001/3019 area is southward with eastward and westward components present. Groundwater in the area may also migrate as stratabound flow, in which groundwater travels primarily along fractures or dissolution features in geologic strata. Dissolution features are known to occur in the Unit D beneath the 3001/3019 area. Stratabound flow appears to be an important transport pathway that results in migration of contaminants in the eastward or westward (along geologic strike) directions.

An aggressive subsurface exploration program will be performed in the 3001/3019 area. The emphasis of the program is to determine the vertical and areal extent of contamination in the area. It will test hypotheses about the presence of a sizable volume of contaminant contained within a localized cavity system(s) in Unit D vs localized contamination related to specific historic pipeline leaks. Both conditions are candidates as a CH-8 plume source and possibly other contamination within the WAG which is a secondary objective of the program. A tertiary objective is to determine the extent that pipeline trenches in the area are transmitters of contamination.

As shown in Fig. 6.1, bedrock wells will be installed adjacent to piezometers 560, 573, and 582, and soil borings SB130 and SB132. New bedrock wells will be installed west of Building 3137, northwest of the NTF, south of Building 3019 in Hillside Drive, and adjacent to a LLLW transfer line at the corner of Hillside Drive and Third Street. Four temporary piezometers will be installed in pipeline trenches southeast of Building 3001 and north of the NTF to investigate eastward and southward migration in pipeline trenches.

Piezometer 573 and a new bedrock piezometer near SB132 and SB130 are in locations very near historic pipeline leaks that may have contaminated groundwater. A new well south of the hot bank would seek to identify contaminants in that area. Piezometer 582 is downgradient from the 3001 canal, and piezometer 560, currently in a nonwater bearing portion of bedrock, is in a position near a possible southwest migrating pathway from a Building 3019 contaminant source that could also be used in CH-8 plume source investigations. Bedrock wells south of Building 3019 will be near a major PWT transfer pipeline and south of the storage tank, respectively. These will look at more localized areas of contamination near Building 3019. The well at the southeast corner of Hillside Drive and Third Street will look at both localized areas and more widespread contamination. Comparison of water elevations with the adjacent interface piezometers would also provide information about perched water.

It must be presumed that significant quantities of contaminant will be encountered during drilling, and decisions about the potential use of the boring in remedial design will need to be made. Because of the possible presence of secondary soil contamination in the area, soil auger drilling will sample and analyze for contamination as field screening dictates. The temporary piezometers in pipeline trenches would address potential migration from the area to the east.

A core hole near piezometer 583 into Unit D will seek to locate a potential contaminant pool south of Building 3019 at depth. The investigation would also be related to the CH-8 plume source investigation. The most desirable exploration method is core drilling which provides high resolution subsurface control. It is anticipated that such exploration to a depth of about 150 ft would proceed by advancing the hole in controlled increments with the ability to set casing during drilling to avoid creating an artificial contaminant pathway and to allow drilling to proceed.

If significant contamination is identified in these activities, installation of an additional piezometer(s) is foreseeable as part of a follow-on RI phase. Criteria for piezometer siting would include (1) areal and vertical contaminant characterization and (2) ability to remove contaminants by pumping if limited pump and treat is selected as the preferred remediation option.

Temporary piezometers in pipeline trenches southeast of the area would address pipeline migration pathways from the area to the east for which there are currently no data. The precise location for the temporary piezometers would be determined in conjunction with ORNL Waste Management and Engineering divisions staff who are knowledgeable about pipeline locations.

6.4.2 Underground Tanks

This section describes groundwater contamination associated with major underground liquid waste storage tanks. In WAG 1, Gunite and associated tanks are considered to be a separate OU. Because the NTF and STF constitute the major tank storage areas, they are treated separately. In addition, remedial investigation/feasibility studies activities are under way to address closure of the NTF and STF. The remaining tanks are then treated together. The approxmiately 80 × 230 ft contiguous area to the east of the STF which contains one 1500-gal capacity Gunite tank and six small stainless steel tanks is not part of the STF OU. The principal objective of investigations in the NTF and STF is to determine the relationship between tank and groundwater elevations.

Figure 3.2 shows the locations of the major inactive underground liquid waste storage tanks in WAG 1, some of which may be potential sources of groundwater contamination. Under normal circumstances leaks from those tanks beneath the water table would contribute greatly to groundwater contamination, but tank sumps and dry wells appear to capture groundwater contaminants and inhibit migration away from the tanks. Dry wells are pumped periodically or as needed to the PWTP or LLLW system for treatment.

During their operation, the tanks were used for temporary storage of low-level, process, and mixed liquid wastes. They were taken out of service because they were no longer needed. Because they concentrated large quantities of wastes (for decades in many cases) and many historic pipeline leaks near the tanks are reported, the tanks are considered to constitute major potential primary and secondary sources of groundwater contamination in WAG 1.

6.4.2.1 North Tank Farm

Tanks in the NTF (Fig. 6.2) were installed in the 1940s and early 1950s to receive LLLW principally from Building 3019 but also from Building 2026. Tanks are either stainless steel or Gunite construction, and all are inactive either because of leaks or because they are no longer needed. Because of inleakage, tank liquid levels are monitored, and liquids are periodically pumped to the LLLW system. The NTF has long been a major liquid waste transfer and storage area at WAG 1. Because several pipeline leaks are known to have occurred during its history, it is recognized as a potentially significant source of groundwater contamination.

The NTF is serviced by a sump system which collects liquids (groundwater or tank outleakage) at the base of each tank. The liquids drain to a common sump in the south central part of the tank farm and then drain by gravity past the west side of the STF to the PWTP for treatment and eventual discharge.

Groundwater data are available only from the periphery of the tank farm which are likely not to be representative of groundwater conditions within the tank farm or the excavations immediately around the tanks. Gross beta analytical data are obtained monthly from the W-1A tank dry well and from the dry well in the southern part of the farm where all the individual tank sumps drain. Radiological contamination is significant in these dry wells (hundreds of thousands of picocuries per liter), but it is uncertain what portion of this contamination, if any, is derived from groundwater.

Analytical results from soil boring SB26 (Table 6.4), which encountered saturated conditions in the 15-ft sample, are interpreted to be representative of groundwater conditions. Significantly less to essentially no contamination was found in the unsaturated soil samples. Nonradiological contamination in the 15-ft sample was not detected above reference values. An anomalously high 212,000 $\mu g/kg$ of beryllium in the 0–5-ft sample is not understood.

Soil boring SB26 is located just north of tank W-1 which has an estimated depth to the bottom of the tank of 13 ft. This suggests that groundwater elevation is below the bottom of tank W-1, and it is assumed that dry wells at other tanks also effectively maintain groundwater levels near the bottom of the tanks. Results from other soil borings in the NTF indicate that contamination is generally in close proximity to tank locations and that contamination generally increases with depth.

Despite the absence of groundwater analytical data from the NTF, its history of operation and proximity along geologic strike from core hole CH-8 has made it a candidate source area for the CH-8 plume. Alternatively, leaks from LLLW or process waste pipelines from the Building 3019 area to the NTF could be the source.

To evaluate these scenarios, a comparison was made of the radionuclides found in CH-8, in SB26, and from temporary piezometer SB132 in a process waste pipeline trench on the southwest corner of Building 3019. The comparison indicates that the suite of radionuclides

as well as their concentrations are similar for all three locations. For example, ^{90}Sr was the most abundant radionuclide found at each location, and gross alpha and ^{238}U were found at all locations. Overall, contaminant suites are most similar between SB132 and CH-8, and contaminant concentrations were most similar between CH-8 and SB26. These results suggest that both the NTF area and Building 3019 areas are potential sources of CH-8 contamination and/or that 3019 is a source of NTF contamination.

Because of the proximity of the NTF slightly south of the CH-8 plume, assuming the level of water in tank sumps and dry wells is representative of groundwater elevation in the immediate vicinity of that location, and assuming that tank sumps effectively capture contaminants in the near vicinity of the tanks, the NTF is not considered to be a candidate source area for CH-8 contamination. However, these assumptions are not confirmed, and essentially no data are available to describe the potential migration of NTF contaminants either through pipelines or groundwater to the west or south.

The data acquisition program for the NTF is designed to describe the configuration of the water table in the immediate vicinity of tank excavations and to determine the effectiveness of tank dry wells in removing contaminants. These data will be used to support decision making for NTF remediation alternative selection.

Six drive points (at the locations shown on Fig. 6.2) will describe the elevation of tanks with respect to the water table and the radius of influence of tank dry wells on the water table configuration. Those located near tanks will be located on the opposite site of the tank from the dry well to describe the configuration of the water table surface immediately around the tank and to compare contaminant concentrations with those in the tank dry wells. The drive point location near the center of the NTF and outside of the tank excavation pits will be used to compare water elevations and contaminant concentrations with those inside the pits. The drive point located along the northern edge of the NTF will be used to compare groundwater elevations and contaminant concentrations upgradient of the NTF with those within the tank excavation pits. After an initial evaluation of the presence of contaminants in the drive point wells, pressure transducers and data loggers will be used to obtain water elevation data from the drive points and tank dry wells to reduce waste generation. Sampling will be performed during high base, low base, and high base storm conditions.

Similarly, with knowledge about the amount of water transmitted through the NTF common sump, in combination with monthly radiological content of the water currently being collected, estimates about the flux of contaminated groundwater being captured by the sump system can be made. Consideration will be given to the feasibility of installing a flow metering device in the NTF common sump.

6.4.2.2 South Tank Farm

The 130 × 200 ft STF (Fig. 6.3) contains six large buried Gunite storage tanks that are approximately 50 ft in diameter and 12 ft in height with a 170,000-gal capacity. They were constructed within a pit excavated into the underlying bedrock. Old photographs suggest the

excavation may be about 5 ft into bedrock. The backfill material around each of the tanks is a 3-ft layer of 2-in. crushed stone surrounding the tank from the base to the top. A dry well and sump system similar to that described for the NTF consists of a concrete pad at the base of each tank and a gutter system that drains water from each pad to one of six individual dry wells. The dry wells in turn drain to a common sump for pumping to the PWTP. In the event of a leak, the liquid was intended to flow through the crushed stone to the concrete base then drain to the sump system. The system was draining an estimated average of 26,500 gal/d in the early 1960s (Mynatt and Webster 1963) as a result of groundwater inleakage into the sump system.

The Gunite tanks were originally built for permanent storage of radioactive liquid waste produced by the plutonium pilot plant. They were to receive waste from the building drains uphill to the north and to overflow from one tank to the next toward the south. As the laboratory grew, the storage tanks became inadequate to handle the volume of liquid waste being generated. The waste was precipitated in the tank by raising the pH with sodium hydroxide; the supernatant was decanted to waste holding basin 3513 and subsequently discharged to WOC. This practice changed in 1949 when a new evaporator was developed to handle the effluent. The use of each tank continued to change over the years as laboratory operations evolved.

Video inspections of Gunite tanks W5, W6, and W8 conducted during or soon after rain events indicated that all three tanks receive inleakage of stormwater from the top. The remainder of the Gunite tanks, except possibly tank W-7, are also expected to have similar inleakage.

Soil samples from 12 soil borings drilled between 1990 and 1991 provide data on soil contamination in the STF (BNI 1992). No groundwater samples have been collected within the STF.

Table 6.5 lists the gross alpha, gross beta, and tritium concentrations for soil samples collected within the STF. The primary radionuclides found in STF samples were ^{90}Sr and ^{137}Cs both of which are beta emitters. As a result, gross beta activities in soil samples from the STF were significantly higher than gross alpha activities. Samples from nine borings exceeded the highest reference gross beta activity. The highest gross beta activity (34,831 pCi/g) was detected in a sample from boring SB183 which is situated near a process waste pipeline that extends from Building 3515. Other locations where samples with high gross beta activities (>1000 pCi/g) were collected include boring SB19 (1394 pCi/g), located next to tank W-10; boring SB20 (1791 pCi/g), located near tank W-7 and next to a process waste pipeline; boring SB182 (17,047 pCi/g), located next to Building 3515 and near a process waste pipeline; and boring SB213 (5204 pCi/g), located near a group of process waste pipelines in the southeast portion of the tank farm.

In contrast to the NTF, gross beta activities were highest in samples collected from depths of 6 ft or less. A total of eight samples from depths >10 ft were collected from five

borings; gross beta activities exceeded 1000 pCi/g in one of these samples. In addition, a sample from the 22–23.1-ft interval at boring SB20 contained 607 pCi/g gross beta.

^{241}Am and isotopes of uranium and plutonium were found at elevated levels in some soil samples from the STF. Samples from five borings contained gross alpha activities that exceeded the highest reference activity (56 pCi/g). The highest gross alpha activities were found in samples from boring SB20 (near tanks W-7, W-9, and process waste pipelines); boring SB182 (near Building 3515 and process waste pipelines); and boring SB213 (near process waste pipelines in the southeast corner of the STF).

In addition to soil boring data, information about a LLLW pipeline leak discovered in the summer of 1993 suggest that another source of contamination may be present. The leak was discovered along Central Avenue in a LLLW line north of tank W-5. High levels of soil contamination were found in the excavation when repairing the leak. The duration of the leak is not known, but it may have been active for a number of years. It is possible that contamination from the leak has leached to groundwater and is impacting groundwater quality in the STF.

The data indicate that significant amounts of contamination exist in shallow soil at the STF. However, information about the nature of the tank/groundwater interactions is not known. Groundwater contamination at the STF may have been derived from historical leaks in pipelines, or from contaminants migrating along pipeline trenches. The soil data suggest that much of the contamination occurs in shallower soils, indicating that contaminants were derived from pipelines to the tanks. However, there are isolated occurrences of contamination found at deeper intervals.

As described above, the STF is contained within a pit that was excavated into bedrock. The major factor affecting groundwater within the pit is likely to be the tank sump system. If the sump system is effective, groundwater within the pit is at least partially contained. Depending upon the effectiveness of the dry well and sump system, some contaminated groundwater may migrate out of the tank farm through pipeline trenches or within the groundwater flow system. Data regarding hydrogeologic conditions within the tank farm are needed to evaluate these scenarios and to evaluate the effectiveness of the dry well system.

Similar to the NTF, the STF data acquisition program is designed to assess groundwater/tank interactions within the excavation pit surrounding the tanks and to compare these data with data from nearby piezometers around the tank farm. In addition, the distribution of contaminants in these locations will provide some indication of the likely migration pathways for groundwater contamination. If significant amounts of contamination are found, additional followup studies may be needed to further evaluate the transport pathways.

Four drive points will be installed in the STF area at locations shown in Fig. 6.3. These well points will be driven to the top of bedrock and will be situated away from any known buried pipelines. The three well points on the north side of the tanks will provide water

elevation and quality data for comparison with similar data from tank dry wells on the opposite side of the tanks. These will describe hydrologic and concentration gradients on opposite sides of the tanks. This configuration assumes that groundwater flow to the excavated pit is from the north. The fourth drive point will be between Building 3515 and tank W-10 will describe hydrologic and concentration gradients between the building and the tank sump.

Similar to the NTF, drive point wells and dry wells will be instrumented with pressure transducers and external data loggers to reduce waste generation. Sampling will be performed during high base, low base, and high base storm conditions. Monthly sampling of the common STF sump in the southwest corner of the tank farm and possible installation of a flow metering device will describe flow volumes to calculate contaminant flux.

The data from the wellpoint near W-5 will also be compared to analytical data for the soils excavated from the pipeline leak site adjacent to the north boundary of the STF. Similarities in isotopic compositions between the groundwater and soil samples may indicate that the pipeline leak is the source of some of the groundwater contamination in the STF.

6.4.2.3 Remaining tank farms and isolated tanks

Remaining tanks at WAG 1 include WC-5, 6, 7, and 9 and TH-1 through TH-3 in the thorium tank farm; WC-10 through WC-17 serving the 4500N area; W-11 and W-12, and W-19 and W-20 southeast of the STF; W-16 through 18 northeast of the STF; TH-4 southwest of Building 3550, and WC-1 in the Isotopes Area.

Tanks W-11 and TH-4 are Gunite construction and the others are stainless steel. WC-9, WC-10, and W-16 are the only remaining active tanks. All are constructed on bermed and graded concrete pads and presumably backfilled with an undetermined combination of rock or excavated saprolite. Dry wells at the lowest part of the tank pad collect water which is pumped periodically from the tank. In the tank farms, individual tank sumps drain to a common sump and dry well.

Monthly liquid tank level data are obtained by Waste Management Division staff and maintained on a computer data base. In those cases (e.g., WC-17) where a sump pump discharges accumulated groundwater near the base of the tank, monthly sump pumping estimates are made based on the rated pumping capacity of the pump and the amount of time the pump operates. The accuracy of the estimate is admittedly subject to question. In the case of WC-17, the relatively constant tank liquid level is attributed to sump pump operation. That the liquid level is maintained at about 300 gal may reflect the elevation of the pump. Camera inspection of the tank after it was emptied showed considerable inleakage into the bottom of the tank. Tank inleakage was also identified in WC-15 when a sudden loss of tank contents, approximately 500 gal of low to moderately contaminated liquid, occurred in August 1993. WC-15 and WC-17 are serviced by a common sump pump that maintains liquids in both tanks at similar elevations. In those cases where tanks and tank sump dry wells are emptied monthly by pumping, the rate at which the tanks or dry wells refill is not known.

No wells or piezometers are in sufficiently close proximity to any of the surplus tanks to accurately estimate the groundwater elevation in the near vicinity of the tanks. However, because groundwater elevation is generally close to the elevation of bedrock and excavations of many tanks can be presumed to have been close to that depth, tank bottoms can be expected to be below normal groundwater elevation at some and certainly below high base groundwater elevation in many cases.

A considerable but unquantified amount of groundwater is considered to be captured from underground tank sumps and dry wells. The presence of these tanks is therefore a possible component of the overall WAG 1 groundwater removal and treatment system that reduces apparent contaminant levels in surface water. In conjunction with knowledgeable Waste Management Division staff, the acquisition of reliable dry well water elevation, refilling rate, and radiological data from selected tank dry wells will allow the flux of contaminant removal to be calculated. These data will be used to describe groundwater/tank interactions to more adequately evaluate remediation options than at present. Recommendations for the locations for monitoring and sampling frequency would be made with input from Waste Management Division staff but would include perhaps as few as three to four locations considered to be representative of conditions throughout the underground tank system.

6.4.3 Isotopes Area

The Isotopes Area is located in the central part of WAG 1, north of Central Avenue, south of Hillside Avenue, and west of Fifth Street. Figure 6.4 shows locations of buildings, wells, soil borings, manholes, and sumps in the Isotopes Area.

During the production of radioisotopes for many years, numerous spills and pipeline leaks have occurred in the Isotopes Area, and it contains both radiological and nonradiological contaminants. Contamination in the general Isotopes Area is also from leaks and spills during operations in the 1950s and 1960s, and contamination is known to occur beneath Building 3047 that is at least partly discharging into the process waste pipeline network in the area.

East-flowing seepage of ^{90}Sr and ^{137}Cs contaminated groundwater into the foundation excavation for Building 3047 is anecdotally reported during building construction in the early 1960s. Neither the extent of contamination nor the volume of the seep are known, but the source was apparently commonly considered at the time to be from the Hillside area. Grimsby (1986) reports significant contamination obtained from piezometers within and near the building in the early 1970s. Inleakage to abandoned process waste pipelines is known to occur, and pipeline in-situform lining in the mid-1980s was not performed on those portions of the pipeline to allow this capturing effect to continue. Water captured in these pipelines is treated in the PWTP.

Elevated levels of gross alpha, gross beta, and tritium were detected in groundwater samples from Isotopes Area wells and sumps (Table 6.6). The highest levels of gross alpha and tritium in Isotopes Area wells were found in the low base sample collected from well 608 in November 1991. Well 608 is located approximately 50 ft south of Building 3033, between

Buildings 3037 and 3038. Alpha-emitting radionuclides detected above background levels in well 608 included ^{228}Th (8.7 pCi/L), ^{230}Th (2.6 pCi/L), ^{232}Th (4.3 pCi/L), and ^{224}Cm (108 pCi/L). The highest gross beta activity in Isotopes Area wells was detected in the March 1991 high base sample collected from well 598, which is located about 50 ft west of Building 3092. Beta-emitting radionuclides detected in this sample included total radioactive strontium (124 pCi/L) and ^{63}Ni (346 pCi/L).

Levels of gross alpha, gross beta, and tritium (including the highest tritium activity detected in WAG 1) which were from two to four orders of magnitude higher than those detected in Isotopes Area wells were found in a water sample collected from the Building 3033 sump. Beta-emitting radionuclides found in this sample included ^{137}Cs (599,000 pCi/L), ^{152}Eu (15,500 pCi/L), ^{154}Eu (8440 pCi/L), ^{155}Eu (2290 pCi/L), ^{57}Co (5790 pCi/L), ^{60}Co (2070 pCi/L), and ^{22}Na (3060 pCi/L). The volume of water pumped by the sump is not known but has been estimated to be about a couple of hundred gallons per day.

The reported presence of ^{22}Na and ^{57}Co are suspect from that sump because those radionuclides were produced in Building 3030 for the cyclotron program. Production essentially ceased in the early 1980s, and in the intervening years, ^{57}Co and ^{22}Na would have gone through 13 and nearly 4 half-lives respectively. Concentrations in the thousands of picocuries per liter today are noncredible for ^{57}Co and suspect for ^{22}Na.

A water sample collected from the Building 3106 sump contained moderately high gross alpha and gross beta activities. The tritium activity in this sample was about four times the maximum reference level.

Elevated levels of gross alpha, gross beta, and tritium were detected in samples collected from soil borings in the Isotopes Area (Table 6.7). The highest levels of gross alpha (1890 pCi/g) and gross beta (3218 pCi/g) were found in the 4–6-ft interval in SB160 at the site of a suspected pipeline leak in Central Avenue. Alpha-emitting radionuclides detected in this sample included ^{234}U (185 pCi/g), ^{235}U (25 pCi/g), and ^{238}U (1383 pCi/g). Beta-emitting radionuclides found in this sample included ^{63}Ni (133 pCi/g) and ^{147}Pm (10.4 pCi/g). Elevated gross beta activities in soil borings SB148 and SB149 were associated with the Building 3028 leak area. Samples from soil borings SB150, SB152, and SB153 which were collected at sites of suspected or known past pipeline leaks contained elevated gross beta activities. The second highest gross beta activity detected in Isotopes Area soil borings (2830 pCi/g) was from the 12–14-ft depth interval in SB40, located directly north of tank WC-1. Beta-emitting radionuclides found in this sample included ^{90}Sr (886 pCi/g), ^{137}Cs (390 pCi/g), and ^{60}Co (100 pCi/g). These elevated activities were likely the result of a leak from tank WC-1 evidenced by the dispersed surface contamination in the surrounding area.

Table 6.8 is a summary of nonradiological contaminants found in Isotopes Area wells. Metals detected in groundwater samples from these wells included beryllium, cadmium, chromium, and lead. These metals were present at levels below to slightly above SDWA MCLs. The VOCs 1,2-DCE and TCE were detected in groundwater samples from well 598,

located west of Building 3092. This well contained the highest concentration of TCE in WAG 1 (210 μg/L in the low base sample collected in October 1990).

Beryllium, chromium, and lead were detected above background but well below RCRA action levels in Isotopes Area soil borings. TCE was detected in one soil sample from the 12–14-ft interval in SB40.

A study of process system flows and radiological monitoring data in Isotopes Area manholes indicates that the flux of gross beta through MH114 is one to two orders of magnitude higher than through MH112. It appears that this additional gross beta activity is entering the process system between the two manholes. As there are no processes discharging to the process system between MH112 and MH114, the source of this beta activity is generally considered to be contaminated groundwater which is being intercepted by an abandoned line exiting MH114 toward the north. MH114 is approximately along geologic strike with the Building 3033 sump. Possible sources of the radiological contamination of groundwater in the sump and in the process system could be uphill in the 3019 or 3042 areas. Contaminants could be transported downdip with groundwater in Unit D, discharge upward to Unit E, and move along strike to the east in a mirror image of the CH-8 plume. Alternatively, there could be a source to the west in the Building 3026 area, a localized pipeline leak, or a combination of sources. This contamination could ultimately be intercepted by the process system and be treated in the PWTP, move off-WAG in permeable pipeline trench backfill, and/or underflow Fifth Creek.

Data acquisition for the Isotopes Area seeks to address the issues of contaminant source and possible underflow of Fifth Creek. In all cases, isotopic comparisons will be used to test alternate hypotheses about contaminant source.

The 30331 sump was resampled in April 1993. This sample will be analyzed for tritium, gross alpha, gross beta, and alpha and beta-emitting radionuclides. The primary purpose of sampling this sump was to confirm the presence of contamination found in previous sampling and to determine the presence or absence of ^{90}Sr and ^{137}Cs. In addition, within the limits of data resolution, the bottom of the Building 3033 sump could be very close to the Unit E stratum through which the CH-8 plume migrates. If so, the contamination in the sump may not necessarily be from a local source but could be from another location to the west or northwest. At present, the available data provide no indication that anything other than a local source is responsible for the contamination. However, the data cannot rule out the possibility of a remote source.

Radioanalytical sampling in manholes MH114 and MH233 would be compared with results from the Building 3033 sump to determine contaminant source locations. Because these manholes are known as groundwater catchment features, analysis for BTEX and TPH will be used in monitoring of petroleum underground storage tanks (USTs). A core hole located to the west of Building 3038 and targeted to the CH-8 plume stratum will address issues of both eastward, mirror image migration of the CH-8 plume, and isotopic comparison with other samples would also address the issue of contaminant source in the Isotopes Area.

Sampling in Stockdale core hole 33 would address possible contaminant underflow of Fifth Creek from the Isotopes Area. Sampling of piezometer 598 will be used to monitor radiological and VOC contamination.

6.4.4 CH-8 Plume

The so-called CH-8 contaminant plume was identified in early 1992 as an apparently narrow, westward migrating, strike-parallel plume which discharges off-WAG to First Creek (Fig. 6.5). Gross beta contaminant levels in CH-8 are among the highest measured in WAG 1, and ^{90}Sr constitutes the majority of the beta activity. Analytical data indicate that a part of the plume seeps into a storm sewer near the northeast corner of Building 2013 and discharges to First Creek via outfall 341. The plume also seeps into an abandoned storm sewer line which parallels First Street and discharges via outfall 342.

Sampling of piezometer 535 to the west of First Creek in conjunction with CH-8 plume investigations in November 1991 revealed gross alpha, gross beta, and tritium values of 116, 322, and 647 pCi/L respectively, which was suggested (BNI 1992) to represent underflow of First Creek. No source for the contamination is known or suspected to be to the west of First Creek. In the absence of data to determine the isotopic composition of the piezometer 535 contamination, it must be presumed that the CH-8 plume is underflowing First Creek.

Similarly, routine sampling of outfall 247 in November 1992 revealed more than 1700 pCi/L gross beta activity, more than 1400 pCi/L of which was attributable to ^{90}Sr; however, seven sampling events from March 1991 through June 1992 revealed an absence of contamination in that outfall, and a sample in March 1993 also showed no contamination. The samples with elevated values were not obtained during periods of particularly high precipitation which might indicate high contaminant flux, and analyses before and since show a lack of contamination. A field reconnaissance survey of the outfall area in May 1993 showed an absence of activity, and the elevated values are considered to be anomalous.

Available indicator radiological data from isolated intervals in CH-8 are in Table 6.9. Data for wells and piezometers within the plume, First Creek, and outfalls 341 and 342 are in Table 6.10. The data indicate relatively stable contaminant levels over the brief period of record with the exception of increasing tritium concentrations in well 812 and piezometer 539. Increasing tritium at these locations may be interpreted to indicate the presence of a separate tritium source or that the plume is evolving and tritium is migrating ahead of other radioisotopes. Because there are no known or suspected tritium sources in the vicinity of well 812 or piezometer 539, the latter interpretation is favored.

Data to further characterize the CH-8 plume have not been obtained. The source of the plume is undoubtedly to the east of CH-8, and the current conceptual model describes upward leakage into Unit E from the Building 3019 area above Unit D where significant quantities of contaminant may reside. Alternatively, or perhaps in combination, leaking pipelines in the NTF area could be a source. Isotopic comparisons, described in Sect. 6.4.2.1,

indicate that both areas are potential sources, but at present the data are insufficient to be more definitive.

An aggressive plume characterization, interception, and source identification program will be performed for the CH-8 plume as an early interim action. The program utilizes data to be obtained from the Building 3001/3019 area, the NTF, and the Isotopes Area described above. Consideration was given to possible dual use in CH-8 source identification in the siting of many of those wells and core holes. Basic components of the program include source identification, plume interception, and investigation of underflow of First Creek.

Early action plume characterization and removal activities described in the paragraphs that follow are included only to provide a comprehensive and coherent presentation of activities related to CH-8. These early actions, however, are not part of this work plan. Rather, they are part of the CH-8 early action Engineering Evaluation/Cost Assessment to be prepared before final approval of this work plan.

Plume characterization activities are designed to support early action remedial design. Eight to ten bedrock weathering interface wells will be installed along the southern plume boundary and across the plume axis to describe the plume areal configuration and to assist in identifying locations for plume interception trenches described below. Two such wells will be installed downgradient of the trenches to monitor interceptor trench effectiveness. A nominal 100 to 150 ft core hole located west of Building 2069 will intersect the contaminated stratum at depth to investigate down dip migration. Semi-annual monitoring of piezometer 535 will continue to address underflow of First Creek, and similar sampling of piezometer 539 and well 812 will be used to monitor interceptor trench effectiveness.

Early action remediation is designed to (1) immediately halt plume seepage into the storm sewer system, (2) intercept the plume at several locations to prevent new such seepage from developing, and (3) identify the source of the plume. Based on analyses of First Creek outfalls 341, 342, and storm sewer locations, the plume is known to be seeping into the storm sewer system. One location is an abandoned portion of the system on the eastern side of First Street which apparently (according to the ORNL Atlas) has a portion of pipeline which continues to the east toward piezometer 539. This pipeline discharges to First Creek via outfall 342. Manholes to the north of Building 2013 also receive plume seepage which, after joining with other parts of the storm sewer system, ultimately discharges to First Creek via outfall 341.

The pipeline near First Street will be videoed to determine where the seepage is occurring, and the pipeline will be lined to prevent further seepage. The manholes north of Building 2013 will be lined and interceptor trenches constructed to the north of the manholes to prevent further seepage in the area. Preliminary conceptual design for the interceptor includes a french drain which would direct water passively captured in the trench to the PWTP for treatment. Quarterly monitoring of Outfalls 341 and 342 will be performed until such time as it is determined that they are no longer discharging contaminants.

Because the plume is in an area of groundwater discharge, two additional passive interceptor trenches are planned at locations across the plume axis to further control seepage. The precise locations for the trenches will be determined after characterization wells more definitively describe the plume, but at present one is envisioned in the vicinity west of Building 2069 and the other is envisioned between Buildings 2011 and 2018. They, too, will contain french drains which will direct captured water to the PWT system for discharge. Bedrock weathering interface monitoring wells will be installed to the west of each extraction trench.

Contaminant removal is also planned for CH-8 because of its high levels of contamination and presumed location near the source. This will be accomplished by low-volume pumping from the Westbay installation sampling ports to the PWT system along Third Street. Semi-annual sampling of the CH-8 Westbay installation will continue until the contaminant removal system is operational to maintain a continuous record, monitor changes in concentration at different phases of the water year, and provide baseline conditions for comparison after initiation of the early action.

In all cases, contaminant removal is designed to minimally perturb the natural groundwater system. It is considered likely that the groundwater flow system and presumed distribution of contaminants may be sensitive to more aggressive removal options (e.g., larger scale pumping) which could lead to possibly undesirable results. At present, the degree and areal distribution of contamination is insufficiently characterized to anticipate the effects of system perturbations. With the exception of minor extraction from CH-8, the plume removal system would simply provide preferred groundwater discharge galleries for the existing discharging system.

Selection of the contaminant removal and treatment option for plume interception is to obtain immediate results with a proven and in-place technology. As the interception system matures and monitoring results are analyzed, the removal and treatment option is likely to be reevaluated in lieu of alternatives such as in-situ remediation technologies.

It is known that historic problems have occurred with a concrete-encased LLLW pipeline on the eastern side of Third Street. To investigate the possibility that the CH-8 plume source is related to this line, three temporary piezometers will be installed near the pipeline in a north-south orientation running across the presumed plume axis. Additional plume source investigations are described in the sections above. Sample analyses from wells and core holes will be compared to describe the levels and compositions of contamination. Depending on the analytical results, source removal or immobilization options will be considered to augment those remedial actions already under way.

6.4.5 Oak Ridge Research Reactor (Building 3042) Area

The Oak Ridge Research Reactor (ORR) was placed in service in March 1958 and was shut down in 1987. The reactor shielding pools and associated equipment are located within the main building (3042). Heat removal systems are located within adjacent buildings.

Containment ducts and filter pit areas are contaminated with ^{137}Cs, ^{90}Sr, and ^{60}Co. Figure 6.6 shows the locations of buildings, wells, soil borings, and sumps.

The primary cooling loop for the ORR, consisting of two parallel 24-in. pipelines, extends underground northeastward to the main circulating pumps in Building 3085. A third perforated pipeline has been installed in gravel backfill in the bottom of the pipe chase for the primary cooling loop. The lowest point of the pipe chase is at elevation 798.53 ft MSL in the ORR basement. The perforated pipeline collects groundwater, which then flows by gravity from the lowest point of the pipe chase to the ORR building sump. The ORR sump consists of two sumps, an inner (shallow) sump with a bottom elevation of approximately 785 ft MSL and an outer (deep) sump with a bottom elevation of about 773 ft MSL. The groundwater collected in the pipeline in the primary cooling loop pipe chase goes to the outer (deep) sump where it is commingled with process waste from the ORR building and pumped to the process waste system. Average flow from the outer (deep) sump is approximately 16 gal/min; however, the contribution of groundwater to this total flow is unknown. The inner (shallow) sump collects groundwater from foundation drains under the ORR building. This water is pumped from the sump to a storm drain for discharge to Fifth Creek. Six additional sumps are located along the pipe chase between the ORR and Building 3085. Groundwater collected in these sumps is pumped to the process waste system.

Activities of gross alpha, gross beta, and tritium which were above reference levels have been detected in groundwater samples collected from 3042 Area wells (Table 6.11). The highest gross alpha activity (125 pCi/L) in 3042 area wells was found in the low base sample collected from interface well 596 in November 1991. Well 596 is located about 50 ft north of Building 3042. Alpha-emitting radionuclides detected above background in this sample included ^{241}Am (20.4 pCi/L), ^{228}Th (2.9 pCi/L), ^{230}Th (2.7 pCi/L), ^{232}Th (3.9 pCi/L), and ^{238}U (1.3 pCi/L). The highest gross beta level (552 pCi/L) was detected in the high base sample from well 589 collected in May 1991. Beta-emitting radionuclides which were found above reference levels in this sample included total radioactive strontium (284 pCi/L) and ^{137}Cs (67 pCi/L). Other beta-emitting radionuclides which were above background levels in samples from 3042 area wells were ^{226}Ra, ^{228}Ra, and ^{99}Tc. The highest tritium activity in 3042 area wells (61,750 pCi/L) was in the low base sample collected from well 603 in November 1991.

Higher levels of radiological contamination than were found in 3042 area wells were observed in the water sample collected from the 3042 sump (30421) in August 1993 (Table 6.11). The gross alpha activity was 23.2 pCi/L and the gross beta activity was 4590 pCi/L in this sample. The bulk of the beta-emitting activity was accounted for by ^{137}Cs (1863 pCi/L), ^{60}Co (1809 pCi/L), and ^{134}Cs (864 pCi/L).

These results differ from those reported by BNI (1992) by more than two orders of magnitude. The vast difference is believed to have been a result of sampling locations. On the basis of an interview with the technician who obtained the BNI (1992) sample, the source of the smaple was the outer (deep) sump, which is not representative of groundwater. However, written documentation of where the sample was taken does not exist.

Levels of gross alpha and gross beta ranging from below to slightly above reference levels were detected in soil samples from borings SB142 and SB257 in the 3042 area (Table 6.12). The maximum tritium activity detected in these borings was from the 4–5.9-ft interval in SB257 (1.17 pCi/g).

Nonradiological contaminants detected above background levels in 3042 area wells included TCE, beryllium, cadmium, chromium, and lead (Table 6.13). The highest levels of beryllium and lead in the wells were detected in the sample collected from well 603 in November 1991. The highest concentrations of cadmium and chromium were found in the sample collected from well 589 in November 1990. The sample collected from the 3042 sump contained about five times the maximum concentration of lead found in 3042 area wells (2230 μg/L).

Beryllium, cadmium, chromium, and lead were detected in 3042 area soil borings. However, they were detected at levels below maximum reference concentrations.

Results of a dye test reported by Huff (1985) indicated that groundwater was flowing eastward, along geologic strike, to the ORR sump from the area of a LLLW line break between Building 3019 and Building 3074. A cavity in the limestone bedrock was observed in the excavation for the line break. Fluorescein dye which had been injected into this cavity was observed in the inner (upper) ORR sump within 48 h. The injection point for the dye was at an elevation of about 820 ft MSL and the collection point for groundwater in the sump was at about 785 ft MSL. Therefore, there was an hydraulic gradient from the injection point to the sump of approximately 35 ft over a distance of 450 ft. This gradient is produced by pumping of water which maintains a groundwater depression in the vicinity of the sump. Therefore, radiological contamination detected in water samples from the ORR sump may be moving from the Building 3001/3019 area along cavities and solution features in Unit D. Contaminants may also be collected in the sump from leaks in nearby underground lines.

Actions for the ORR seek to determine the sources and migration pathways to the ORR sump. The inner (upper) 3042 sump will be sampled and isotopic analyses of the sample will be conducted to determine the radiological fingerprint of the sump sample. The isotopic composition of the contamination will be compared to isotopic analyses of samples collected in the 3019 area to determine if contaminants in the sump are derived from the Building 3019 area.

Drilling of a bedrock well immediately to the south of piezometer 588 will seek to obtain groundwater data between the ORR and the Building 3001/3019 area. Comparison of the analytical results with those from the ORR sump and wells in the Building 3001/3019 area will provide information about source areas and migration pathways.

6.4.6 Surface Impoundments (3524, 3513, 3539, and 3540)

The four inactive impoundments in this area were used for settling and/or emergency storage of LLLW waste and as settling basins as part of the process waste system. These

impoundments still contain water and sludges. Figure 6.7 shows the locations of the impoundments, piezometers, wells, and soil borings discussed in this section.

The unlined waste detention basin (DB) 3513 was constructed in 1944. In some places the bottom of the basin is within 1 ft of limestone bedrock. During its operational life (1944 to 1976) the DB received the supernatant outflow from the STF LLLW tanks; later, water treated in the original PWTP was held in the DB before being discharged to WOC. Nonradiological contaminants detected in water samples from the DB include chromium, lead, and selenium. Radiological contaminants detected in the water are ^{137}Cs and ^{90}Sr; nonradiological contaminants in sludge samples from the DB included mercury and, possibly, selenium. Radiological constituents detected in the sludge samples are ^{60}Co, ^{137}Cs, ^{90}Sr, ^{154}Eu, ^{238}Pu, ^{239}Pu, ^{241}Am, and ^{244}Cm.

The equalization basin (EB) 3524 was originally built in 1945 as two adjacent, unlined ponds for emergency storage of LLLW. In 1957 the earthen dike between the two ponds was removed to create a larger EB for the original PWTP. The basin was further enlarged in 1961 to a final capacity of 1 million gal. Perimeter rock exposures and bedrock pinnacles are seasonably visible in the EB, and the expanded, western half of the basin shows clear evidence of simple cut-and-cover construction with an absence of a well-defined perimeter berm. It is thus very likely that excavation was to bedrock and that fissures and cavities allow for outleakage. The EB was removed from service in 1989, although it is still available for emergency overflows from the current process waste system. Analyses of sludge samples from the EB in 1984 found ^{137}Cs, ^{90}Sr, ^{241}Am, ^{60}Co, and ^{154}Eu. VOCs detected in sediment samples and in samples of the water directly overlying the sludge in 1986 were benzene, chloroform, and methylene chloride.

The process waste ponds 3539 and 3540 were constructed in 1964 with compacted clay liners as a surge basin system designed to receive and discharge process waste streams from the Building 4500 area. The ponds were removed from service in 1990. VOCs detected in samples of water directly overlying the sludge in these ponds were methylene chloride and chloroform. Sludge samples collected in 1986 contained slightly elevated levels of methylene chloride and 1,2-*trans*-DCE. Total radioactivity in the ponds has been estimated to be <10 Ci.

Table 6.14 is a summary of radiological contamination detected in groundwater samples from wells in the DB (3513) area. Gross alpha, gross beta, and tritium were detected above maximum background (reference) levels in wells 877, 1102, 1103, and 1104 in the DB area. The highest gross alpha (120 pCi/L) and gross beta (2200 pCi/L) activities in the DB area wells were detected in the samples collected from well 1102 in February 1991 during high base storm conditions and in June 1992 during high base conditions respectively. The highest activities of manmade beta-emitting radionuclides in the DB area were ^{90}Sr (1020 pCi/L) and ^{228}Ra (308 pCi/L) in the sample from well 1102 in February 1991. This well is located to the south of and hydraulically downgradient of the DB. The highest tritium activities were observed in samples collected from well 1104 in February 1991 during high base storm conditions (79,500 pCi/L) and in April 1991 during high base conditions (50,950 pCi/L). This well is to the west of the DB and downgradient of the EB.

Radiological contamination detected in groundwater samples from EB (3524) area wells is summarized in Table 6.15. Elevated gross alpha, gross beta, and tritium activities were detected in groundwater samples from these wells. The highest tritium activities in the Impoundments Area (827,670 pCi/L to 912,000 pCi/L) were detected in samples from the 875/885 well pair, which is located directly south and hydraulically downgradient of the EB. Tritium activities in samples from other downgradient wells (874, 876, 1100, and 1101) ranged from 104,000 to 404,000 pCi/L, except for the sample from well 1100 in May 1991 (2540 pCi/L). Tritium activities in the closest upgradient well (579) were two orders of magnitude lower than activities in the downgradient wells in samples collected in February 1991 and April 1991 (7280 and 3330 pCi/L respectively). The highest gross alpha (74 and 287 pCi/L) and gross beta (2710 and 5710 pCi/L) activities in the EB area were detected in the high base storm samples collected in February 1991 from wells 874 and 875 respectively. Isotopes contributing to the gross alpha activity in the February 1991 sample from well 875 included ^{234}U and ^{230}Th. Manmade beta-emitting radionuclides which were detected in the February 1991 sample from well 875 were ^{90}Sr, ^{228}Ra, and ^{147}Pm. The data indicate that radiological contamination is most prevalent in shallow interface wells than in the bedrock well downgradient of the EB.

A water sample collected from the temporary piezometer installed in SB189, located in a process waste pipeline trench west of the EB, contained a gross beta activity of 34,000 pCi/L. Only a small portion of this beta activity was accounted for by gamma spectroscopy. The activity found in this sample may be related to ^{63}Ni contamination detected in soil samples from this boring.

Gross alpha, gross beta, and tritium activities only slightly elevated above reference levels were detected in groundwater samples from wells in the area of the 3539/3540 impoundments (see Table 6.16). Tritium activities ranged from 1710 to 3020 pCi/L, except in the April 1991 sample from well 882 (10,400 pCi/L). Gross alpha and gross beta activities showed little evidence of contamination in this area, ranging from below their respective MCLs to slightly above reference levels. The elevated gross alpha and gross beta activities detected in well 877 may have been due to contamination from the 3513 and/or 3524 areas.

In general, significant radiological contamination was found downgradient (south) of the EB and DB and was not found in the 3539/3540 area. The highest levels of contamination occurred in samples collected during high base storm conditions. This contamination consisted primarily of high levels of tritium, moderately high levels of gross beta (predominantly ^{90}Sr and ^{228}Ra) and moderately low levels of gross alpha.

Elevated levels of gross alpha, gross beta, and tritium were detected in soil borings in the DB and EB areas (see Tables 6.17 and 6.18). Principal alpha-emitting radionuclides detected were ^{234}U, ^{235}U, and ^{238}U; principal beta emitters were ^{137}Cs, total radioactive strontium, and ^{147}Pm. Gross alpha and gross beta in 3539/3540 area borings were detected at levels below or near background (see Table 6.19). With the exception of gross alpha and gross beta in SB189, elevated levels of radiological contaminants in Impoundments Area soil borings are likely due to leakage from the impoundments or lines associated with the impoundments.

SB189 was completed as a temporary piezometer in a process system pipeline trench. Levels of gross beta in soil samples from this boring were one to two orders of magnitude higher than in other Impoundments Area borings. Nickel-63 accounted for most of the gross beta activity in SB189. This isotope was not detected in soil samples from any of the other borings in the Impoundments Area. The soil contamination found in SB189 may be the result of a leak in the process system pipeline near the boring. Alternatively, the contamination may be the result of outleakage from the EB or a leak in a pipeline in the Isotopes Area, the NTF, and/or the STF and migration of contaminants through permeable pipeline trench backfill materials.

Nonradiological contaminants detected in Impoundments Area wells included TCE, 1,2-DCE, vinyl chloride, cadmium, chromium, and lead (see Tables 6.20, 6.21, and 6.22). Metals (cadmium, chromium, and lead) were generally found at concentrations which were below maximum background and/or MCLs. VOCs (TCE, 1,2-DCE, and vinyl chloride) were detected at low levels which were slightly above their respective MCLs.

Nonradiological contaminants detected in soil included chromium and lead (see Table 6.23). These metals were present below or near maximum background concentrations and well below RCRA action levels.

Seepage of contaminated water from the EB and DB impoundments is apparently a major source of tritium, ^{90}Sr, and ^{228}Ra contamination of groundwater in WAG 1. Video inspection of a 24-in. storm sewer to the west of the EB in December 1992 revealed numerous inleaking joints, particularly in that portion of the storm sewer on the northwest side of the EB. All of the observed flow in the storm sewer was derived from inleakage which is subsequently pumped back into the EB. Because most of the leaks were from the EB side (east) of the pipeline and a head potential exists from the EB to the pipeline, it is reasonable to assume that the pipeline inleakage is derived at least partly from seepage from the EB. Sampling of the inleaking water has not been performed.

Radiological contaminants have been found in overburden, interface, and bedrock wells. Contaminants should move southward (downgradient in the overburden and down-dip in bedrock), eventually discharging to WOC. Contaminants may also be migrating in pipeline backfill materials. Given the relatively short half-life and slow transport velocity in groundwater of ^{228}Ra, it should undergo significant decay before it reaches WOC. Therefore, tritium and ^{90}Sr are the primary contaminants which could reach WOC and be transported off-WAG.

The following actions will be performed in the Impoundments Area:

- consideration will be given to determine the need for an interim, early action separate from this work plan to retard the migration of contaminants from the impoundments to groundwater. Discussions will begin during scoping meetings held to initiate the RI/FS process for the Surface Impoundments OU. Considered actions might include the

feasibility of installing a temporary liner or implementing other source control technology before closure or accelerating the final closure schedule where feasible;

- sampling of groundwater twice yearly in wells 874, 875, 885, 876, and 1104 downgradient of the EB and wells 1102, 1103, and 1104 downgradient of the DB; these samples will be analyzed for gross alpha, gross beta, and tritium;
- resampling of groundwater in the temporary piezometer in SB189; this sample will be analyzed for gross alpha, gross beta, tritium, and isotopics to confirm the observation of elevated gross beta activity in the December 1991 sample and to determine whether ^{63}Ni is present in the groundwater at this location.

The impoundments will eventually be closed. After closure, monitoring of downgradient wells for gross alpha, gross beta, and tritium should continue during high base and high base storm conditions to determine the effects of closure on radiological contamination of groundwater and on discharge of contaminants to WOC. No monitoring of nonradiological contaminants is necessary because VOCs should volatilize within hours of entering WOC and metals are present at levels below MCLs.

6.4.7 Solid Waste Storage Areas 1 and 2

Figures 6.8 and 6.9 show wells, piezometers, and soil borings in SWSAs 1 and 2 respectively. Wastes were stored in these areas in the early to mid 1940s. SWSA 1 received solid wastes, and SWSA 2 received both solid and liquid wastes. Some time after 1946, the wastes and contaminated soil were removed from SWSA 2 and transferred to SWSA 3, but some objects may remain in SWSA 2. Both areas are grassed, and SWSA 1 is fenced.

In 1990 geophysical surveys were performed to investigate subsurface objects in SWSAs 1 and 2. Five areas with geophysical anomalies were identified in SWSA 1, and seventeen were identified in SWSA 2. The nature of the objects is not known but could include portions of a waste transfer line in the case of SWSA 1 and storage tanks and vehicles in the case of SWSA 2. The extent to which these remaining objects may contribute to groundwater contamination is not known, but much higher iron concentrations in downgradient piezometer 622 (17,700 $\mu g/L$) than upgradient locations suggests the potential that buried objects are impacting the groundwater.

Indicator radiological data from SWSAs 1 and 2 are given in Tables 6.24 and 6.25. For SWSA 1, the relatively complete historical data for many wells indicate generally stable contaminant concentrations over time and between high and low base groundwater conditions. Gross alpha and beta concentrations are generally below reference levels, and tritium values range between about 1000 and 2500 pCi/L. The highest tritium concentrations in bedrock wells 828 and 947 suggest the possibility of flow paths below the water table surface. In addition, piezometer 571 contains several radionuclides (e.g., $^{239}Pu/^{240}Pu$, ^{228}Ra), which could suggest westward migration of contaminants from SWSA 1. Nonradiological contamination is generally below to only slightly above MCLs and reference values.

SWSA 1 soils radiological data (not tabulated) are generally below or only slightly above reference levels. The exception is SB63 which contained 2166 pCi/g gross beta from the 0–1.8-ft sample. $^{239}Pu/^{240}Pu$ was also detected (below reference levels) from that location. The absence of similar contamination from nearby soil borings SB61 and SB62 indicates that SB63 contamination is very localized, and no major areas of soil contamination are present.

Table 6.25 for SWSA 2 indicates that tritium contamination is prevalent throughout much of the area, with the highest concentrations within and southwest of SWSA 2—suggesting southwestward migration. Slightly higher gross alpha and beta in the downgradient piezometer also suggest minor radiological migration. This is corroborated by the presence of radiological contamination in Fifth Creek outfall 165 that serves a small segment of a storm sewer from Fifth Street. Because no other source for the outfall 165 contamination is apparent, it is presumed to be coming from discharging groundwater from SWSA 2. The data from adjacent bedrock wells 820 (about 20 ft deep) and 821 (about 80 ft deep) indicate that contamination decreases with depth. With the exception of iron in piezometer 622 above reference values, nonradiological contamination is at or below MCLs and reference sampling results. No soils data are available from SWSA 2.

Monitoring will be performed in SWSAs 1 and 2. To augment reduced environmental compliance monitoring of the WAG 1 water quality wells, wells 827, 828, 829, 946, and 947 and piezometer 571 will be sampled in SWSA 1. Piezometer 622 and well 822 will be monitored in SWSA 2. Monitoring will be performed during high and low base conditions, and sampling coordination will be arranged with environmental compliance monitoring to maximize efficiency.

6.4.8 Pipelines

Because pipelines, particularly process waste pipelines, are known to collect significant amounts of contaminated groundwater, available flow and radiological data from process waste manholes which are monitored monthly were analyzed. Figure 3.2 shows the locations of process waste manholes for which radiological data are available. The purpose of the analysis was to investigate possible relationships with groundwater elevation. A description of the results of Phase 1 RI temporary piezometer installation in pipeline trenches follows the description of the process waste manhole analysis.

Performance of the process waste manhole analysis relied on monthly process waste flow and radiological data and underground tank level and dry well radiological data acquired and provided by ORNL Waste Management Division staff. Because these data are collected for purposes other than groundwater studies and may not represent a suitably high degree of accuracy, the absolute data values are emphasized less than apparent trends in the data. Irregularities in process waste production in facilities served by any manhole and periodic tank pumpage seriously complicates the analysis.

Groundwater elevation data are those contained in BNI (1992), and piezometers were selected to be representative of both recharge and discharge locations. Precipitation data are

from Walker Branch Stations RG1 and RG3, and surface water stage data are for First Creek and Northwest Tributary collected by the Office of Environmental Compliance and Documentation. Thus, the data are from several unrelated programs and projects at ORNL.

Because the data were collected at various frequencies, the analysis was conducted on summaries of the monthly frequencies. No attempt was made to validate the data beyond that conducted by the data custodians. The data generally cover the time period from 1985 through 1992, but most of the data series are incomplete for the entire time period. When short data records correlated highly with longer data records, a surrogate was used to increase the data density. For example, some of the groundwater data from some piezometers correlated highly with stage data from creeks, and the use of the surrogate creek data greatly increased the number of groundwater data points available for analysis.

The analysis considered the dependence of several variables on an observation to determine causal relationships. When plotted, dependence is observed as a diagonal, straight line pattern to the data. An absence of such a straight line pattern indicates an absence of dependence. Total contaminant flux through the process waste pipeline system at any location was calculated by multiplying monthly manhole flow rate and radiological data. The principal objective of the analysis was to determine if flow or contaminant flux through process waste manholes was related to either precipitation or groundwater elevation which would provide some indication of the interaction between the process waste pipeline system and groundwater. Complicating the analysis is the variable generation of process waste liquids from user facilities around ORNL.

Efforts to relate tank levels to precipitation and groundwater elevations were generally unsuccessful. The typical pattern observed was a steady increase over time followed by a precipitous drop which is undoubtedly from pumping.

With the exception of several potentially outlier data points, a relatively weak relationship between process waste pipeline flow and precipitation is apparent in MH229. No other manholes exhibited dependence. However, dependence between manhole contaminant flux and precipitation is apparent at PS1, MH149, MH229, and MH234. Dependence between manhole contaminant flux and groundwater elevation is apparent at PS1, MH114, MH149, MH229, and MH234. That contaminant flux at MH114 is not dependent on precipitation is probably because the pipelines to that manhole are in Unit D where a lag between precipitation and aquifer response is likely.

Dependence between manhole contaminant flux and precipitation and/or groundwater elevation supports the concept that contaminant mobilization occurs principally during periods of elevated water table despite apparently lower concentrations due to dilution. It also suggests that contaminants residing in groundwater or in the vadose zone immediately above the water table are mobilized above the bedrock weathering interface in response to water table rise.

BNI (1992) reports the installation of nine temporary piezometers in pipeline trenches. Water level monitoring and sampling was performed between November 1991 and March 1992. Estimated well depths and high and low base groundwater elevations indicate that only two (SB187 and SB208) of the nine piezometers (and trenches) are seasonally below or very near the water table elevation. However, monitoring data indicate that all but two of the piezometers (SB195 and SB197) contained water in at least one monitoring event during the monitoring period, and four piezometers contained water during each monitoring event. Because of the time period of monitoring, these conditions can be considered to generally represent high base conditions.

Maximum radiological content data for the temporary piezometers indicate negligible to significant radiological contamination in all piezometers which contained water. Contamination in SB187, apparently located in a storm sewer, suggests the possibility of pipeline crossover or leakage from a process waste or LLLW line to the storm sewer system. Significant concentrations in SB132 are likely related to a process waste line leak in the area, and concentrations in SB189 could result from along-line migration or outleakage from the 3524 EB. The general absence of radiologic contamination in soil borings near piezometers SB189 and SB197 suggests that along-line migration occurs. Hydraulic conductivity estimates in piezometers SB208 and SB224 of 3.71×10^{-4} and 1.24×10^{-4} cm/s are comparable to average hydraulic conductivity values for interface piezometers. Alternatively, generally uniform contaminant concentrations in soil borings in the vicinity of SB195 suggests more diffuse areal contamination.

Compared to contaminant concentrations in underground tank dry wells, the level of contamination in pipeline trenches is comparatively small. However, although tank dry wells tend to capture contaminated groundwater, pipeline trenches may tend to distribute contamination.

The identification of ^{63}Ni, an unusually occurring radioisotope, in several soil borings and temporary piezometers provides some qualitative insight into migration within pipeline trenches. ^{63}Ni was detected during the Phase 1 RI in samples from six soil borings and one piezometer in WAG 1. The highest activities of ^{63}Ni were found in borings SB182 and SB183 near Building 3515 and in temporary piezometer SB189 to the west of the EB (3524). Lower ^{63}Ni activities were found in SB194, located east of Building 3517; SB174, south of Building 3503; and SB160, in Central Avenue southwest of Building 3038. ^{63}Ni was also detected in a groundwater sample collected from piezometer 598, located in the Isotopes Area between Buildings 3026 and 3092. The ^{63}Ni found in the Isotopes Area may have originated in the Low Intensity Test Reactor, where it has been found in the core and in the heat exchangers. It may have migrated downhill in permeable pipeline backfill material.

The ^{63}Ni found in SB182 and SB183 near Building 3515 may be the result of past pipeline leaks in the area. Boring SB194 is located near a process waste pipeline which originates at Building 3515. The ^{63}Ni found in this boring may have migrated from the Building 3515 area in the process waste pipeline trench. Boring SB174 is also located near a process waste pipeline. The process waste pipeline adjacent to temporary piezometer SB189

is connected to the process line originating at Building 3515 via MH117. Therefore, the ^{63}Ni found in temporary piezometer SB189 may also have originated in the Building 3515 area and migrated to SB189 in pipeline trench backfill. Alternatively, the ^{63}Ni found in SB189 could have resulted from leakage from the EB (3524). The ^{63}Ni found in SB174 may also have a source at Building 3515 as this boring is located near a process waste pipeline connected to the line from that building. Assuming that a potential source for the ^{63}Ni found in most of the soil borings was derived from Building 3515 pipeline leaks, then migration along pipeline trenches would be measured in hundreds of feet and is to various parts of the pipeline system.

To trace possible migration pathways for ^{63}Ni in pipeline trench backfill, it would be necessary to drill numerous borings in pipeline trenches and install temporary piezometers in these borings. Many of these borings would have to be performed in contaminated areas with potentially high risk of exposing workers to radiological contamination. Due to the many pipelines which are located in the areas which would need to be investigated, identifying these migration pathways would be expensive both in terms of time and money. Therefore, such an investigation will not be conducted.

With the exception of the limited data pertaining to contaminant migration in pipeline trenches within WAG 1, further resolving migration pathways within WAG 1 is considered to be an essentially hopeless endeavor. Pipeline routes and system interconnections are only generally known, and the map atlas is over 10 years old. Rather than attempting to unravel WAG interior pathways, sampling of trench backfill near pipeline discharge locations at surface water bodies which either coincide with a WAG boundary or are within the WAG will be performed. Identified excursions can then be traced back on a case-by-case basis via atlas information and/or camera to locate the source. Decisions about the most appropriate remediation option can also then be made on a case-by-case basis pending results of the investigation. In conjunction with the pipeline trench sampling, a seep and spring inventory and selective sampling program will be implemented. Because BNI (1992) reports such an investigation at First Creek related to the CH-8 plume investigations, the program need be implemented only at Fifth Creek and WOC. Because seep and spring data would be obscured by PWTP discharges, seep and spring sampling in WOC downstream of the PWTP discharge would not be needed.

6.4.9 Unit F

Because Stueber et al. (1981) describe strike-parallel flow and contaminant transport in Unit F from SWSA 3, consideration is given to such flow in WAG 1. Three areas of contamination in or immediately outside of WAG 1 could describe strike-parallel flow related to Unit F.

6.4.9.1 Piezometer 536 and Well 810

Table 6.26 contains water elevation and indicator radiological data for piezometers and wells potentially related to low levels of radiological contamination in piezometer 536 and well 810 (Fig. 6.10). Nonradiological contamination is absent. Contaminant levels are within

to barely above background concentrations, but the data are of concern because the presence of contamination in piezometer 536 and well 810 could be interpreted to suggest possible migration along Unit F from WAG 1 and underflow of First Creek. No information suggests the possibility of a spill in the area to account for the contamination.

The data in Table 6.26 indicate an absence of either a hydraulic or concentration gradient from piezometers or wells in WAG 1 toward piezometer 536 or well 810. Very close control on the elevation of First Creek in the vicinity of Unit F indicates a reverse hydraulic potential from the creek to well 810. These data essentially preclude WAG 1 as a source of contamination in piezometer 536 and well 810. Rather, hydraulic and concentration gradients do exist from piezometer 533 toward piezometer 536 and well 810 which indicates an eastward migrating plume. Because strike-parallel flow has been documented within Unit F in SWSA 3, the most logical explanation for the source of piezometer 536 and well 810 contamination is from SWSA 3 where a hydraulic gradient exists. If this is the case, it suggests that the Northwest Tributary is an incomplete groundwater discharge surface water body and that First Creek is the ultimate discharge location for eastward migrating groundwater.

The data indicate that contamination in piezometer 536 and well 810 is not derived from WAG 1 but from an eastward migrating plume with a possible source area in SWSA 3. In addition, a hydraulic potential beneath First Creek into WAG 1 does not exist. Therefore, contamination in piezometer 536 and well 810 is not a WAG 1 groundwater issue but a Bethel Valley Groundwater OU issue and will be addressed by the Bethel Valley OU. Because existing data are relatively complete to describe changes in water elevation and radiological contamination in piezometer 536 and well 810, no further monitoring or sampling will be performed as part of this RI.

6.4.9.2 Building 2533 Sump Plume

Table 6.27 contains indicator radiological data for piezometers and sumps which appears to describe another contaminant plume in the vicinity of Unit F (Fig. 6.10). The data indicate the presence of a plume originating in the vicinity of the Building 2533 sump and migrating in a southwesterly direction. The plume exhibits highly elevated concentrations of tritium and gross beta; nearly 75% of the gross beta activity in the Building 2533 sump is ^{137}Cs.

The plume appears to terminate in Unit F. Piezometer 567 to the south of Unit F in the apparent plume migration direction does not exhibit radiological contamination. Radiological contamination slightly above background levels in piezometer 541, about 650 ft to the west in Unit F, could represent strike parallel migration since no other apparent source for that contamination (especially ^{137}Cs) is in the area, but the data are insufficient to substantiate such migration.

Soil boring radiological data (see Table 6.28) indicate nominally one order-of-magnitude elevated gross beta values over background for SB181. Because SB078 (near the apparent high concentration portion of the plume) does not exhibit similar elevated values, it is considered unlikely that the SB181 (located near or outside of the apparent eastern border

of the plume) contamination is related to the plume. The nature of the SB181 contamination is unknown, but the data show no relationship between the groundwater plume and soil contamination.

Facility monitoring by Energy Systems personnel indicates no activities in Building 2533 could serve as an ongoing source, but assumed intermittent sump pump operation is likely to be the cause of plume development. The recent identification of a leak in a LLLW line north of the STF which feeds the Building 2533 evaporator is considered to be a likely source. The pipeline has been leaking for an undetermined period of time, but leaks into and migration along the pipeline backfill material are possible. Both the Building 2533 sump water and soil surrounding the leak contain the beta emitters ^{155}Eu, ^{154}Eu, ^{152}Eu, ^{60}Co, and ^{137}Cs in considerable amounts. The alpha emitters $^{239/240}Pu$, ^{238}Pu, and ^{244}Cm present in the soil is apparently not present in the Building 2533 sump. Alternatively, the extremely high contaminant concentrations suggest some relation to a former leak from a process waste pipeline in the area. The data are currently insufficient to confidently identify a source.

After possible source areas are discussed with knowledgeable personnel, drive points can be installed along suspected pipelines in an attempt to identify a source. Pending results of those studies further source reduction measures can be considered. Semi-annual sampling of the sumps in Buildings 2533 and 2531 and piezometers 564, 566, and 567 during high and low base conditions will be ongoing. Isotopic comparison between the Building 2533 sump and soil samples around the LLLW pipeline leak will support source investigations along the pipeline trench.

6.4.9.3 Core hole CH-9

Sampling in two straddle packer test intervals in CH-9 (Fig. 6.10) revealed the presence of ^{137}Cs (about 17 pCi/L) and tritium (about 18,000 to 30,000 pCi/L) and minor nonradiological contamination. One explanation for the contamination in core CH-9 is down-dip migration within Unit F. Such migration is potentially significant because, contrary to the current conceptual model of the flow field, it would indicate the presence of long deep flow paths actively involved in contaminant migration.

Table 6.29 contains radiological and VOC data and estimated head values from the two CH-9 straddle packer test intervals. Data from piezometers located up dip from the CH-9 contaminated intervals are also included.

The lower CH-9 contaminated interval (from about 314- to 327-ft depth) is within Unit F and has elevated tritium concentrations. The data from well 886 (screened in Unit F) do not indicate contaminant migration from that location to depth. Temporal differences between the piezometer 565 and CH-9 contaminant data prohibit definitive comparisons; however, neither exhibit a head gradient to the CH-9 interval. Toluene and acetone are also absent from well 886. Data are not available from other nearby surface locations (e.g., south of the STF) to identify another source.

The upper CH-9 contaminated interval (about 126 to 138 ft deep) is within Unit G and would project to a surface location about 10 m south of the 3524 EB. Insufficient data are available to describe the head potential from that area to the CH-9 upper contaminated interval. The generally upward head profile from CH-9 packer testing indicates water moves up the hole, and radiological contamination can be considered to be dispersed throughout the hole.

As stated in Sect. 3.3, flow meter testing in CH-9 by Moore and Young (1992) determined that water entered the hole in the vicinity of 338 ft depth and exited the hole at 135 ft. Geochemical sampling of the contaminated intervals indicates that the waters are of the sodium chloride type which has been interpreted to represent deep and older water (e.g., BNI 1992). Mixing between the time the hole was drilled and straddle packer tested may render these results subject to question for the upper interval. These data suggest that the upper interval contaminants are derived from the lower interval. The presence of significantly higher tritium concentrations in the upper interval, however, is inconsistent with that interpretation.

Analysis of the data provides no reasonable explanation for the presence of contaminants at depth in CH-9. The absence of contamination in other packer tested intervals suggests that contaminants were not introduced to the hole by the straddle packer equipment. The data do indicate, however, that the open condition of CH-9 is serving as an artificial contaminant migration pathway.

Because of the comparatively great depths to the contaminated intervals, contamination in CH-9 comes under the responsibility of the Groundwater OU and is not a WAG 1 groundwater issue. However, the OU should consider CH-9 as a candidate for a Westbay multiport sampling installation to prohibit continued mixing of contamination throughout the hole and to monitor changes in contaminant concentration over time.

No other locations in WAG 1 exhibit contamination in Unit F, but the available data suggest that Unit F may be at least a partial barrier to gradient-normal flow and a strike-parallel transmitter of contaminants. The data do not presently support the hypothesis that Unit F is a pathway for contaminant migration to depth.

6.4.10 Localized Areas of Contamination

6.4.10.1 Well 830

Grimsby (1986) describes the area near well 830 (Fig. 6.11) as an ILW line break in the early 1970s which resulted in leakage to WOC. The historic data in Table 6.30 show that tritium is by far the most prevalent contaminant. Nonradiological contaminant data for groundwater are not available. Soil samples in the area exhibit considerable gross beta contamination likely associated with pipeline leaks, but the soil samples do not exhibit the tritium contamination present in well 830. These data suggest that secondary contaminant sources are not present in the area. WOC sediment sampling radiological contamination at

CS-3 described in BNI (1992) cannot be attributed to the well 830 area because other upstream sources may be responsible for the streambed contamination.

No data exist to determine whether contamination from the vicinity of well 830 is seeping into WOC. Data are also insufficient to determine how contamination in well 830 has changed over time, but since nearly two tritium half-lives have expired since the reported pipeline leak, it can be presumed to be significantly reduced.

Seep and spring sampling in the vicinity of well 830 will be performed to determine if contaminants are reaching the creek. If no contamination is found, and no information is uncovered to suggest an ongoing release, only continued monitoring of well 830 will be performed.

6.4.10.2 Piezometer 584

Piezometer 584 (Fig. 6.11) is located at the intersection of Central Avenue and Fourth Street, south-southwest of Building 3026. Results of Close Support Laboratory analyses of a sample collected from this piezometer in December 1991 indicated the presence of significant radiological contamination (see Table 6.31). The highest gross alpha (6611 pCi/L) and gross beta (1,346,395 pCi/L) in WAG 1 groundwater were detected in this sample. This piezometer was resampled in April 1993; and the sample has been submitted for laboratory analyses of gross alpha, gross beta, tritium, and isotopics.

Piezometer 584 is located near several LLLW pipelines which run parallel to Central Avenue. A likely source of the contamination detected in this piezometer is historical leaks in these pipelines or in pipelines to the north associated with Building 3026. During recent construction of the new LLLW pipeline along Central Avenue, significant leakage of ^{137}Cs into the process waste system is reported to have occurred near piezometer 584.

Pending results of laboratory analyses of the most recent sample, samples will be collected from piezometer 584 twice yearly during high base and high base storm conditions. These samples will be analyzed for gross alpha and gross beta.

6.4.10.3 Piezometer 590

Piezometer 590 (Fig. 6.11) is located north of Central Avenue, directly west of Building 3026 and east of the site of the former Building 3024. Table 6.32 summarizes radiological contamination detected in a groundwater sample from piezometer 590 and soil samples from SB165 and SB241. The groundwater sample, collected during low base conditions in November 1991, contained elevated gross alpha and tritium activities and a high gross beta activity (5278 pCi/L). Soil samples from boring SB165, one of five borings performed to investigate reported leaks associated with Building 3026, contained elevated activities of gross beta and tritium. A relatively high gross beta activity (1084 pCi/g) was detected in the sample from the 4–5.5-ft interval in SB241. The purpose of this boring was to investigate possible soil contamination from a leak in tank WC-4.

Possible sources of the radiological contamination found in piezometer 590 are leaks from Building 3026 and from tank WC-4. In addition, Grimsby (1986) reported numerous leaks and spills associated with the former Building 3024, located to the west of piezometer 590. However, Building 3024 was in a nonradiological area, and the source is suspected to be former pipeline leaks. These releases may also be sources of the groundwater contamination in the area.

Samples will be collected twice yearly from piezometer 590 during high base and high base storm conditions. These samples will be analyzed for gross alpha, gross beta, and tritium.

6.4.10.4 Piezometer 593

Piezometer 593 (Fig. 6.11) is located to the south of Building 3525 along Fourth Street. Table 6.33 is a summary of radiological contamination found in a groundwater sample from piezometer 593 and in soil samples from borings south of Building 3525. Elevated gross alpha and gross beta activities (114 pCi/L and 128 pCi/L respectively) were observed in the high base sample collected from piezometer 593 in February 1991. Levels of gross alpha and gross beta in the borings were all below maximum reference levels. Grimsby (1986) reports that leaks have occurred in low-level waste lines discharging water into a ventilation duct which in turn feeds a sump located near Building 3525. These leaks may be a source of the contamination detected in piezometer 593.

A sample will be collected from piezometer 593 once yearly during high base storm conditions. This sample will be analyzed for gross alpha and gross beta.

6.4.10.5 Core hole 7A

Core hole 7A is located in the northwestern part of WAG 1 north of Building 2009, between Buildings 2026 and 2007 (see Fig. 6.11). It was drilled to a total depth of 184.6 ft BGS in Unit C of the Chickamauga Group in 1991. Chickamauga Unit D was encountered at 28 ft BGS and Unit C was penetrated at 147.6 ft BGS.

Fractured intervals in Unit D which have been identified on geophysical logs of CH-7A occur at 49 to 51, 66 to 67, 72 to 73, 89 to 90, and 162 to 163 ft BGS. Shifts in the temperature and differential temperature logs are noted in these intervals, with the most dramatic shifts occurring at 49 to 51 and 89 to 90 ft. These temperature shifts are inferred to show active groundwater flow in these fractured intervals. A 1-ft cavity was encountered while drilling at approximately 90 ft BGS.

Packer tests, which included piezometric head measurements and hydraulic conductivity tests, were completed in six intervals in CH-7A. Piezometric heads and hydraulic conductivities for the packer test intervals are summarized in Table 6.34. In general, Unit D in CH-7A appears to be a zone of low piezometric head. The lowest head was observed in the interval from 84 to 91 ft BGS. This interval contains the 1-ft cavity which was encountered at 90 ft and the fractured interval from 89 to 90 ft identified on geophysical logs.

The presence of a cavity, indications of active groundwater flow on temperature logs, detection of low levels of contamination, and the low head imply that this interval may include a significant groundwater discharge zone in Unit D. The relatively low hydraulic conductivity estimated for this interval (6.0×10^{-5} cm/s) may not be accurate, and should be retested. The highest hydraulic conductivities in CH-7A, 10^{-2} and 10^{-3} cm/s, were observed in the 124–131-ft and 117–124-ft intervals respectively.

Groundwater samples were collected from two of the packer test intervals: 84 to 91 and 70 to 77 ft BGS. Results of analyses of these samples for radiological and nonradiological parameters are shown in Table 6.35. Gross beta and tritium activities slightly above maximum reference levels were observed in the 84–91-ft interval. Gross alpha and gross beta activities elevated slightly above maximum reference levels were detected in the sample from 70 to 77 ft. Concentrations of VOCs (tetrachloroethene, TCE, chloroform, and toluene) above maximum reference levels were also measured.

A Westbay multi-port system will be installed in this core hole in order to isolate multiple zones and characterize groundwater flow/contaminant migration pathways in Unit D. Measurements of piezometric head, aquifer tests to estimate hydraulic conductivities, and collection of samples for analyses of radiological and VOC contamination will be performed in the isolated zones. Packer intervals which should be constructed and reasons for isolating these intervals are as follows:

- 45 to 55 ft BGS because this depth range contains the fractured zone with active groundwater flow at 49 to 51 ft BGS identified on geophysical logs;
- 85 to 95 ft BGS because this zone includes the cavity encountered while drilling at 90 ft, the fractured interval with active groundwater flow detected at 89 to 90 ft BGS on geophysical logs, and the sample interval which exhibited low levels of radiological and VOC contamination;
- 116 to 131 ft BGS because this range comprises the two packer test intervals which had the highest estimated hydraulic conductivity values in CH-7A.

6.4.10.6 Mercury contamination of soil

Four sites in the southeastern part of WAG 1 (Fig. 6.12) have been grouped into a Mercury Spill Soils OU: Building 4501, Building 4508, an area beneath the roadway just south of Building 3503, and an area immediately to the south of Building 3592.

In 1954, ton quantities of mercury were used in Building 4501 for about 6 months to operate a small pilot plant for lithium separation (OREX process). During these operations, spills occurred that were cleaned up; but some mercury was able to escape through cracks in the concrete floor and contaminate soil under the building. Soil samples collected in 1983 from locations around the building had mercury concentrations ranging from 0.05 to 465 ppm (ORNL 1990). In 1991, soil samples were collected from four soil borings which were advanced under Building 4501. Concentrations of mercury in these samples ranged up to 12,600 μg/kg in the sample from 2 to 4 ft BGS in SB203. Elevated concentrations of mercury

Elevated concentrations of mercury ranging up to 16.7 μg/L were also detected in water samples collected from four sumps in the building in 1990. Mercury was not detected in groundwater samples from downgradient piezometers (618, 623, and 626) or core hole CH-4. Therefore, it appears that groundwater contaminated with mercury from the Building 4501 spills is being captured by the building sumps and treated in the PWTP. The sumps will be monitored twice yearly for mercury concentrations.

Research activities in Building 4508 are reported to have used <100 lb of mercury; however, there have been no reports of spills (ORNL 1990). Mercury was not detected in soil samples from four soil borings around Building 4508, nor in a water sample collected from the building sump. A mercury concentration of 0.33 μg/L was detected in a groundwater sample collected from well 824, located south of the building, in March 1991. This concentration is slightly above the maximum reference level of 0.20 μg/L, but well below the MCL of 2.0 μg/L. The source of the mercury found in well 824 may or may not be soils under Buildings 4508 or 4501, and this well will be monitored twice yearly for mercury.

During the 1950s and early 1960s, substantial quantities of mercury were used in Building 3503 in the spent fuel reprocessing program known as PUREX. No information is available on the amount of possible losses of mercury during these operations. Mercury concentrations reported from analyses of soil samples collected from various locations around Building 3503 in 1983 ranged from 0.8 to 25 ppm (ORNL 1990). The contaminated soils are located just south of the building. A relatively low mercury concentration of 560 μg/kg was observed in the soil sample collected from the 4–6-ft depth interval in SB173. Mercury was not found in groundwater samples from piezometer 601 or wells 879 and 881, located hydraulically downgradient of Building 3503. Water is currently being pumped from tank sumps in the thorium tank farm south of Building 3503 and treated in the PWTP. Groundwater which may be contaminated with mercury in this area is probably being captured and treated by this system. In addition, relatively high activities of gross alpha (2839 pCi/g) and gross beta (2996 pCi/g) were found in the soil sample from 2 to 3.3 ft BGS in SB174. Because of the low levels of mercury found in soils, the presence of radiological contamination in the area, and the likelihood that contaminated groundwater is being captured and treated in the PWTP, additional exploration or remedial activities for mercury contamination of soils in this area will not be performed. Samples collected from piezometer 601 as part of monitoring for radiological contamination (see Sect. 6.4.10.9) should be analyzed for the presence of mercury.

In 1956, work was carried out in Building 3592 in support of the lithium separation project in Building 4501 during which approximately 60,000 lb of mercury were used. Accurate estimates of the amount of mercury lost during these operations are not available; however, operating personnel reported that about 2000 to 3000 lb were lost to spills and leaks. Analyses of soil samples taken from various locations around Building 3592 in 1983 showed mercury concentrations ranging from 4.1 to 320 ppm (ORNL 1990). Table 6.36 summarizes analyses of soil samples for mercury from SB175 and SB176. Concentrations of mercury exceeded the RCRA action level of 20,000 μg/kg in the 1–2-ft and 2–4-ft samples from SB175. Elemental mercury was visible in the soil from 2 to 3.25 ft BGS during sampling of

SB175. Concentrations of mercury observed in samples from SB176 did not exceed the RCRA action level.

Actions that will be performed at this site include:

- hand-augering of soil borings and collection of soil samples to ascertain the extent of mercury contamination of soils;
- installation of a piezometer and collection of groundwater samples to determine whether groundwater in the area is contaminated with mercury;
- if groundwater is contaminated with mercury, the contaminated soils will be hydraulically isolated (e.g., by repaving the area) to prevent further movement of mercury from the soil into groundwater.

Given the relatively small volume of contaminated soil, consideration should also be given to excavating and disposing of mercury-contaminated soil south of Building 3592 in order to prevent future groundwater contamination. However, complicating factors may be the presence of a process waste pipeline and low levels of radiological contamination of soils in the potential excavation area (see Table 6.36).

6.4.10.7 Piezometer 553

Piezometer 553 (Fig. 6.11) is located near the southwest corner of the steam plant (Building 2519) adjacent to a diesel UST which has been removed since sampling. Table 6.37 is a summary of radiological and nonradiological contaminants detected in groundwater samples from piezometer 553. Gross alpha, gross beta, and tritium activities which were elevated slightly above maximum reference levels were observed in groundwater samples from this well. The metals beryllium, cadmium, chromium, cobalt, nickel, silver, and vanadium were found in the low base sample at the highest concentrations in WAG 1 groundwater. A possible source of these metals is fallout from atmospheric emissions from coal combustion at the steam plant. The VOCs benzene, toluene, ethylbenzene, and xylenes (BTEX) were also observed at the highest concentrations in WAG 1. These aromatic VOCs may be evidence of a release from the nearby diesel UST.

A groundwater sample will be collected during high and low base conditions from this well and analyzed for metals, BTEX, and total petroleum hydrocarbons.

6.4.10.8 Area northwest of WAG 1 boundary

This area comprises the northern 2000 part of the Laboratory (see Fig. 6.11). Elevated gross alpha, gross beta, and tritium activities were detected in low base and high base samples collected from wells in this area in 1990 and 1991 (Table 6.38). Alpha-emitting radionuclides detected above maximum reference levels were $^{228/230/232}$Th and $^{234/238}$U; beta-emitting radionuclides observed above maximum reference levels were $^{226/228}$Ra and total radioactive strontium. In general, activities of these radionuclides were higher in the high base samples than in the low base samples.

Nonradiological contaminants detected above maximum reference levels included beryllium, chromium, cobalt, copper, lead, mercury, nickel, silver, vanadium, TCE, and toluene (see Table 6.39). Metals detected above their respective MCLs were beryllium in wells 538, 546, 549, and 572; chromium and lead in well 538; chromium and nickel in well 549; and lead in well 587. TCE was detected above its MCL of 5 $\mu g/L$ in the well 546 high base sample.

Samples will be collected from wells 538, 549, 572, and 547 during high base storm conditions and analyzed for radiological parameters, metals, and VOCs.

6.4.10.9 Piezometer 601

Piezometer 601 is located in the south-central portion of the WAG, about 50 ft south of Building 3537 (see Fig. 6.11). During drilling of the borehole for this piezometer, a 3-in. PVC underground pipeline originating in the TH-3 tank sump was broken, allowing radiologically contaminated water to come to the surface. About 2 weeks after it was broken, the pipeline was repaired and contaminated soil was excavated and disposed of.

Radiological contamination detected in groundwater samples collected from piezometer 601 is summarized in Table 6.40. Gross alpha, gross beta, and tritium activities above maximum reference levels were detected in the low base sample; elevated gross alpha and gross beta activities were detected in the high base sample. This groundwater contamination may be due to the release of contaminated water from the broken pipeline or it may have a source elsewhere in WAG 1. A groundwater sample will be collected twice yearly from this piezometer and analyzed for gross alpha, gross beta, tritium, and mercury (see Sect. 6.4.10.6).

6.4.11 Tracers

One anticipated byproduct of the additional data obtained as part of this work plan is further definition of areas of contamination and better insight into groundwater flow paths, especially in cavitose Unit D but also in other locations. These flow paths could be major transmitters of contamination over wide areas in WAG 1. If the data provide the anticipated insight, it is feasible that dye tracing may be performed to further define areas of contamination, describe flow paths, identify source areas, and distinguish between suspected commingling plumes. In addition to a description of flow pathways, dye tracing data could provide estimates of flow velocity and contaminant flux. At present, tracers are anticipated to be dyes, but decisions about the choice of tracers will be made in conjunction with decisions to perform the test(s). Dye tracing may also be performed in other locations in WAG 1 (e.g., the impoundments or tank farms) to support remediation option selection decision making and reduce uncertainty.

6.5 MONITORING

This section describes the monitoring and sampling program that will be performed at existing wells, piezometers, and core holes to more fully understand the nature and extent of

Action Mem. CH8

1. PURPOSE

This action memorandum documents approval for a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) non-time-critical removal action. The action is being taken to reduce the release of ^{90}Sr into First Creek from the Oak Ridge National Laboratory (ORNL) Waste Area Grouping (WAG) 1 Corehole 8 Plume, as measured at White Oak Dam.

2. SITE CONDITION AND BACKGROUND

2.1 SITE DESCRIPTION

2.1.1 Physical Location

ORNL is located on the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) in East Tennessee at the Anderson and Roane County lines, approximately 24 km (15 miles) west of Knoxville, Tennessee, and 16 km (10 miles) southwest of the city of Oak Ridge (Fig. 1).

ORNL consists of buildings and operation areas which are restricted to public access except for designated public access and visitors areas. The ORNL main plant is set apart by a security fence that surrounds the buildings and adjacent land. A portion of ORNL, generally in the western end of the main plant area, but extending beyond the security fence in the west and southwest directions, is designated as WAG 1. The western boundary of WAG 1 approximates the stream bed for First Creek. It begins near the western entrance into the ORNL main plant at Central Avenue (Portal 3) to the confluence of First Creek with White Oak Creek (Fig. 2).

The headwaters of First Creek, a tributary to White Oak Creek, originate within ORR. First Creek flows southward and parallel with the western ORNL security fence. Potential contaminants entering First Creek would flow into White Oak Creek and then across White Oak Dam to the Clinch River. White Oak Dam was constructed across White Oak Creek and is located adjacent to where State Highway 95 crosses White Oak Creek (Fig. 1).

Bounding ORNL-managed areas south and southwest of the main plant is the Clinch River. Across the river from ORNL is private rural land used primarily for farming. Areas within ORR not occupied by the ORNL main plant and the two other DOE facilities have been declared a wildlife management area by DOE and the Tennessee Wildlife Resources Agency.

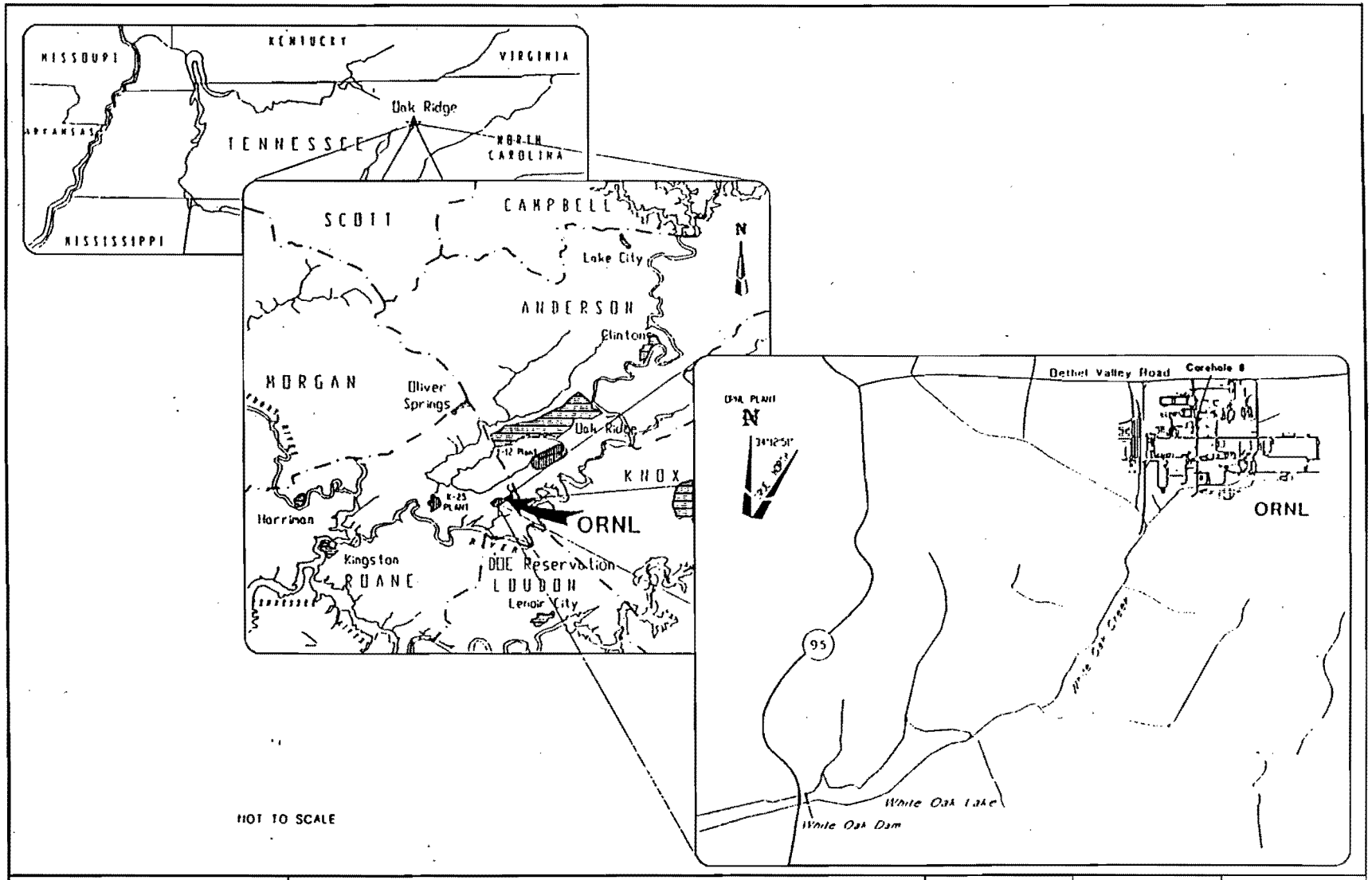

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Fig. 1

Regional location map

DOE - ORNL, Corehole 8 - Oak Ridge, Tennessee

DOCUMENT ID: 350830
5201.99 / ACT MEMO

DRAWING ID
94-0075DWG

DRAWING DATE
OCTOBER 25, 1994

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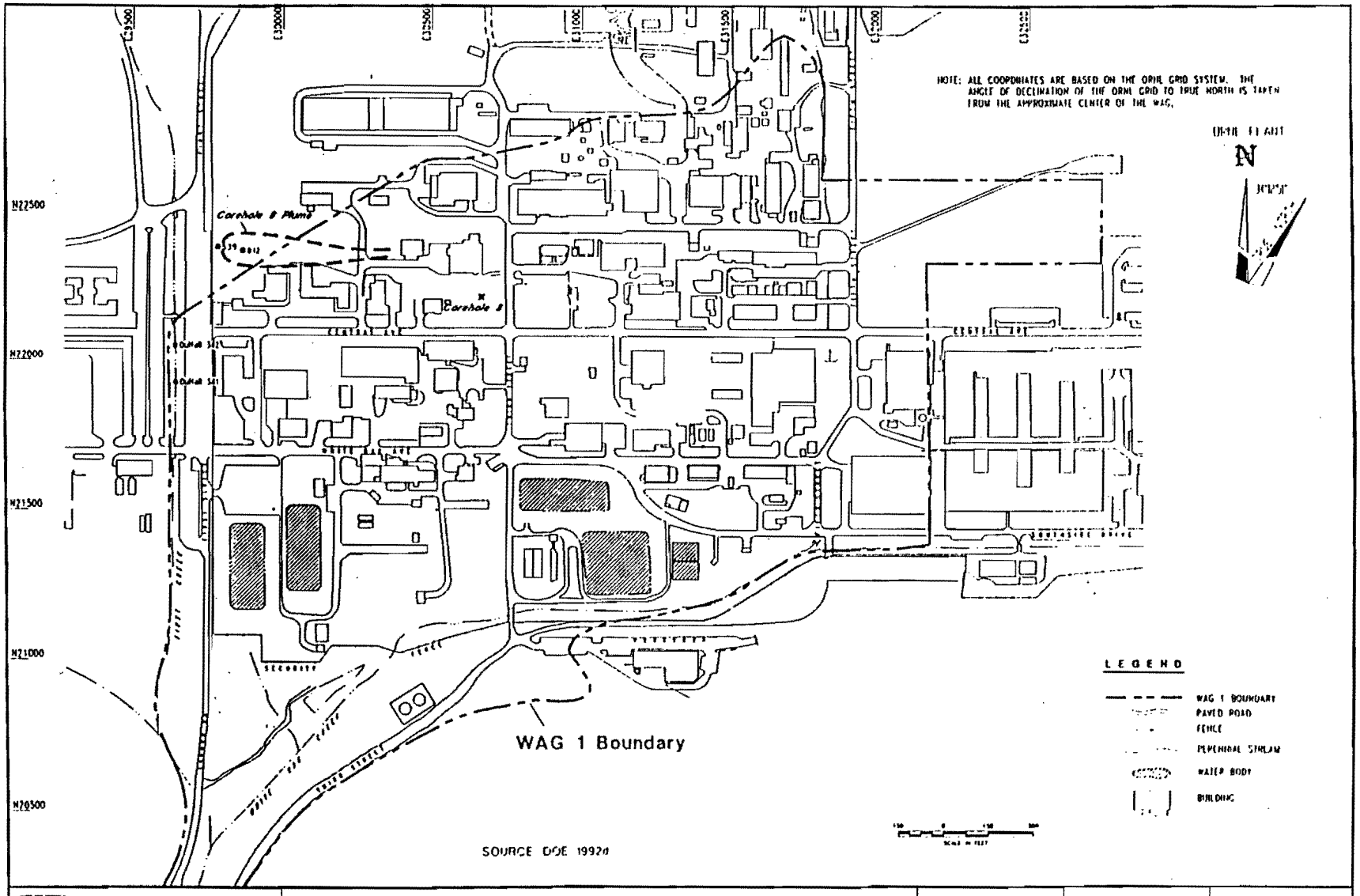

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WAG 1, White Oak Creek, and White Oak Lake lie within the restricted areas of ORNL, thus restricting public access to the potentially contaminated areas. All but the contaminant-free headwaters of First Creek are within the restricted area surrounding the main plant.

2.1.2 Removal Site Evaluation

The WAG 2 remedial investigation of White Oak Creek surface water contaminant source areas identified First Creek as a contributor of approximately 10 percent of the ^{90}Sr being transported by White Oak Creek to White Oak Dam. Results from 1991 sampling activities in First Creek indicated that almost all of the ^{90}Sr detected in First Creek emerges in the area of Outfalls 341 and 342. Using the 1991 sampling results, along with results from sampling activities in July 1994, influxes of contaminated groundwater into the storm sewers associated with these two First Creek outfalls were identified. The ^{90}Sr-contaminated groundwater originates from a plume in an area north of the storm sewers. A break in a portion of the storm sewers that extends into the area of the plume will permit contaminated groundwater into the storm sewers and into First Creek via Outfalls 341 and 342.

A video camera examination of the storm sewer pipes in the system associated with Outfall 342 located an influx of groundwater. The influx was observed near the intersection of pipes from the two stormwater inlets. No other significant influx of water into the storm sewer was observed; there was a small trickle of water in the storm sewer flowing from the north branch. The flow rate for the contaminated groundwater was measured during the July 19, 1994, sampling. Contaminated groundwater flowing from the storm sewer pipe where influx was observed (sampling location SW 30) was measured at 11 L/min (3 gal/min). Outfall 342 (SW 28) had similar flow rates. The reported concentration of gross beta during the July 1994 sampling in the storm sewer and at Outfall 342 was between 7,100 and 8,000 pCi/L (Table 1).

Contaminated groundwater influx into the storm sewer associated with Outfall 341 occurs in two stormwater inlets north of Building 2013. The contaminated groundwater influx into the stormwater inlet located immediately outside the north exiting door in the west end of Building 2013 (SW 24) was estimated July 5-6, 1994, as approximately 23 L/min (6 gal/min). In the stormwater inlet approximately 8 m (26 ft) southeast of the same north exiting door from the west end of Building 2013, the contaminated groundwater influx was estimated at about 4 L/min (1 gal/min). The concentration of gross beta in the groundwater influx at these locations has been measured as being between 7,290 and 9,200 pCi/L (Table 1).

Table 1. Summary of gross beta flux estimates for WAG 1 Corehole 8 Plume at ORNL, Oak Ridge, Tennessee

	1991[a]	July 5-6, 1994			July 19, 1994		
Sample location	Gross beta concentration (pCi/L)	Discharge (L/min)	Gross beta concentration[b] (pCi/L)	Gross beta flux (mCi/month)[c]	Discharge (L/min)	Gross beta concentration[a] (pCi/L)	Gross beta flux (mCi/month)[c]
Seep SE of SW 27	1,458	NS	NS	NS	NS	NS	NS
Manhole NE of SW 33	270	NS	NS	NS	NS	NS	NS
Catch Basin NE of SW 38	270	NS	NS	NS	NS	NS	NS
Catch Basin NE of SW 24	14.3	NS	NS	NS	NS	NS	NS
Catch Basin SE of SW 24	7,830	NS	NS	NS	NS	NS	NS
SW 24	7,290	23	9,200	9	15	7,600	5
SW 25	NS	23	9,200	9	NS	NS	NS
SW 26	NS	<0.4	330	<0.01	NS	NS	NS
SW 27	NS	0.4	7,700	0.1	NS	NS	NS
SW 28	2,700	76	7,100	23	11	7,300	4
SW 29	7,020	133	8,300	48	129	4,300	24
SW 30	NS	15	8,000	5	11	7,800	4
SW 31	NS	90	540	2	NS	NS	NS
SW 32	NS	< 0.4	380	<0.01	NS	NS	NS
SW 33	8,370	23	3,800	4	151	6,600	43
SW 34	64.8	38	9,200	15	27	8,700	10
SW 35	NS	95	250	1	53	NS	NS
SW 36	3.8	53	150	0.3	NS	NS	NS
SW 37	267.3	2.6	1,000	0.1	NS	NS	NS
SW 38	NS	0.08	900	0.003	NS	NS	NS
SW 39	NS	NS	NS	NS	8	250	0.1
SW 40	NS	NS	NS	NS	42	240	0.4
SW 41	NS	NS	NS	NS	0.3	320	0.004
SW 42	NS	NS	NS	NS	1,469	590	37
SW 43	NS	NS	NS	NS	848	570	21

[a]Discharge rates were not determined during 1991, so flux estimates are not available.
[b]Value represents the highest activity from each location, regardless if filtered, unfiltered, or duplicate.
[c]Calculations are based on 30 days per month.

L = liter
mCi = millicurie
min = minute
NE = northeast
NS = not sampled
ORNL = Oak Ridge National Laboratory
pCi = picocurie
SE = southeast
WAG = Waste Area Grouping

000068

2.1.3 Site Characteristics

Monitoring Wells 539 and 812, located approximately 40 m (132 ft) north of Central Avenue near the west security fence (Fig. 2), are screened below the weathered bedrock surface. Groundwater samples from these wells have consistently shown ^{90}Sr levels of 4,000-8,000 pCi/L. The ^{90}Sr contamination detected at these wells and the contamination detected in the storm sewer groundwater influx indicate the presence of a groundwater plume. However, because of the lack of pertinent data, characterization and source location of the suspected ^{90}Sr plume in the groundwater between the wells and the storm sewers is not possible at this time. Conceptually the source of this ^{90}Sr plume has been projected to be about 10 m (33 ft) north of Corehole 8. Projections from geological and hydrogeologic understanding of the site indicate contaminated water moves downgradient along strike in a westerly direction toward First Creek. Support for this hypothesis is based on the detection of 585,495 pCi of ^{90}Sr in groundwater at a depth of approximately 15 m (50 ft) during the installation of Corehole 8 in 1991. The contaminated groundwater in the stratum is thought to move up dip to the top of bedrock surface. Monitoring Wells 539 and 812, located down strike of the stratum transporting the ^{90}Sr, may be some of the receptor points for the ^{90}Sr-contaminated groundwater. For this reason, the groundwater plume located approximately 35-50 m (115-165 ft) north of Central Avenue and between First Street and Second Street, and possibly as far east as Third Street, has been named the Corehole 8 Plume.

The probable source of contaminated groundwater influx into the storm sewers associated with Outfalls 341 and 342 is the Corehole 8 Plume. Reaches of the two storm sewer systems associated with Outfalls 341 and 342 extend into areas where the contaminated groundwater associated with the Corehole 8 Plume may come in contact with stormwater inlets, manholes, and storm sewer pipes. Where an inlet, manhole, and/or pipe is not watertight, contaminated groundwater enters the storm sewer. Based on 9 months of observation, influx of contaminated groundwater into the storm sewers is continuous.

2.1.4 Release or Threatened Release of Contaminants

The primary contaminant of concern released into First Creek and detected at White Oak Dam is ^{90}Sr, a CERCLA hazardous substance. Monthly sampling results from the First Creek Gauging Station indicated the ^{90}Sr flux ranges from a low of 5.7 mCi/month to a high of 52 mCi/month. The results extrapolated from the July 19, 1994, First Creek and storm sewers sampling indicate a ^{90}Sr flux of 21 mCi/month, which is consistent with the monthly sampling results. Data from the WAG 2 remedial investigations indicate that First Creek contributes approximately 10 percent of the total ^{90}Sr flux detected at White Oak Dam.

5. PROPOSED ACTION AND ESTIMATED COSTS

The action to intercept and remove ^{90}Sr-contaminated groundwater from the storm sewers associated with Outfalls 341 and 342 will reduce the ^{90}Sr-contaminated water reaching First Creek by an estimated 20–50 percent. First Creek contributes approximately 10 percent of the ^{90}Sr detected in the water at White Oak Dam. The reduction of ^{90}Sr in the storm sewers will correspondingly reduce the amount of ^{90}Sr detected at White Oak Dam by an estimated 2–5 percent. This action will reduce the risk to human health, welfare, and the environment until additional and/or permanent actions to eliminate the source of contaminants are taken.

5.1 PROPOSED ACTION

Three alternatives were identified to reduce the amount of ^{90}Sr reaching First Creek via the storm sewers associated with Outfalls 341 and 342 (Jacobs 1994). Alternative 1 planned to stop ^{90}Sr-contaminated groundwater from entering First Creek by lining the storm sewers and making them watertight, thus keeping contamination out of the storm sewers and eliminating the pathway between the Corehole 8 Plume and First Creek. Alternative 2 planned to collect all the water, stormwater, and contaminated groundwater in the two storm sewer systems, thus eliminating the storm sewers as a pathway to the creek for all collected water. Alternative 3 was selected to intercept contaminated groundwater as it enters the storm sewers from the Corehole 8 Plume and prevent it from entering First Creek.

Alternative 3 proposes to use the Process Waste Treatment Plant (PWTP) for removal of the ^{90}Sr contamination from the water collected from the storm sewers by this action. The PWTP removes low concentrations of radionuclides, including ^{90}Sr, to concentrations in the effluence to less than 20 Bq/L. The discharge requirements for the PWTP effluent meet DOE Order 5400.5 requirements. The effectiveness of the PWTP in removing ^{90}Sr from water collected by the Corehole 8 Removal Action is greater than 90 percent. The selection of PWTP was made because of its effectiveness and its availability and cost. Treatment of the contaminated groundwater collected by this removal action will not be charged against the costs of this project. This is reflected in the proposed costs presented in Appendix A and Section 7.3 of the EE/CA (Jacobs 1994). The EE/CA stated that the National Pollutant Discharge Elimination System (NPDES) permit is for the PWTP; however, the permit is actually for the Nonradiological Wastewater Treatment Plant (NRWTP) which receives and treats the discharge from the PWTP.

Regardless of whether or not the Corehole 8 plume is entering the storm sewer system, it is a known pathway of contaminants in WAG 1 groundwater. The concerns with the Corehole 8 plume should be addressed as quickly as possible either through this removal action or the WAG 1 Groundwater Program.

Response:

Section 4.4.3 refers to sampling necessary for evaluating the placement of a French drain somewhere in the Corehole 8 Plume area. Initial action to intercept contaminated groundwater from entering the First Creek via the storm sewers will begin during the first quarter of FY 1995, as documented in this Action Memorandum, and should begin operation during the second quarter FY 1995. Monitoring the effectiveness of the initial action will take place during the third quarter of FY 1995. Sampling in the Corehole 8 Plume will occur in the third quarter of FY 1995, if it is deemed necessary. The only reason for sampling in the Corehole 8 Plume area is to collect data to determine the effectiveness, implementability, and cost of installing a French drain. If the initial action, as presented in this Action Memorandum, is sufficient, and no follow-up action is necessary, sampling in the Corehole 8 Plume will not be necessary because the purpose of the removal action will have been accomplished.

11. REFERENCES

Jacobs (Jacobs Environmental Restoration Team). 1994. *Engineering Evaluation/Cost Analysis for the Waste Area Grouping 1 Corehole 8 Plume Removal Action at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/02-1303&D2).

5. CONTAMINANT FATE AND TRANSPORT

This section describes the analysis of fate and transport of contaminants in WAG 1; the analysis, essentially qualitative, is not directed at determining exposure point contaminant concentrations. Calculations in this section are not calibrated to specific sources or receptors. The purpose of this section is to provide general information on the fate and transport process at WAG 1, which will form the basis for more detailed, operable unit-specific evaluations to be completed during future investigations. Fate and transport are addressed for all environmental media except air, which was not assessed as part of this investigation. Fate and transport of contaminants via the food chain is also not addressed.

Fate and transport of a contaminant in an environmental medium are governed by the physical, chemical, and biological characteristics of the contaminant and the environmental medium with which it interacts. In addition, transport is governed by environmental factors including meteorology, hydrology, and geology.

Analysis of the fate and transport of contaminants requires consideration of transformation, transport, and speciation processes. This section considers these processes generally, using both literature-based and site-specific data. For example, the effect of speciation processes on the mobility of metals and radionuclides is addressed through distribution coefficients having values based on the physical and chemical characteristics of the contaminated media. Similarly, biochemical transformation processes, which are especially important for organics, are complex and site-specific; any description of biotransformation processes is generalized for the WAG 1 site. Transformation of radionuclides through radioactive decay is generally well understood. Phase I of the RI did not include numerical modeling of groundwater flow and contaminant transport in WAG 1.

Section 5.1 describes the relevant physical, chemical, and biological characteristics of the contaminants and the environmental media. Section 5.2 uses information on the physical characteristics of WAG 1 (given in Sect. 3) to develop a site conceptual model for the analysis of fate and transport. Section 5.3 integrates information on the physical characteristics of WAG 1 with the information on the nature and extent of contamination described in Sect. 4 to perform the fate and transport analysis within the conceptual framework developed in Sect. 5.2.

5.1 CHARACTERISTICS OF CONTAMINANTS AND ENVIRONMENTAL MEDIA

5.1.1 Contaminants

WAG 1 is a mixed-waste site with both radiological and chemical contaminants present in the various media; however, radiological contamination is dominant.

5.1.1.1 Radiological contaminants

Radiological contaminants of potential concern for WAG 1 are listed with their half-lives in Table 5.1.1. The list includes fission and activation products and daughter products of the plutonium-241, uranium-238, and thorium-232 series.

The properties of radionuclides most relevant to their fate and transport are their half-lives and their mobility in water. Half-lives are radionuclide-specific and can be obtained from literature. The mobility of radionuclides is influenced by such site-specific factors as the particular chemical form of the radionuclide, the geochemistry of the waters in which the radionuclide is transported, and the mineralogic composition and texture of the solid medium with which the transporting water comes in contact. These factors are incorporated into the distribution coefficient (K_d), which is a bulk measure of the mobility of the solute. A high distribution coefficient indicates low mobility, and a low distribution coefficient indicates high mobility. The two most important parameters that influence the distribution coefficient are the soil/rock type and the pH of the transporting water.

Table 5.1.2 lists distribution coefficients of radionuclides. Values for cesium, cobalt, radium, strontium, and technetium in soils are based on laboratory measurements for soil samples from three WAG 1 soil borings. Section A.5 of Appendix A describes the locations and the methodologies used to derive the estimates. Typical values not specific to WAG 1 are also listed for various soil and rock types. The large variation in K_d values illustrates the sensitivity of the values to local site characteristics, including pH and soil type. For example, the values for cesium in soil at WAG 1 range from 330 to 1429. These variations introduce a high degree of uncertainty to estimates of subsurface contaminant transport velocities in addition to uncertainties associated with the complex hydrogeology of the site.

5.1.1.2 Metals

Metals of potential concern found in WAG 1 are listed in Table 5.1.3, as are typical distribution coefficients. Mobility and sorption of metals in groundwater depend on the aqueous and solid matrix chemistry in a very complex manner. Heavy metals such as mercury are generally strongly retained by the soil material, so leaching is often negligible. As mentioned earlier, mobility and sorption characteristics of metals are expressed here in terms of distribution coefficients.

5.1.1.3 Organic contaminants

Table 5.1.4 lists organic contaminants of potential concern found in WAG 1 and five chemical properties of each that are important for fate and transport: water solubility, vapor pressure, Henry's law constant, organic carbon partition coefficient (K_{oc}), and persistence in various media. The first eight organics listed, all BNAEs, are distinguished by their low water solubility and high K_{oc}; they tend to remain fixed in soils. The last 11 organics in the table are all volatiles distinguished by their high solubility in water and relatively low K_{oc}; these have been detected in some groundwater and surface water samples (see Sect. 4).

Organics biodegrade to varying degrees both in soil and water in the presence of certain microbial populations. Abiotic transformations caused by hydrolysis and photolysis can also be important, and transformed products are often more mobile and toxic than their parent materials. A notable example of an organic found in groundwater of WAG 1 that biodegrades to more toxic products is trichloroethylene (TCE); the microbial degradation chain of TCE is depicted in Fig. 5.1.1.

5.1.2 Environmental Media

A typical pathway of a contaminant from its source to an exposure point involves one or more of the following media: vadose zone (soil/saprolite), groundwater, surface water, and sediments. Characteristics of these media are detailed in Sect. 3. Characteristics relevant to contaminant fate and transport are summarized in this section.

5.1.2.1 Vadose zone

South of Central Avenue, the vadose zone is generally within the regolith, but north of Central Avenue, it includes weathered and fresh rock. The thickness of the vadose zone decreases from topographic highs to topographic lows at groundwater discharge areas. The vadose zone thickness in WAG 1 ranges from 0 to approximately 60 ft. At any vertical section it varies with water table fluctuations, which are more than 13 ft in the northern (recharge) portion of the WAG.

The physical properties of the vadose zone that influence the movement of water are saturated hydraulic conductivity; total and effective porosities; moisture content; and characteristic curves relating hydraulic conductivity and moisture content to the pressure head. Transport of particle-reactive contaminants is influenced by pH, cation exchange capacity, and total organic content of the vadose zone medium. While most of these parameters were not measured specifically for WAG 1 during this phase of the RI, approximate values can be assigned on the basis of the soil type and properties and the results of previous investigations conducted in and around ORNL.

The total porosity of the vadose zone is probably in the range of 0.3–0.7, typical of clay-rich soils (Freeze and Cherry 1979). The effective porosity, however, may be considerably less, on the order of 10^{-2} to 10^{-3} (Moore 1989; Solomon et al. 1989). Saturated hydraulic conductivity is probably on the order of 10^{-2} to 10^{-3} m/day (Moore 1989).

WAG 1 soils are generally strongly leached, often acidic, and low in organic content. TOC is probably on the order of 0.01–0.1%, and the CEC is between 10 and 50 meq/100 g of soil (see Sect. 3.2). The pH is in the 4.5–8.2 range (Boegly et al. 1987). The higher pH is associated with Gladeville clay series, one of the two principal clay series found in the ORNL complex. Collegedale, the other principal clay series, has pH ranging from 4.5 to 5.5.

Significant portions of the vadose zone have been excavated and backfilled occasionally in connection with construction activities. Materials used in the backfill and their degree of compaction generally differ from the native soil and can alter the flow characteristics of the

disturbed zone. Hydrologic properties of the vadose zone reported by Moore (1989) are applicable to the entire ORR, including undisturbed areas. Values within WAG 1 may vary from these estimates. However, in preliminary tests in the pipeline trench backfills, hydraulic conductivity was not found to be significantly different from the native soil (see Sect. 3.3).

5.1.2.2 Groundwater

Groundwater flow in WAG 1 occurs in two distinct hydrogeologic regions. The upper region is in the regolith, where flow directions are controlled by hydraulic gradients; this is also the region where man-made influences are the most pronounced. The lower region is in the fractured bedrock, where flow directions are chiefly controlled by the geologic structure of the rock. Much of this flow tends to be along fractures (see Sect. 3.3.4).

Geochemically, an upper flow region that includes both regolith and fractured bedrock is characterized by waters rich in calcium bicarbonate. This is underlain by a transition zone characterized by waters rich in sodium bicarbonate. A deeper third region is characterized by waters rich in sodium chloride without circulation. The combined thickness of the upper two regions, where there is groundwater circulation, is approximately 150 ft. Limited head data from coreholes in recharge areas suggest that local groundwater recharge affects only the upper 50 ft of the saturated aquifer (see Sect. 3.3).

The groundwater flow regime in WAG 1 is controlled by the presence of three discharge boundaries—First Creek to the west, Fifth Creek to the east, and WOC to the south—as well as a recharge area to the north. It is believed that most of the flowing groundwater ends up in one of the three creeks. It is possible that some groundwater may remain strata-bound and flow under the creek beds. However, based on evidence available to date, it is assumed that all groundwater discharges into the WOC drainage system.

Groundwater flow is governed by the saturated hydraulic conductivity, direction and magnitude of the hydraulic gradient, orientation of fracture zone or solution features, and effective porosity. Mobility of particle-reactive contaminants in groundwater is influenced by aqueous and solid-matrix chemistry. As discussed in Sects. 5.1.1.1 and 5.1.1.2, sorption and mobility characteristics of metals and radionuclides are expressed in terms of distribution coefficients. Transport is also influenced by the bulk density of the solid matrix and total and effective porosities (or primary and secondary porosities for fractured rocks).

Saturated hydraulic conductivity. Measurements of hydraulic conductivity in the various mappable units of the shallow bedrock revealed considerable variation, though an overall trend of decreasing conductivities with depth could be discerned (see Sect. 3). On average, there is little difference between the hydraulic conductivity of the overburden material and that of the bedrock aquifer. The mean hydraulic conductivity for overburden and bedrock is about 4×10^{-4} cm/s.

Hydraulic gradients. Horizontal hydraulic gradients in the overburden shallow bedrock as estimated from water table contour maps range from about 0.01 to 0.1. Vertical hydraulic gradients, based on head measurements in the coreholes, are generally steeper and upward;

gradients are downward in the recharge areas. The steepest vertical hydraulic gradient (approximately 0.15 upward) was observed in CH001.

Total and effective porosities. No measurements of total and effective porosities have been made for the WAG 1 aquifer. In fractured rock, storativity is commonly assumed to be equal to effective porosity (Moore 1988). Moore (1988) estimates a mean effective porosity of 0.0025 for the shallow aquifer in the ORNL area. Solomon et al. (1989), however, have used a value of 1.8% for effective porosity. The total porosity would be much higher, probably between 0.3 and 0.5.

5.1.2.3 Surface water and sediments

The physical properties of surface water relevant to fate and transport are flow discharge and velocities, lateral and vertical extent of flow, and the amount of suspended sediment present. Lateral and vertical extent of flow are important factors for large streams where mixing of contaminants can be confined to a portion of the total flow cross section. WAG 1 streams are small, however, and total mixing of contaminants in the entire flow cross section can be reasonably assumed.

Flows in First Creek are generally less than 1 cfs at gauging station SW-7 and only about 0.1 cfs when the groundwater is low (see Sect. 3.4). At station SW-4 in Fifth Creek, calculated base flows ranged from about 0.5 to 3.0 cfs during the RI. At WOC station SW-6, base flows during the RI ranged from about 6 to 9.5 cfs. An approximately 5-year record (from April 17, 1985, to December 8, 1990) of flows at SW-6 shows the median flow to be about 7 cfs. A significant fraction, especially during low flows, of WOC flows is imported water from the DOE water treatment plant, supplied at an average rate of approximately 6.2 cfs to satisfy ORNL's potable and process water needs. About 62% of this water is discharged to the WOC surface water system.

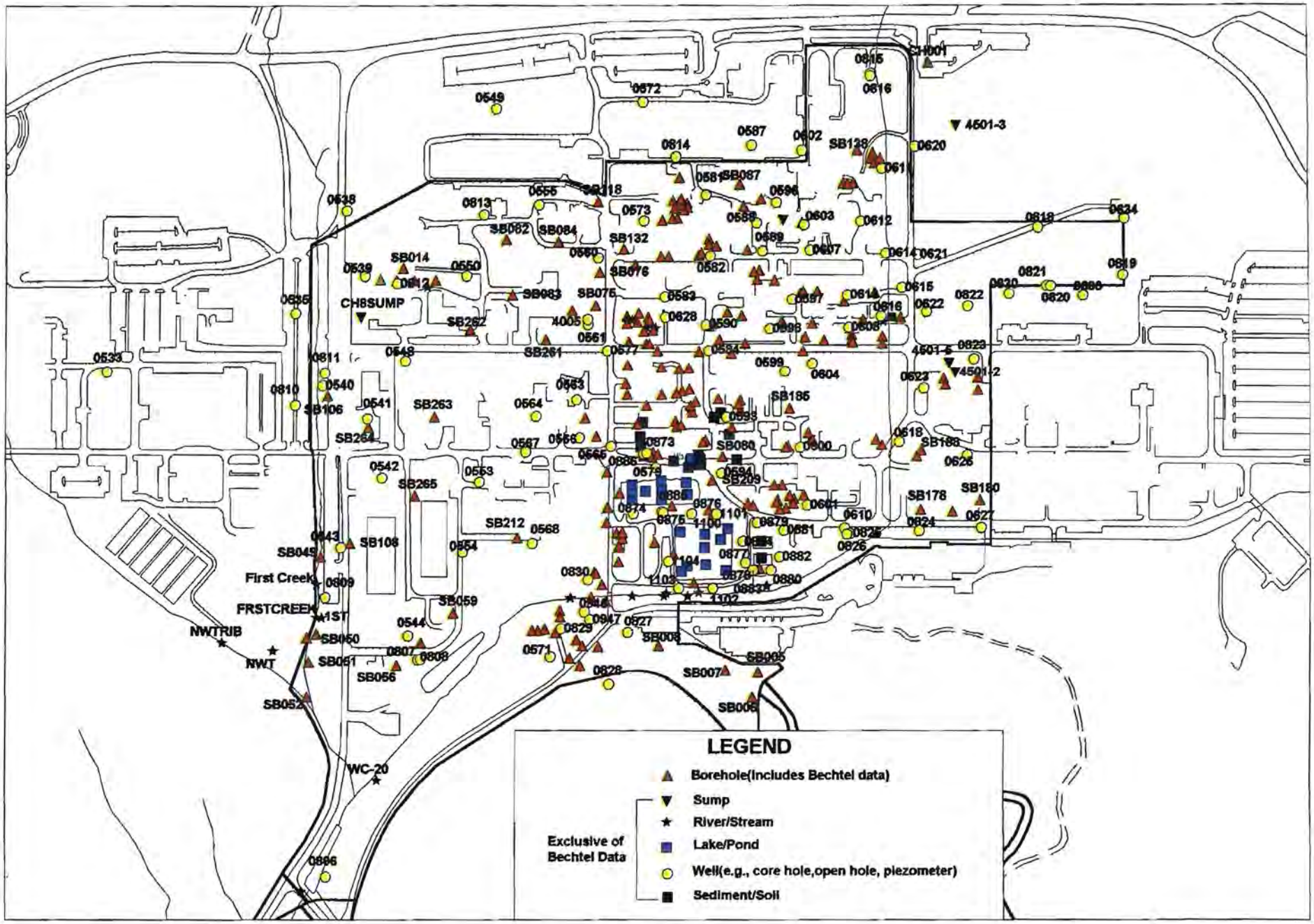
Flow velocities, measured only in Fifth Creek, were generally less than 1 fps. On the basis of stream size, flow velocities in First Creek are expected to be lower than in Fifth Creek and somewhat higher in WOC.

Concentrations of suspended sediment were not measured. As comparisons of cesium-137 (a highly particle-reactive contaminant) concentrations in filtered surface water samples with unfiltered sample concentrations demonstrate, suspended sediment can play a significant role in transport of particle-reactive contaminants.

Beyond analyzing for contaminant concentrations, detailed physical and chemical characterization of streambed sediments was not performed. The primary physical characteristics are texture and organic matter content, including humic material. These physical properties influence the affinity of sediments for all classes of contaminants. Visual observations suggest that bed sediments have a significant proportion of coarse-textured particles with low humic content.

The chemical properties of sediments that affect their mobility and bioavailability include pH, oxidation-reduction, particle mineralogy, and the amount of potentially reactive iron and

WAG 1 MONITORING LOCATIONS



WAG 1 WELLS SAMPLED AFTER 1992

The table below describes the wells that were sampled after 1992. The Wag perimeter wells were sampled in four quarters beginning May 1993, July 1994, April 1995, and May 1996. The remaining wells were sampled on a variety of dates beginning in 1993.

WELL	EASTING	NORTHING	GROUND ELEVATION	EST. NUMBER OF RESULTS	RADS	METALS	VOCS	OTHERS	
0535	29541.41	22235.11	797.54	30+	Y				
0538	29736.18	22630.29	812.66	30+	Y	Y	Y		
0539	29807.39	22379.31	799.84	37	Y				
0549	30311.39	23013.09	856.49	30+	Y	Y	Y		
0553	30243.72	21584.37	797.36	30+	Y	Y	Y		
0555	30472.94	22652.17	854.74	30+	Y				
0563	30615.41	21899.82	809.48	4	Y				
0564	30459.19	21836.37	809.16	30+	Y				
0566	30625.08	21755.47	805.93	6	Y				
0567	30419.37	21700.2	803.15	8	Y				
0571	30515.25	20920.68	781.8	30+	Y				
0581	31115.05	22689.91	859.81	30+	Y		Y		
0583	30954.85	22298.95	826.45	30+			Y		
0584	31122.9	22089.87	802.22	1	Y				
0593	31191.49	21833.08	799.07	11	Y				
0598	31358.87	22175.01	806.2	30+	Y		Y		
0599	31417.95	22009.55	801.14	30+	Y		Y		
0600	31475.14	21719.22	793.9	30+	Y		Y		
0601	31503.38	21497.54	787.92	30+	Y				
0614	31803.05	22465.66	805.36	30+	Y		Y		
0616	31784.19	22222.73	800.65	30+	Y				
0622	31960.23	22239.98	798.24	30+	Y				
0806	29657.3	20082.9	774.94	1000+	Y	Y	Y	Y	Wag perimeter
0807	30008.5	20909.3	774.53	1000+	Y	Y	Y	Y	Wag perimeter
0808	30018.6	20910.2	774.5	1000+	Y	Y	Y	Y	Wag perimeter
0809	29652.5	21142.9	776.74	1000+	Y	Y	Y	Y	Wag perimeter

000087

000088

WAG 1 WELLS SAMPLED AFTER 1992

WELL	EASTING	NORTHING	GROUND ELEVATION	EST. NUMBER OF RESULTS	RADS	METALS	VOCS	OTHERS	
0810	29539.2	21879.3	790.19	1000+	Y	Y	Y	Y	Wag perimeter
0811	29652.3	22002.7	791	1000+	Y	Y	Y	Y	Wag perimeter
0812	29931.4	22350.4	803.19	1000+	Y	Y	Y	Y	Wag perimeter
0813	30261.9	22615	848.86	1000+	Y	Y	Y	Y	Wag perimeter
0814	30999.2	22831.8	877	1000+	Y	Y	Y	Y	Wag perimeter
0815	31746.3	23144	823.99	1000+	Y	Y	Y	Y	Wag perimeter
0816	31746.7	23134.2	823.44	1000+	Y	Y	Y	Y	Wag perimeter
0818	32390.3	22564.6	851.55	1000+	Y	Y	Y	Y	Wag perimeter
0819	32714.9	22382.4	827.83	1000+	Y	Y	Y	Y	Wag perimeter
0820	32422	22341.8	807.35	1000+	Y	Y	Y	Y	Wag perimeter
0821	32436	22340.7	808.55	1000+	Y	Y	Y	Y	Wag perimeter
0822	32116.7	22262.8	797.58	1000+	Y	Y	Y	Y	Wag perimeter
0823	32141.8	22057.3	799.51	30+	Y				
0824	31932	21399.2	787.05	1000+	Y	Y	Y	Y	Wag perimeter
0825	31666.2	21388.3	787.96	1000+	Y	Y	Y	Y	Wag perimeter
0826	31654.4	21387.3	788.07	30+	Y				
0827	30813.5	21012.5	784.63	1000+	Y	Y	Y	Y	Wag perimeter
0828	30741.4	20815.2	814.11	1000+	Y	Y	Y	Y	Wag perimeter
0829	30557.1	21026.1	775.56	1000+	Y	Y	Y	Y	Wag perimeter
0830	30659.5	21211.7	778.35	1000+	Y	Y	Y	Y	Wag perimeter
0873	30872.46	21692.62	794.4	30+					
0874	30833.78	21464.06	782.4	30+	Y				
0875	30943.46	21473.94	784.8	30+	Y				
0876	31058.84	21465.27	783.3	30+	Y				
0885	30949.28	21468.07	782.9	30+	Y				
0946	30646.76	21091.05	777.74	1000+	Y	Y	Y	Y	Wag perimeter
0947	30666.93	21061.66	778.82	1000+	Y	Y	Y	Y	Wag perimeter
0987	25857.89	21650.14	857.11	30+	Y				
0988	25471.29	21075.73	910.97	30+	Y				
0990	24723.62	21657.34	853.91	30+	Y				
0991	25051.49	21736.64	854.79	30+	Y				
0992	25069.69	21737.04	854.54	30+	Y				
0993	25619.08	21884.35	840.39	30+	Y				
0994	25639.92	21895.03	840.41	30+	Y				

000089

000030

WAG 1 WELLS SAMPLED AFTER 1992

WELL	EASTING	NORTHING	GROUND ELEVATION	EST. NUMBER OF RESULTS	RADS	METALS	VOCS	OTHERS
0996	26458.18	21920.17	830.31	30+	Y			
0997	26467.5	21911.04	830.24	30+	Y			
1102	31141.45	21180.43	783	50+	Y			
1103	31009.21	21180.33	782.2	50+	Y			
1104	30970.03	21281.89	780.8	50+	Y			
4005	30659.35	22211.96	815.9	50+	Y			

000091

260000

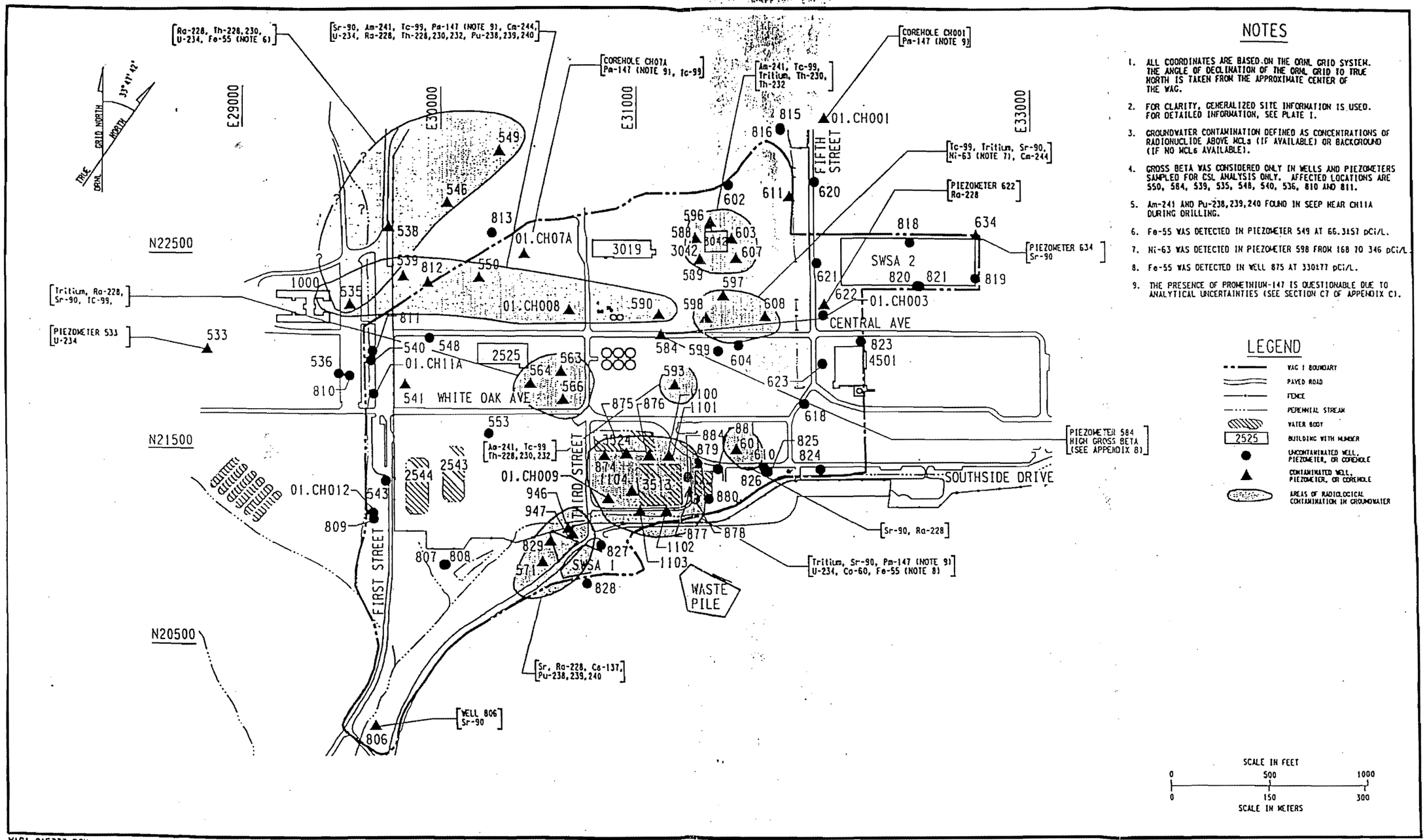


Fig. 3.3. Overview of radiological contamination in groundwater at WAG 1. *Source:* Energy Systems 1992a.

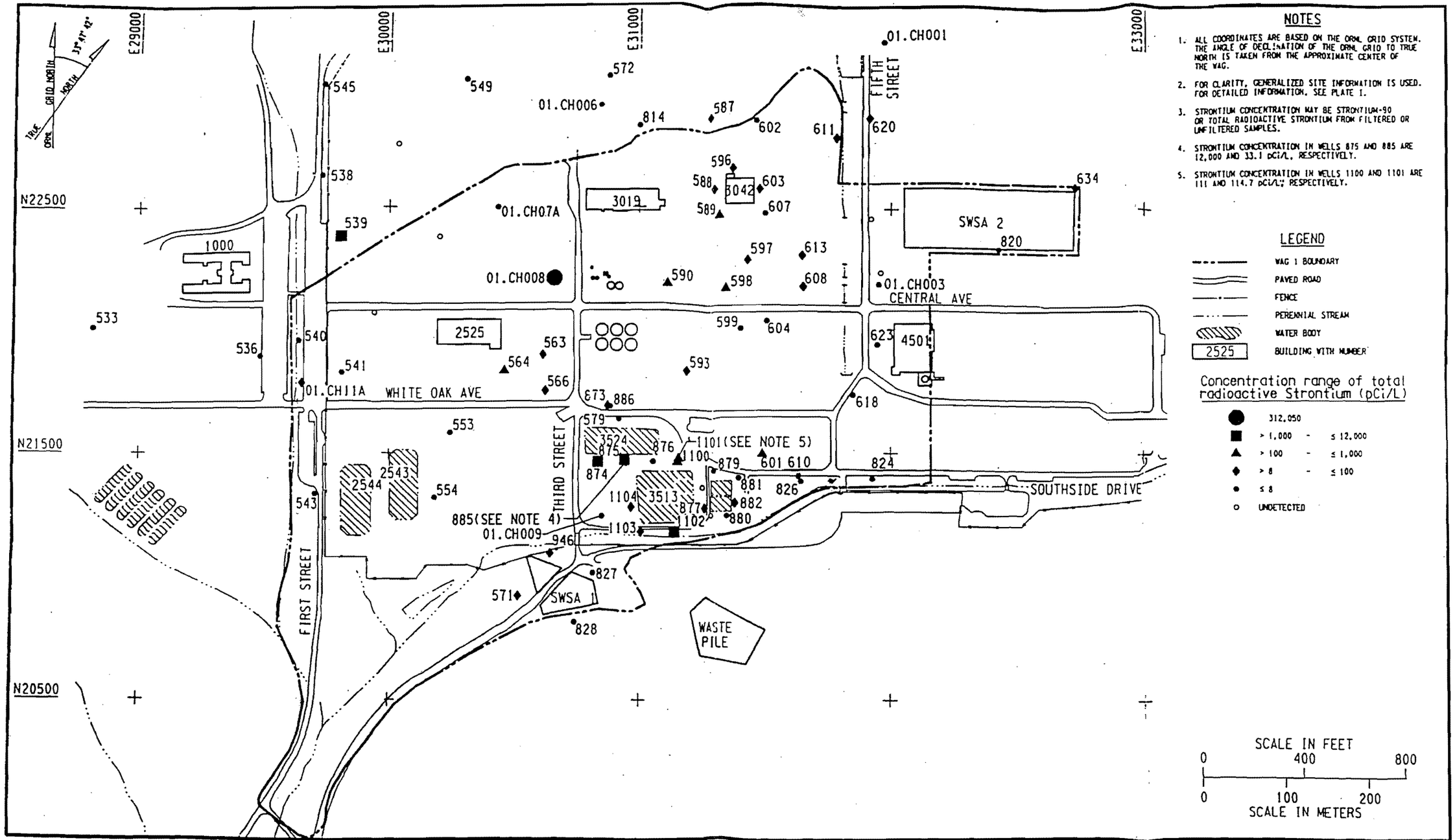
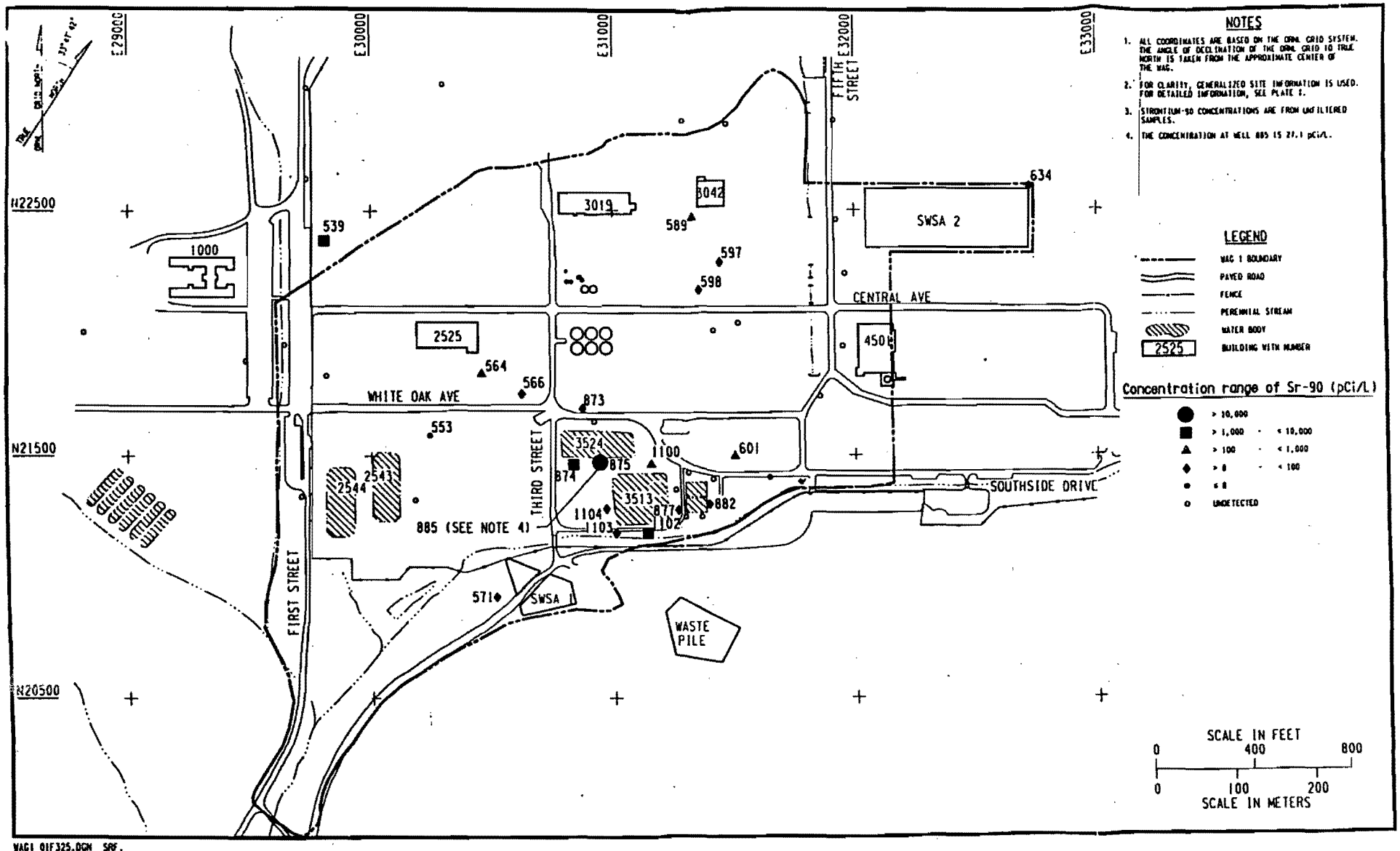


Fig. 4.3.1. Strontium: maximum concentrations in all wells, piezometers, and coreholes sampled.

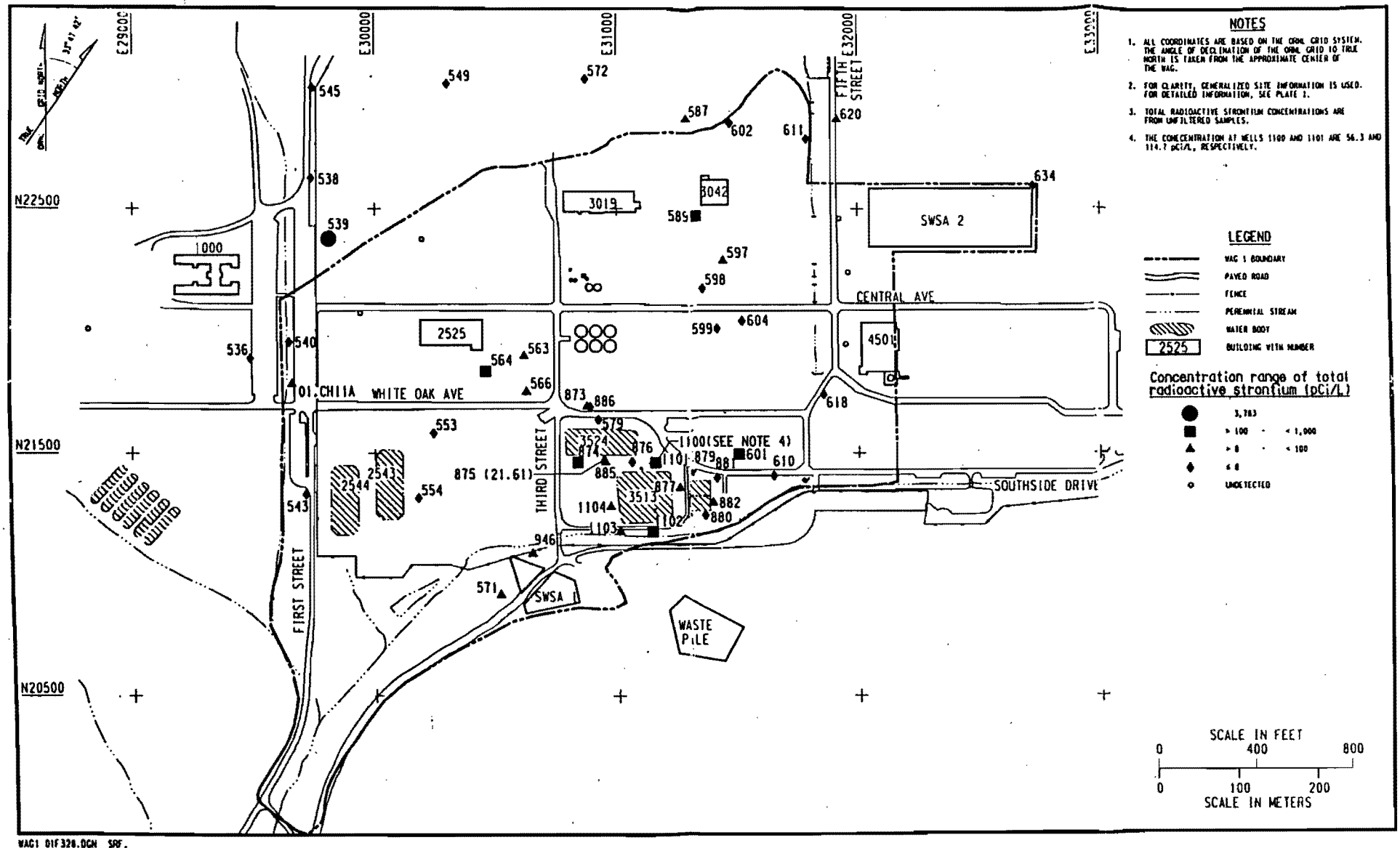


WAG1 01F325.DGN SRF, 9/11/92

Fig. 4.3.2. Strontium-90: maximum consentration in wells and piezometers sampled during low base flow conditions.

0000097

000098



WAG1 DIF328.DGN SRF, 9/11/92

Fig. 4.3.3. Total radioactive strontium: maximum concentrations in wells and piezometers sampled during high base flow conditions.

000069

000100

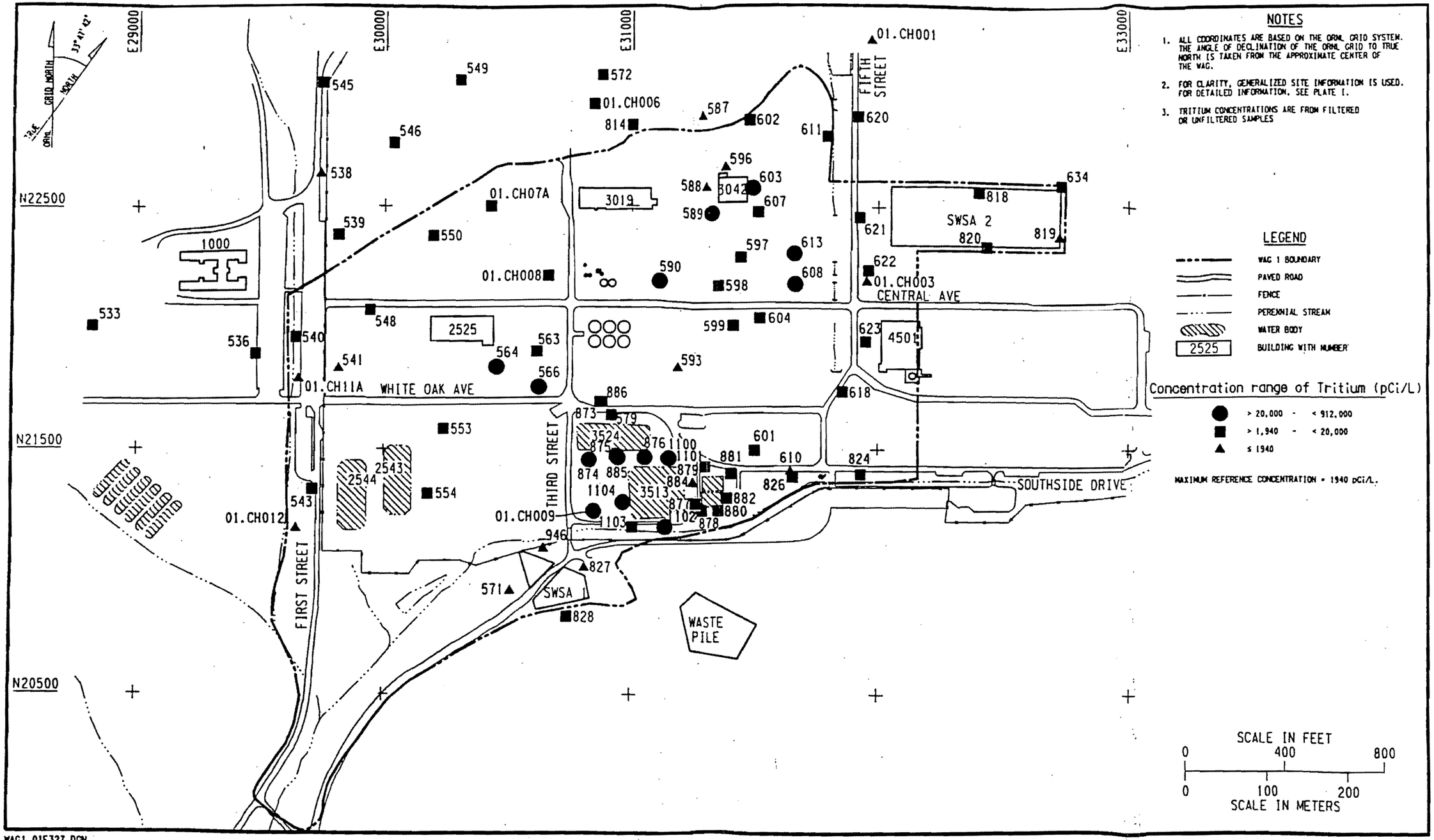
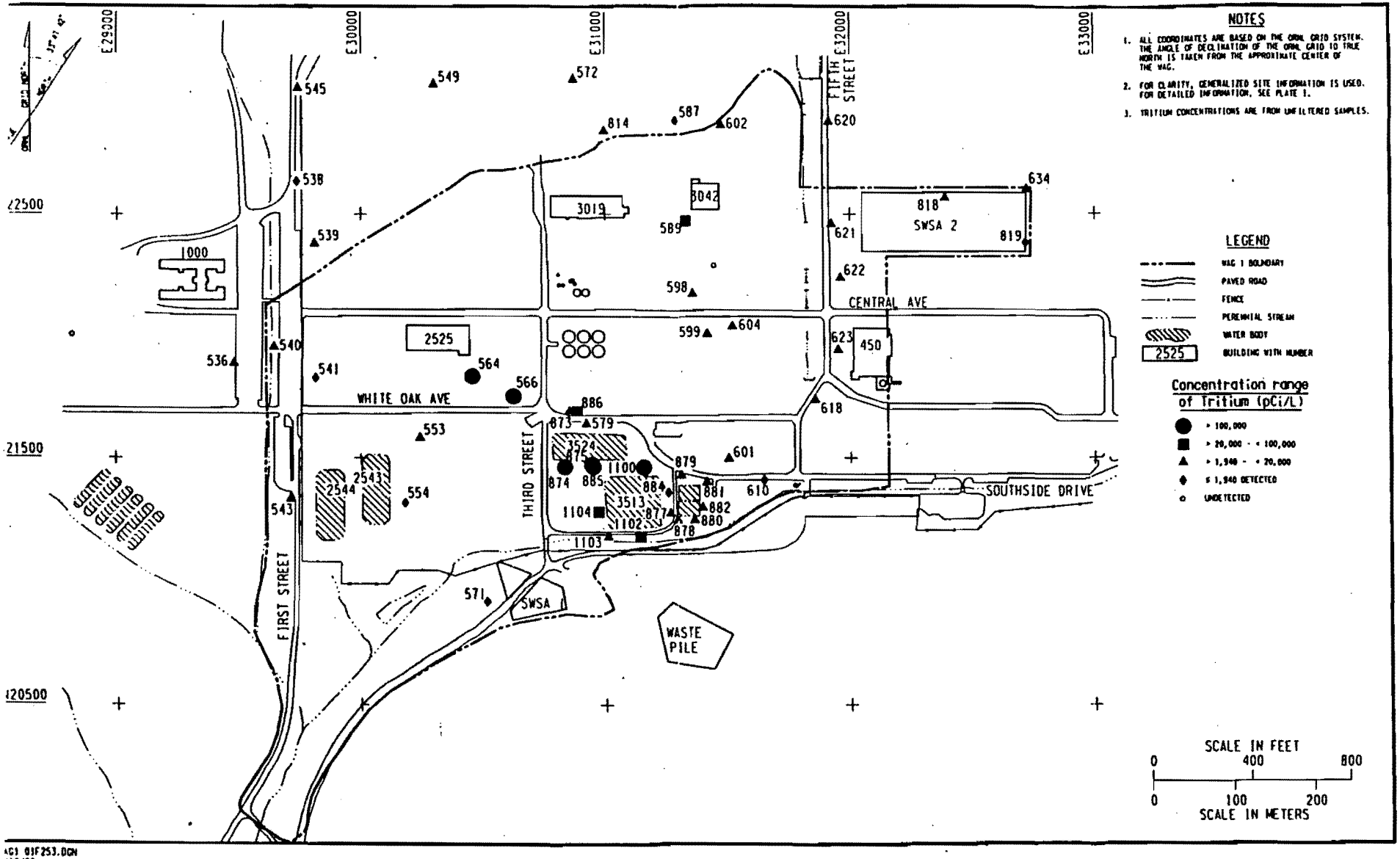


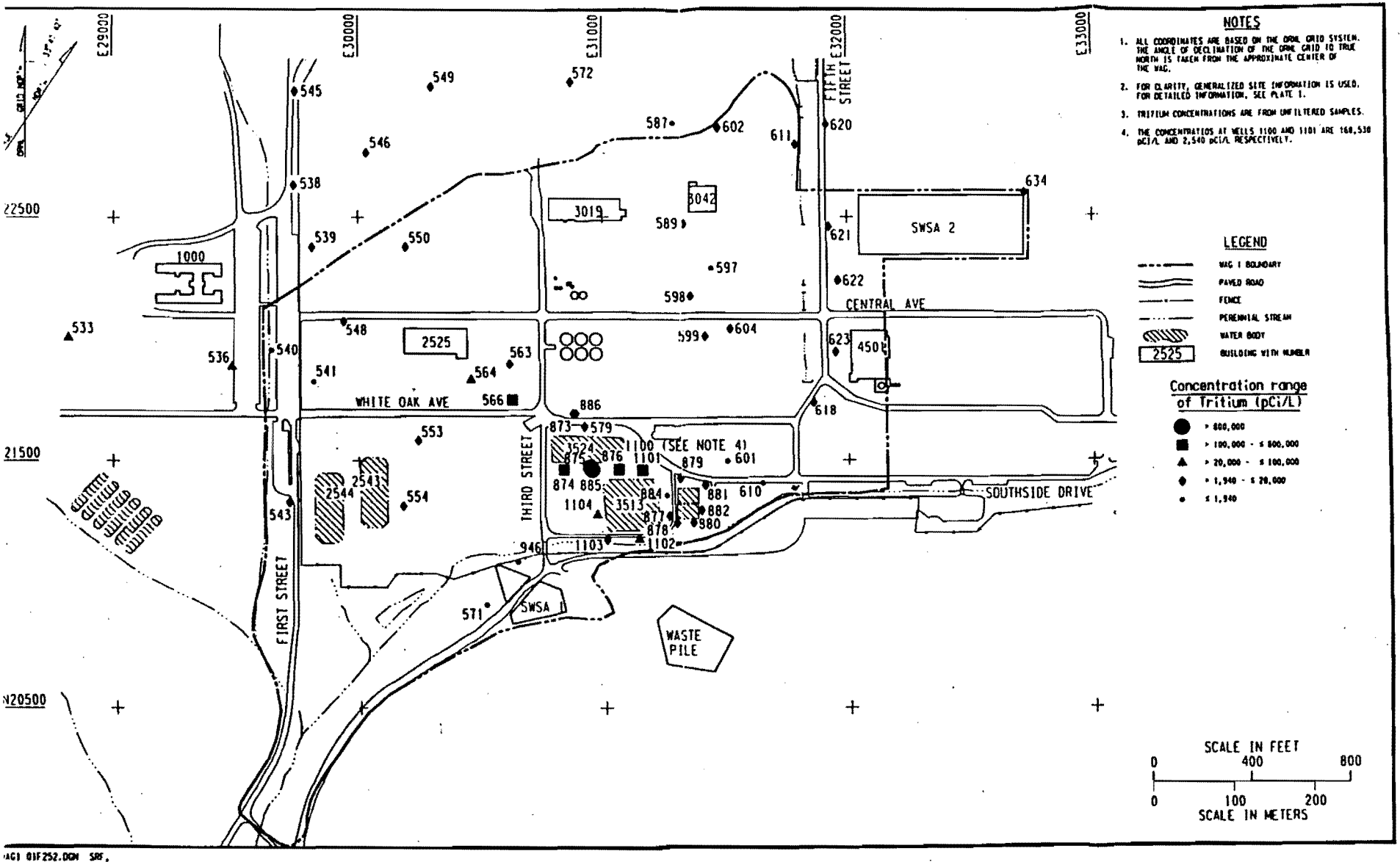
Fig. 4.3.4 Tritium: maximum concentrations in all wells, piezometers and coreholes sampled.



AG1 01F253.DGN
/10/92

Fig. 4.3.5. Tritium: maximum concentrations in wells and piezometers sampled during low base flow conditions.

000103

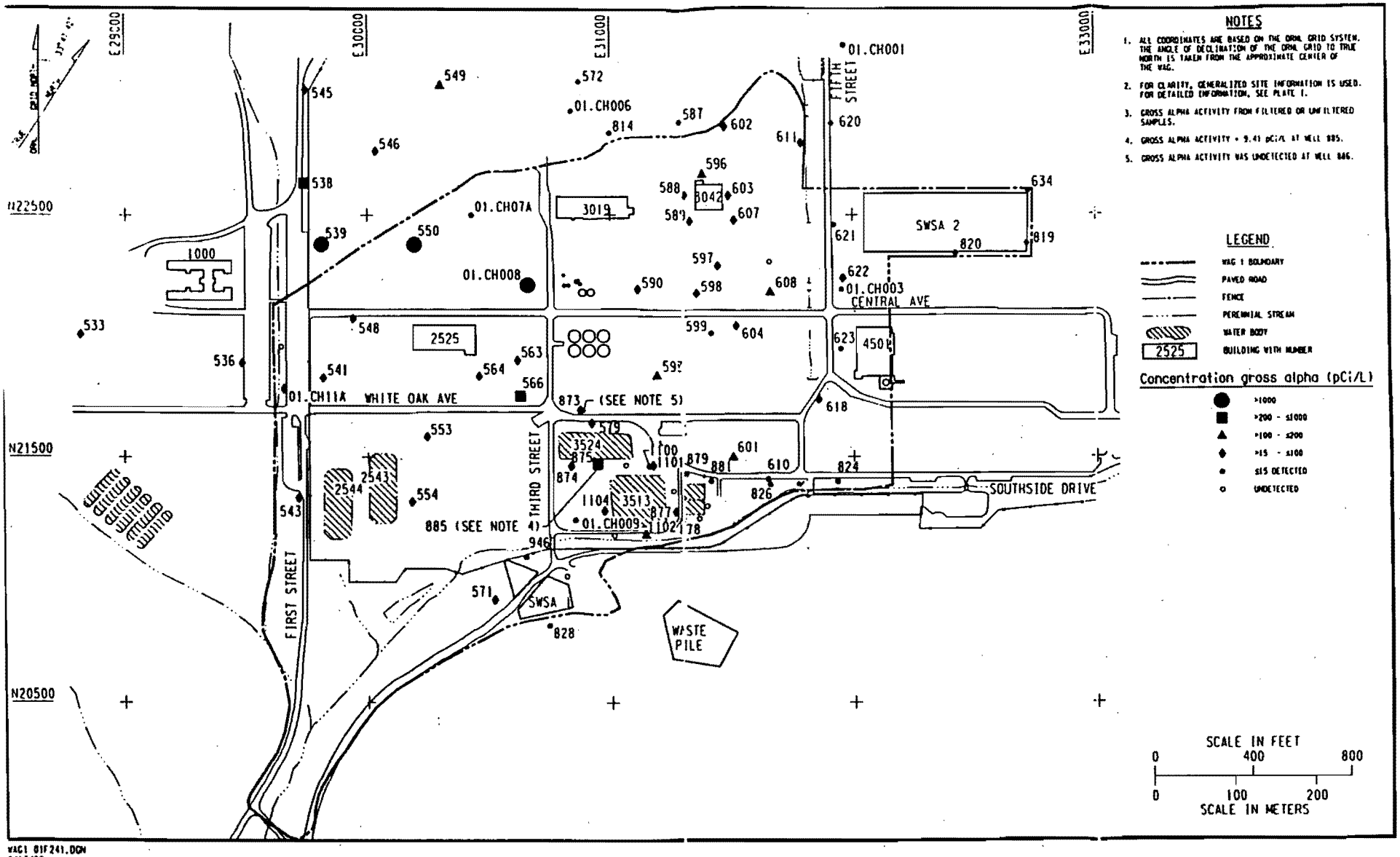


WAG1 01F252.DGN SRF, 1/11/92

Fig. 4.3.6. Tritium: maximum concentration in wells and piezometers sampled during high base flow conditions.

000105

000106



WAG1 81F241.DGN
9/17/92

Fig. 4.3.7. Gross alpha: maximum activity in all wells, piezometers and coreholes sampled.

301000

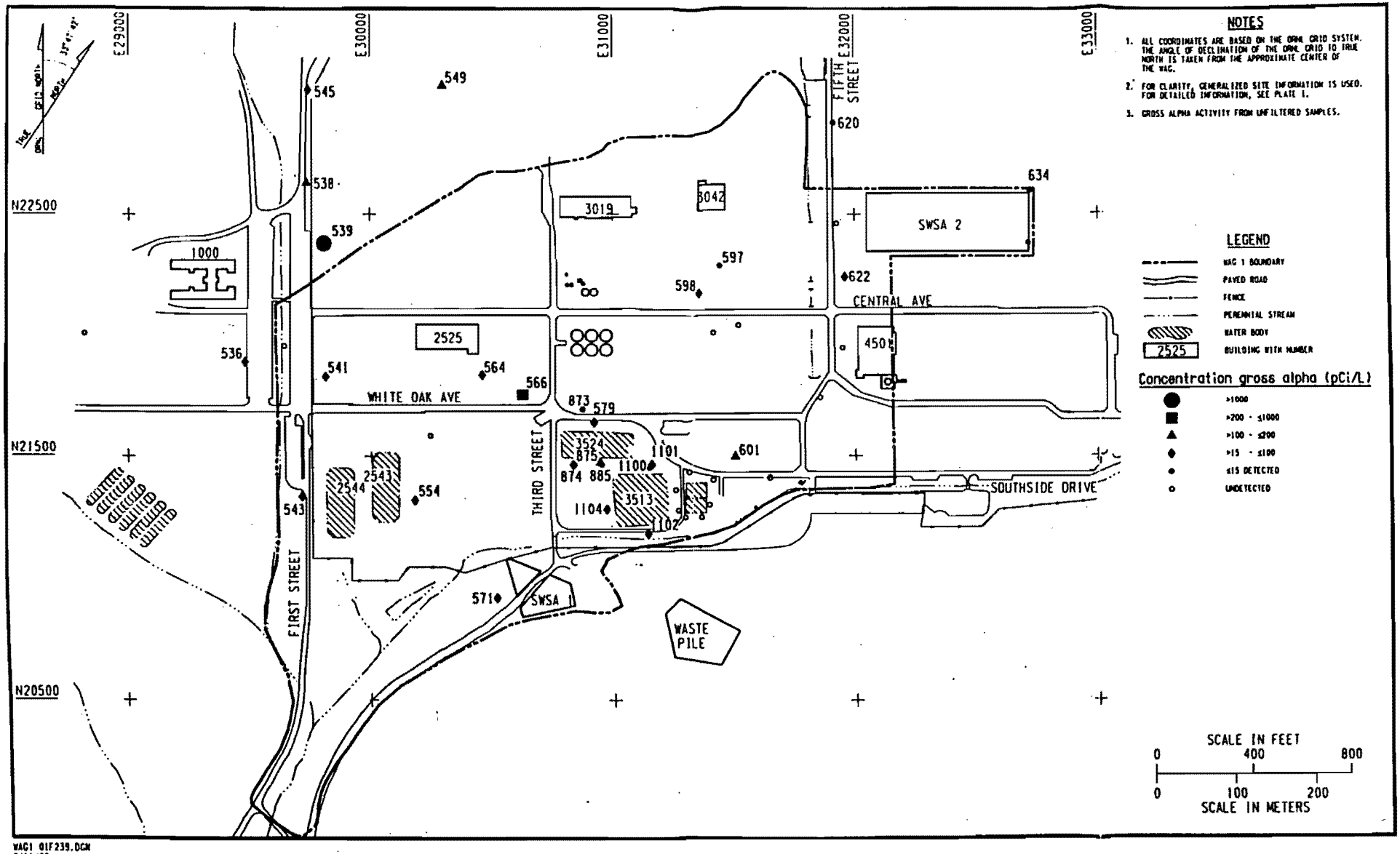
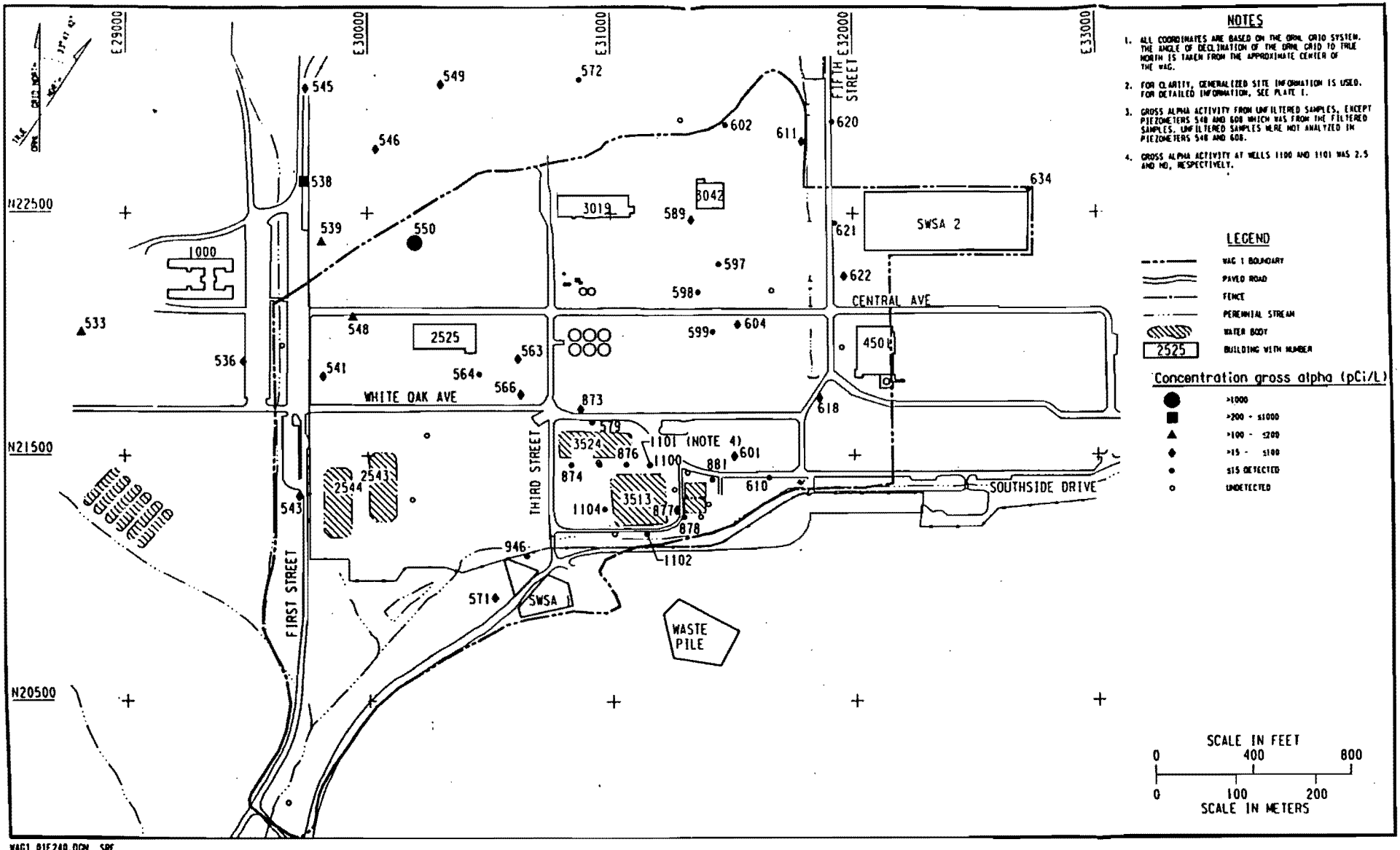


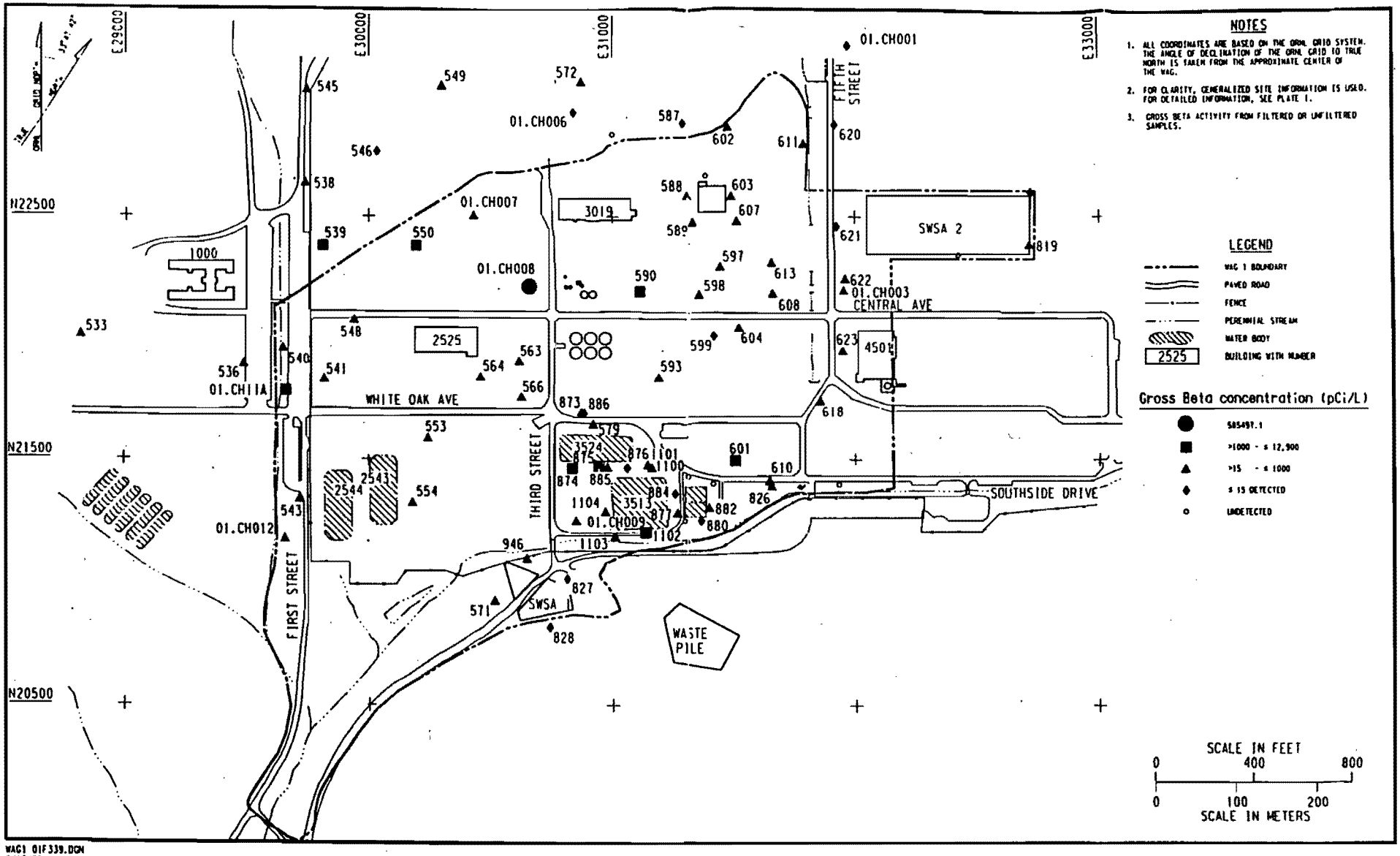
Fig. 4.3.8. Gross alpha: maximum activity in all wells and piezometers sampled during low base flow conditions.

000109



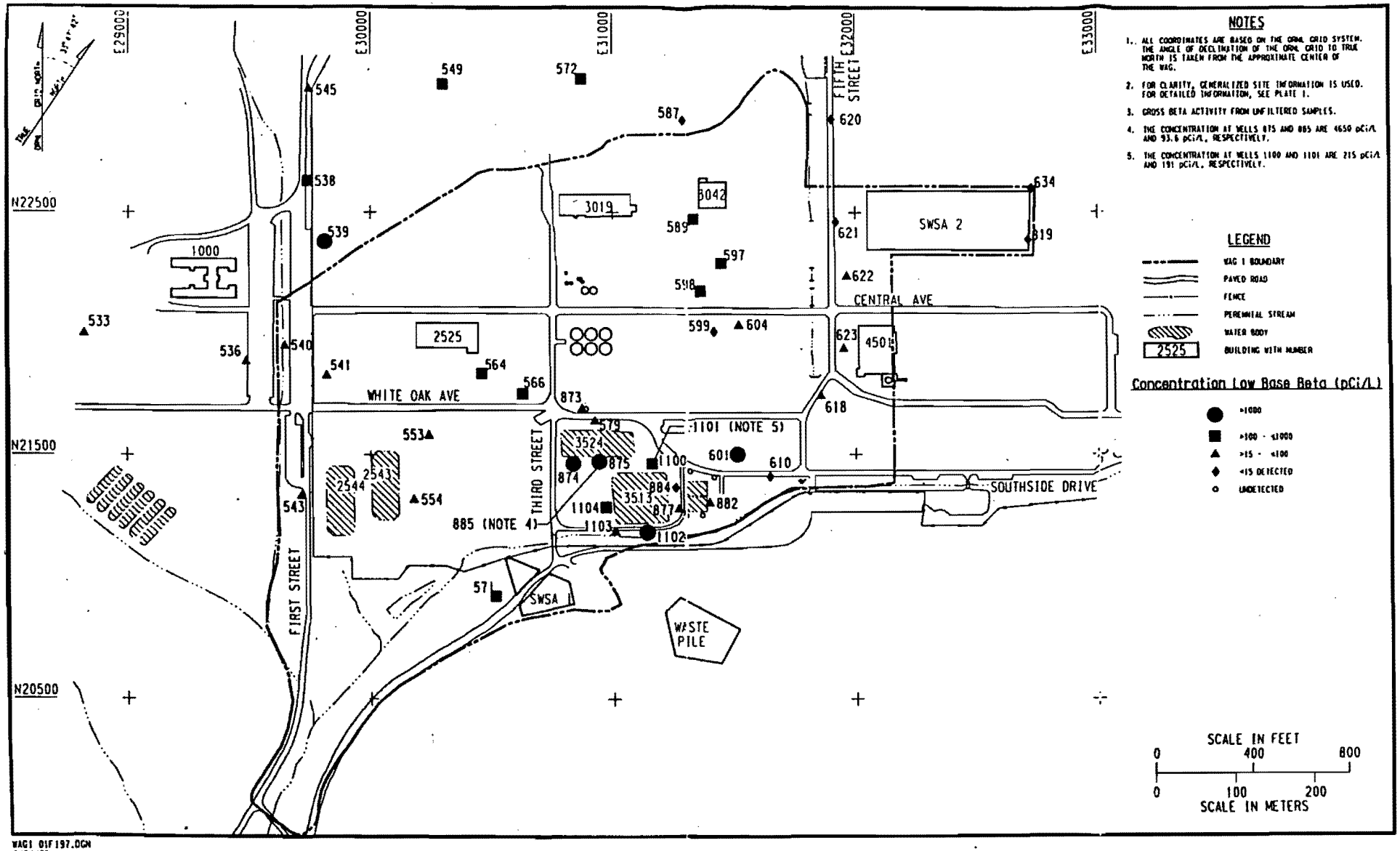
WAG1 01F240.DGN SRF, 9/17/92

Fig. 4.3.9. Gross alpha: maximum activity in wells and piezometers sampled during high base flow conditions.



WAG1 01F339.DGN
9/17/92

Fig. 4.3.10. Gross beta: maximum activity in all wells, piezometers and coreholes sampled.



WAG1 01F197.DGN
9/24/92

Fig. 4.3.11. Gross Beta: maximum activity in wells and piezometers sampled during low base flow conditions.

000116

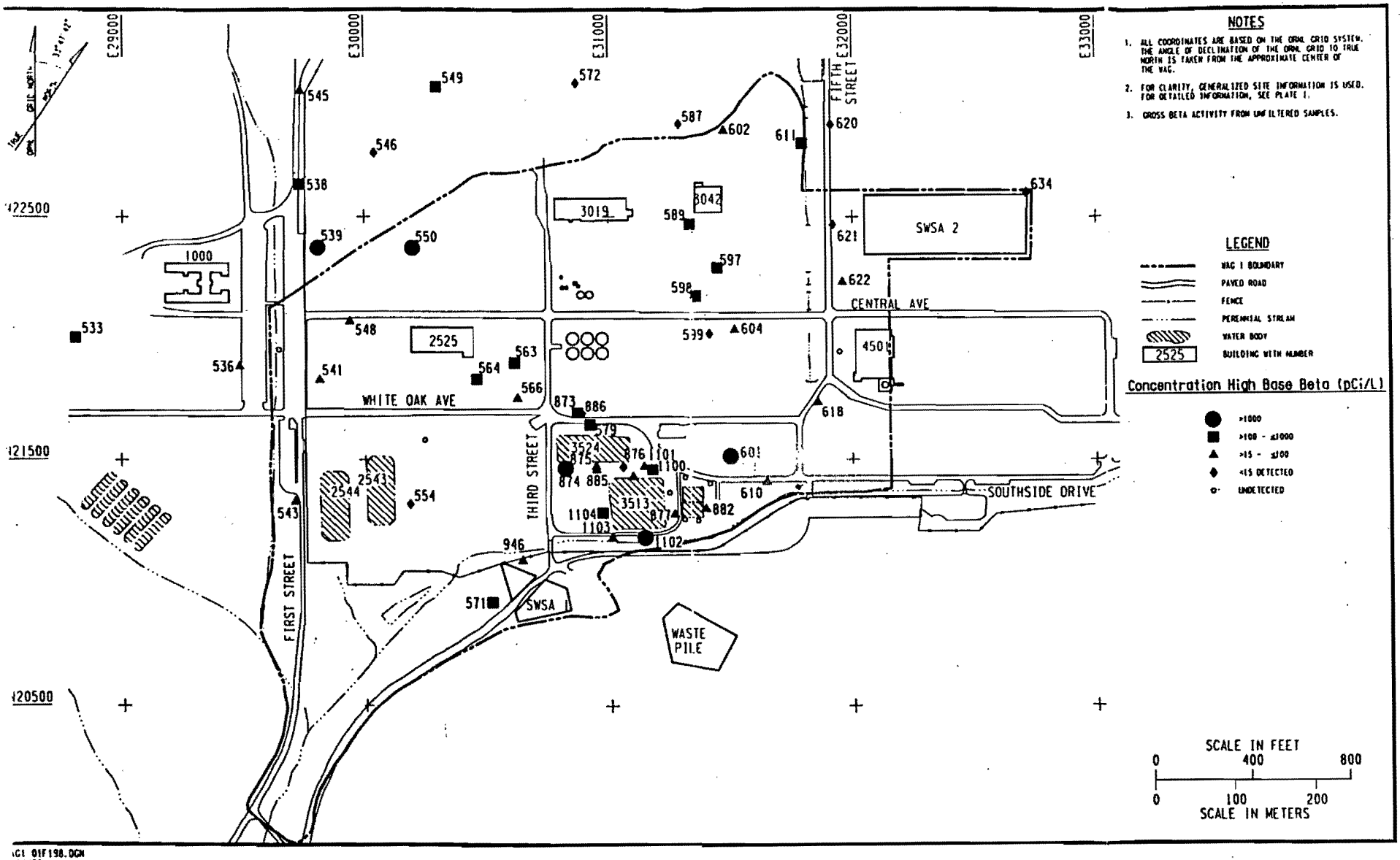
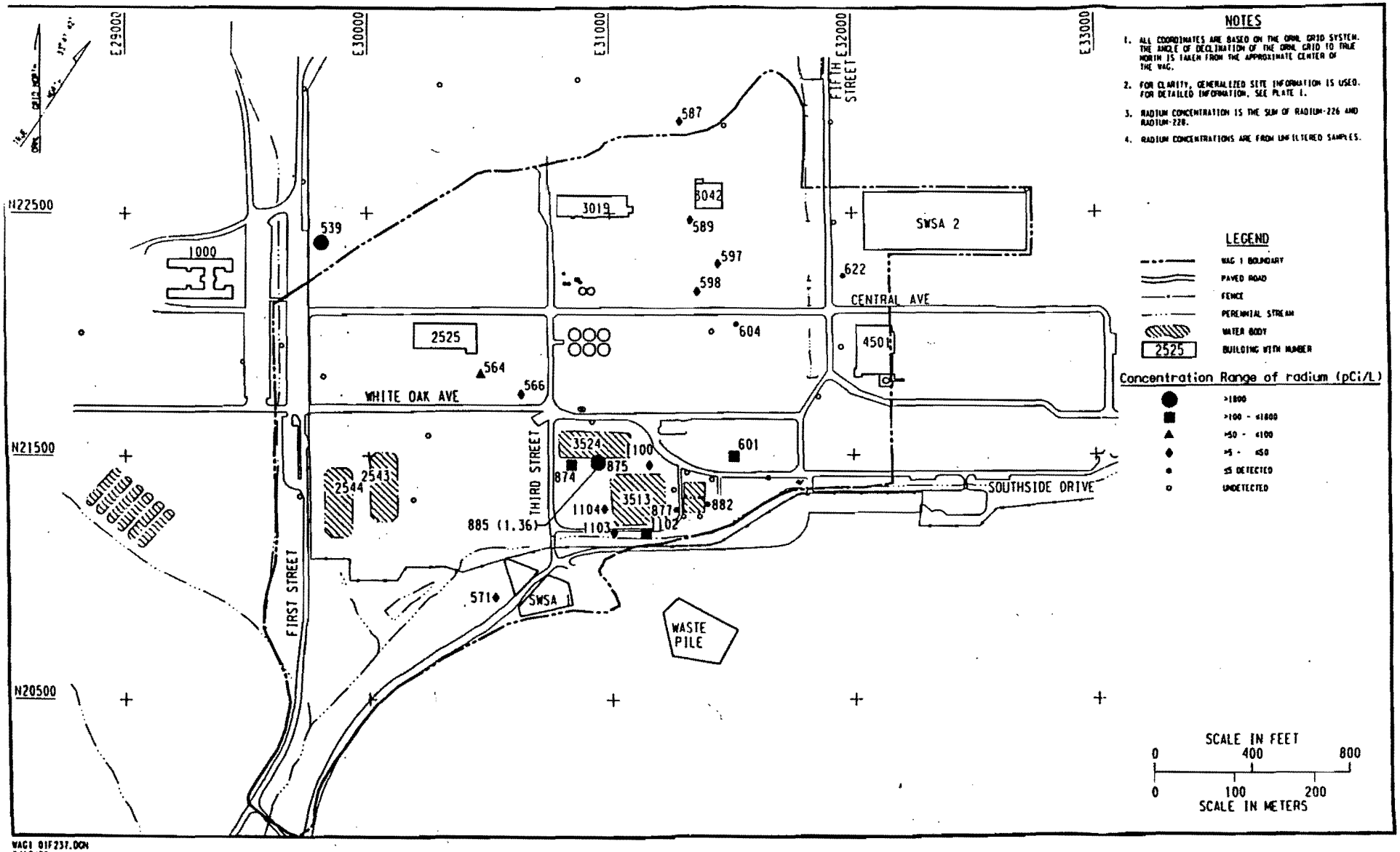


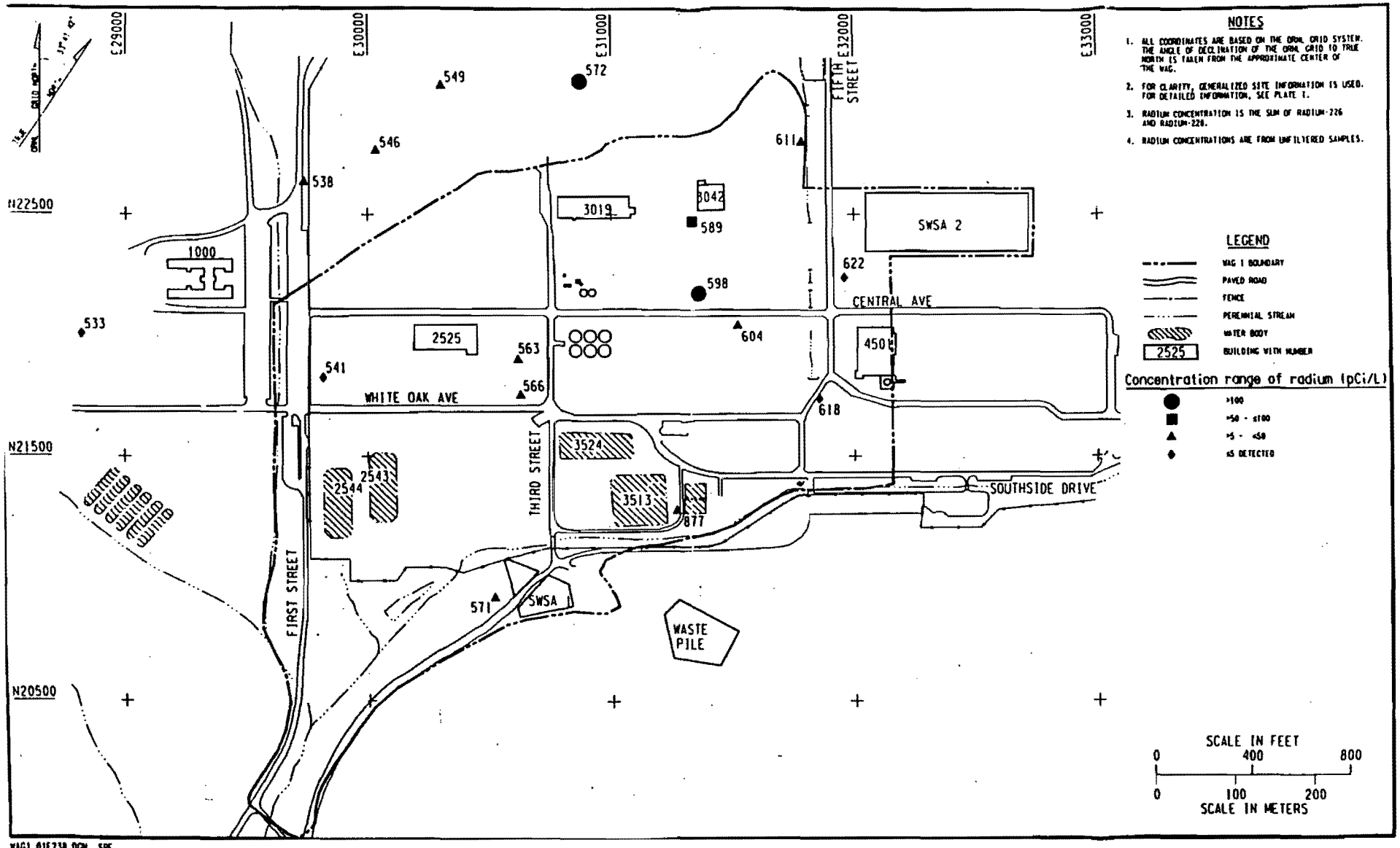
Fig. 4.3.12. Gross Beta: maximum activity in wells and piezometers sampled during high base flow conditions.



WAG1 01F237.DGN
9/17/92

Fig. 4.3.13 Radium: maximum concentration in wells and piezometers sampled during low base flow conditions.

000120



WAG1 01F238.DGN SRF, 9/17/92

Fig. 4.3.14. Radium: maximum concentration in wells and piezometers sampled during high base flow conditions.

0001121

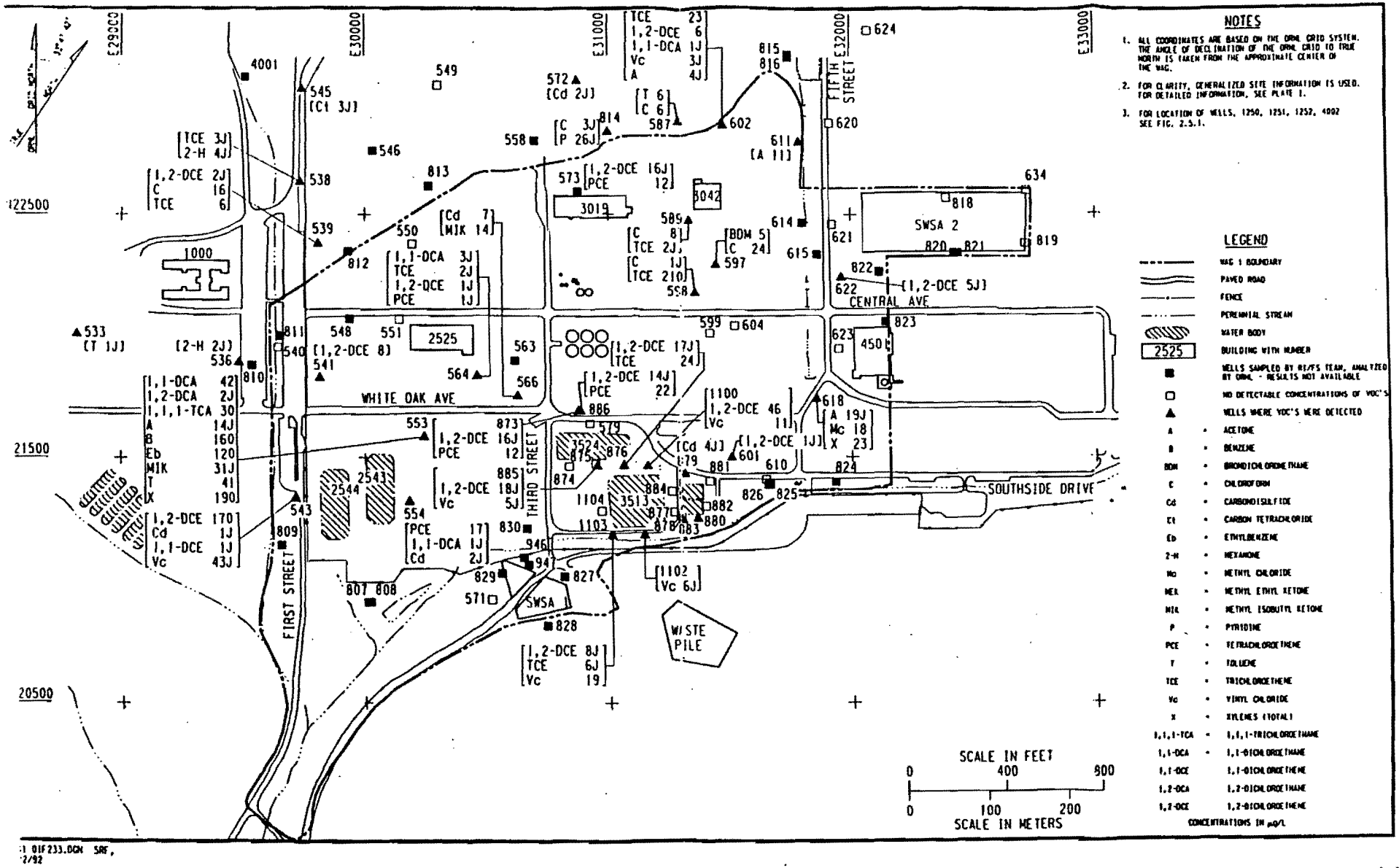
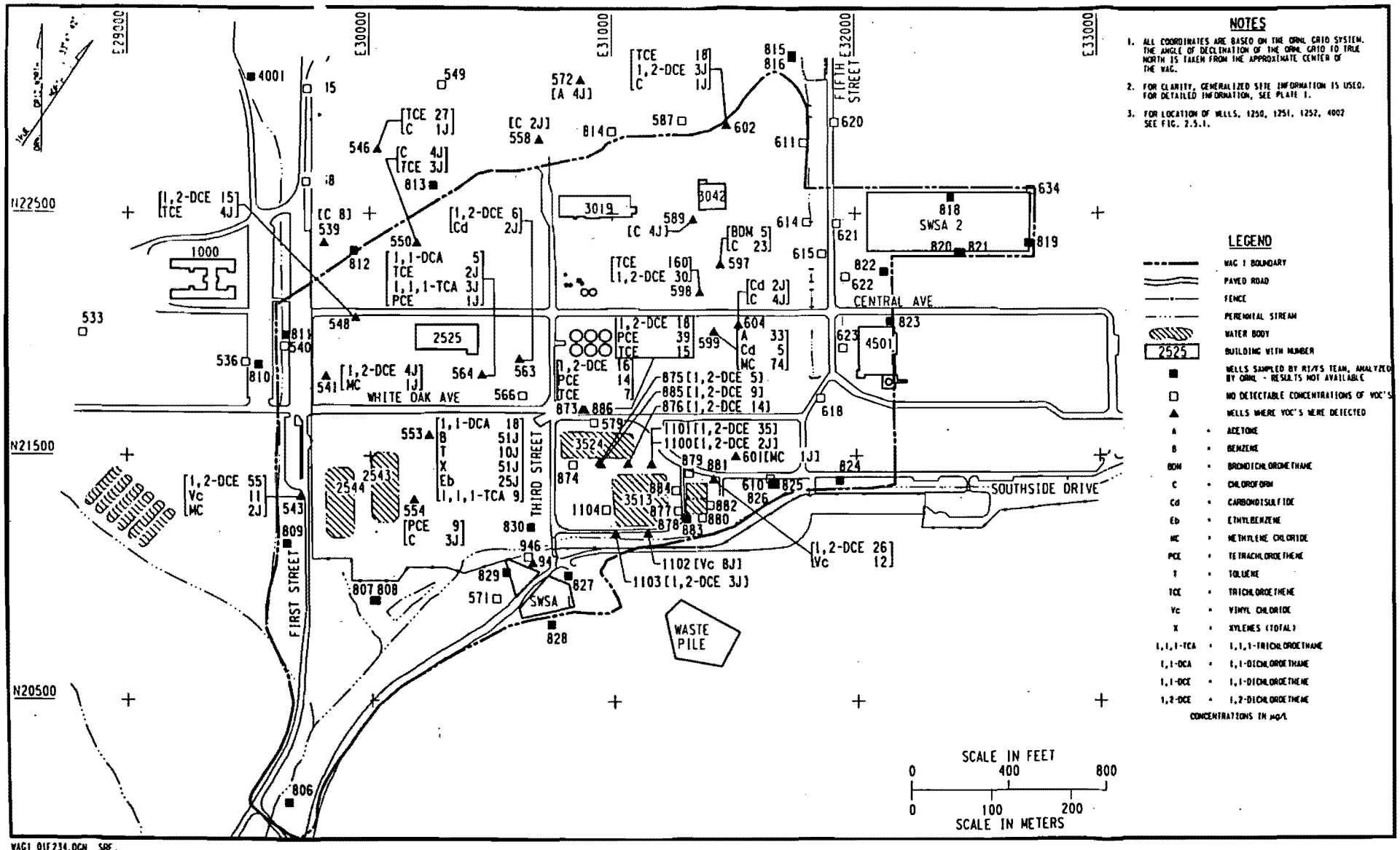


Fig. 4.3.15. Volatile organic compounds detected in groundwater during low base flow conditions.



WAG1 01F234.DGN SRF, 6/22/92

Fig. 4.3.16. Volatile organic compounds detected in groundwater during high base flow conditions.

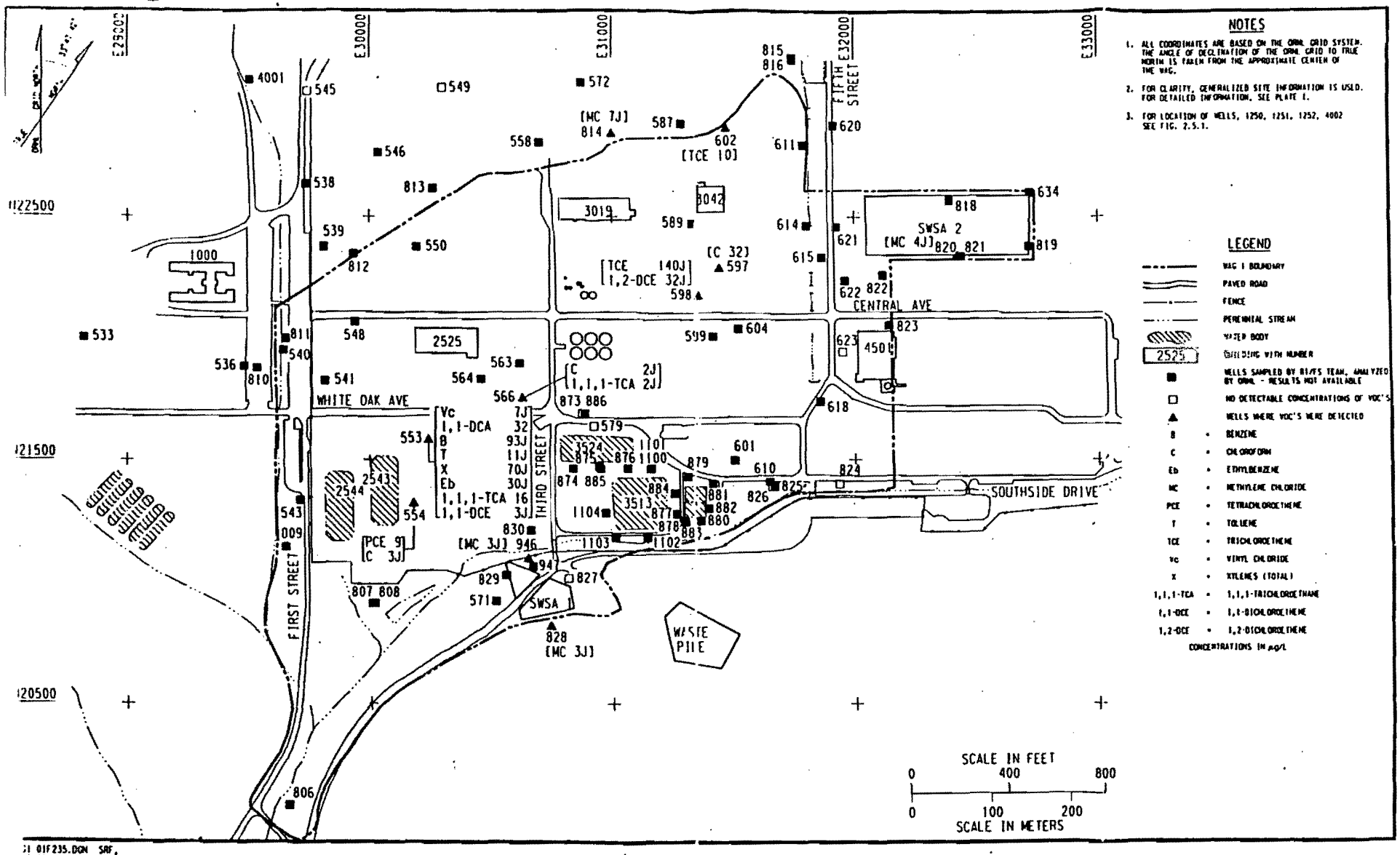
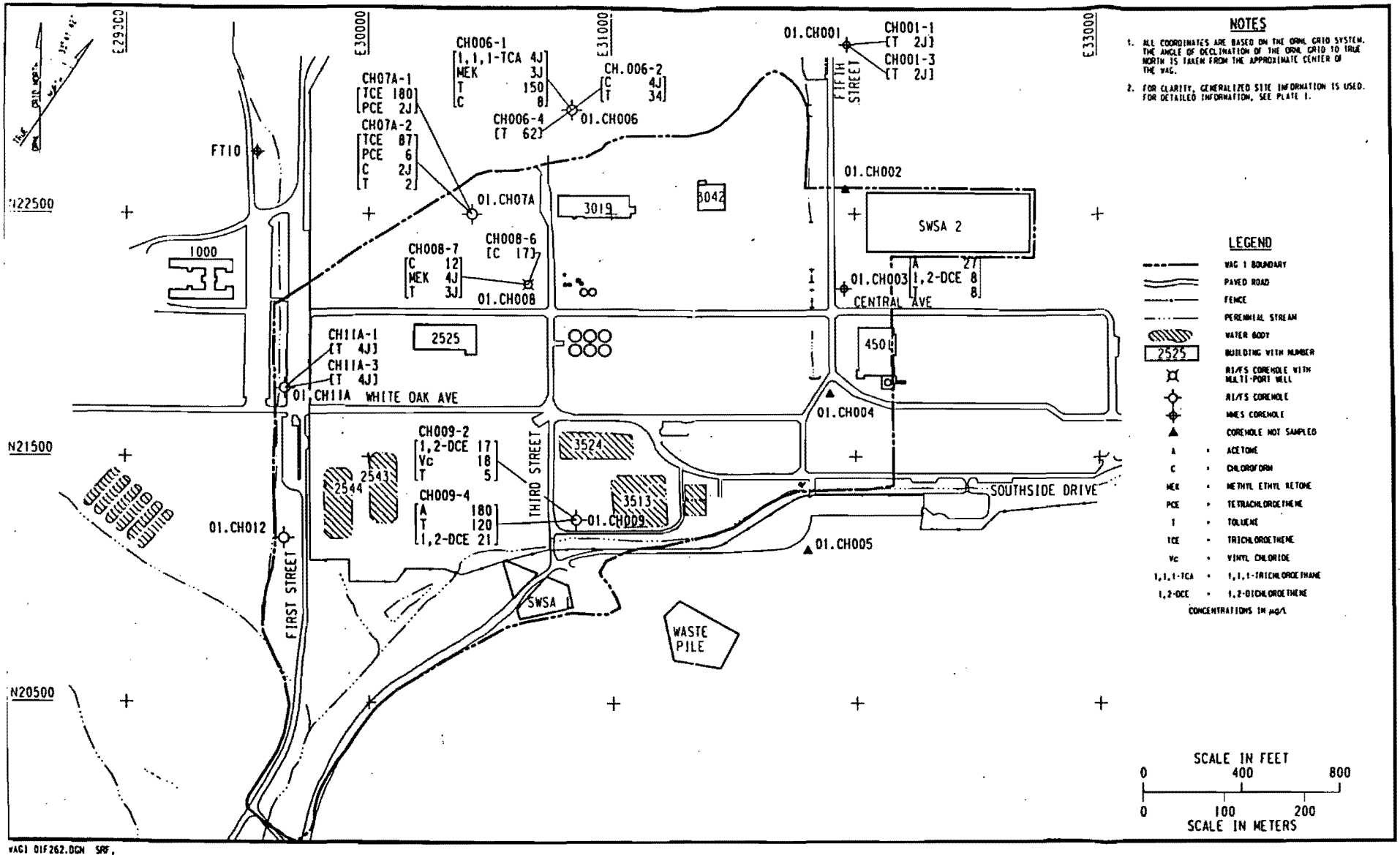


Fig. 4.3.17. Volatile organic compounds detected in groundwater during a storm event, high base flow conditions.

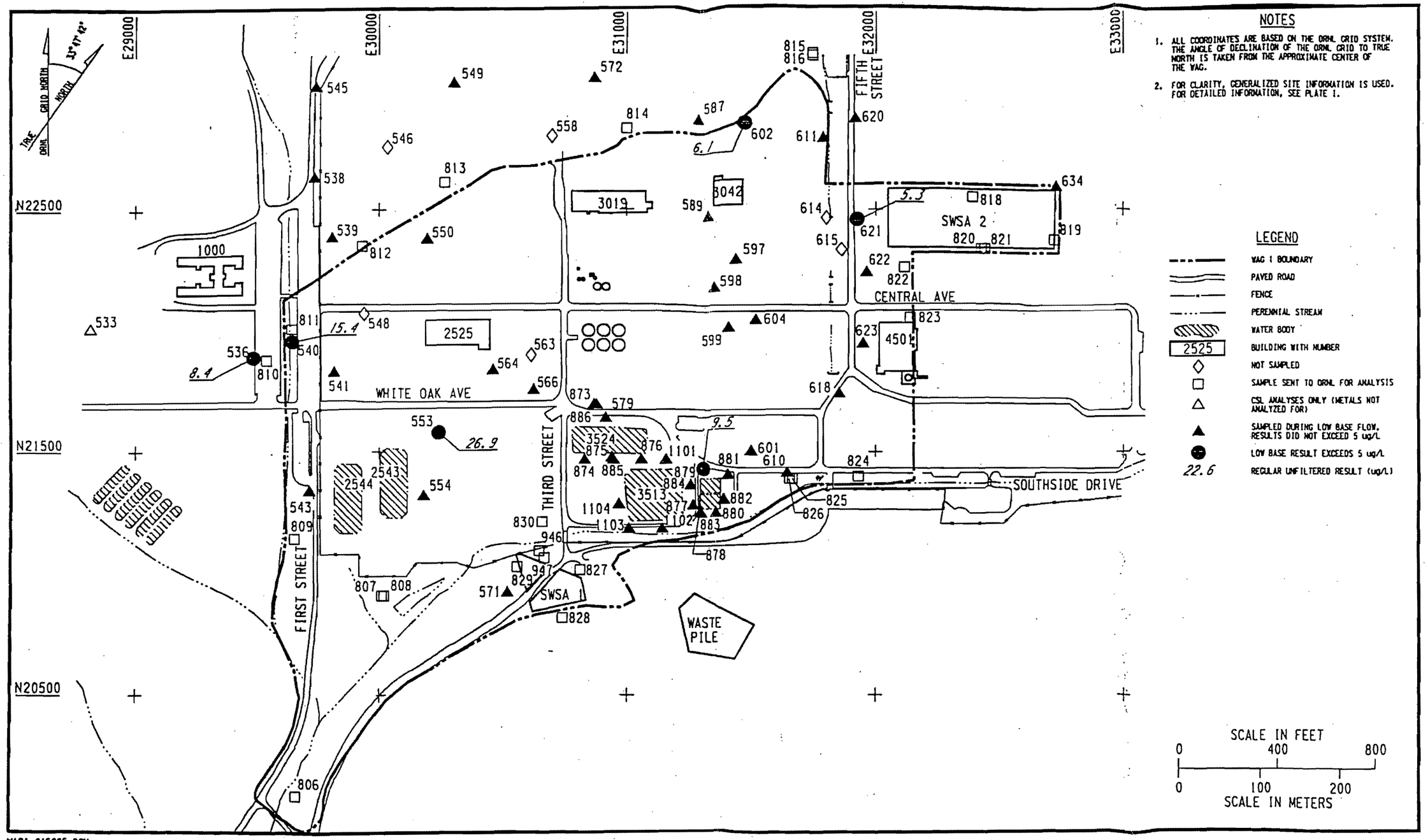
000127



VAG1 DIF262.DGN SRF, 6/19/92

Fig. 4.3.18. Volatile organic compounds detected in groundwater from corehole locations.

0001129



WAG1 01F265.DGN
9/25/92

Fig. 4.3.19. Cadmium detected in unfiltered groundwater samples exceeding 5 ug/L during low base flow conditions.

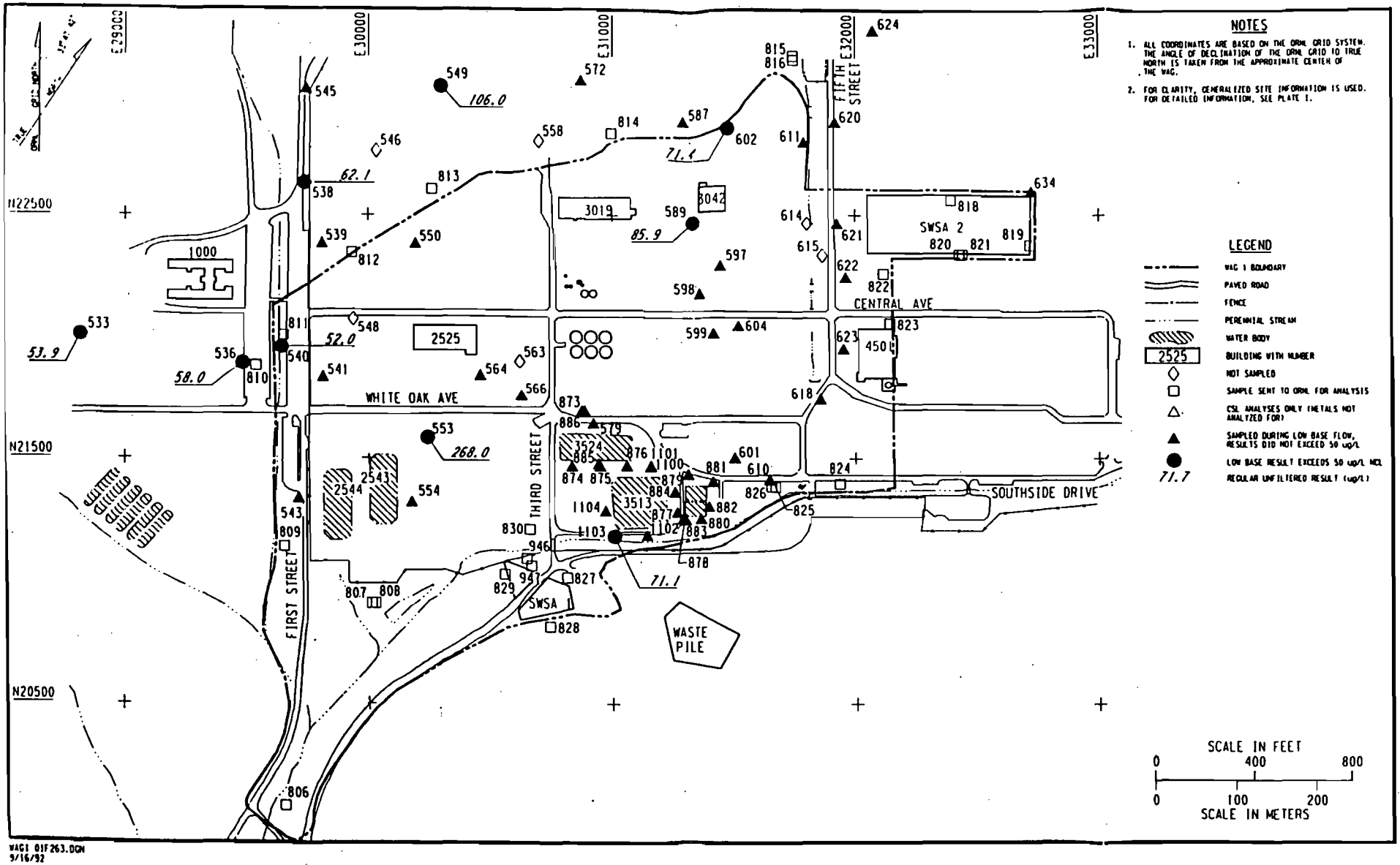
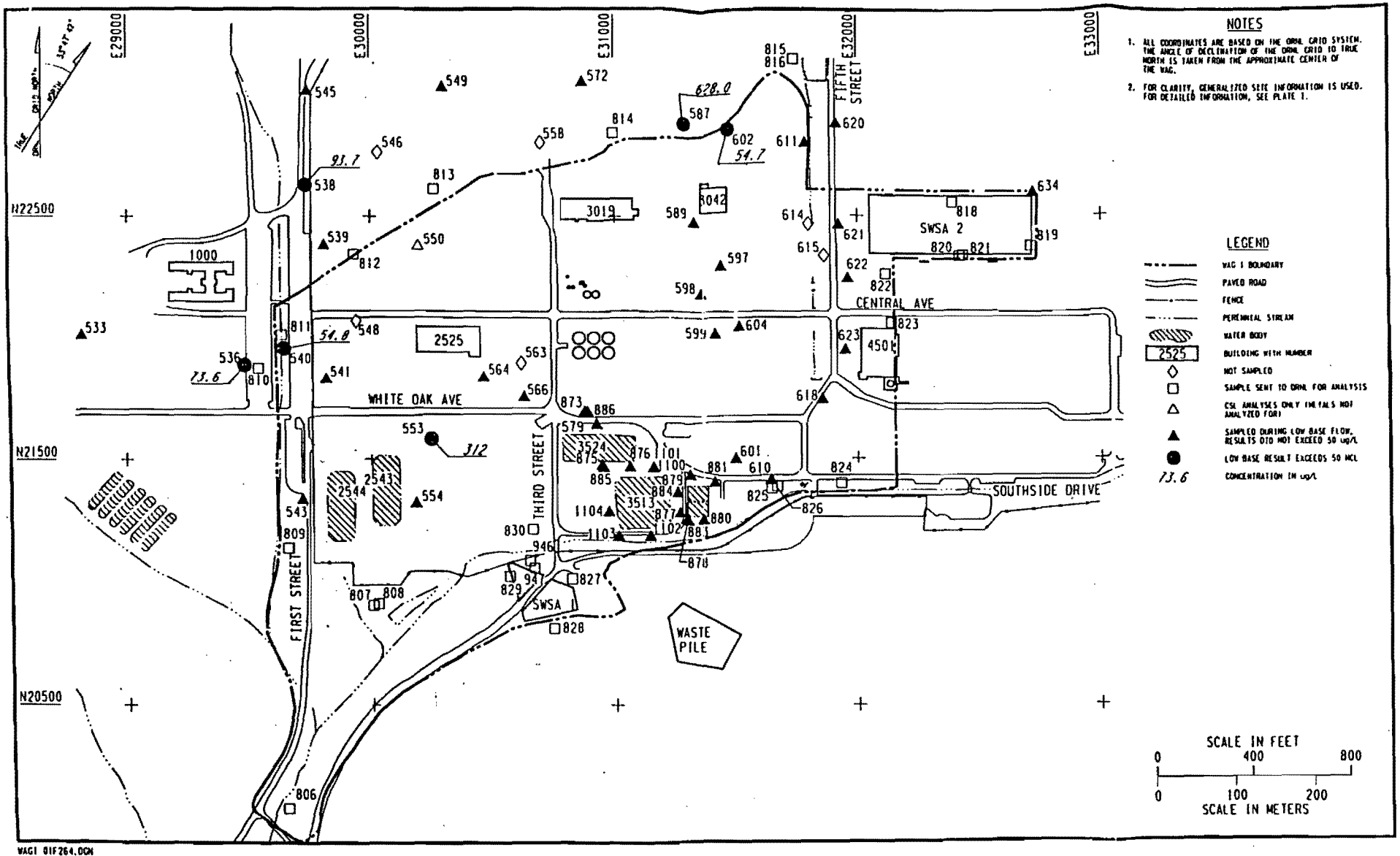


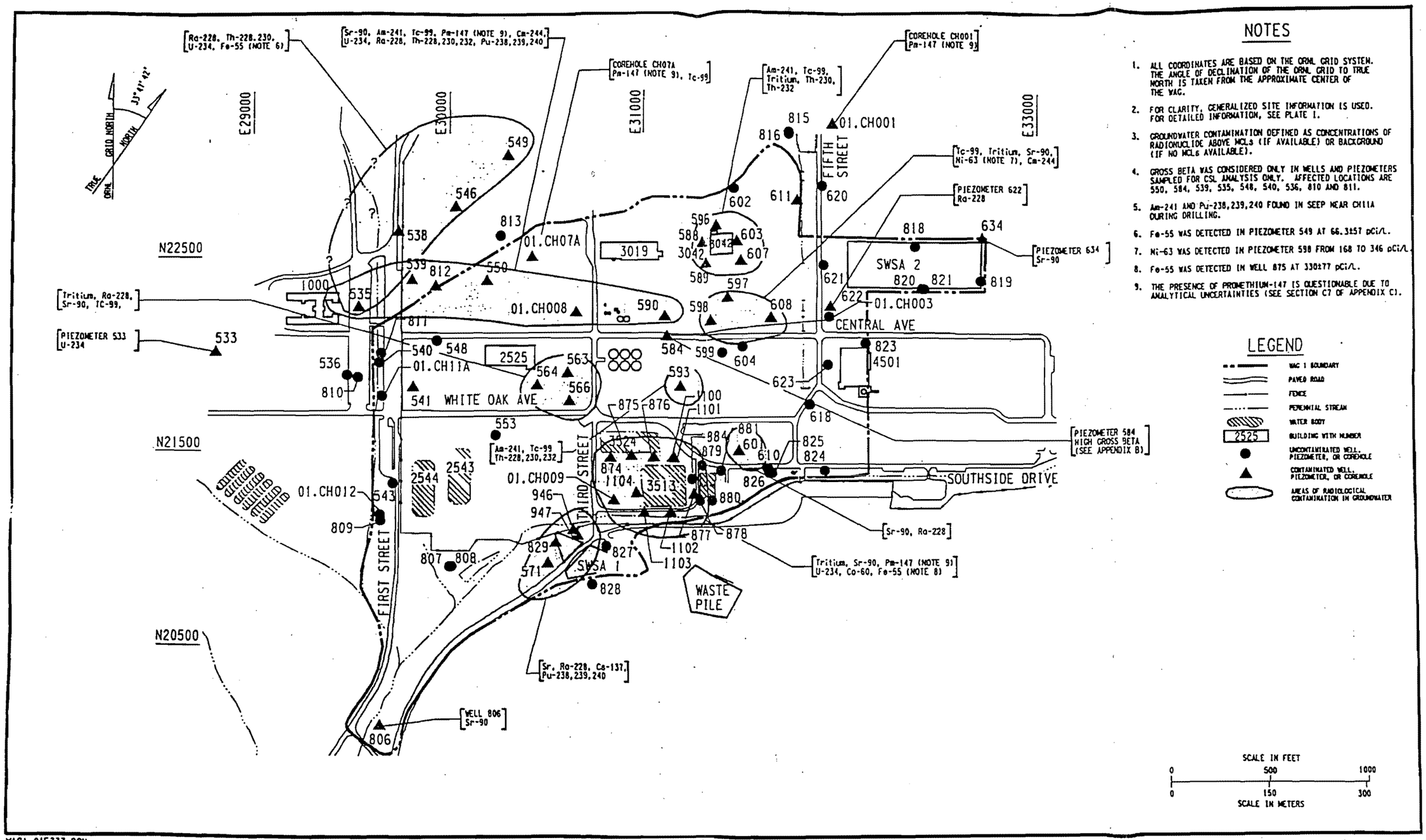
Fig. 4.3.20. Chromium detected in unfiltered groundwater samples exceeding 50 ug/L during low base flow conditions.

000134



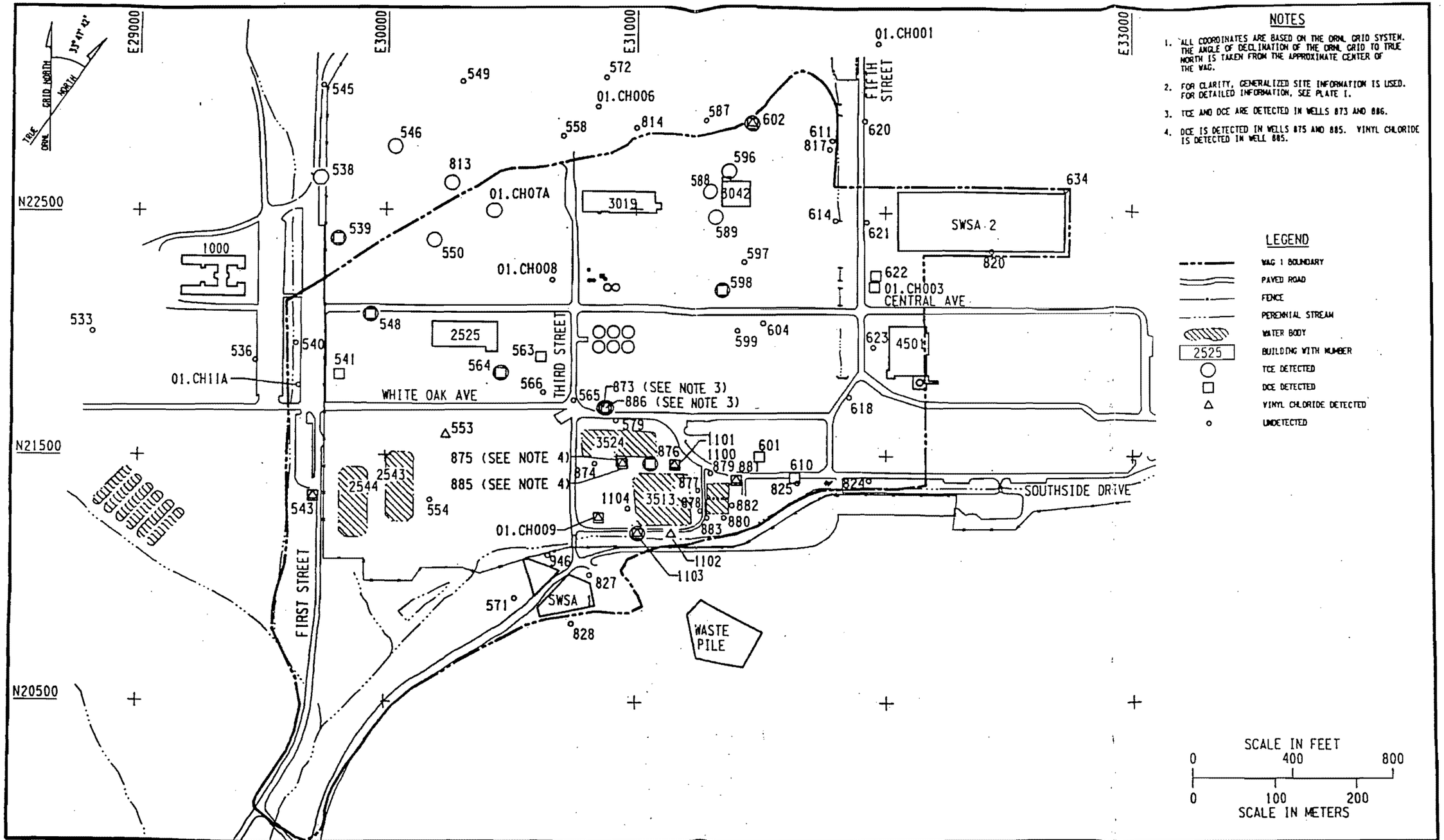
WAG1 81F264.DGN
9/25/92

Fig. 4.3.21. Lead detected in unfiltered groundwater samples exceeding 50 ug/L during low base flow conditions.



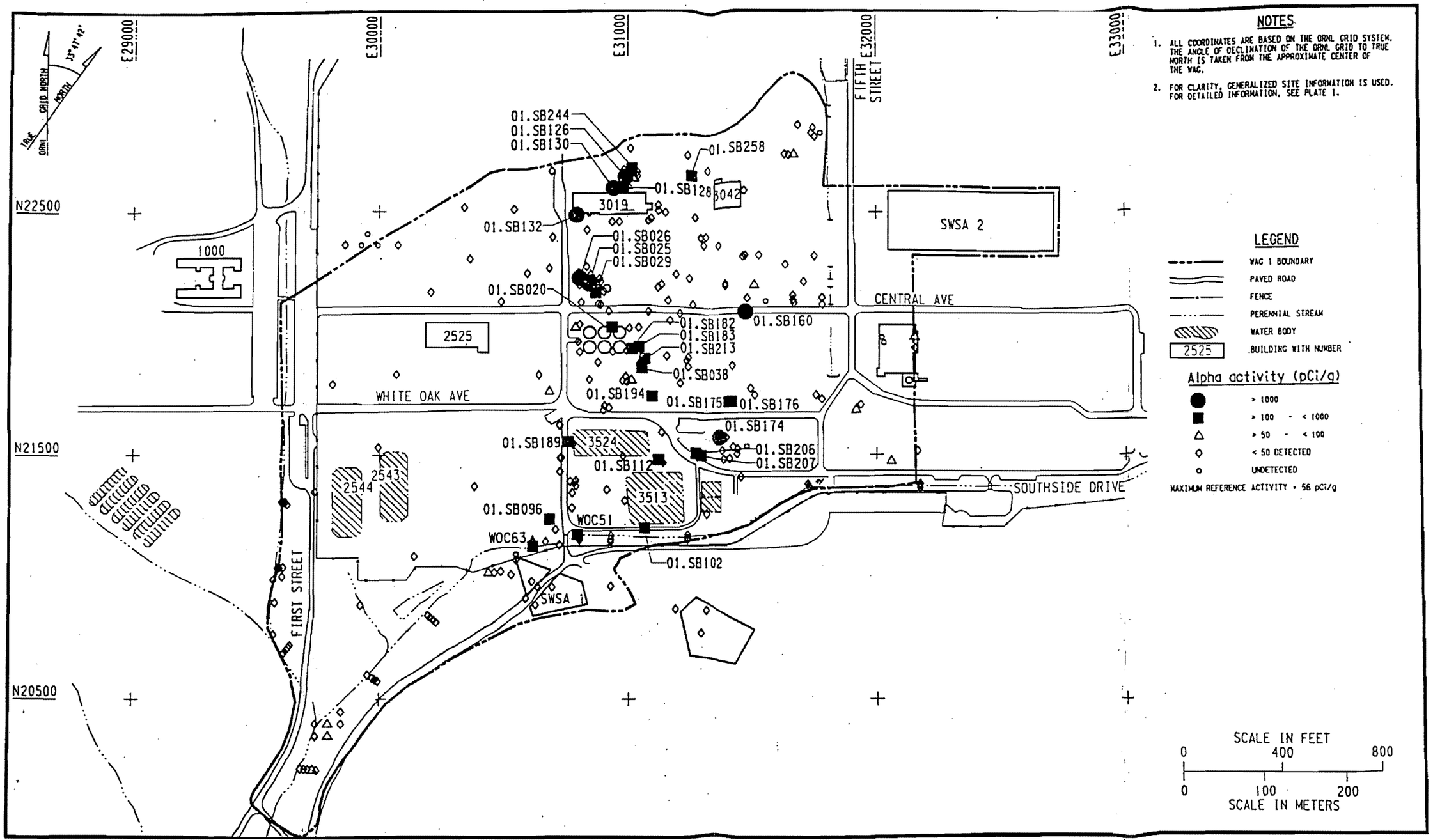
WAG1 01F337.DGN
9/25/92

Fig. 4.3.22. Overview of radiological contamination in groundwater.



WAG1 01F338.DGN SRF, 9/22/92

Fig. 4.3.23. Distribution of TCE and degradation prod in groundwater.



WAG1 01F335.DGN SRF, 9/21/92

Fig. 4.4.3. Maximum gross alpha activity in soil borings.

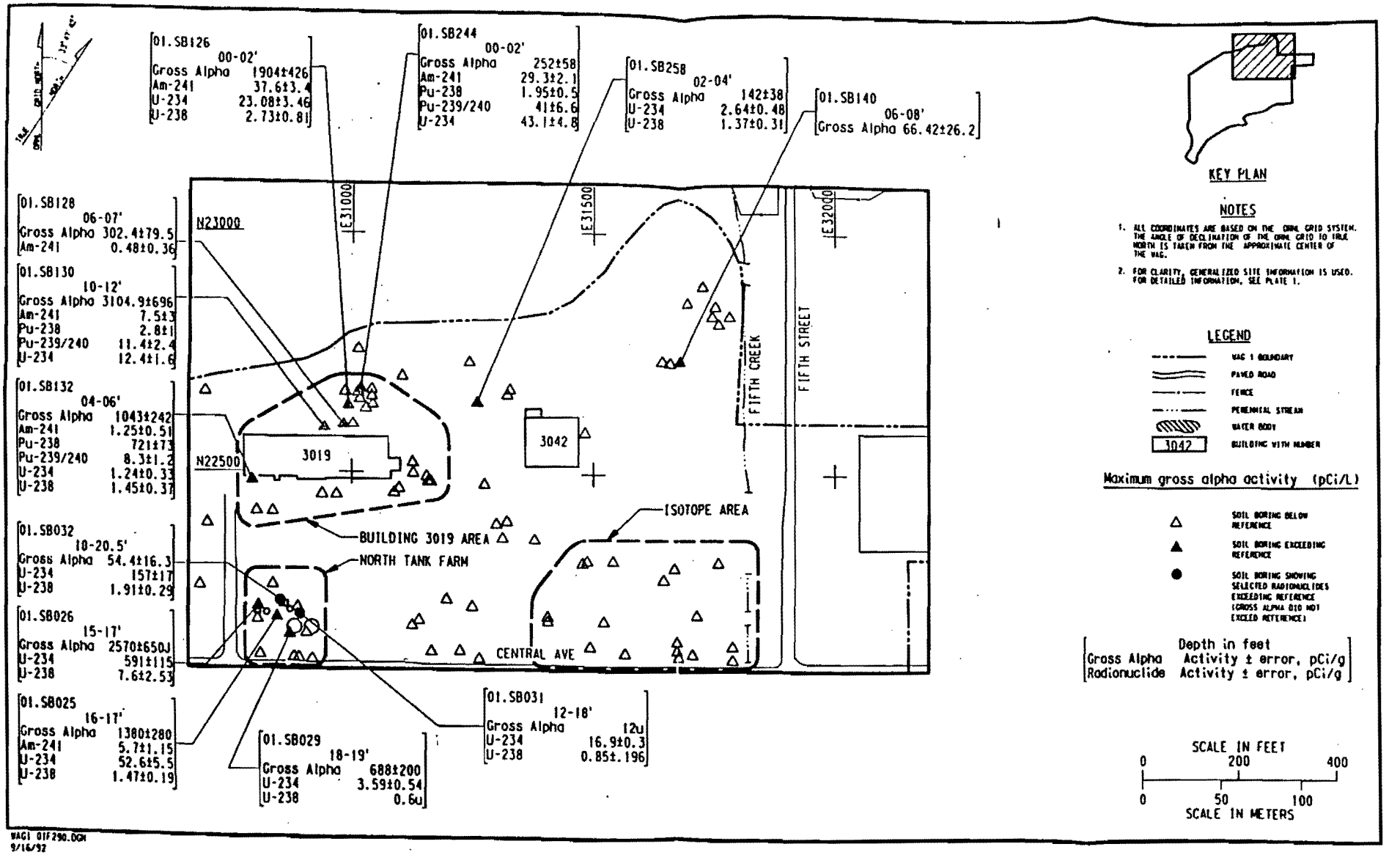


Fig. 4.4.4. Alpha-1. Selected alpha-emitting radionuclides and maximum gross alpha exceeding reference in soil borings.

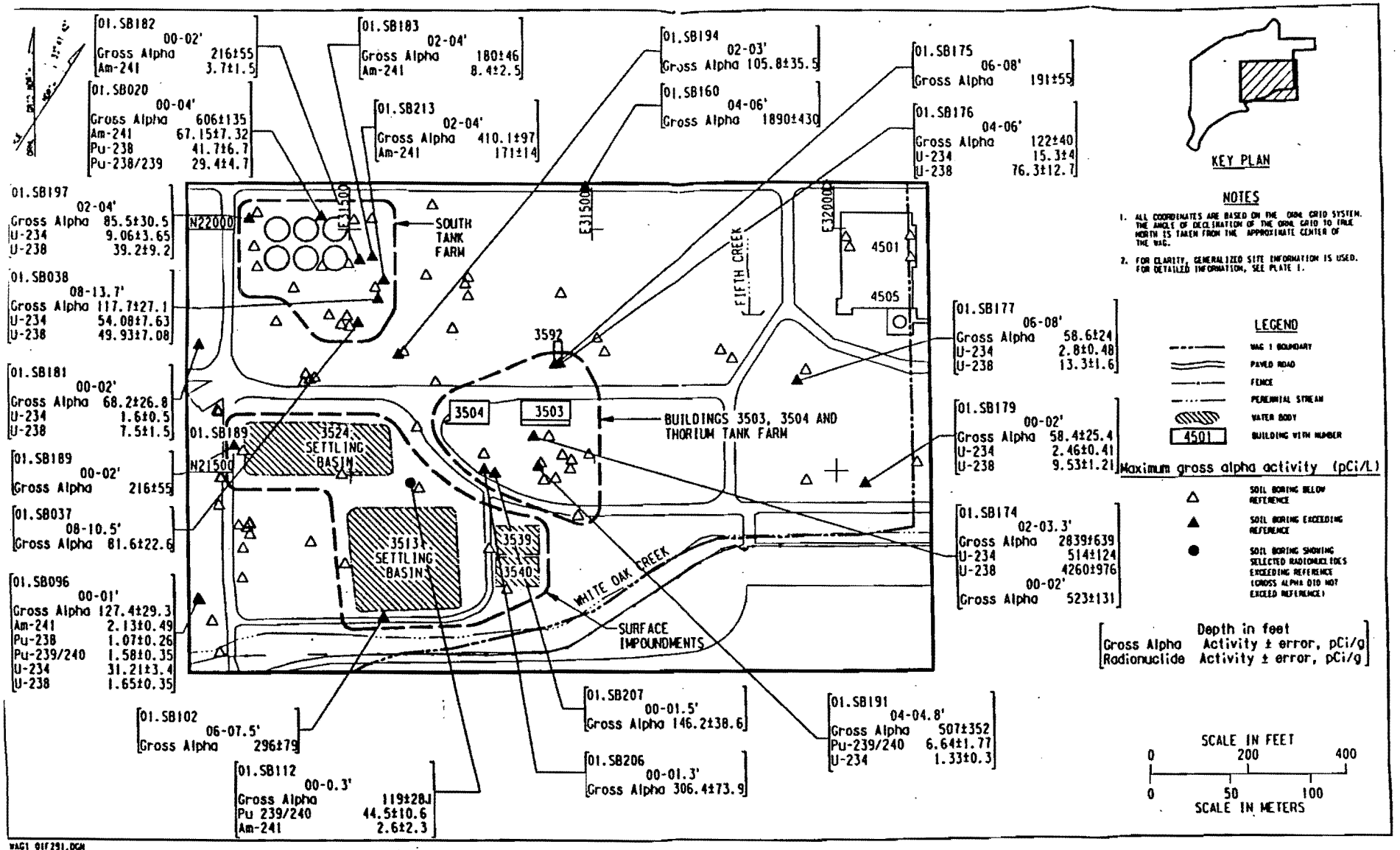
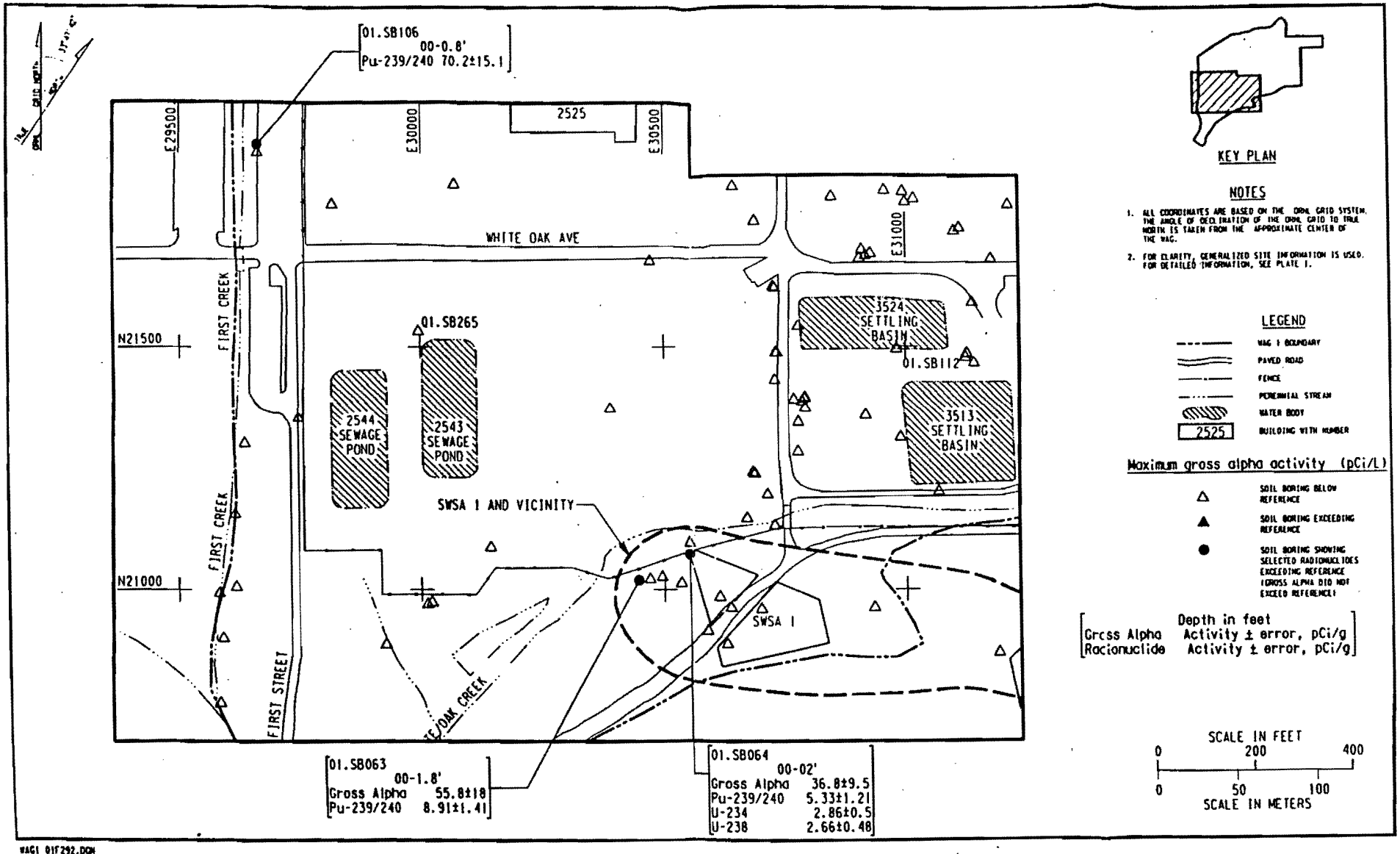


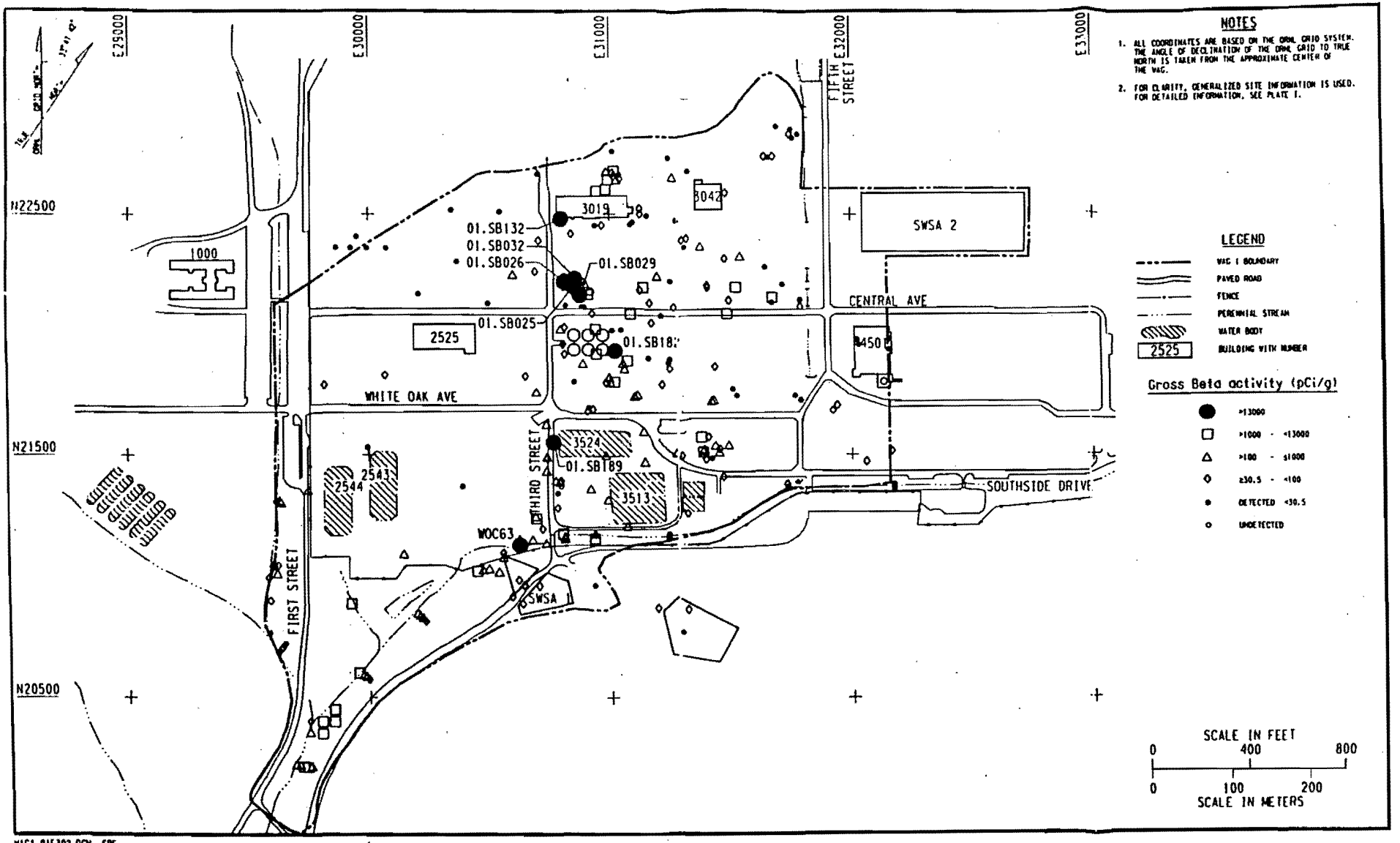
Fig. 4.4.5. Alpha-2. Selected alpha emitting radionuclides and maximum gross alpha activity exceeding reference in soil borings.



WAG1 01F292.DGN
9/16/92

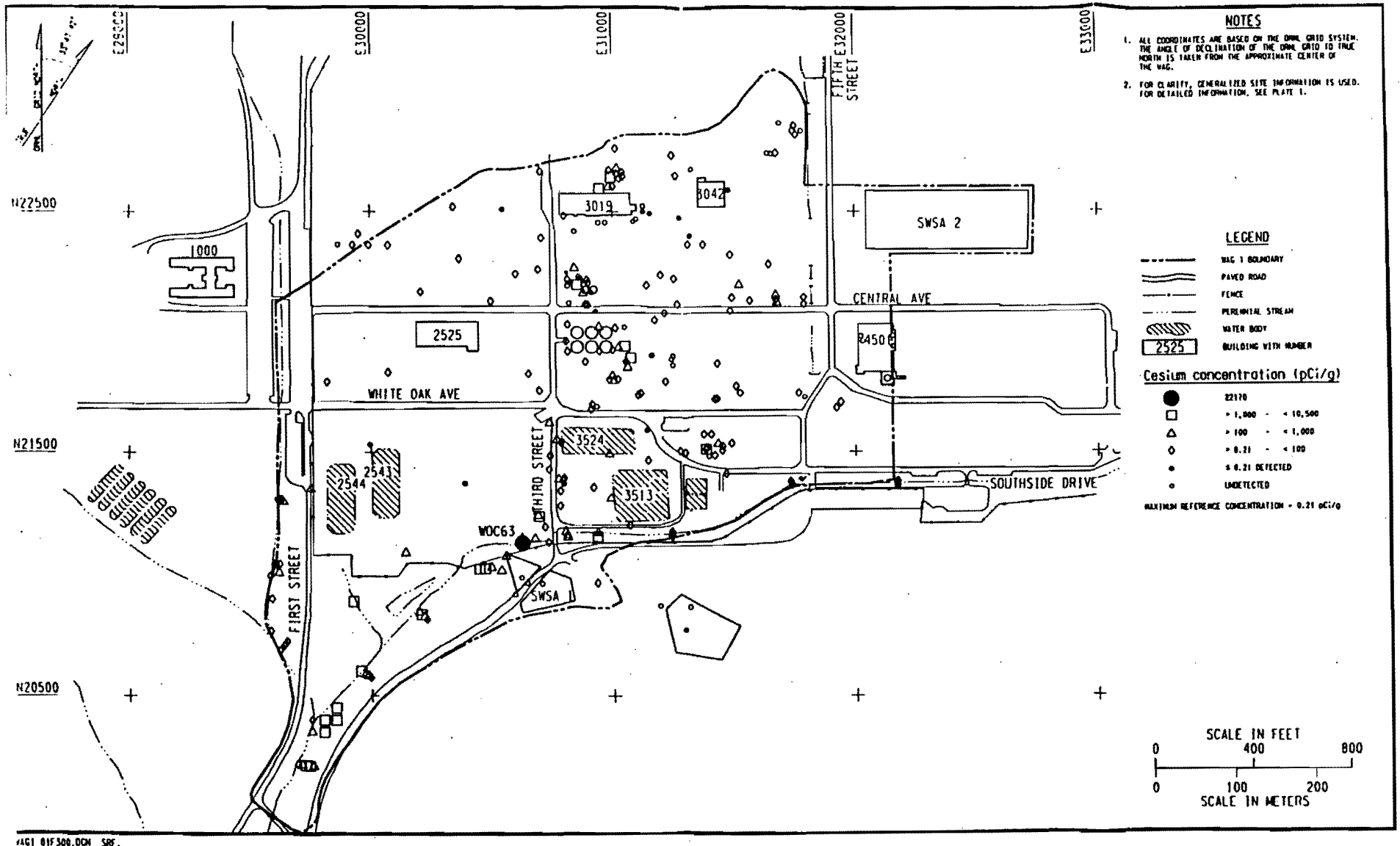
Fig. 4.4.6. Alpha-3. Selected alpha-emitting radionuclides and maximum gross alpha activity exceeding reference in soil borings.

000148



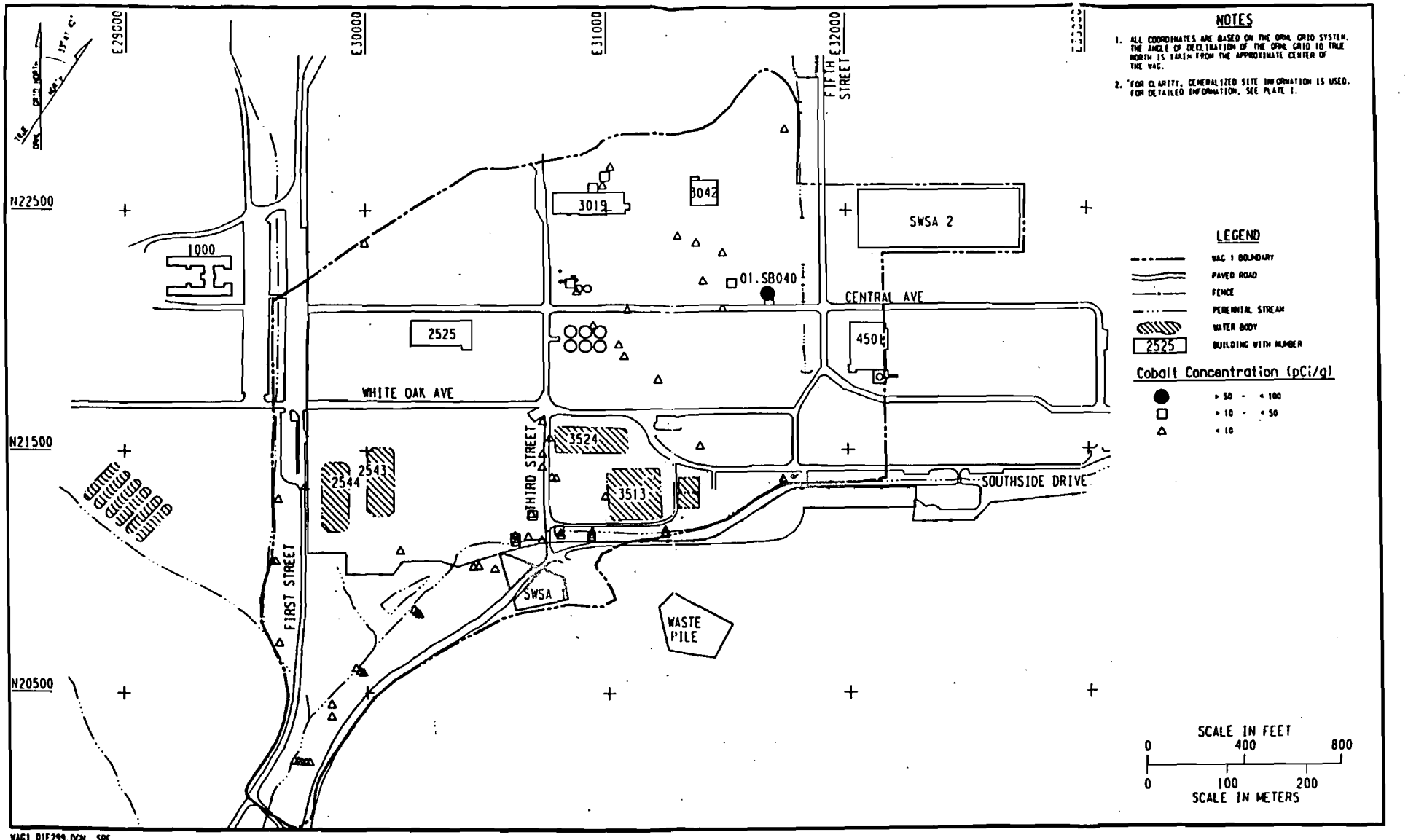
VAG1 01F302.DGN SRF, 9/16/92

Fig. 4.4.7. Maximum gross beta activity in soil borings.



WAG1 01F300.DGN SRF, 1/22/92

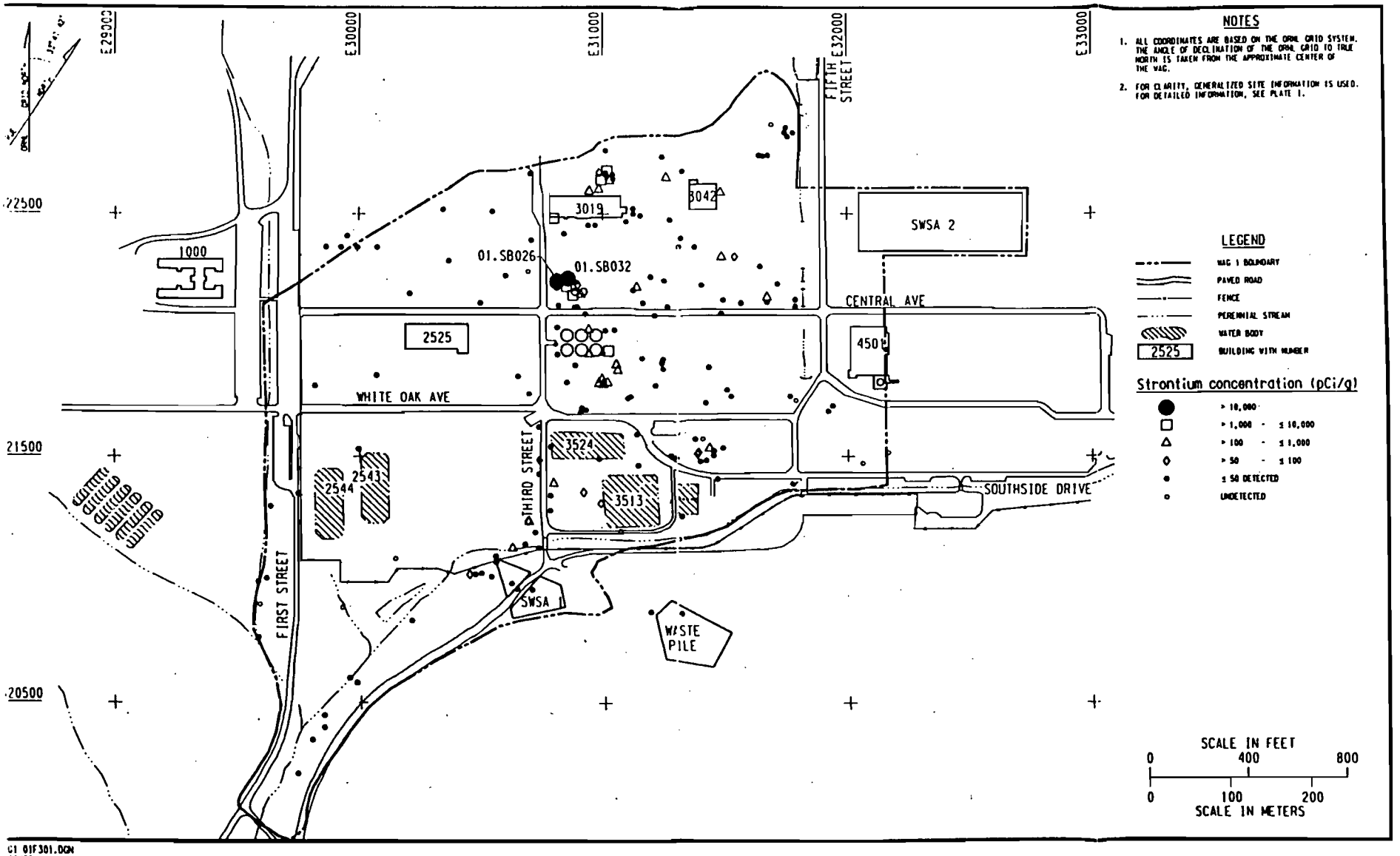
Fig. 4.4.8. Maximum cesium-137 concentrations in soil borings.



WAG1 01F299.DGN SRF, 9/14/92

Fig. 4.4.9. Maximum cobalt-60 concentrations in soil borings.

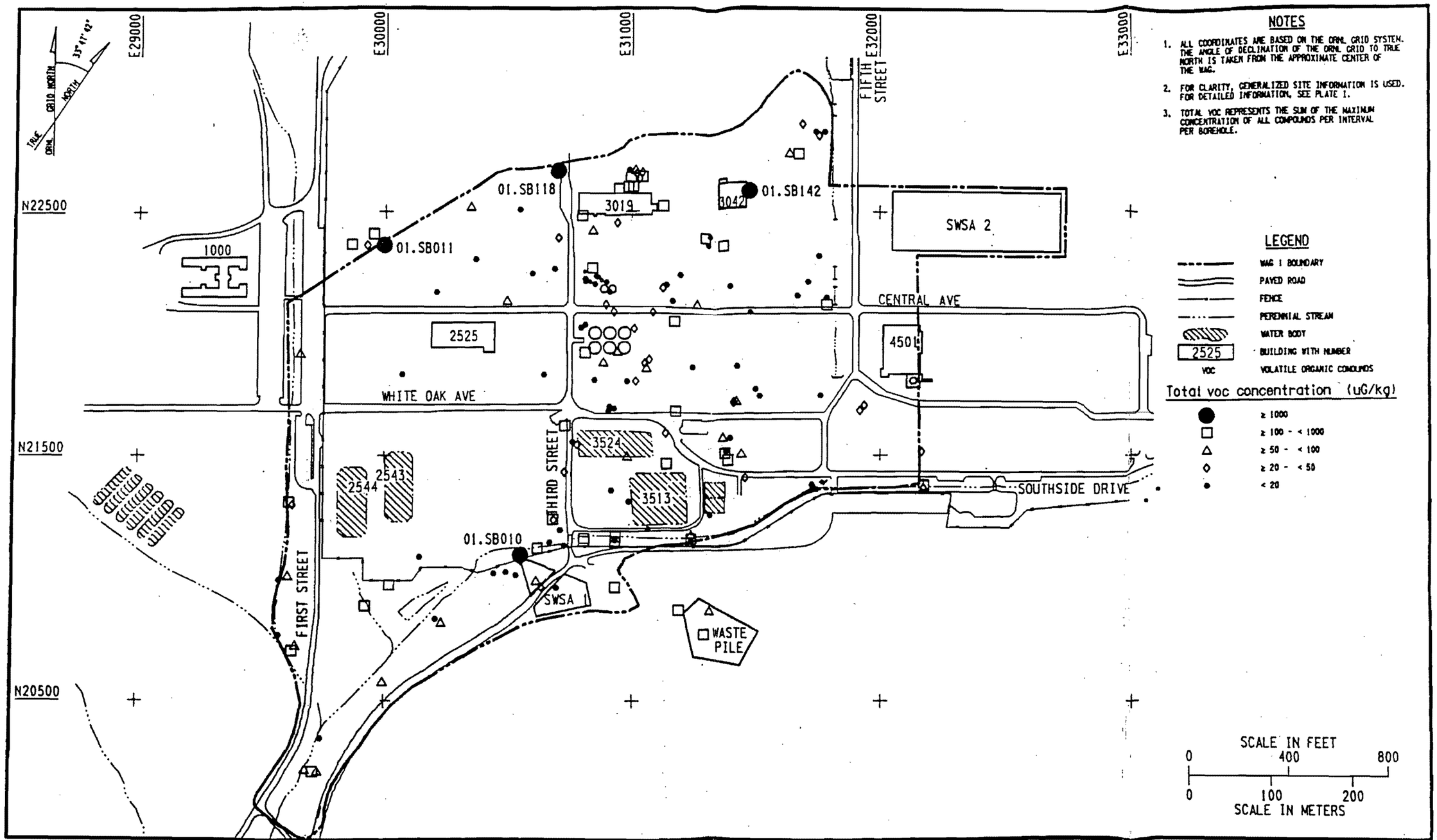
0001153



G1 01F301.DGN
22/92

Fig. 4.4.10. Maximum strontium concentrations in soil borings.

000155



WAG1 01F289.DGN SRF, 6/14/92

Fig. 4.4.11. Total VOCs in soil borings.

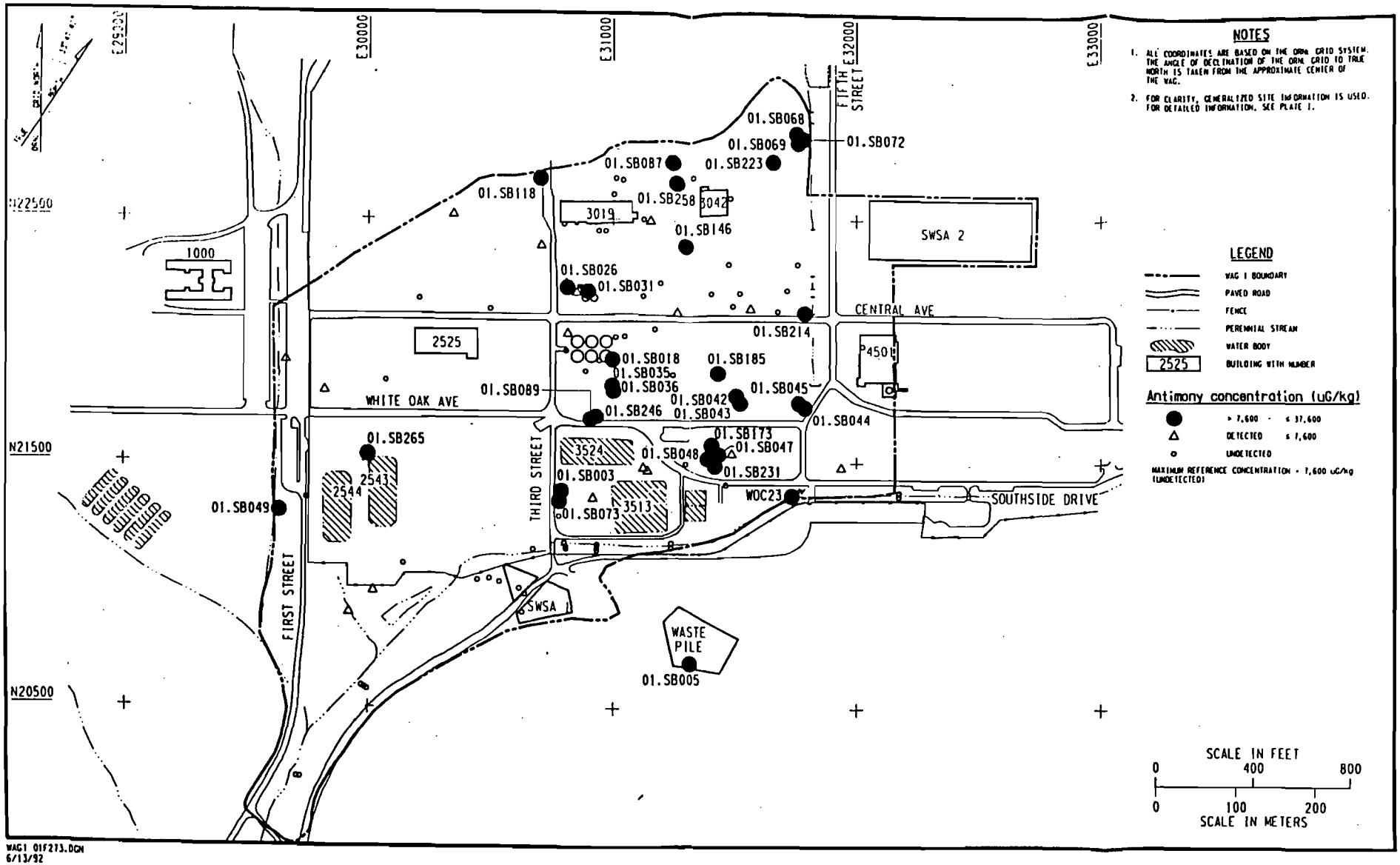


Fig. 4.4.12. Maximum antimony concentrations in soil borings.

000159

000160

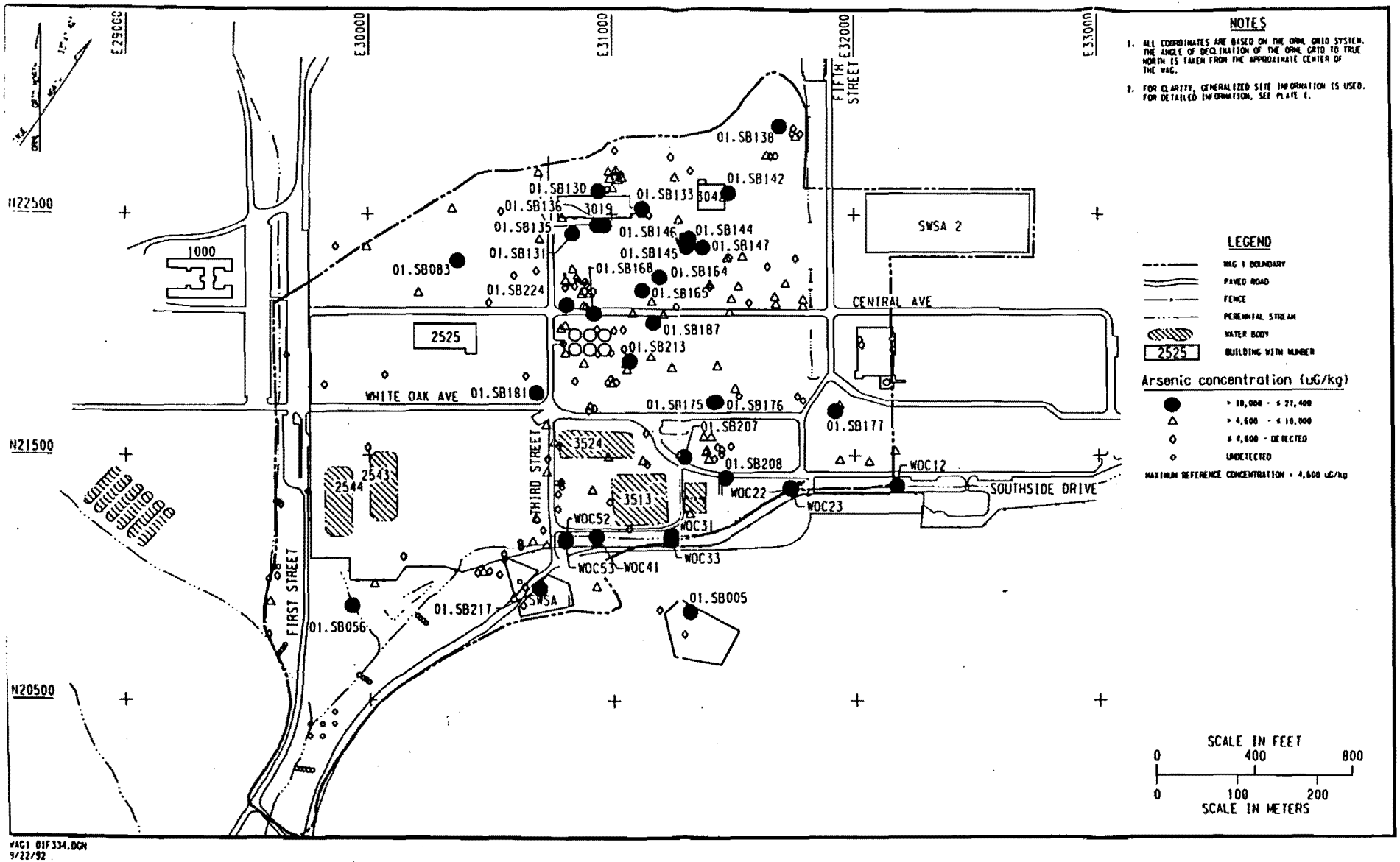


Fig. 4.4.13. Maximum arsenic concentrations in soil borings.

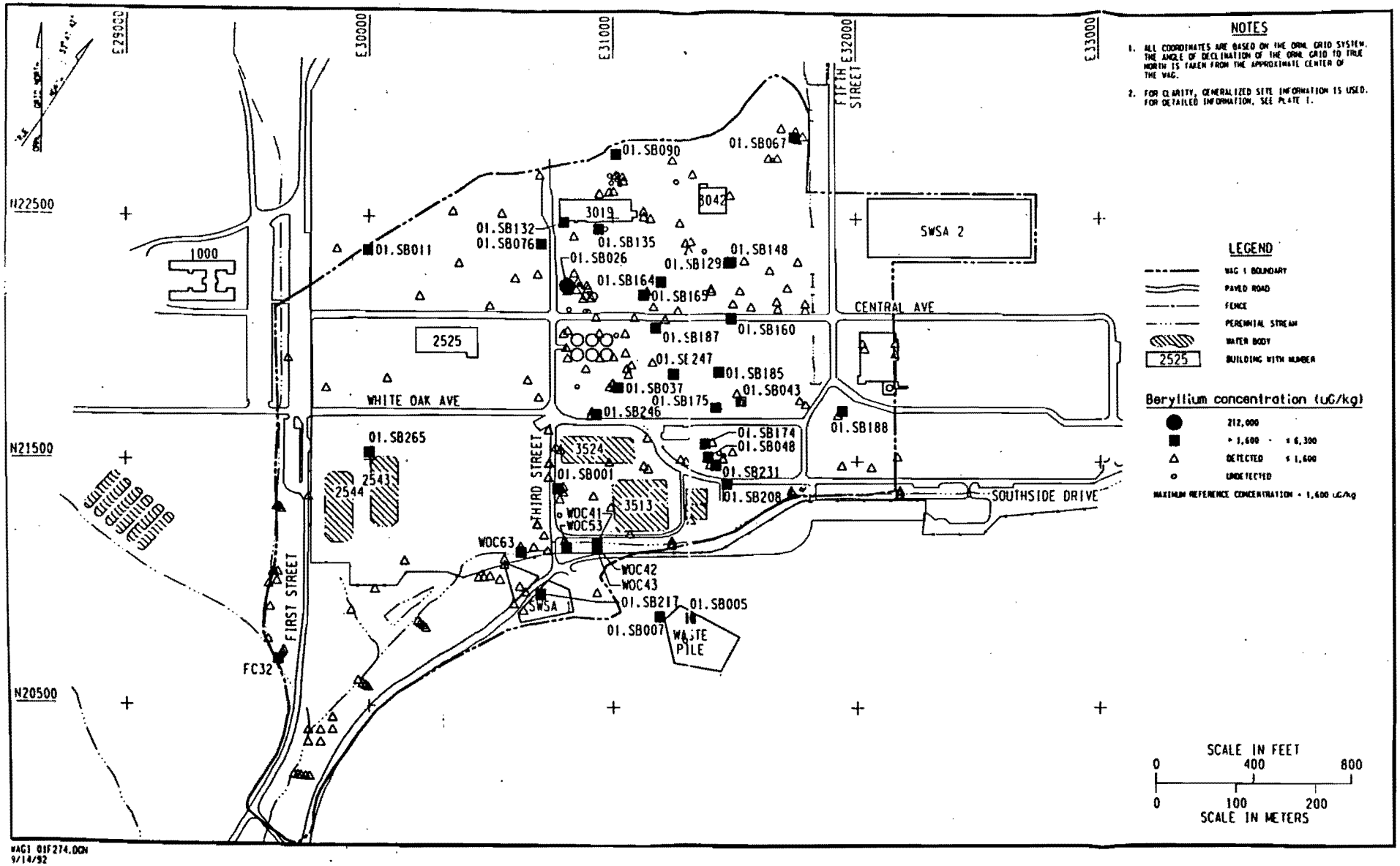


Fig. 4.4.14. Maximum beryllium concentrations in soil borings.

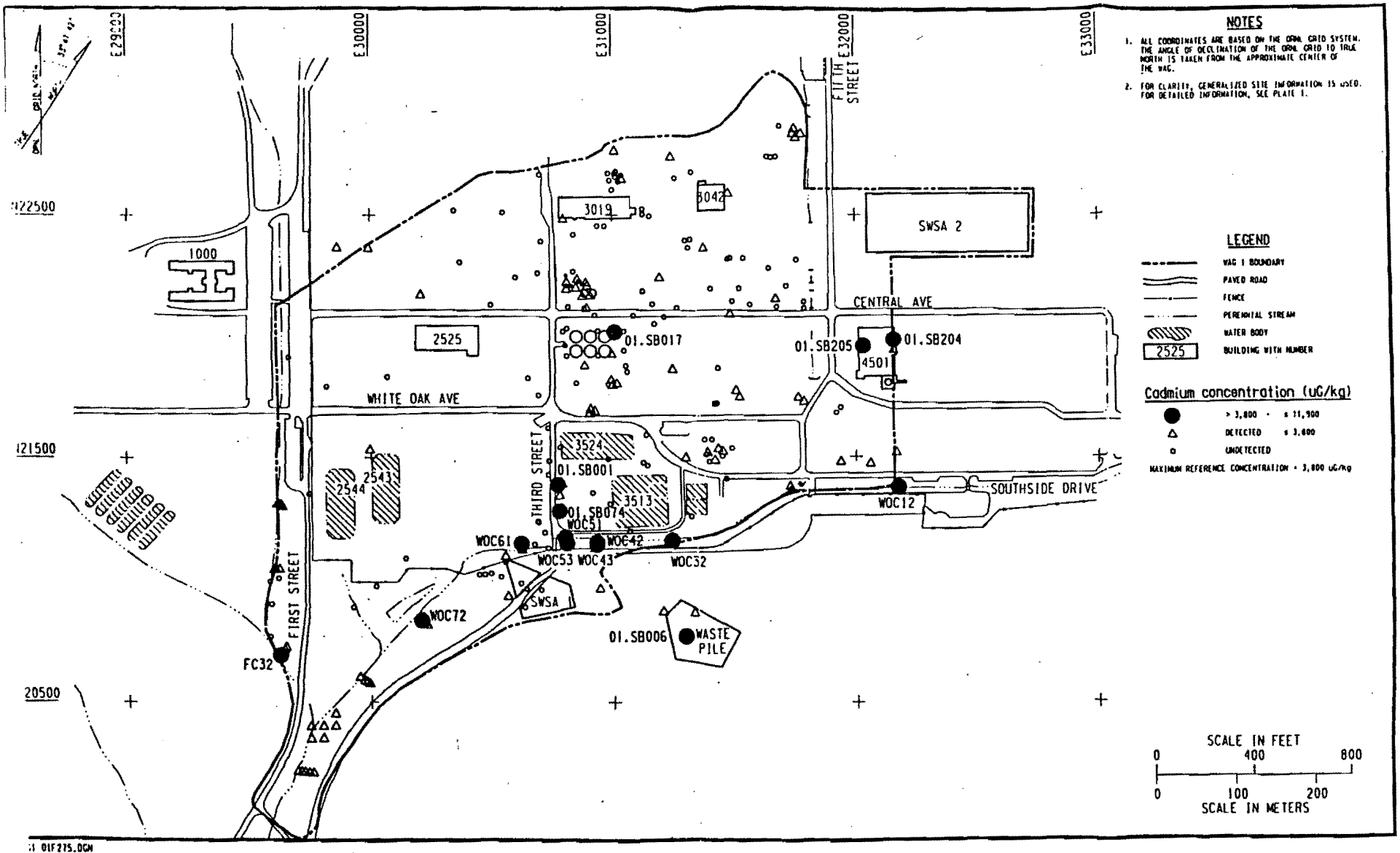
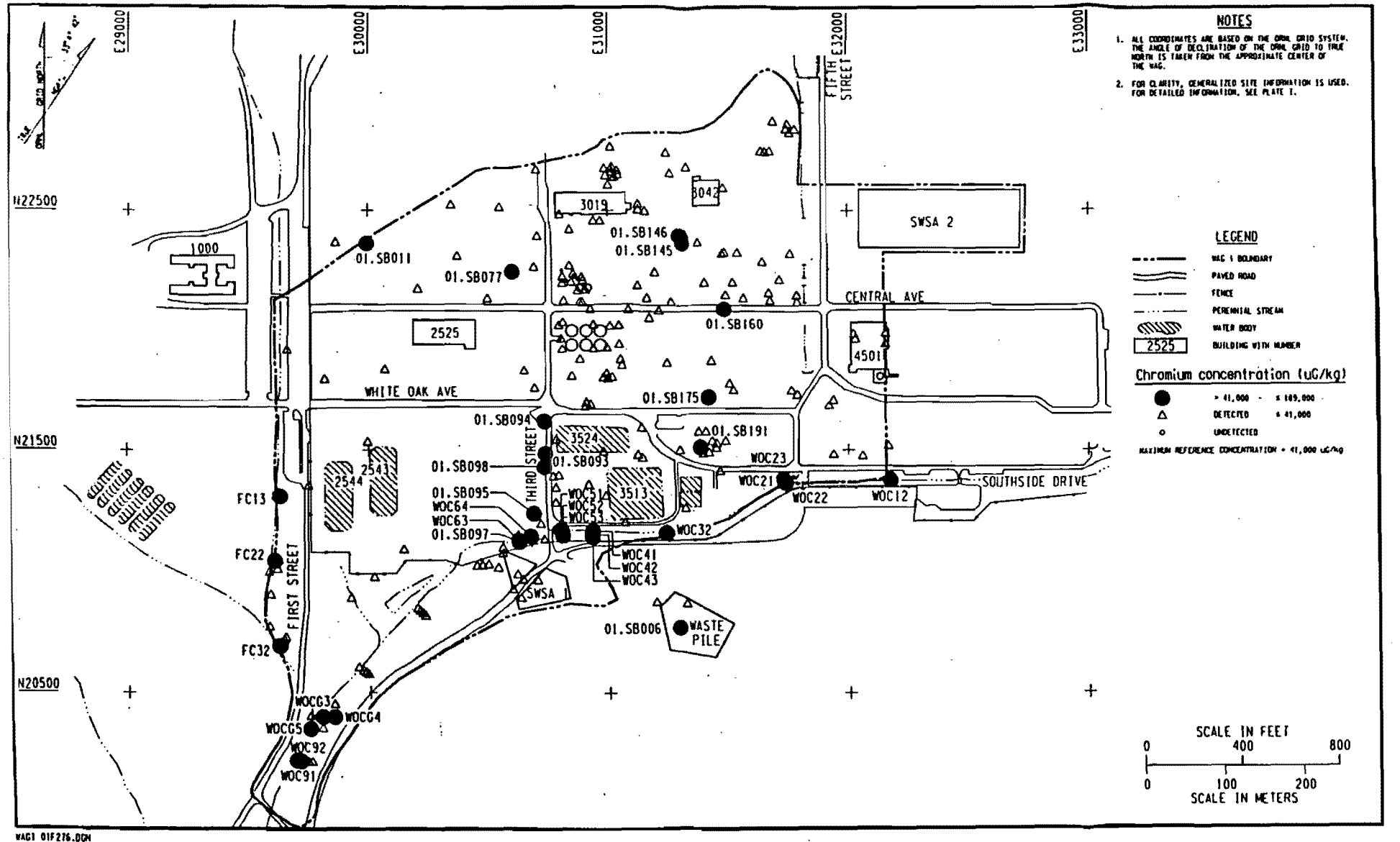


Fig. 4.4.15. Maximum cadmium concentrations in soil borings.

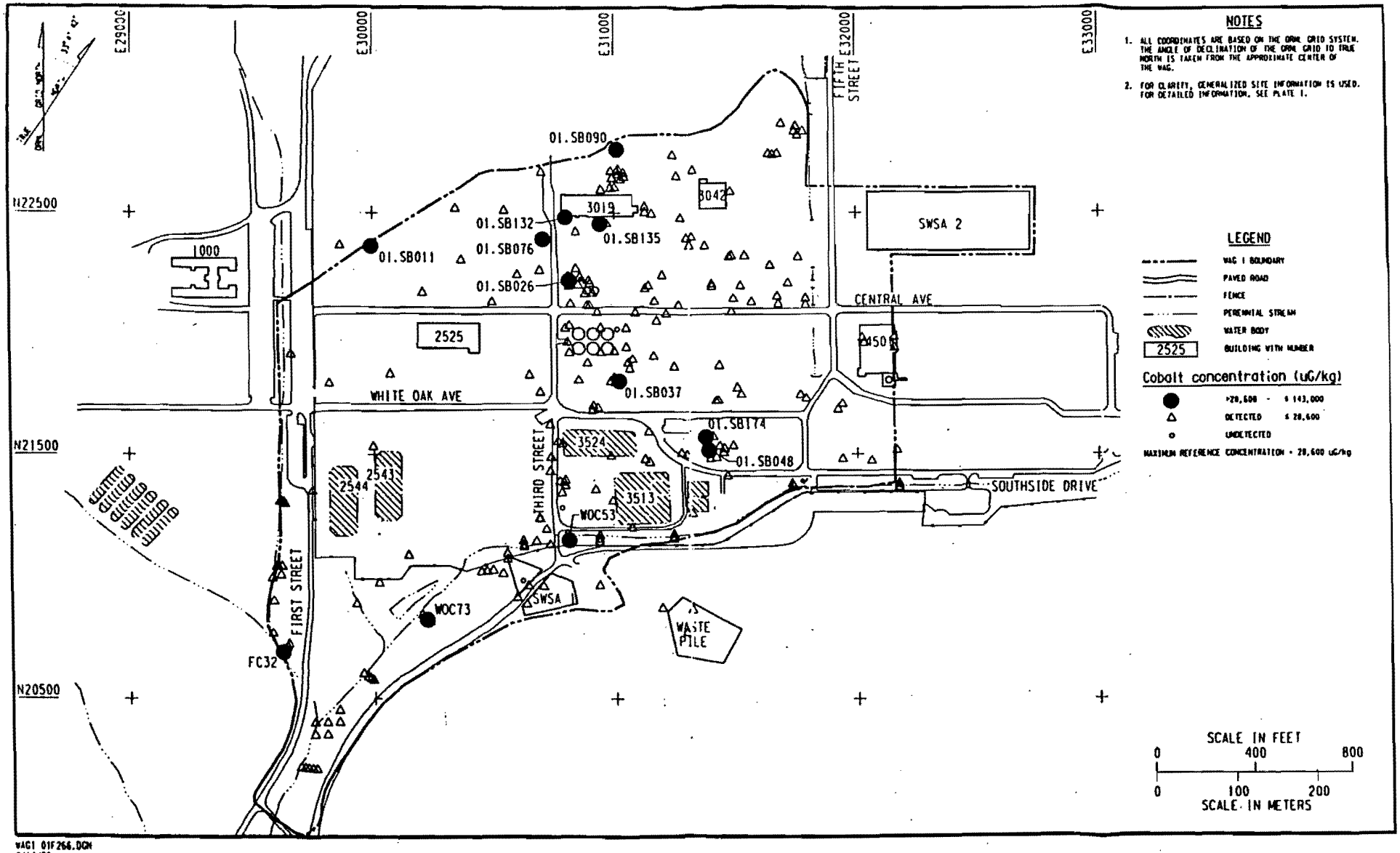
000165

000166



WAG1 01F276.DGN
9/15/92

Fig. 4.4.16. Maximum chromium concentrations in soil borings.



WAG1 01F266.DGN
9/14/92

Fig. 4.4.17. Maximum cobalt concentrations in soil borings.

000169

021000

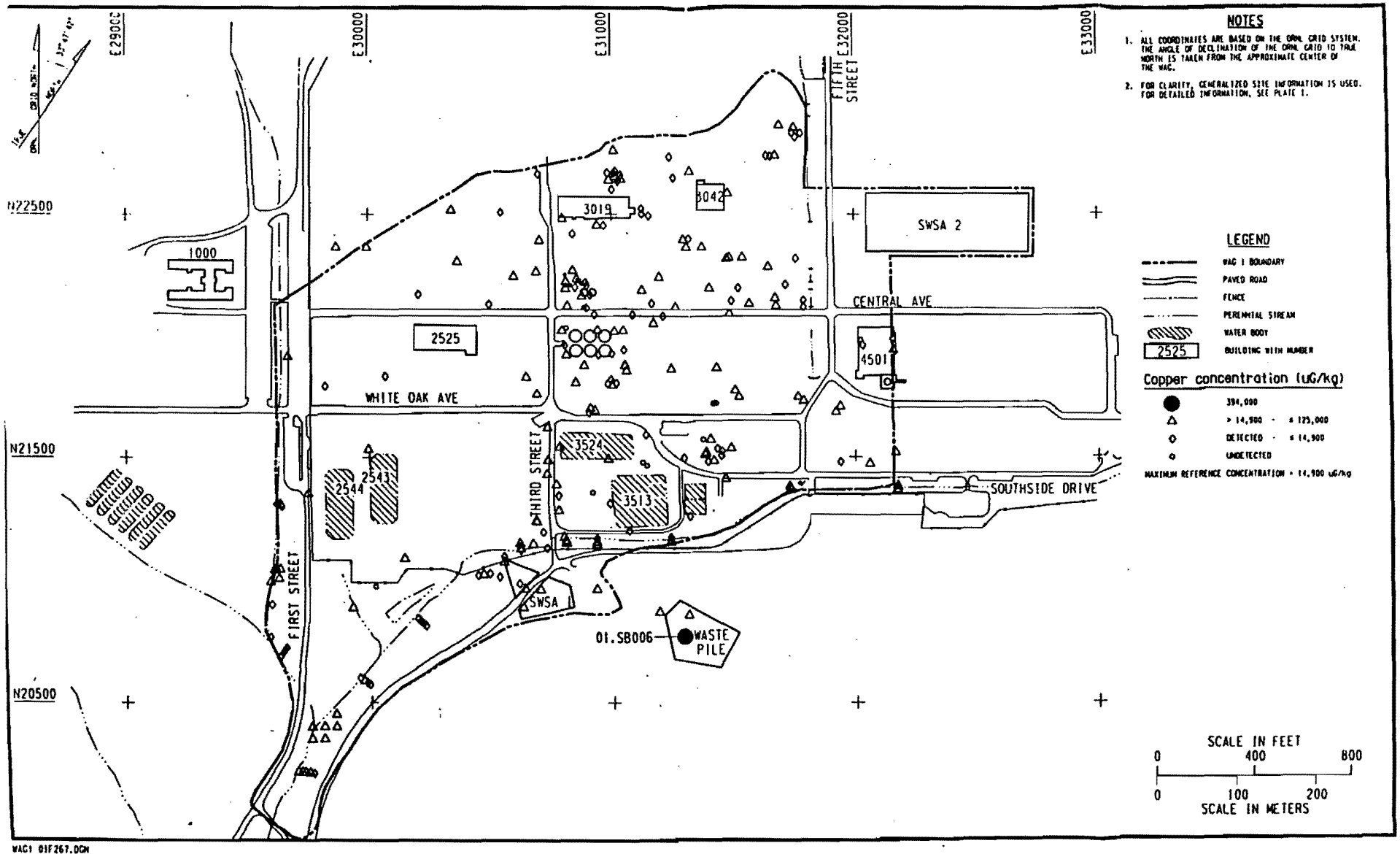
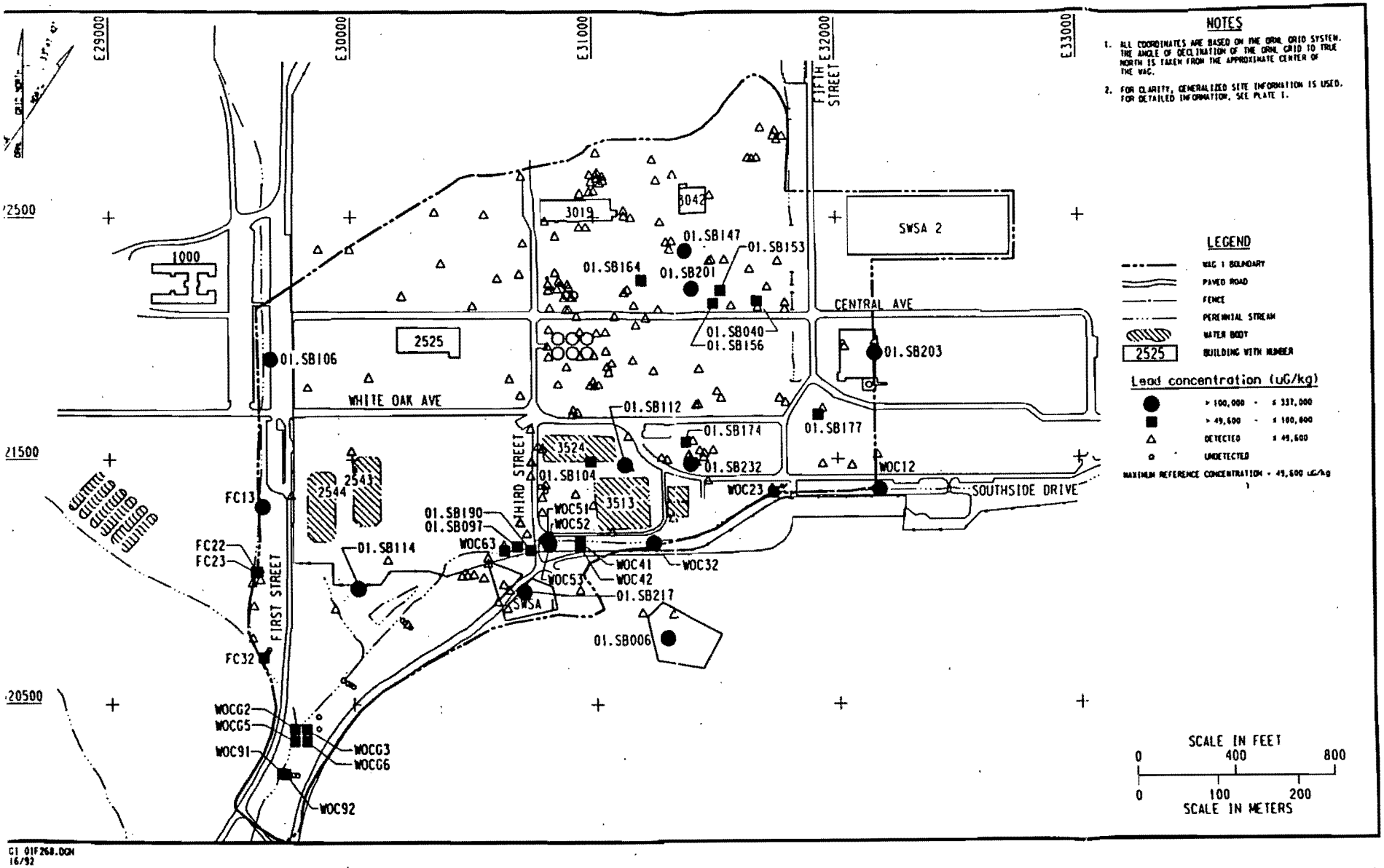


Fig. 4.4.18. Maximum copper concentrations in soil borings.

000172



G1 01F268.DGN
16/92

Fig. 4.4.19. Maximum lead concentrations in soil borings.

000173

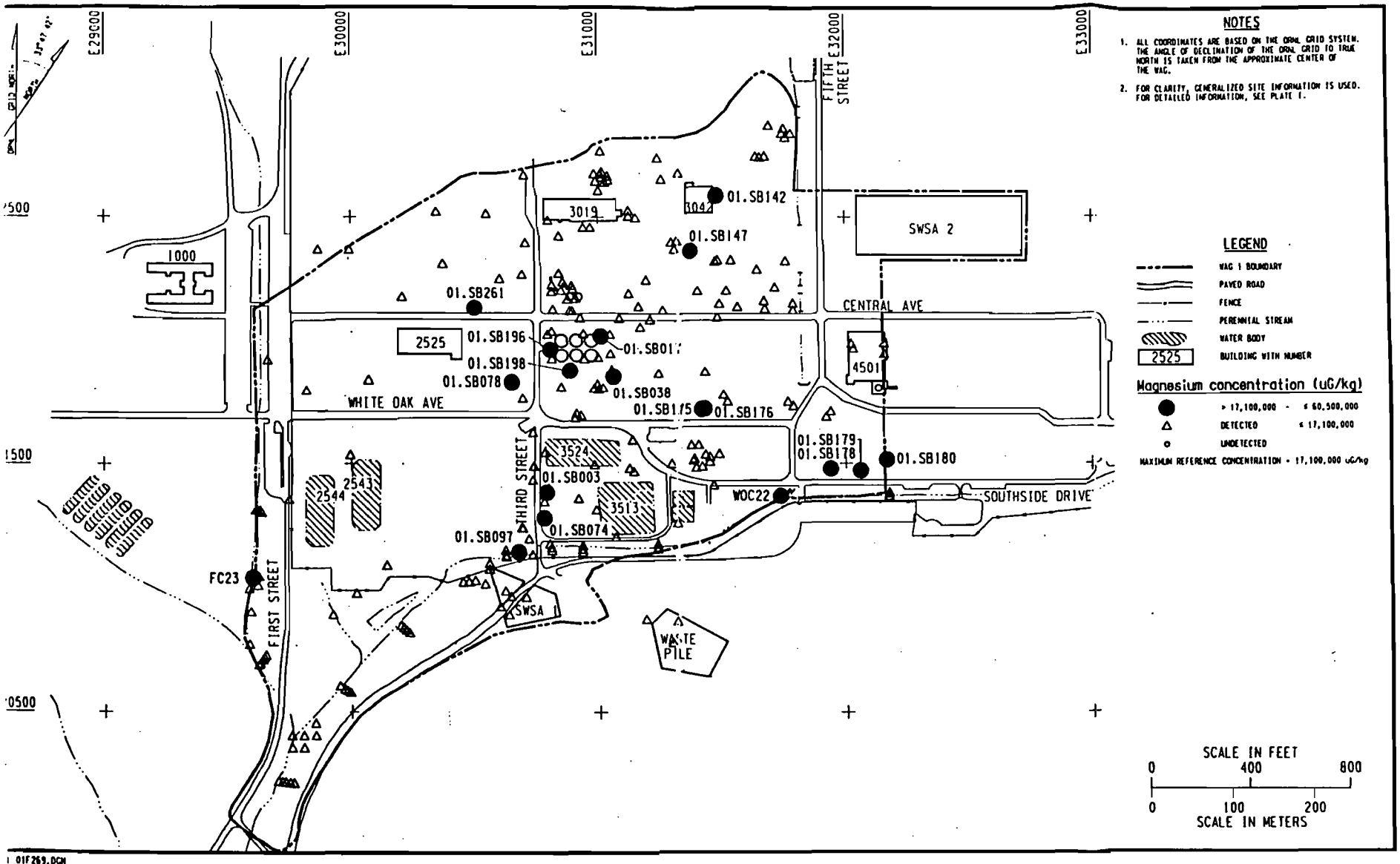


Fig. 4.4.20. Maximum magnesium concentrations in soil borings.

000176

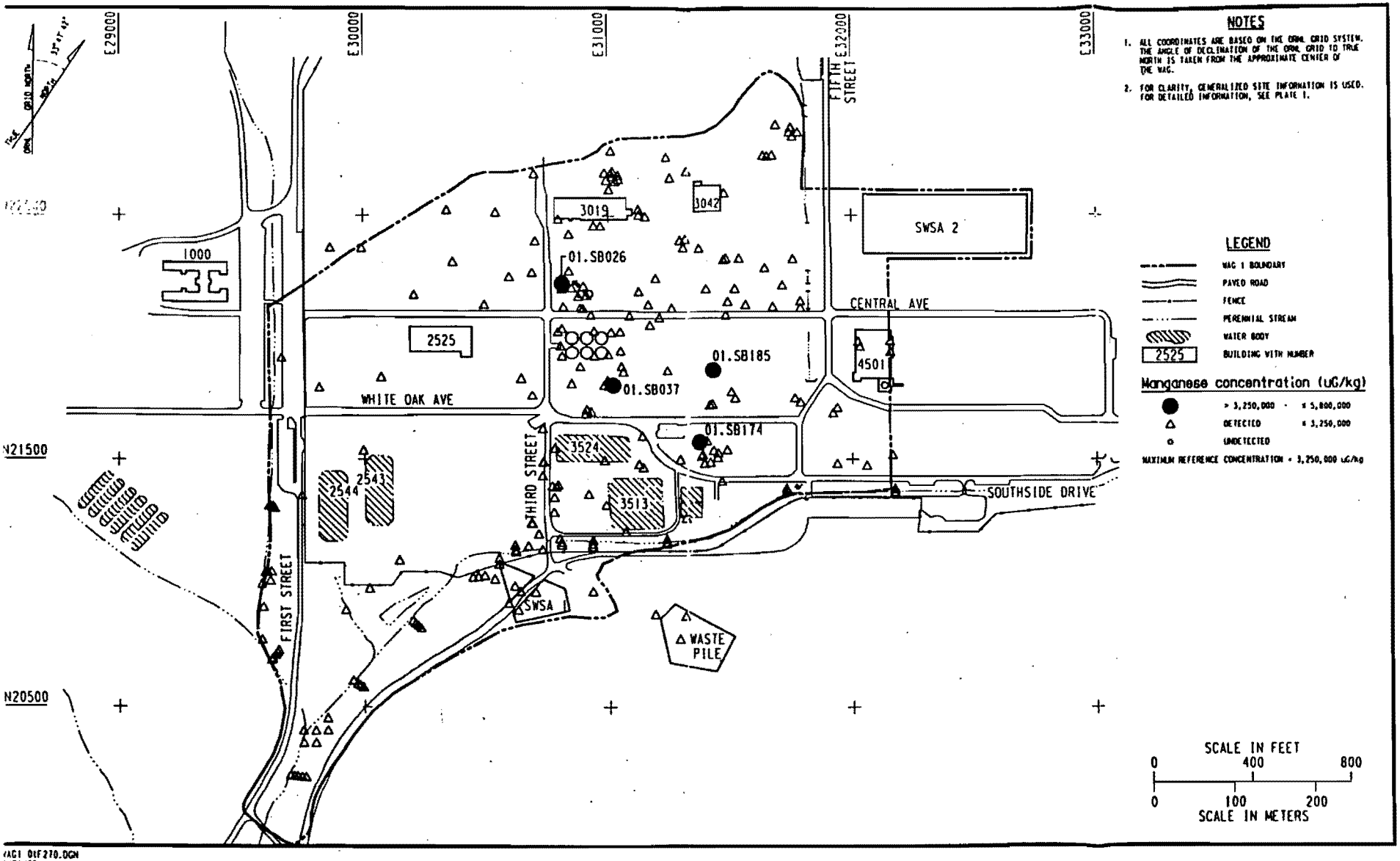


Fig. 4.4.21. Maximum manganese concentrations in soil borings.

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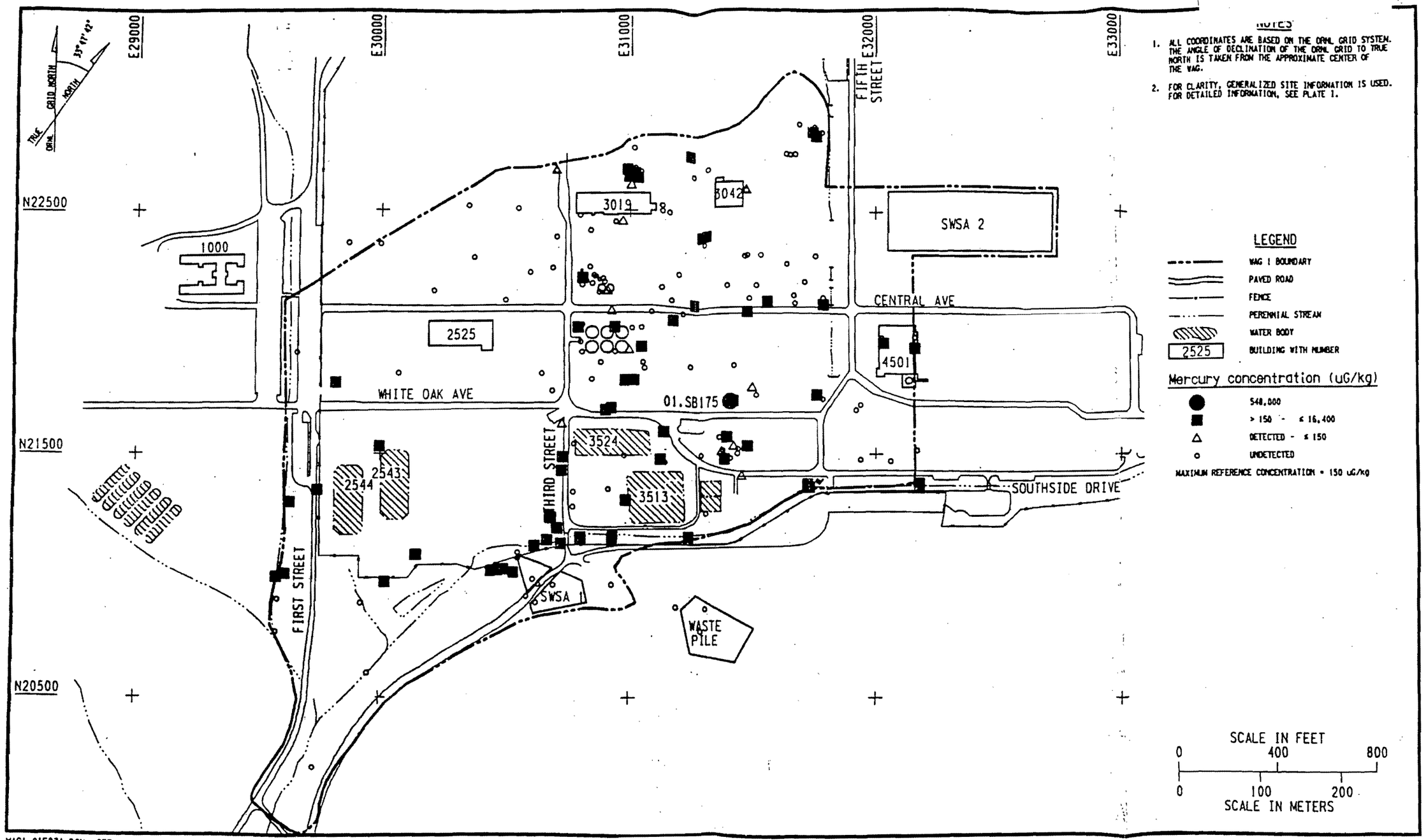


Fig. 4.4.22. Maximum mercury concentrations in soil borings.

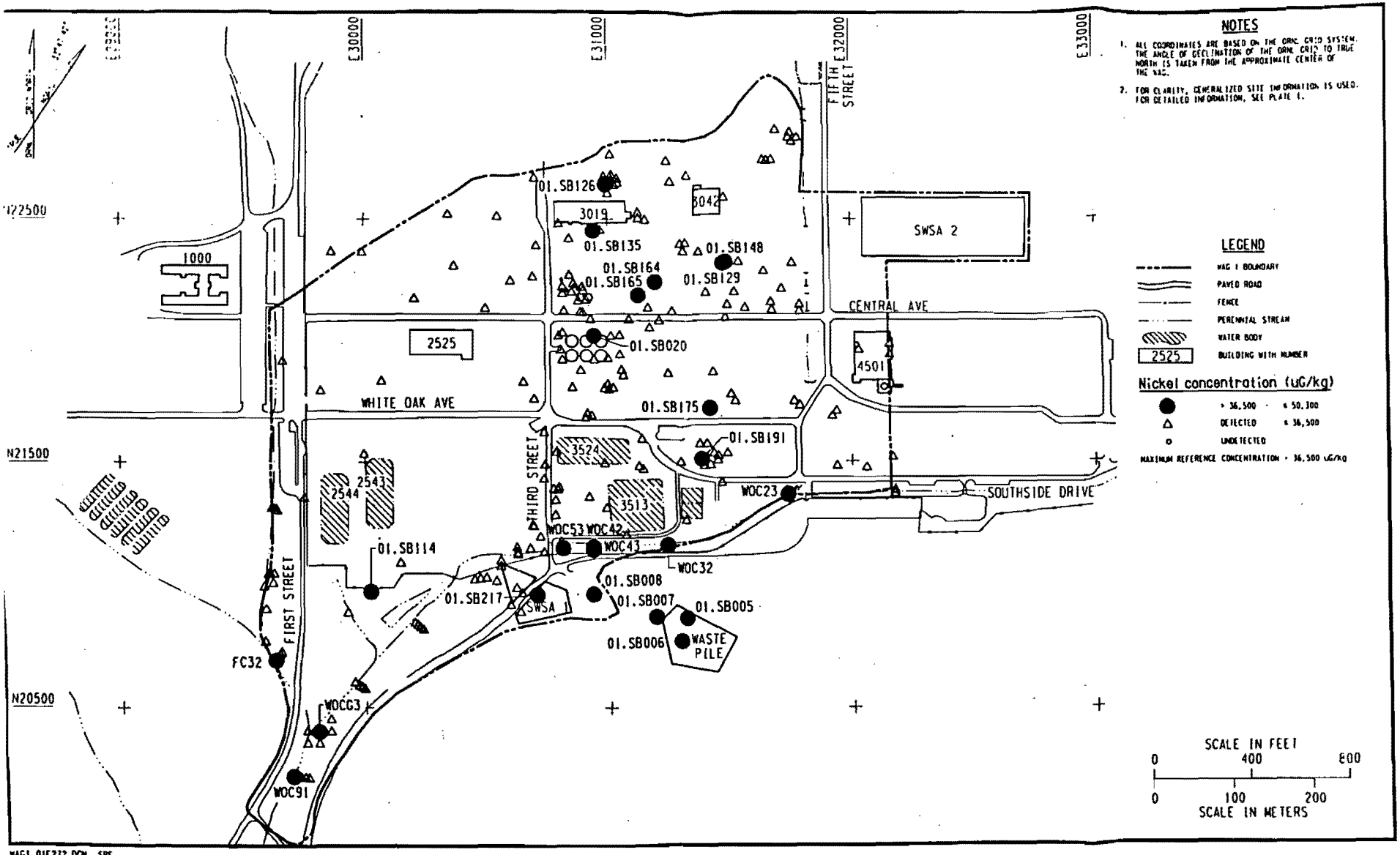


Fig. 4.4.23. Maximum nickel concentrations in soil borings.

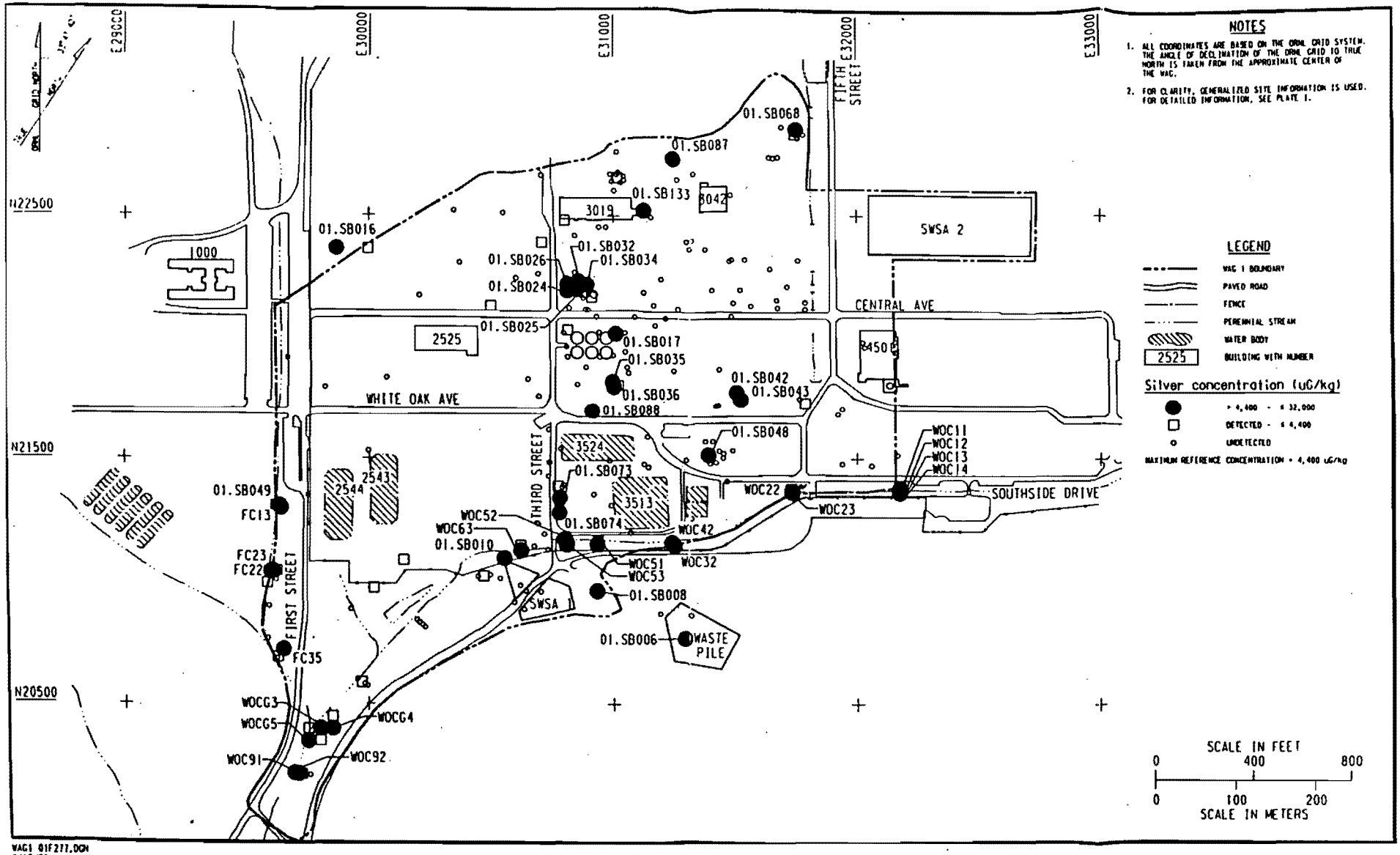


Fig. 4.4.24. Maximum silver concentrations in soil borings.

0001184

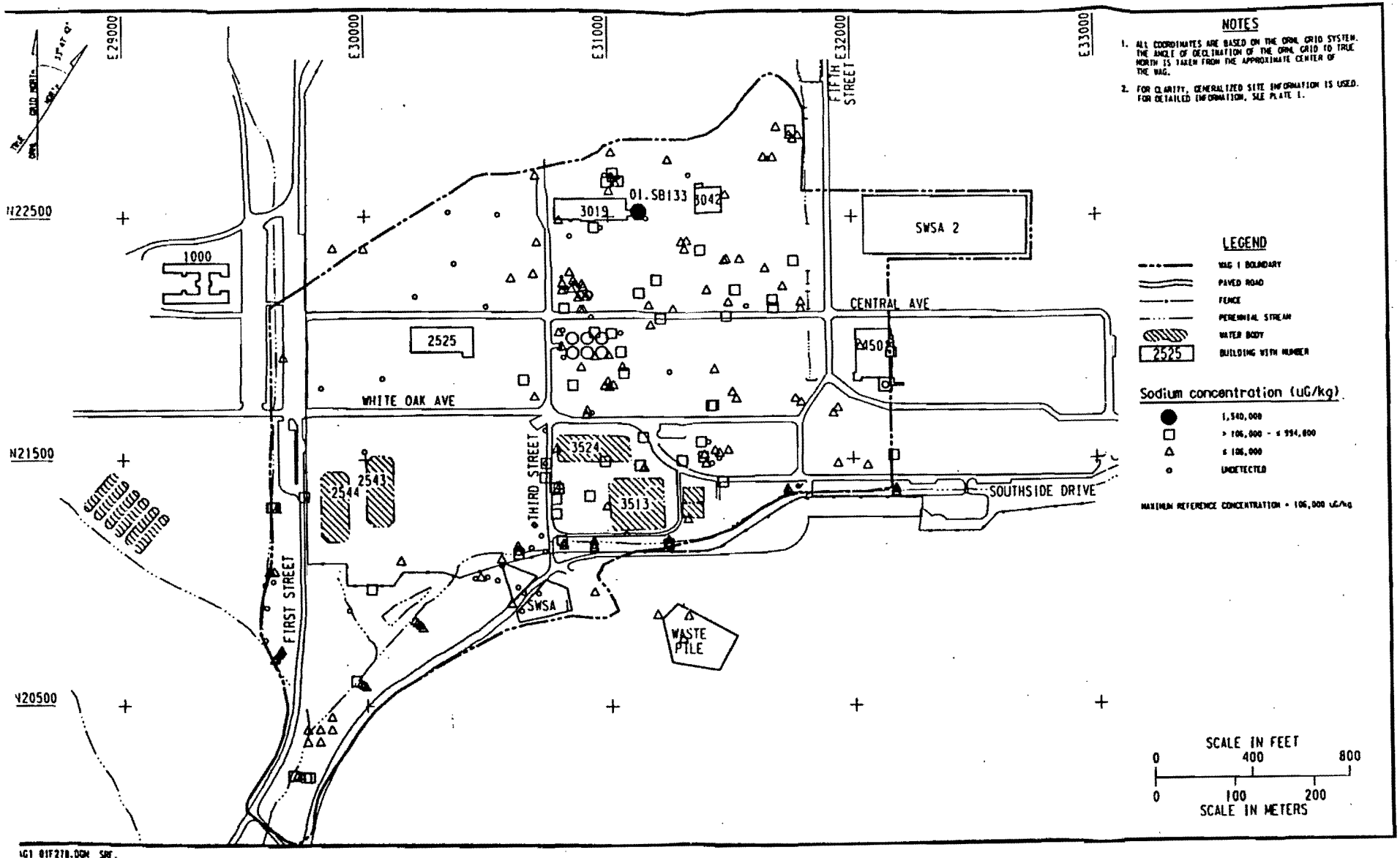


Fig. 4.4.25. Maximum sodium concentrations in soil borings.

000186

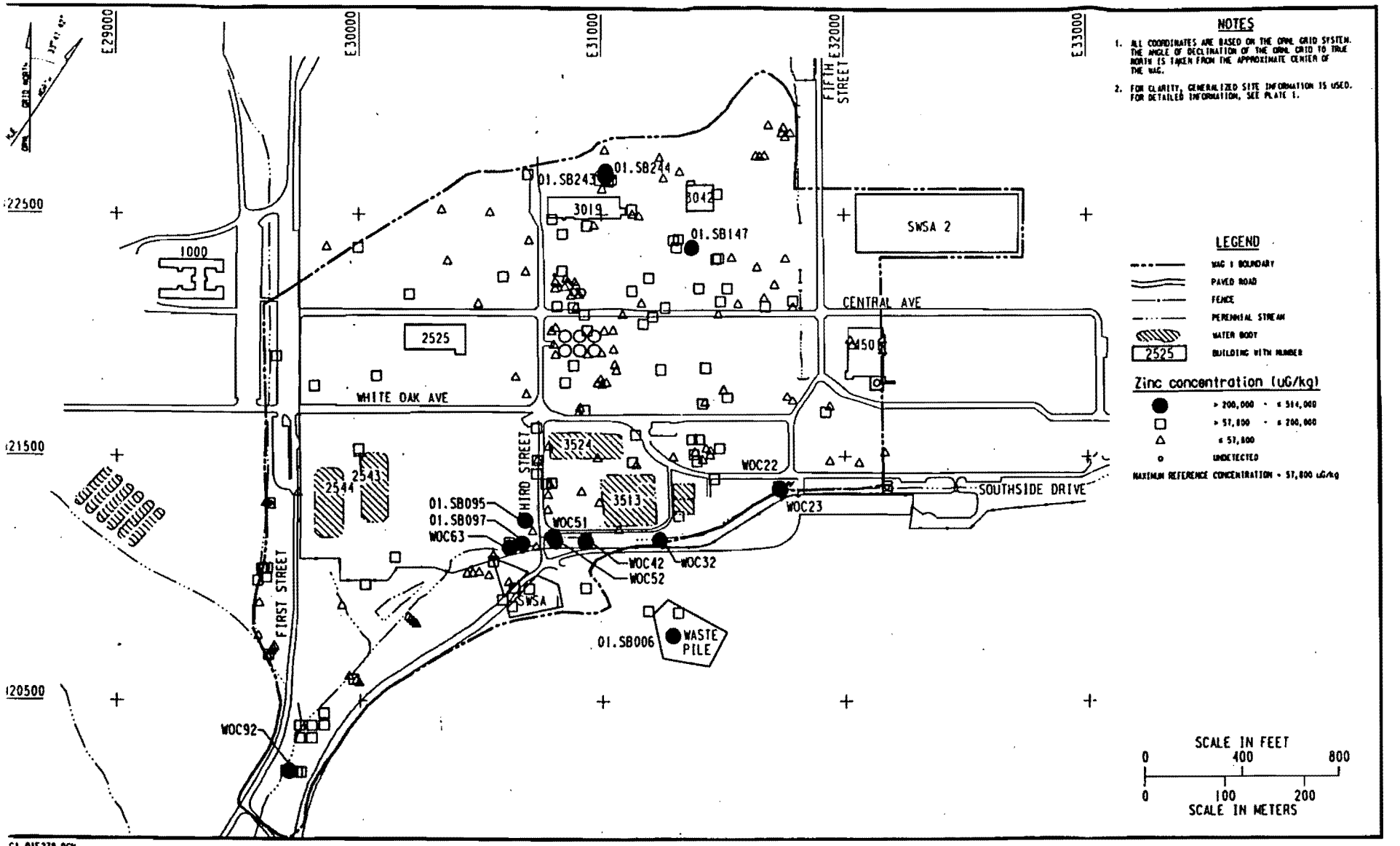


Fig. 4.4.26. Maximum zinc concentrations in soil borings.

000188

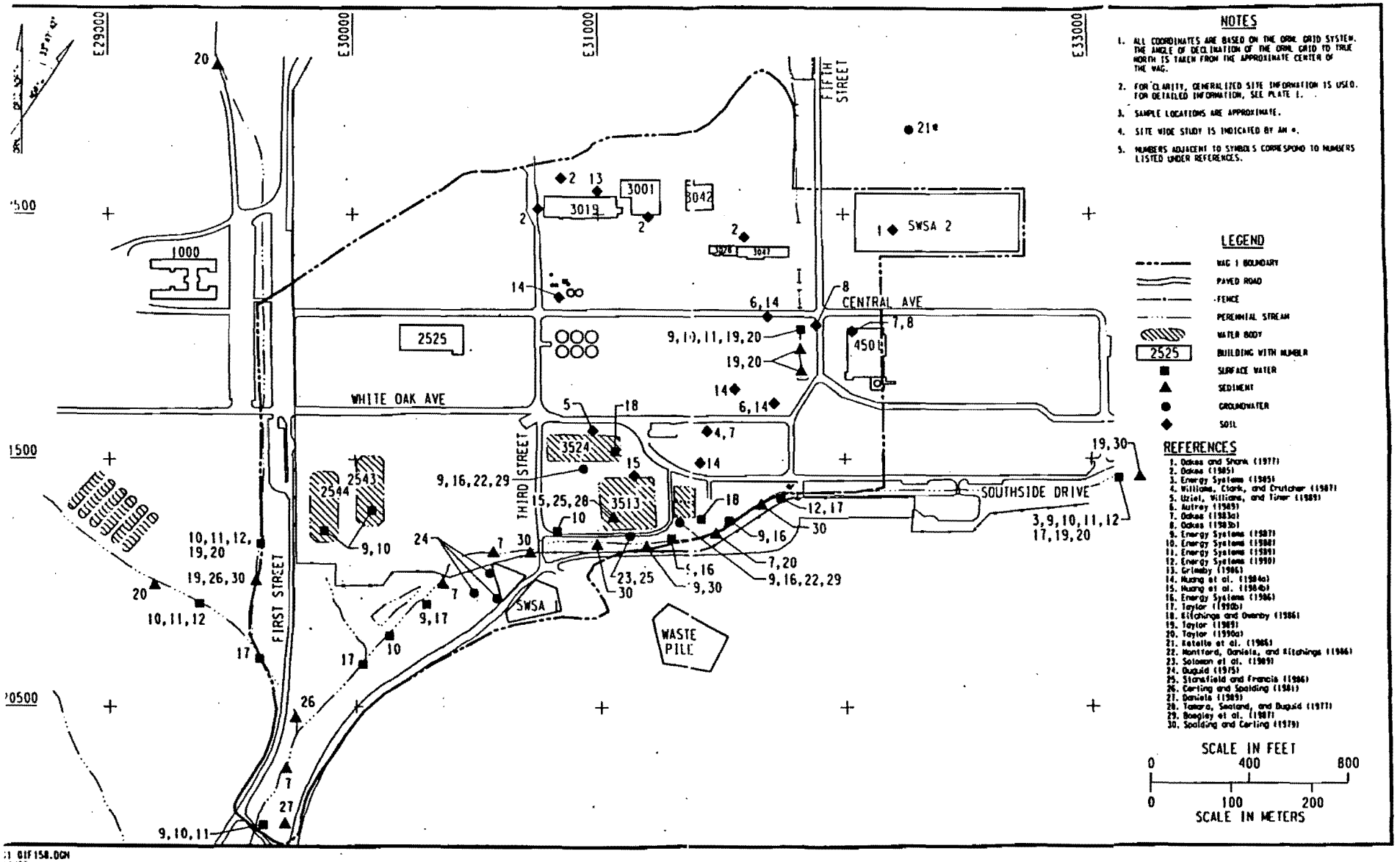
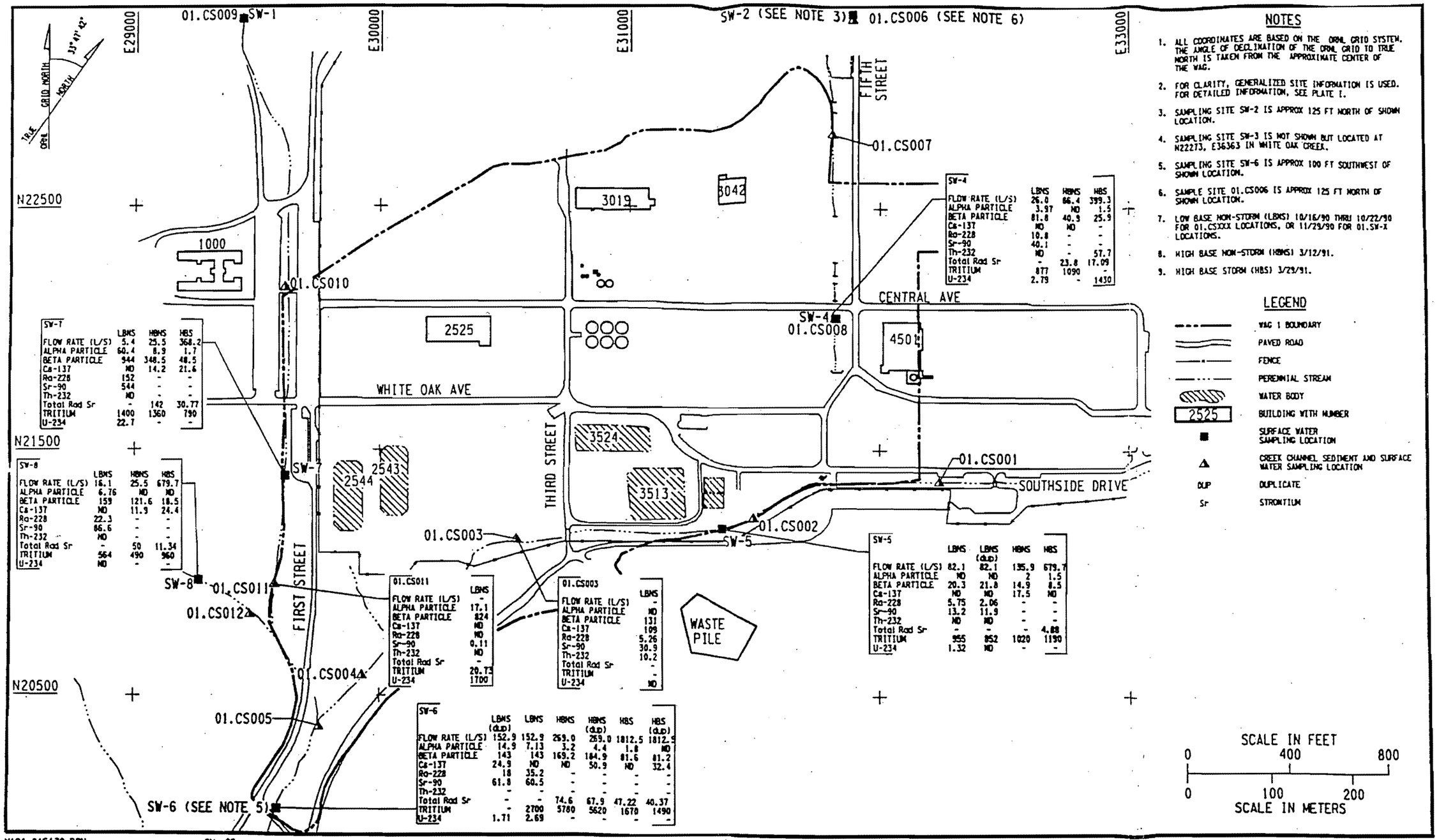


Fig. 4.5.1. Locations of previous studies and available data of groundwater, soil surface water and sediments.

000180

000130



SW-4	LBNS	HBNS	HBS
FLOW RATE (L/S)	26.0	66.4	399.3
ALPHA PARTICLE	3.97	ND	1.5
BETA PARTICLE	81.8	40.9	25.9
Cs-137	ND	ND	-
Ra-228	10.8	-	-
Sr-90	40.1	-	-
Th-232	ND	-	57.7
Total Rad Sr	-	23.8	17.09
TRITIUM	877	1090	-
U-234	2.79	-	1430

SW-7	LBNS	HBNS	HBS
FLOW RATE (L/S)	5.4	25.5	368.2
ALPHA PARTICLE	60.4	8.9	1.7
BETA PARTICLE	944	348.5	48.5
Cs-137	ND	14.2	21.6
Ra-228	152	-	-
Sr-90	544	-	-
Th-232	ND	-	-
Total Rad Sr	-	142	30.77
TRITIUM	1400	1360	790
U-234	22.7	-	-

SW-8	LBNS	HBNS	HBS
FLOW RATE (L/S)	16.1	25.5	679.7
ALPHA PARTICLE	6.76	ND	ND
BETA PARTICLE	159	121.6	18.5
Cs-137	ND	11.9	24.4
Ra-228	22.3	-	-
Sr-90	86.6	-	-
Th-232	ND	-	-
Total Rad Sr	-	50	11.34
TRITIUM	564	490	960
U-234	ND	-	-

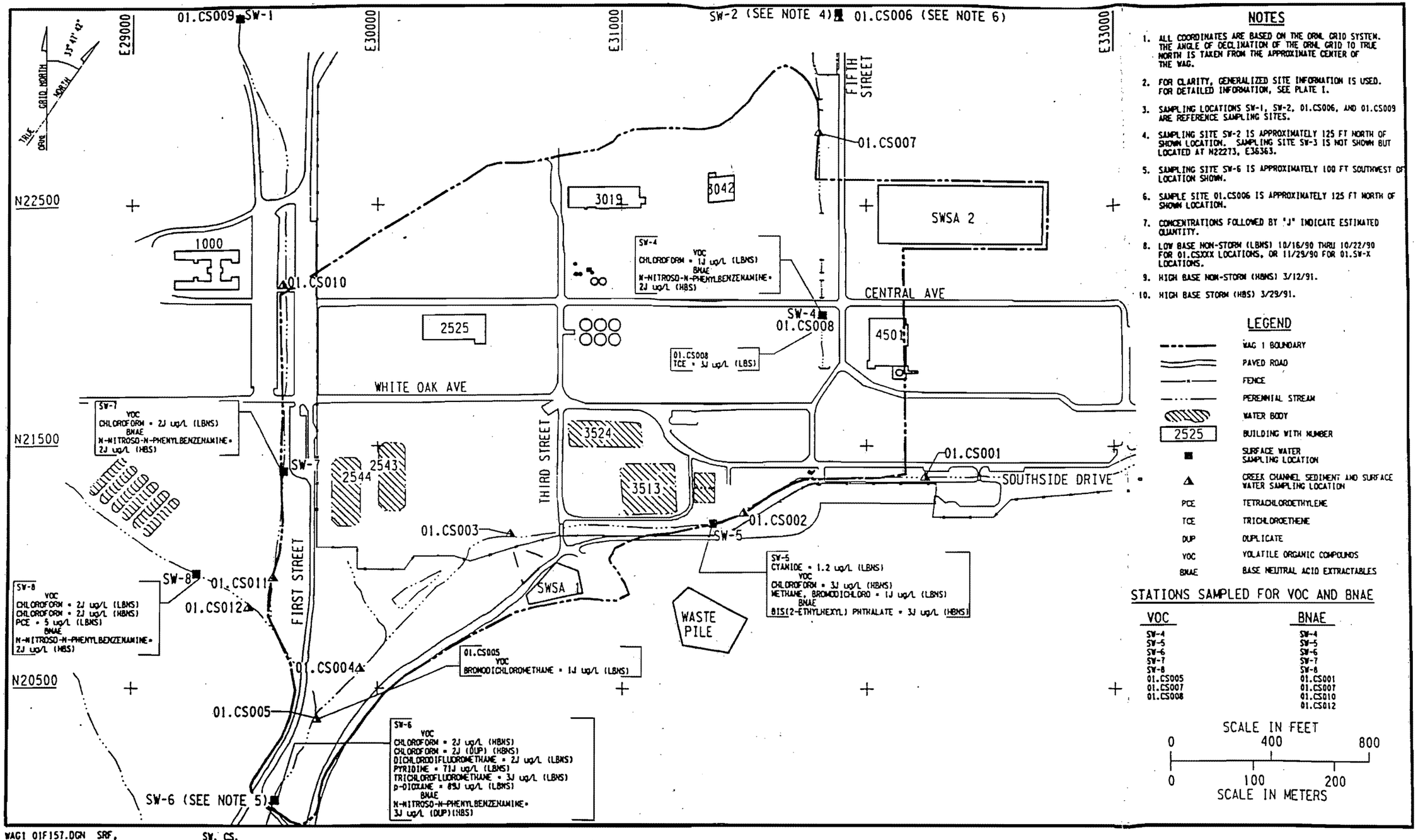
01.CS011	LBNS
FLOW RATE (L/S)	-
ALPHA PARTICLE	17.1
BETA PARTICLE	824
Cs-137	ND
Ra-228	ND
Sr-90	0.11
Th-232	ND
Total Rad Sr	-
TRITIUM	20.73
U-234	1700

01.CS003	LBNS
FLOW RATE (L/S)	-
ALPHA PARTICLE	ND
BETA PARTICLE	131
Cs-137	109
Ra-228	5.26
Sr-90	30.9
Th-232	10.2
Total Rad Sr	-
TRITIUM	-
U-234	ND

SW-5	LBNS	LBNS (dup)	HBNS	HBS
FLOW RATE (L/S)	82.1	82.1	135.9	679.7
ALPHA PARTICLE	ND	ND	2	1.5
BETA PARTICLE	20.3	21.8	14.9	8.5
Cs-137	ND	ND	17.5	ND
Ra-228	5.75	2.06	-	-
Sr-90	13.2	11.9	-	-
Th-232	ND	ND	-	-
Total Rad Sr	-	-	-	4.88
TRITIUM	955	852	1020	1190
U-234	1.32	ND	-	-

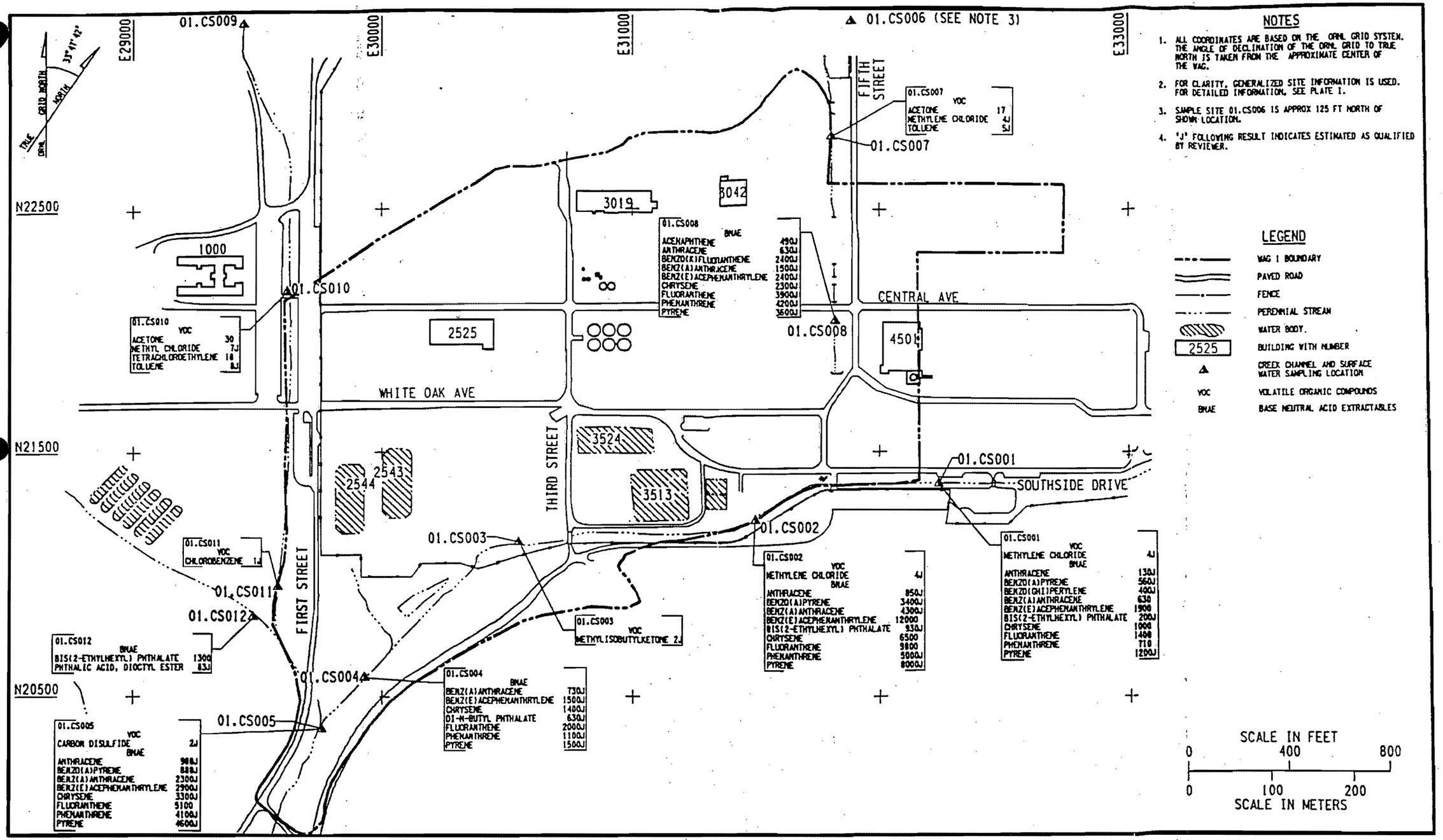
SW-6	LBNS (dup)	LBNS	HBNS	HBNS (dup)	HBS	HBS (dup)
FLOW RATE (L/S)	152.9	152.9	269.0	269.0	1812.5	1812.5
ALPHA PARTICLE	14.9	7.13	3.2	4.4	1.8	ND
BETA PARTICLE	143	143	169.2	184.9	81.6	81.2
Cs-137	24.9	ND	ND	50.9	ND	32.4
Ra-228	18	35.2	-	-	-	-
Sr-90	61.8	60.5	-	-	-	-
Th-232	-	-	-	-	-	-
Total Rad Sr	-	-	74.6	67.9	47.22	40.37
TRITIUM	-	2700	5780	5620	1670	1490
U-234	1.71	2.69	-	-	-	-

Fig. 4.5.10. Flow rates and radiological results (pCi/L) in surface water.



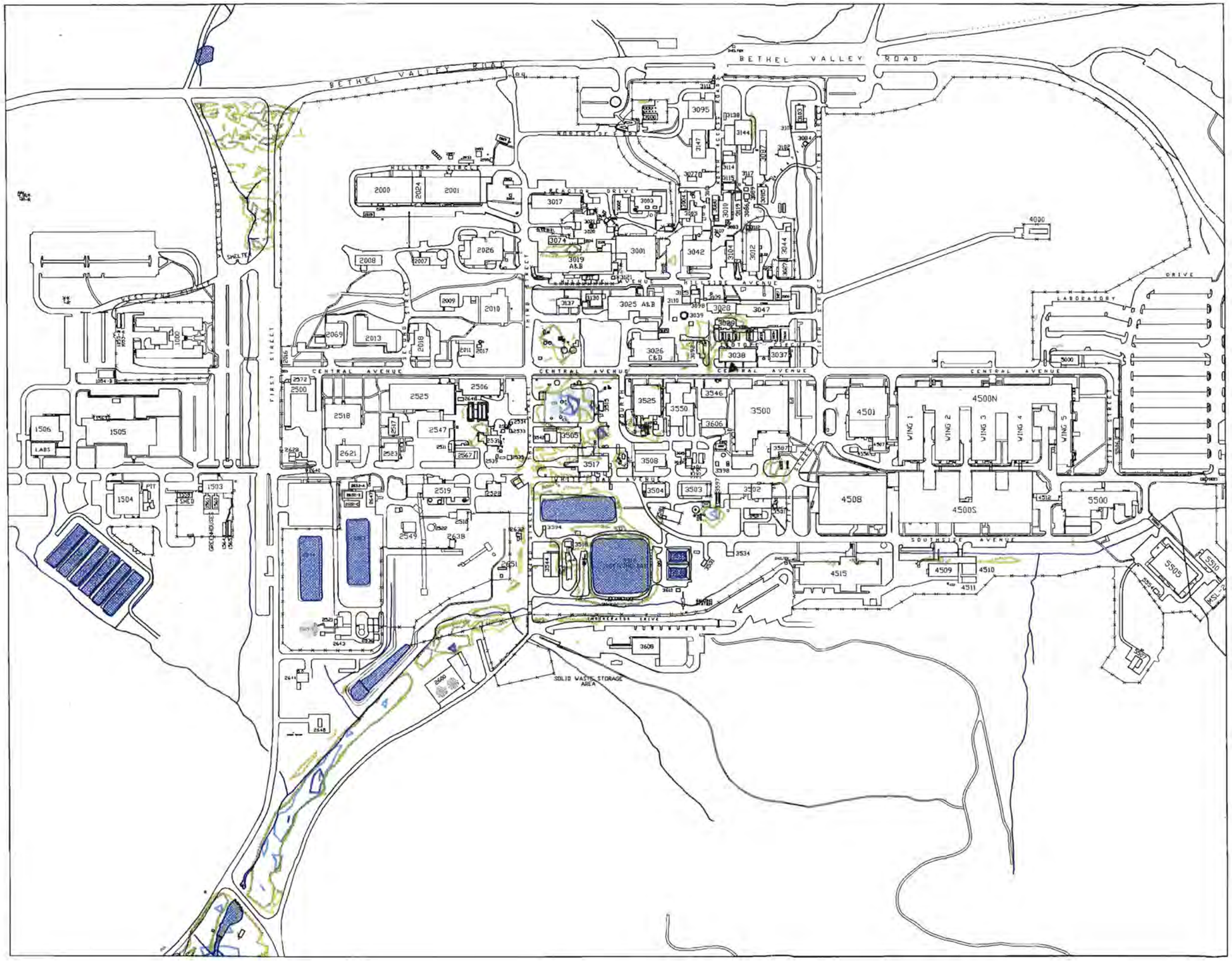
WAG1 01F157.DGN SRF, 9/15/92 SW, CS,

Fig. 4.5.11. VOCs, BNAEs, and cyanide detected in surface water.



WAG1 01F180.DGN SRF, 6/14/92 CS.

Fig. 4.6.4. VOC and BNAE results (µg/kg) from creek sediment samples.



LEGEND:

- BUILDINGS
- PRIMARY & SECONDARY ROADS
- CREEK & TRIBUTARIES

USRADS SURVEY (μ REM/hr)

- 10000
- 5000
- 1000
- 500
- 100
- 50

34°12'51"
ORNL NORTH
TRUE NORTH

0 200 400 800
SCALE: 1" = 400'

BETHEL VALLEY
USRADS SURVEY

SAIC®
Science Applications International Corporation

REV.	DRAWN BY:	CHKD. BY:	DATE:
0	J. Chason	A. Parker	04/18/97

97010/DWGS/663RAD2.DWG
CAD FILE #

Site Characterization Plan for WAG 1 GW
(DOE/OR/01-1994 &D2)

3.5 CONCEPTUAL MODEL

The WAG 1 groundwater flow conceptual model is that the WAG is the groundwater discharge area for the Knox Group aquifer underlying the adjacent Chestnut Ridge recharge area. The maintenance of elevated hydraulic head in Units C and D, despite the presence of cavities in those units, is considered to reflect hydraulic influences from the Knox which are transmitted through the relatively impermeable Units A and B. Local recharge occurs on the WAG 1 hilltop area underlain by Units C and D where the water table is generally beneath bedrock. Perched water develops seasonally but apparently infiltrates rapidly to the water table. Groundwater elevation is perennially above bedrock in Units E and G, and fluctuation

below bedrock is not observed. Presumably because of its comparatively greater clastic content that adjacent units, Unit F bedrock is perennially above the water table which may partially explain apparent strike-parallel flow near Unit F.

The groundwater system is thus envisioned to contain local recharge on the hilltop area which discharges through the overlying geologic units to surface water. Seasonal water table rise is a system-wide, piston-like response to precipitation. Throughout much of the WAG, significant amounts of discharging groundwater are intercepted by the extensive underground process waste pipeline and liquid waste tank storage network which is then sent to the PWTP for treatment.

The greatest flux of contaminants through groundwater to this network occurs during periods of elevated water table in response to precipitation. It is partly because of this network that contaminated WAG 1 groundwater is generally not detected in adjacent surface water bodies. The extent of surface water contamination would be anticipated to be much greater in the absence of this network.

Although cavities are known to occur in Unit G, the influence of these cavities on flow and transport is not known. The available data for WAG 1 Unit G bedrock piezometers indicate no piezometers were constructed in cavities. While drilling logs indicate the presence of fracturing in several of those piezometers, their hydraulic conductivity estimates do not differ significantly from those without fracturing. Air rotary drilling methods used in WAG 3 piezometer installation to the west of WAG 1 would not identify cavities. However, Stueber et al. (1981) indicate that off site migration of ^{90}Sr is along small, presumably strike-parallel cavities in Unit G near the geologic contact with Unit F.

The occurrence of stratabound groundwater flow at WAG 1 has been described by Ketelle and Lee (1992). Observations of stratabound flow were made in Melton Valley (Webster 1976) and in WAG 3 (Stueber et al. 1981). Stratabound flow has also been suggested to occur in Chestnut Ridge (Lee and Ketelle 1987), in a groundwater dye tracer test in Bear Creek Valley (Lee et al. 1989), and by the configuration of the S-3 Pond plume at the Y-12 plant (Geraghty and Miller 1990).

A simplified block diagram (Fig. 3.3) illustrates the basic components of the process as it is currently envisioned. The bulk of groundwater movement is envisioned to be essentially confined within discrete geologic strata. The direction of movement is determined by the hydraulic gradient within the stratum from a point of observation to the nearest surface water drainage. Comparatively minor stratum outleakage occurs with the local or site-wide hydraulic head profile. Vertical outleakage continues until another stratum is encountered through which stratabound flow can occur. Groundwater flow and contaminant migration is thus envisioned to occur in a trellis-like pattern. The scale at which the trellis movement is not resolved but simply resembles gradient-driven flow is not known but likely varies by bedrock unit.

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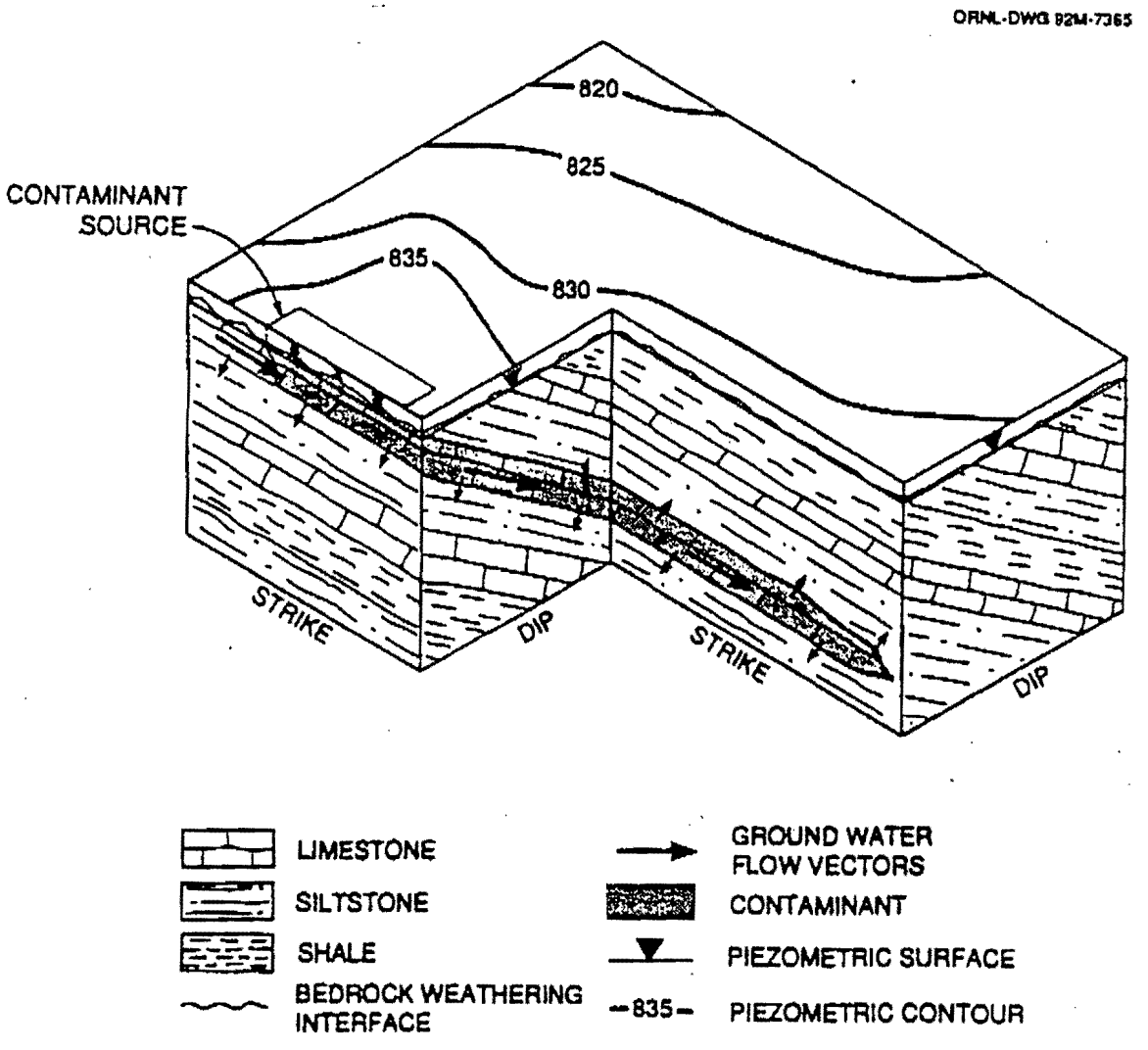

Fig. 3.3. Idealized block diagram of the stratabound pathway concept.

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Stratabound flow is considered to occur most commonly in homogeneous, comparatively thick (on the order of about 1 m), limestone strata within which laterally extensive fractures can develop. As such, stratabound flow would not be expected to occur in thin bedded (nominally up to several centimeters thick) rocks with a mixed carbonate and clastic composition which do not contain laterally extensive fractures. Because the bulk of ORNL facilities are underlain by thin bedded rocks of Units E and G, stratabound flow is not considered to be the only flow and transport mechanism at WAG 1. However, strata do occur in these units which have the potential for stratabound flow development, and that mechanism must be considered to occur at least locally.

The underground process waste pipeline system and underground tank sumps and dry wells remove an amount of groundwater equal to approximately one-half of all expected runoff from an area the size of WAG 1, although this is only an estimate. The fractions of this water derived from bedrock groundwater, shallow subsurface flow, and leaking water supply lines are not known. However, estimates of expected recharge to the bedrock system from infiltration are considered to be only a few inches per year. Thus, the extensive pump and treat system that operates in WAG 1 significantly alters natural flow conditions.

000206

WAG 1 SCSR (1992)

5.2 SITE CONCEPTUAL MODEL

The process of contamination of an environmental medium, in its most rudimentary form, involves a source of contamination and a release mechanism whereby contamination is transferred from the source to the environmental medium. Once in the environmental medium, the contaminant can reside in it, be transported with it, or be transferred to another medium. For WAG 1, the principal potential source→release mechanism→contaminated media chains are presented in Table 5.2.1.

5.2.1 Sources

Although each SWMU within WAG 1 is a potential source for the spread of contamination in the various media, it is impractical to address them separately. Section 3.5 describes individual waste management units within WAG 1. SWMUs can be grouped together on the basis of their proximity and similarity of contaminant inventory; Table 5.2.1 uses such groupings of sources.

The principal sources of WAG 1 contamination, both radiological and chemical, are the inactive tanks and associated pipes and radiological impoundments and the contaminated soils around them. The contaminant inventories of the tanks and impoundments are described in Sect. 3.5.

Approximately 95% of the total documented radioactivity of the inactive waste management units in WAG 1 is contained in the six large Gunite tanks in STF. The radiological impoundments are believed to be a major source of tritium contamination of groundwater as evidenced by very high concentrations (ranging from a few hundred thousand to over 800,000 pCi/L) in the groundwater downgradient of them (see Sect. 4.3). The inventory of tritium in these impoundments is not known. Impoundments are also sources of strontium-90 contamination of groundwater.

An NPDES-permitted outfall associated with the Process Waste Treatment Plant (X07) has been a known source of cobalt-60 and cesium-137 discharges into WOC. However, since April 1, 1990, when the new Nonradiological Wastewater Treatment Facility began operating, this outfall and some others have been eliminated (Energy Systems 1991). Some contaminants (e.g., pyridine and p-dioxane) may have discharged to the WOC surface water

000208

system through outfalls. These contaminants are distinguished by their presence in surface water only and have not been identified in groundwater samples (see Sects. 4.3 and 4.5).

5.2.2 Release Mechanisms

Leaks from underground tanks and associated piping and seepage from impoundments are the primary release mechanisms responsible for contamination of the surrounding soil and groundwater. Infiltrating precipitation transfers soil contamination deeper, finally contaminating groundwater. Contaminated groundwater transfers contaminants to the solid aquifer matrix through direct contact, and, for fractured bedrock, also through slow diffusion into the rock matrix pores. Surface water is contaminated through discharge of contaminated groundwater. Because of the extensive network of pipeline trenches in WAG 1, some below the groundwater table, contaminated groundwater has leaked into the outfall systems. In the past, some outfall discharges, most notably X07, were significant contributors to surface water contamination. Release of contaminants by surface runoff is not believed to be significant. Sediments are contaminated through direct contact with contaminated surface water.

Some release mechanisms (e.g., those involving direct contact) are reversible, depending on the relative concentrations of contaminants in the media involved. For example, contaminated sediments can contaminate surface water through desorption. Such reverse releases are usually important after some level of cleanup of one of the media has been achieved.

Because of the deteriorating condition of some of the tanks (see Sect. 3.5), a potential for release of contaminants exists following structural failure (e.g., collapse of a tank roof). Contaminants could be released to the environment through suspension and transport of soil particles in air, through volatilization and transport of volatiles in air, and through direct radiation from radioactively contaminated sludges.

5.2.3 Transport Media

Water is the principal transport medium for contaminants in WAG 1. All contaminants are soluble in water to varying degrees, and most are predominantly transported in dissolved phase. For particle-reactive contaminants such as cesium-137, transport associated with colloids and suspended sediment can also be important.

The subsurface/surface water system is described in detail in Sects. 3.3 and 3.4 and is summarized in Sect. 5.1.2.2. A few additional observations that have particular relevance to transport of contaminants are presented here.

Subsurface flow in the vadose zone takes place under approximately a unit hydraulic gradient. Using a hydraulic conductivity on the order of 0.3 ft/day (approximately equal to the WAG 1 average saturated hydraulic conductivity of 10^{-4} cm/s) and an effective porosity on the order of 10^{-2}, the average linear flow velocity in the vadose zone is estimated to be on the order of 30 ft/day. This is a high velocity resulting from flow being confined to relatively few macropores of very small overall porosities. The total porosity, however, is

quite large, more than an order of magnitude higher than the macropore porosities. Thus, a large, relatively immobile buffer zone exists for the contaminants from which they can flow in and out through slow diffusion.

Most of the groundwater flow takes place in the shallow bedrock in discrete intervals containing fractures. Strike-preferential flow resulting from flows in fractures aligned with bedding planes can be referred to in terms of anisotropy. There is unmistakable evidence of this anisotropy in WAG 1 aquifers, as evidenced by the observed directions of contaminant plumes in relation to the hydraulic gradients (see Sect. 4.3).

Average linear groundwater velocities in different regions of WAG 1 were calculated for the overburden and shallow bedrock on the basis of local hydraulic gradients and hydraulic conductivities. An effective porosity of 1.8% was assumed in both the overburden and shallow bedrock (Solomon 1989); the results are presented in Sect. 3.3. The velocities ranged from 0.0042 to about 45 ft/day. The mean groundwater flow velocity in the portion of the WAG south of Central Avenue, where most of the contaminant transport takes place, is estimated to be between 1.3 and 1.5 ft/day. Computed velocities in this region range from less than 0.01 ft/day to greater than 12 ft/day.

An analog of what exists in the vadose zone exists in the saturated zone, where flow takes place predominantly in discrete rock fractures of very low overall porosities, and a large, relatively immobile volume exists in the fine pores of the rock matrix. This sets the stage for the well-known phenomenon of matrix diffusion of contaminants. Contaminant transport takes place largely by advection in discrete fractures. At the same time, contaminants are transferred from fractures to the rock matrix by slow diffusion. Matrix diffusion retards and attenuates contaminant migration. Contaminants in the matrix are potential sources.

Another phenomenon that may be important for transport of particle-reactive contaminants is transport by colloids. Contaminants attached to colloids are much more mobile than would be expected based on their distribution-coefficient-dependent retardation factors. Colloidal transport may be important in both the macropores of the vadose zone and the fractures of the saturated zone. The degree to which such transport is important depends on the colloid attachment following collisions with surfaces of macropores or fractures, or on the so-called sticking efficiency of the surfaces (LLNL 1992). This, in turn, depends on the electrostatic and van der Waals forces between the particles and the surface. When the ionic strength of the solution is weak, sticking efficiencies approach zero. Even when sticking efficiencies are low, "colloids should not be transported more than a few tens of meters unless other processes are at work to release them" (LLNL 1992). In large fractures such as those found in the northern section of WAG 1, enough turbulence may exist to release colloids from surfaces.

The active zone of groundwater flow is confined to approximately the upper 150 ft or less of the water table aquifer. Sufficient vertical gradients near the three discharge boundaries exist, suggesting that most contaminants in the active flow zone may discharge to streams. However, some contaminants may flow under the stream as strata-bound flow (see Sect. 3.3). When contaminants flow toward First or Fifth Creek, the flow appears to

be strata-bound and is confined to certain geologic layers. However, flows toward WOC are interstrata.

Groundwater discharging into the WOC surface water system flows off site as part of creek base flows. Surface water is the final transport medium for contaminants that are carried off site either in dissolved phase or bound to suspended particles.

5.3 FATE AND TRANSPORT

The medium most immediately and most commonly affected by a contaminant release from its source is soil. The nature and extent of soil contamination is described in Sect. 4. The leachability of contaminants from soil is a good indicator of their mobility and transferability to other media. Soil samples were selected from areas suspected of high metal and radiological contamination and subjected to leachability (modified TCLP) analysis using deionized water. The analytical results of this leachability test are presented in Appendix A, Sect. A.5. Based on results of this analysis, all metals and radiological contaminants, with the obvious exception of tritium, are found to be strongly held in soils (Table 5.3.1). Radioactive strontium was the only other radionuclide consistently detected in the extracts above quantitation limits (cesium-137 was detected in two extracts). These observations are consistent with the generally widespread occurrence of tritium and strontium in groundwater samples (see Sect. 4).

The relative immobility of metals and radionuclides in soils explains why, although their concentrations in soils may be high, they remain relatively low in groundwater and surface water. All BNAEs listed in Table 5.1.4 are also strongly held in soils, as indicated by their high K_{oc} values; few BNAEs have been detected in surface water. Volatile organics, on the other hand, leach readily from soil to groundwater and, because their distribution coefficients are generally low, are transported in groundwater relatively rapidly. When discharged into surface water, their concentrations decrease rapidly because of loss from volatilization.

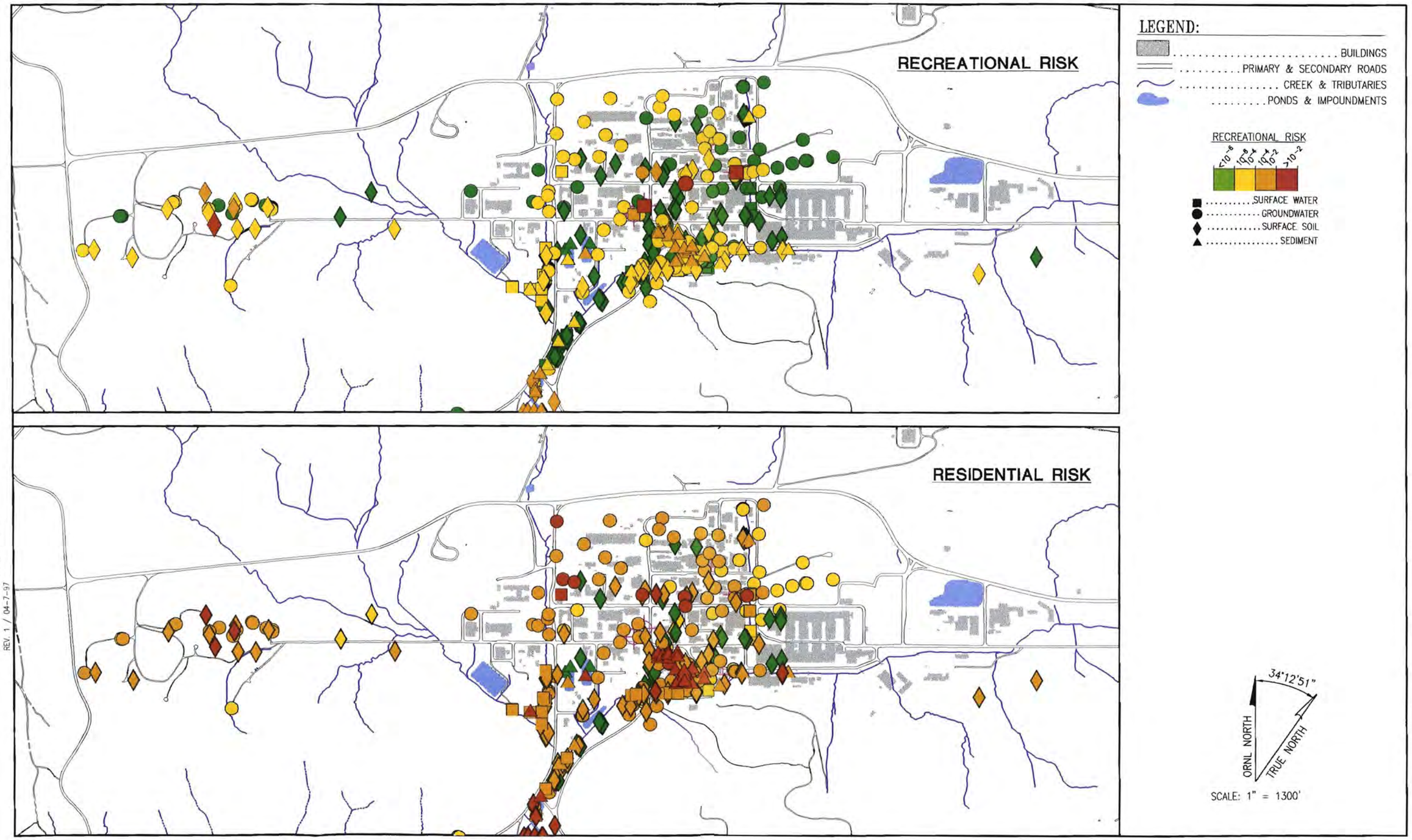
5.3.1 Groundwater

Subsurface transport of particle-reactive contaminants occurs at a velocity that depends both on the average linear groundwater velocity and contaminant-specific distribution coefficient. The velocity of contaminant transport is given by

$$V_c = \frac{V_g}{\left(1 + \frac{\rho_b K_d}{\theta}\right)} = \frac{V_g}{R}$$

where V_c = velocity of contaminant transport, LT^{-1}
V_g = average linear groundwater velocity, LT^{-1}
ρ_b = bulk density of the solid matrix, ML^{-3}
K_d = distribution coefficient, L^3M^{-1}
Θ = moisture content, dimensionless, and
R = retardation factor, dimensionless.

000214



Distribution of potential human health risk in Bethel Valley

Site Charac. Pl. for GW in WAG 1 DOE/OR/01-1194 D2

4. POTENTIAL RECEPTORS AND EXPOSURE PATHWAYS

4.1 INTRODUCTION

The primary purpose of a risk assessment is to provide relevant information for environmental decision making. Risk assessment under CERCLA has two main goals: to determine the need for action at a site and to establish remedial goal options for consideration in the feasibility study. The need for action is established through the process of identifying pathways and contaminants of concern at a site and subsequently calculating risk on the basis of a set of exposure assumptions. In the feasibility study, the primary use of a risk assessment is to determine remedial goal options that will serve as a baseline for the amount of risk reduction afforded by implementation of the alternatives identified by the feasibility study if action is necessary. In order to achieve this task, reasonable land use scenarios must be identified for the on-source and off-source components of the risk assessment.

In this section, characterization of the human and ecological populations that may be affected by the WAG 1 Groundwater OU are considered. The receptor assessment aims to identify those individuals or populations with a current or future potential for exposure to contaminants originating from the site. The exposure pathway assessment identifies the routes by which a receptor might be exposed. Assessments will be used to evaluate risk posed by contaminants in source OUs that move through the shallow groundwater to surface water. Pathways to be included in the assessment are ingestion, inhalation, and dermal contact of the surface water. Risk characterization will be conducted using data from ongoing monitoring efforts and the WAG 1 remedial investigation. Groundwater data will be collected to determine which source OUs are contributing to contaminants found in the surface water. This information will also be used in an integration point assessment to prioritize the source OUs for remedial actions.

The risk assessment strategy for source OUs is designed to assist the ER program by focusing actions on sites that are a high risk priority for either on-site or off-site exposures and to provide adequate risk baselines for measuring the potential effectiveness of proposed remedial alternatives. Most of any off-site public exposure to ORNL contaminants results from surface water, which is the major transport mechanism for contaminant fluxes to off-site receptors. Other potential transport mechanisms (e.g, the food chain, the air pathway, and direct groundwater transport) are not currently primary sources of off-site fluxes. The integration point assessment is designed to actively use monitoring, surveillance, compliance, and RI data to evaluate the off-site risk from a variety of sources that contribute to the surface water integrator OU. The data will be used to establish a baseline for evaluating the risk at different points within the integrators, to identify and prioritize source areas within the context of the integrator, and to establish the degree of risk reduction a source control action can potentially achieve.

Residential pathways will be evaluated for the off-source assessment of risk from the source OUs. Selection of the off-source receptor point in the WOC floodplain at the WAG 1 boundary is consistent with what was established in the preliminary risk assessment report (IAHS 1990). The results of the WOC floodplain receptor will be used to evaluate the no-action alternative and combined with information obtained in the feasibility study to evaluate the amount of risk reduction obtained by any in-situ options for the FS. This will serve as a baseline for the relative degree of risk reduction in the future for implementation of the various options. Data from Phase II of the site characterization activities will be used in conjunction with data from ongoing site-wide monitoring programs to provide input for integration point assessments. These risk assessments will address current and future on-source OU and off-source OU exposures and will support (1) Records of Decision for interim or final actions and (2) removal actions.

4.1.1 Human Populations and Exposure Pathways

An exposure pathway is the means by which contamination from any contaminated media is transported to a receptor. The components necessary to complete the pathway are (1) a contaminated source and a mechanism for release, (2) a transport medium, (3) an exposure point, (4) potential receptors, and (5) an exposure route.

The WAG 1 Groundwater OU is located within the ORNL site and is part of the DOE ORR (which covers approximately 35,000 acres). WAG 1 is an area of 150 acres that includes most of the original research and development facilities and associated waste management units. WAG 1 Groundwater OU is situated in an industrial area and no residences or drinking water sources are currently located on the site. Security precautions currently limit the presence of persons in this controlled area; consequently, the potential for human exposure to contaminants is limited. Employment at the ORNL site (as of January 1992) consisted of approximately 5000 full-time on-site personnel, the majority of which work in the main ORNL complex. Because most of the source areas have been closed and intrusive activities are limited, exposure to the on-site worker is generally limited to a small group of maintenance-type workers and future sampling and remediation workers. Given the extensive development of the main plant area, it is expected that WAG 1 will maintain an industrial land use classification in the future.

Nine public water supply systems serve about 91,500 people within a 32-km (20-mile) radius of the ORR. The intake for Kingston, located on the Tennessee River, is about 0.6 river km (0.37 miles) above the confluence of the Clinch and Tennessee rivers and about 34.1 river km (21.3 miles) below the White Oak Dam outfall. Kingston withdraws approximately 9% of its average daily supply from the Tennessee River. Sixteen public groundwater supplies are located within a 32-km (20-mile) radius of ORNL. Of these sources, the closest to ORNL is the Allen Fine Spring supplying the Dixie-Lee Utility District in Loudon County. This groundwater source, about 11 km (6.8 miles) southeast of ORNL, serves 6700 people with an average of 1,500 m^3 (53,000 ft^3) of water per day. Private single-family wells are common in adjacent rural areas not served by public water supply. Most of the residential wells, other than those adjacent to the City of Oak Ridge, are south of the

Clinch River. These wells are hydrologically isolated from impacts originating from the ORR because of the Clinch River. The nearest resident is approximately 3.7 km (2 miles) from the WAG 1 boundary.

All drainage and effluents from WAG 1, as well as from other WAGs, discharge to WOC and therefore, to White Oak Lake. Under normal flow conditions and during precipitation events, waterborne radioactivity and radioactively contaminated sediments can be carried through White Oak Dam and discharged to the Clinch River. WAG 1 has been a historical contributor of ^{90}Sr and ^{137}Cs to the overall contaminant inventory in the WOC watershed.

4.1.1.1 On-site potential human receptors and exposure pathways

An industrial future land use for the on-source assessment of risk at WAG 1 is the most appropriate given EPA guidance. This location meets the definition for areas that are defined as industrial sites under the future land use condition; the term "on-site" strictly means buildings and their associated infrastructure for purposes of the baseline risk assessment. Selection of an industrial scenario is consistent with the NCP and EPA guidance. *Risk Assessment Guidance for Superfund* (EPA 1989) states that "an assumption of future residential land use may not be justifiable if the probability that the site will support residential use in the future is exceedingly small."

For future on-site land use, a reasonable maximum exposure risk assessment will be done based on industrial exposure at the source OUs. All water used on the ORR is imported from the Clinch River. Well yields are low in WAG 1 and are considered insufficient to serve as a reliable potable water supply currently and in the future. Because groundwater is not usable as a source of potable water at WAG 1, risk from groundwater within the site boundaries will not be assessed for the purposes of supporting specific remedial decisions. It will be assumed that future industrial receptors will continue to import their water from off-site. The emphasis for risk assessment and for remedial decisions will be on source control for groundwater contamination within the WAG 1 plant boundaries because the groundwater discharges to surface water in WOC.

4.1.1.2 Off-site potential human receptors and exposure pathways

The greatest potential for off-site human exposure is believed to be from surface water runoff and shallow groundwater discharge into WOC. The contaminants found in these integrators affect downstream surface water bodies, including the Clinch River. These water bodies are used for domestic and industrial water supply, fishing, recreation, and irrigation.

Under the current land use conditions, an integration point assessment will be used to evaluate potential exposure to off-site receptors. In brief, this assessment is designed to evaluate off-site human health risk from exposure to contaminants from the source OU (i.e., WAG 1 Groundwater OU). Conservative (residential) exposure parameters will be used to evaluate risk from ingestion of and dermal contact with surface water and for inhalation of

VOCs in the water at the WOC Dam. Contributions from the WAG 1 Groundwater OU will be ranked relative to other source OUs in the WOC watershed based on their flux contributions of contaminants of concern.

For future off-site land use, modeled results could be used to evaluate future risk to off-site receptors. Exposure pathways to be evaluated include (1) ingestion of soil and water, (2) inhalation of wind-generated dust, (3) inhalation of volatiles in water, (4) dermal contact with soil and water, and (5) external exposure to radionuclides in soil. The point of residential exposure pathway assessment for future land use is the WOC floodplain at the WAG 1 boundary as previously established in the Preliminary Risk Assessment Report.

4.1.2 Ecological Populations and Exposure Pathways

Previous ecological assessments of the WOC watershed indicate that severe effects are not occurring in the aquatic habitats of WAG 2 and a diverse and productive aquatic community is present. However, reference stream surveys of aquatic biota indicate that there is some evidence for effects on fish reproduction and on benthic invertebrate community composition. Toxicity tests that have been performed for surface water have not indicated toxicity to *Ceriodaphnia dubia* or to larval fathead minnows in 7-d exposures. As ongoing studies within the scope of WAG 2 and the Biological Monitoring and Abatement Program continue, any contaminant migration originating from WAG 1 that can be linked to detrimental environmental effects will be targeted for remedial action.

4.2 HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

The integration point assessment is a flux-based risk assessment. Flux is an important concept for source control because of the number of actual and potential sources of contaminants that exist on the ORR and the variability in flow rates of the different surface water systems that transport these contaminants to the surface water integrator OUs and eventually to the Clinch River. Source control actions taken at areas that have high fluxes of integrator contaminants of concern are the quickest means to reduce off-site exposure to levels that are as low as reasonably achievable.

An important objective during early phases of a large investigation is to assimilate available information from existing programs in order to estimate fluxes and mass balances of contaminants within the integrator system. The information is then used to assess fluxes within the watershed and compare them with fluxes that input into public access areas in order to differentiate between various contaminant sources at the ORR. Mass balance information is important to describe the accumulation of contaminants within a system where inputs and outputs are known and to assess the net impact of a reach or source area. The integration point assessment provides a means for communicating this information in terms of risk to the public and to risk managers. It also provides an important risk link between the source control and integrator OUs so that the effects of source control actions can be evaluated in the integrator.

3rd ERMA

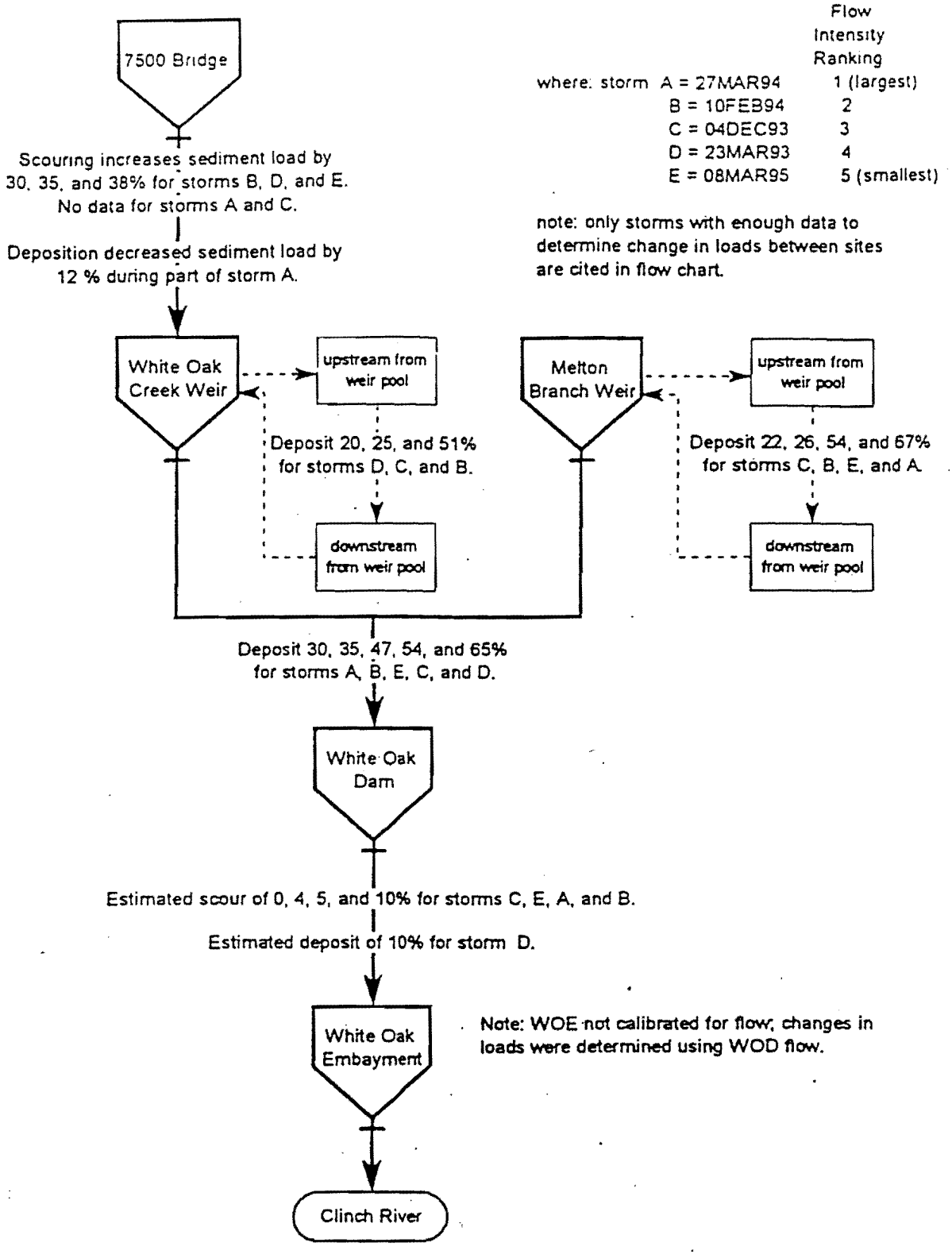


Fig. 5.2. Conceptual model of storm transport of ^{137}Cs in the White Oak Creek watershed. (Data are provisional; contaminant discharge at White Oak Dam has not been adjusted for recent revision in the weir rating curve.)

CM-1

WAG 1 Preliminary Human Health Evaluation (1992)

2.1.2 Overview of Site Conditions

The WOC floodplain area used for the PHHE is at the southwestern end of WAG 1. The area is not fenced but is marked as a radiation area. Trees, grasses, and other vegetation cover the area. Access to this general area is restricted by guard stations located on nearby access roads. When the stations are not manned, a barrier is used to restrict road traffic. It has been known for some time that the floodplain soil was contaminated with cesium-137 as a result of historic discharges. The RI floodplain soil sampling program was designed to determine the extent of cesium-137 contamination and ascertain the presence and concentrations of other contaminants. The surface water sampling program was designed to provide information on the nature and concentration of contaminants in the surface water.

The samples used for the PHHE represent a small portion of the total number collected during the Phase I RI. A larger portion of these samples are used for the EE and the HSI. Data from all samples collected are used in the SCSR to describe the nature and extent of contamination. These samples also provide a technical foundation and source of information for future OU-specific environmental restoration activities. Site conditions are summarized in the WAG 1 Document Summary and discussed in detail in the SCSR. The rationale for using this subset of the samples is presented in Sect. 2.1.4.1.

2.1.3 Objectives

The primary objectives of the PHHE are presented in Sect. 1.3.1. Briefly, these are to

- assess the need for remedial action to control migration of contaminants from WAG 1,
- assess the need for remedial action for the WAG 1 WOC floodplain soils,
- provide a basis for comparison with other ORNL WAGs, and
- provide a basis for evaluating reduction of contaminant migration as a result of remediation relative to risk.

2.1.4 Approach

A hypothetical resident receptor on the WOC floodplain was evaluated under a no-action scenario; the following paragraphs explain why this receptor was chosen and how the PHHE was performed.

2.1.4.1 Hypothetical receptor

A hypothetical resident living on the WOC floodplain between the 7500 bridge and the main plant area fence (Fig. 1.1.2) was chosen as the receptor for the PHHE. This decision was made after consideration of the site conceptual model, EPA guidance, and the objectives for the PHHE.

The site conceptual model for WAG 1, presented in the SCSR ~~(Sect. 5.2)~~, assumes that groundwater flow, with its associated contaminant movement, eventually discharges to WOC upstream of the 7500 bridge. WOC also receives overland storm flow, any infiltration of groundwater to the storm sewer system, and eroded soil, as well as discharges permitted under the state's National Pollutant Discharge Elimination System (NPDES) program. It is currently believed that most, if not all, waterborne releases of environmental contaminants that originate within WAG 1 are received in WOC upstream of the 7500 bridge. A receptor exposed to the water of WOC at the WOC floodplain would be exposed to any contaminants migrating off site from WAG 1 (at upstream locations). While these are not necessarily the greatest concentrations that are present in surface water or groundwater within WAG 1, the WOC floodplain is the only area where surface water samples would represent influence from the entire WAG.

As a result of discussion at the December 4, 1991, DOE Technical Working Group meeting mentioned previously, it was decided that the human health evaluation for the first phase of the WAG 1 RI should be generalized and represent an evaluation of the risk from the overall WAG. It was also determined that since this human health evaluation will be used to document the need for continued action, it need not be as detailed as a human health evaluation presented in support of a no-further-action decision.

The PHHE intentionally only addresses discharges that represent present-day releases from WAG 1 as a whole. The analyses presented in this PHHE likely do not estimate the full magnitude of potential risk associated with individual OUs or sources of contamination within the WAG. Other potential risks (i.e., scenarios) will be addressed in future OU-specific risk assessments.

2.1.4.2 PHHE methodology

A no-action scenario was developed that assumed DOE's current access restrictions (including warning signs, patrols, and institutional controls) for the WOC floodplain became ineffective immediately, allowing a resident to occupy a homestead on the WOC floodplain. Although this is not a reasonable scenario for WAG 1, it allows evaluation of a no-action scenario as required under Sect. 300.430(e) of the National Contingency Plan (NCP) (EPA 1990a).

Approaches for quantifying conservative and nonconservative exposures were patterned after the approach used in *Preliminary Screening of Contaminants in the Off-Site Surface Water Environment Downstream of the U. S. Department of Energy Oak Ridge Reservation* (Hoffman et al. 1990). A conservative approach was designed such that there is high confidence that the actual risk is not underestimated. A nonconservative approach was designed to represent limited exposure at the site such that there is high confidence that the actual risk is not overestimated. These two approaches serve to put the calculated risk values into perspective.

5. SUMMARY AND CONCLUSIONS

5.1 PRELIMINARY HUMAN HEALTH EVALUATION

The PHHE was developed from data collected during the Phase I RI at WAG 1. Phase I, as well as previous investigations, identified contaminants present on and migrating from the WAG. Contaminants identified include radionuclides, organics, and inorganics.

Risk was calculated for a hypothetical WOC floodplain resident receptor. Two approaches, one conservative and the other nonconservative, were assessed for reasonable maximum and average exposure assumptions, respectively. The PHHE results indicated that risks to the hypothetical WOC floodplain receptor were greater than EPA's upper risk limit of 10^{-4} for radioactive contaminants of potential concern for both conservative and nonconservative approaches. For chemical contaminants of potential concern, the risk was greater than EPA's lower risk limit of 10^{-6} for the conservative approach. The PHHE results establish a need for continued action to address radioactive contaminants migrating in surface water in WOC as well as contaminated soils in the WOC floodplain.

Risk from radioactive contaminants was driven by radium-228 and strontium-90 and their daughters for ingestion of surface water and by cesium-137 and its daughter for direct exposure to the floodplain soils. For chemical contaminants, the potential carcinogenic risk for the conservative approach fall between the upper and lower bounds of EPA's target risk range. The noncarcinogenic hazard index for ingestion of surface water as drinking water (at 2.3 for the conservative approach) is greater than the adverse effect threshold of 1. Assessment of secondary exposure pathways (e.g., ingestion of vegetables irrigated with chemically contaminated water) would probably not yield a significant increase in the current risk values because one of the chemicals driving the chemical carcinogenic risk (p-dioxane) is characterized by a low K_{ow} and does not readily bioaccumulate. In addition, the noncarcinogenic risk is a result of ingestion of drinking water, and the chemical driving this risk (pyridine), is also characterized by a low K_{ow} and is not readily bioaccumulated. Many of the remedial actions that might be taken at WAG 1 to address migration of radioactive contaminants would probably produce a significant mitigation of chemical contaminant migration. With these considerations in mind, the need for further definition of the potential risks due to chemicals is probably not necessary.

When the WAG 1 PHHE results are used to compare the risk attributable to WAG 1 as a whole with the risk from other WAGs, it should be determined whether a larger or smaller number of pathways (especially secondary pathways) have been assessed for the other WAG. Assessment of different pathways for other WAGs could result in a total risk number that might not be comparable to the WAG 1 PHHE calculated risk.

The PHHE risk values should provide a basis for either quantitative or qualitative risk reduction comparisons for WAG 1 OU-specific alternatives evaluations. In these comparisons, consideration should be given to comparing the potential increased risk to workers from OU-specific remediation activities with the risk reduction for the hypothetical WOC floodplain receptor.

5.1.1 Scope

The hypothetical WOC floodplain resident was selected for evaluation under a no-action scenario based on the site conceptual model, EPA guidance, and the objective of the PHHE. The objective of the PHHE was to determine the potential threat to a hypothetical WOC floodplain resident receptor to

- assess the need for remedial action to control migration of contaminants from WAG 1,
- assess the need for remedial action for WOC floodplain soils,
- provide a basis for comparison with other ORNL WAGs, and
- provide a basis for comparison with risk reduction estimates during WAG 1 OU-specific alternative evaluations.

The site conceptual model assumes that groundwater flow (and associated contaminant movement) at WAG 1 eventually discharges to WOC before leaving the WAG. The location of the hypothetical resident exposes him or her to any contaminants migrating off site from WAG 1 via water pathways.

As required by the NCP (EPA 1990a), effects on the receptor were evaluated under a no-action scenario, which assumed that DOE's current access restrictions for the WOC floodplain (i.e., outside the WAG 1 fence) became ineffective immediately. Although this is an unrealistic assumption, it is required by the National Contingency Plant (EPA 1990a). Both conservative and nonconservative approaches were used to calculate a range of risk to the hypothetical receptor.

The *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual* (EPA 1989) and other EPA and ORNL guidance documents were used in preparing the PHHE. The PHHE consisted of four components: selection of contaminants of potential concern, exposure assessment, toxicity assessment, and risk characterization.

5.1.2 Selection of Contaminants of Potential Concern

Contaminants of potential concern were selected from surface water and soil samples taken under the Phase I RI. The PHHE included all soil and surface water samples taken in the WOC floodplain and reference samples taken from upgradient locations. Chemical and radioactive contaminants of potential concern were selected by excluding contaminants (e.g., they were naturally present in the environment, were below reference concentrations, were essential nutrients, or did not contribute significantly to risk).

The selection process resulted in a list of 7 radioactive and 21 chemical contaminants (4 VOCs, 9 semivolatile organics, and 8 inorganics) of potential concern.

5.1.3 Exposure Assessment

Because WAG 1 is on the ORR, all land around it is government-owned and there are no residents. Risks to the hypothetical resident were evaluated under a no-action scenario which assumed that DOE's current access restrictions at the WOC floodplain became ineffective immediately. Although this scenario is not reasonable because DOE plans to continue operating ORNL well into the future, it was used because a no-action scenario is required under the NCP.

Conservative and nonconservative approaches were used to estimate a range of risk for the hypothetical receptor using exposure factors developed by ORNL (White 1992). The conservative approach used reasonable maximum exposure parameters, and the nonconservative approach used average exposure parameters.

Five potential primary exposure pathways were evaluated:

- direct exposure to ionizing radiation from WOC floodplain soils,
- inhalation of particulates, volatiles, and evaporated tritium,
- ingestion of surface water for drinking,
- incidental ingestion of WOC floodplain soil, and
- dermal contact with WOC floodplain soil and surface water (for chemical contaminants only).

Secondary exposure pathways (e.g., eating vegetables grown in contaminated soil) were not evaluated because the initial assessment was that the total risk for primary pathways alone would exceed the EPA action threshold of 10×10^{-4}.

Except for inhalation, the specific concentrations of contaminants used to assess exposures were from environmental media samples collected during the Phase I RI. For inhalation, modeling was used to estimate air concentrations of VOCs and evaporated tritium from surface water and particulate-bound contaminants from soils.

5.1.4 Toxicity Assessment

Toxicity values (slope factors and reference doses) were identified for contaminants of potential concern in surface water and soil for the ingestion, external exposure, and inhalation pathways. Toxicity values were identified for all seven of the potential radioactive contaminants of concern. Seven of the nine semivolative organic and two of the eight inorganic contaminants of potential concern did not have toxicity values and were not considered further in the evaluation. All of the radioactive and seven of the chemical contaminants of potential concern are classified as known or probable human carcinogens. Nine of the chemical contaminants of potential concern are classified as noncarcinogens.

5.1.5 Risk Characterization

5.1.5.1 Risk from radioactive contaminants of potential concern

Risks from radioactive contaminants of potential concern for the nonconservative and conservative approaches were 4.0×10^{-4} and 3.8×10^{-2}, respectively. Both of these exceed the upper limit of EPA's target risk range (10^{-4}). External exposure is the dominant pathway (approximately 99% of the total risk from radioactive contaminants of potential concern). The risk due to external exposure was calculated two ways, one using the radionuclide-specific RI sampling data and the other using dose measurements from the USRADS walkover survey. The results from both methods were within the same order of magnitude. Cesium-137 and daughter were responsible for the majority of the risk from direct exposure.

The risk from ingestion of drinking water also exceeded the upper end of EPA's risk range (10^{-4}). Radium-228, strontium-90, and daughters were the major contributors to this risk.

5.1.5.2 Risk from chemical contaminants of potential concern

Carcinogenic risks from chemical contaminants of potential concern for the conservative and nonconservative approaches were 1.9×10^{-5} and 8.1×10^{-7}, respectively. These risks do not exceed the upper limit of the EPA's target risk range (10^{-4}), but for the conservative approach, they do exceed the lower limit (10^{-6}). Ingestion of surface water was the primary pathway for the conservative exposure assumptions (approximately 84% of the total risk from chemical contaminants of potential concern). p-Dioxane and dichlorobromomethane were the primary contributors to carcinogenic risk for ingestion of surface water (conservative approach).

Only ingestion of surface water using the conservative approach resulted in a noncarcinogenic hazard index greater than 1. The hazard index for this pathway was 2.3; the volatile organic pyridine was the only chemical with a hazard index greater than 1 (1.9). Pyridine produces adverse effects on the liver.

5.1.6 Identification of Uncertainties

Each step of the PHHE (selection of contaminants of potential concern, exposure assessment, toxicity assessment, and risk characterization) contributes uncertainty to the final risk estimates. Uncertainties were addressed qualitatively. The individual sources of uncertainty were discussed and categorized regarding whether they have the potential to overestimate risk, underestimate risk, or both. Qualitative assessments are also made as to the effect of each uncertainty on meeting the objectives of the PHHE. Given this uncertainty, the risk estimates should not be taken as an absolute indicator of whether adverse health effects could occur. Rather, they should be used as a gauge for the need for remedial action, as a means for comparison with other WAGs, and for future comparison in the alternatives assessment process to evaluate risk reduction.

5.2 ENVIRONMENTAL EVALUATION

Relying on a combination of BMAP studies and data collected during the Phase I RI, the EE demonstrated that there is a present or potential risk of detrimental effects to the environment in the absence of any remediation at WAG 1.

Data from BMAP studies indicated that surface waters have elevated levels of metals and elevated temperatures. Most of Fifth Creek and the middle section of WOC receive substantial inputs of chlorine and other toxicants. Studies on biota reported that benthic macroinvertebrate, periphyton, and fish populations all appear to be impacted by ORNL operations. In addition, both waterfowl and groundhogs collected from WAG 1 had high tissue concentrations of radionuclides.

Concentrations of contaminants detected during Phase 1 were compared with the NAWQC for surface water and with RCRA action levels (EPA 1990b) for soils and sediments to determine the initial list of contaminants of potential concern. The reference levels and known toxicity were then considered in further reducing the number of contaminants. Of the nonradiological contaminants, mercury and PCBs are likely to cause adverse effects to aquatic species and piscivorous animals. Several contaminants [cadmium, chromium, lead, copper, aluminum, silver, and bis(2-ethyl-hexyl)phthalate] are likely to cause adverse effects to aquatic species, but information was generally insufficient to assess their potential for detrimental effects to terrestrial species. Although beryllium and antimony are present in concentrations that might pose a hazard to biota, there is insufficient toxicity information on their effects to nonhuman species to evaluate their potential effects on WAG 1 biota.

Regulatory guidelines for radionuclides for the protection of environmental receptors are lacking, and information on radiation effects in the natural environment on WAG 1 species is limited, thus precluding an assessment of their specific effects. However, on the basis of BMAP studies that reported deposition in body tissues and the high concentration of radionuclides in WAG 1, it is likely that some detrimental effects are occurring at least to individual inhabitant species.

5.3 HAZARD SCREENING INDEX

A methodology for calculating the relative hazard of the OUs in WAG 1 was derived from EPA's rHRS (EPA 1990c). The HSI is one of two factors used in the prioritization of OUs (the other is a qualitative assessment of exposure potential) in the OUSD. Modifications were made to enhance the differentiation of OUs relative to concentration, toxicity, and quantity of contaminated material present.

5.3.1 Method

The HSI is the product of a concentration-weighted toxicity factor and a waste quantity factor; this is illustrated by the following equation:

$$HSI = CWTF \times WQF$$

where

HSI	=	hazard screening index
CWTF	=	concentration-weighted toxicity factor
WQF	=	waste quantity factor

The CWTF is the summation of the individual CWTF values for each hazardous constituent that exceeds its risk-based benchmark concentration for a given medium. The benchmark against which all concentrations are compared corresponds to a 10^{-6} individual cancer risk for carcinogens or to the reference dose for noncarcinogens. To determine a CWTF, a toxicity value is assigned to each hazardous constituent within an OU, as described in the rHRS. On the basis of the concentration of the constituent as reported in the sampling data, the toxicity value is weighted to give an individual CWTF value. Individual CWTF values are summed to determine the total CWTF for the OU.

The calculation of the WQF follows the methods discussed in the rHRS guidance. The WQF is based on the volume of contaminated materials associated with each OU. Both chemical and radionuclide WQFs are calculated; the chemical and radionuclide WQFs are summed to give the total WQF for the OU.

5.3.2 Results

The HSI values are used to establish a ranked order of OUs. The higher the HSI score, the higher the ranking and associated hazard for that OU. For the WAG 1 OUs, the HSI score for the Gunite tanks (liquids and sludges) was the highest (1.72×10^{23}), followed by groundwater, surface impoundments (liquids and sludges), and steel tanks (liquids) with scores of 6.43×10^{17}, 4.02×10^{16}, and 2.47×10^{15}, respectively. The lowest score was for SWSA 2 (0). Values for the remaining OUs ranged from a low of 3.25×10^{6} (pipeline discharges) to a high of 1.26×10^{13} (3000 watershed soils).

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NO ADDITIONAL INFORMATION IS AVAILABLE

WAG 1 Burial Grounds - Data Summary

- Burial grounds at WAG 1 include SWSA 1, SWSA 2 (Site 4003), Buried Waste at the Nonrad Water Treatment Site, Former Waste Pile Area, Abandoned Burn Pit, and the West End Dump Site.

- SWSA 1 is contaminated with unknown radionuclides and unidentified chemical constituents. The presence of drummed waste is suspected on the basis geophysical survey data and radiological contamination of groundwater exists near SWSA 1.

- SWSA 2 is reported to contain no waste. However, geophysical surveys suggest the presence of isolated metalic objects buried at the site.

- Buried waste was discovered during construction activities at the Nonrad Water Treatment Site. Excavated materials included general construction debris, glass bottles, transite, carbon blocks, and metal shavings. Some lead-contaminated soil was removed from the site. Personal reports suggest that additional buried waste exists at the site.

- The Former Waste Pile Area was used for disposal of waste from construction operations and as a soil borrow area. Exact dimensions and capacity of this area are not known.

- Little information is available for the West End Dumpsite and the Abandoned Burn Pit sites.

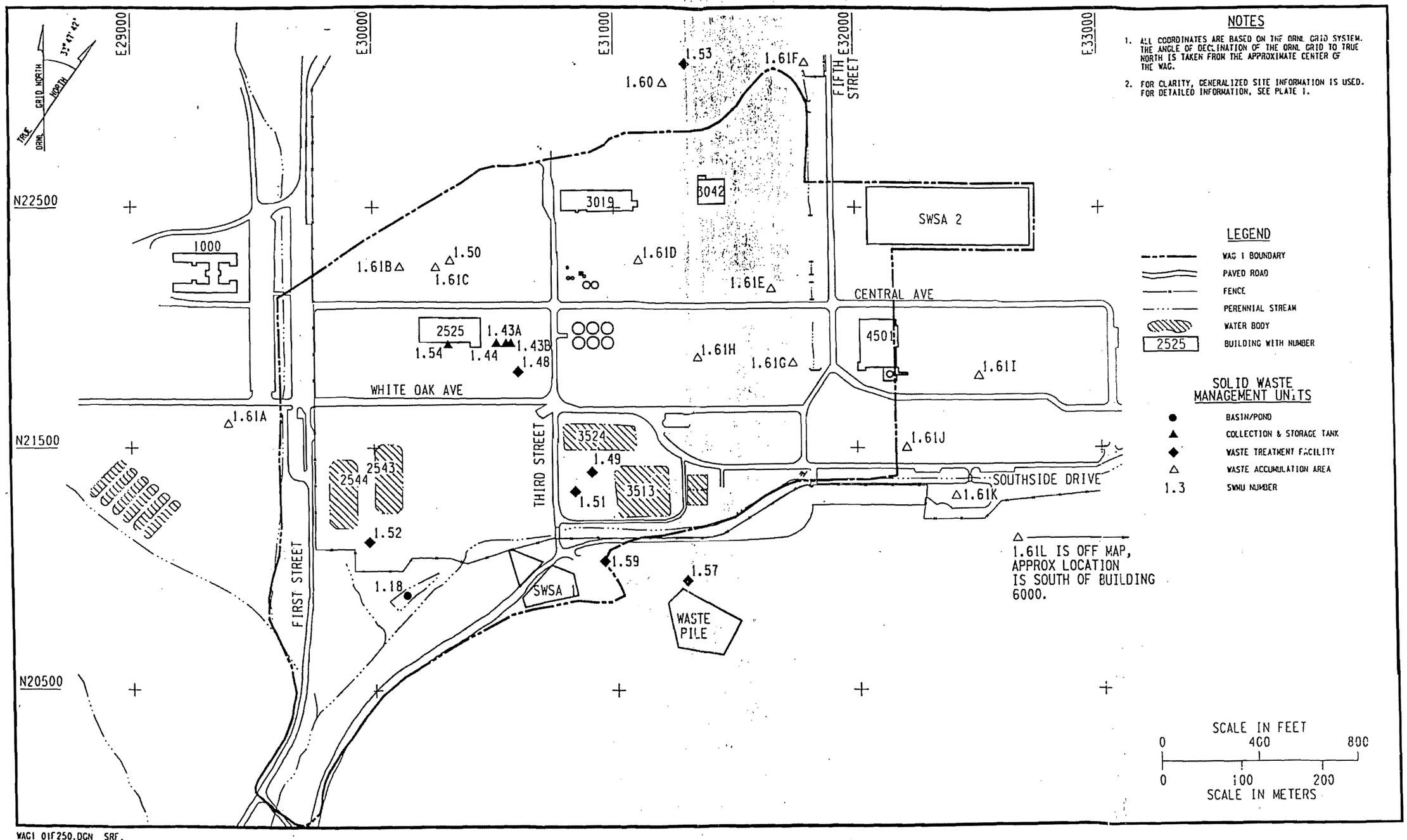

Fig. 3.5.2. SWMU waste storage and treatment facility.

DATA SUMMARY SHEET FOR WASTE AREA GROUPING 1
CERCLA Status:

Waste Unit Description	Unit Type	Status	Size/ Capacity	Ownership	Waste Forms	Inventory					Contaminant Releases				Hydrologic Model		Potential Risk (note 1)			
																	Human		Ecological	
						RAD	TRU	PCB	Hg	Other*	Surface Water	Groundwater	Soil	Sediment	Hydrologic Class	Transport Pathways	Current	Future	Current	Future
SWSA 1	BW	I	~ 1 acre	EMEF	SdW/SB	X				X	◒	◒	◒	◒	◒	◒	◒		◒	
SWSA 2	BW	I	3.6 acres	EMEF	SdW/SB					X	NA	◒	◒	O	◒	◒	◒		◒	
West End Dump Site	BW	I	10' x 8'	EMEF	SdW/SB					X	O	O	O	O	O	O				
Abandoned Burn Pit	BW	I	Not Available	EMEF	SdW/SB	X				X	O	O	O	O	O	O				
Former Waste Pile Area	BW	I	1.58 acres	EMEF	SdW/SB					X	O	O	◒	O	◒	◒	◒		◒	
Buried Waste at Nonrad Water Treatment Site	BW	I	Not Available	EMEF	SdW/SB					X	O	O	O	O	◒	◒				

Unit Types:
B = Building
T = Tank
R = Reactor
P = Pipeline
DD = D&D Facility
BW = Buried Waste
I = Impoundment
CS = Contaminated Soil
CG = Contaminated Groundwater
CW = Contaminated Surface Water

Status:
A = Active
T = Transition
I = Inactive
R = Remediated

Ownership:
(See Attachment 1)

Waste Forms:
G = Gas
GW = Groundwater
SW = Surface Water
SD = Sediment
SL = Sludge
SS = Surface Soil
SB = Subsurface Soil
L = Liquid
SdW = Solid Waste

*** Other:**
VOA
Metals

Well Defined: ●
Partially Defined: ◒
Not Defined: O

Notes:
1. Potential Risk is for WAG 1 in general and not specific to the burial grounds
2. Waste inventory at the Abandoned Burn Pit is suspected, not confirmed.

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000274

Bethel Valley RI/FS Historical Data Review

Form Completed by: [illegible]
Date: 4/1/97

Document Reviewed: Remedial Investigation Plan for OU1 at ORNL
Doc ID: DOE/OR/01-1252 & D1
Author/Date: SAK 3/94

Comments: Summary information on SWSA 1 & SWSA 2
Map showing gw-contamination (risk) overview

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence

General:
NA = Not Available
NR = Not Researched
(blank) = Unknown

Sampling Media:
surface soil
subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

Sampling Protocol:
G = grab
SG = stormflow grab
BG = baseflow grab
FC = flow composite
SC = spatial composite
V = vertical profile
S = site survey

Analytical Fraction:
I = Inorganics
O = Organics
P = PCBs/Pesticides/Herbicides
GR = gross alpha/beta
ISO = isotopic rads
B/G = beta/gamma survey
FLD = field measurements

Decision Rule / Hypothesis
1 = Source characteristics
1A = design/operation
1B = leachate
1C = waste inventory
1D = waste unit hydrology
1E = other FS information
2 = Current releases
2A = shallow groundwater, seeps
2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000275

000276

Bethel Valley RI/FS Historical Data Review

Form Completed by: M Collins/Gerald
Date: 4/7/97

Document Reviewed: Site Characterization Summary Report 9/92
Doc ID: ORNL/ER/SRB/87-99053/59/V2
Author/Date: Beckel et al

Comments:

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
1	GW	SWSA 1		'75	GW	WELL 1-1		ISO		L-M
		SWSA 2		"		1-2		ISO		L-M
				"		SEP 1-1		ISO		L-M

General:
NA = Not Available
NR = Not Researched
(blank) = Unknown

Sampling Media:
surface soil
subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

Sampling Protocol:
G = grab
SG = stormflow grab
BG = baseflow grab
FC = flow composite
SC = spatial composite
V = vertical profile
S = site survey

Analytical Fraction:
I = Inorganics
O = Organics
P = PCBs/Pesticides/Herbicides
GR = gross alpha/beta
ISO = Isotopic rads
B/G = beta/gamma survey
FLD = field measurements

Decision Rule / Hypothesis
1 = Source characteristics
1A = design/operation
1B = leachate
1C = waste inventory
1D = waste unit hydrology
1E = other FS information
2 = Current releases
2A = shallow groundwater, seeps
2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000027

000278

Bethel Valley RI/FS Historical Data Review

Form Completed by: M. Allen Sigmond
Date: 4/7/97

Document Reviewed: Site Description of ER Units at ORNL
Doc ID: ORNL/TM-391
Author/Date: Rubenstein/Parker 2/97

Comments: Good site description - no data

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
1	SWSA 1	BW	INACTIVE							
1	SWSA 2	"	owned by							
1	Former Waste Site	"	EMEF							
1	Wetland Impoundment	"								
1	Ab. Burn Pit	"								

General:
NA = Not Available
NR = Not Researched
(blank) = Unknown

Sampling Media:
surface soil
subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

Sampling Protocol:
G = grab
SG = stormflow grab
BG = baseflow grab
FC = flow composite
SC = spatial composite
V = vertical profile
S = site survey

Analytical Fraction:
I = Inorganics
O = Organics
P = PCBs/Pesticides/Herbicides
GR = gross alpha/beta
ISO = isotopic rads
B/G = beta/gamma survey
FLD = field measurements

Decision Rule / Hypothesis
1 = Source characteristics
1A = design/operation
1B = leachate
1C = waste inventory
1D = waste unit hydrology
1E = other FS information
2 = Current releases
2A = shallow groundwater, seeps
2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000279

0002230

DOCUMENTS REVIEWED

Site Characterization Summary Report for Waste Area Grouping 1 at Oak Ridge National Laboratory, Oak Ridge, Tennessee (Volumes 1-5) DOE/OR-1043/V1&D1, September 1992.

Remedial Investigation Work Plan for the Groundwater Operable Unit at Oak Ridge National Laboratory, Oak Ridge, Tennessee, DOE/OR/01-1252&D1, March 1994.

Site Descriptions of the Environmental Restoration Units at Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL/ER-391, February 1997.

Surveillance and Maintenance Plan for Waste Area Groupings at Oak Ridge National Laboratory, Oak Ridge, Tennessee, for FY 1993-2002, ORNL/ER-39, December 1992.

Annual Summary Report on the Surveillance and Maintenance Activities for the Oak Ridge National Laboratory Environmental Restoration Program for Fiscal Year 1995, ORNL/ER-345, November 1995.

UNIT NAME: Solid Waste Storage Area (SWSA) 1 - (2624)

Unit Number:

Project Status: Remedial Investigation completed (Bechtel et al 1992)

Unit Location: SWSA 1 is located in Bethel Valley at the foot of Haw Ridge, and the closest edge is ~ 25.0 ft (7.6 m) south of White Oak Creek. ORNL grid coordinates are N 20,980 ft and E 30,710 ft. (ORNL 1990)

Approximate Dimensions and Capacity: The site is triangular in shape and encompasses ~ 1 acre (0.4 ha). It is fenced and grassed. (ORNL 1990)

Dates Operated: Site commissioned: 1943. Taken out of service: 1944. (ORNL 1990)

Present Function: Not in operation.

Life Cycle Operation: SWSA 1 was the first area used for burial of low-level solid wastes. (ORNL 1990). Contaminated solid wastes were buried in SWSA 1 in trenches using earthen cover. (Bechtel et al 1992)

Waste Characteristics: The burial ground is contaminated with unknown radionuclides and unidentified chemical constituents. Only a small amount (2,000 - 4,000 Ci) of solid radioactive waste was buried in SWSA 1. (ORNL 1990)

In 1987 a surface radiological investigation of SWSA 1 was conducted by ORNL. Results from this survey show that most of the surface gamma radiation of SWSA 1 is due to radiation emanating from nearby White Oak Creek. Measurements of gamma levels determined that exposure rates at the surface were generally elevated above typical ORR background values (13 uR/h), ranging from 20 to 200 uR/h. (ORNL 1990)

Results of the 1992 WAG 1 Site Characterization Summary Report indicate elevated groundwater concentrations of strontium-90, and radium-228, very low levels of plutonium-238/239/240, and cesium-137 in proximity to SWSA 1. Soil samples were contaminated with CS-137 significantly above reference. (Bechtel et al 1992)

Release Data: The burial ground lies within the pathway of surface water drainage from Haw Ridge to White Oak Creek, causing marshes to develop in the topographically low portions of the area following periods of heavy rains and wet seasons. (Bechtel et al 1992). Groundwater movement in the area is to White Oak Creek and is, therefore, monitored via the ORNL Stream Monitoring System. Monitoring activity in 1973 (when water samples were taken from two monitoring wells and a surface seep) indicated a low concentration of Sr-90. In 1975, water samples were taken from two wells and a surface seep and analyzed for Sr-90, Cs-137, and transuranic elements. The results from one well indicated low concentrations of Sr-90 (9.4 dpm/mL) and no indication of Cs-137 or transuranic elements. (ORNL 1990)

Site Status: CERCLA (ORNL 1990)

Media of Concern: Groundwater

Comments: This site was included in a CERCLA remedial investigation (Bechtel et al 1992) and will be remediated in accordance with the FFA.

References:

Bechtel National, Inc./CH2M Hill/Ogden/Peer, September 1992. *Site Characterization Summary Report for Waste Area Grouping 1 at Oak Ridge National Laboratory*, DOE/OR-1043/V1 & D1, Oak Ridge, Tennessee.

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

A.1.1 Solid Waste Storage Area 1

1. SITE NAME: Solid Waste Storage Area 1 (2624).

2. LOCATION: SWSA 1 is located in BV at the foot of Haw Ridge, approximately 25 ft south of WOC and is bisected by the south portion of Third Street. ORNL grid coordinates are N 20,980 and E 30,710.

3. SERVICE DATES: 1943 to 1944, with the earliest recorded waste burial being in April and May 1943.

4. STATUS: Inactive; controlled by WMRAD (L. Holder, Jr.).

5. DESCRIPTION:

   (a) Operating History—SWSA 1 began operating in 1943. Both auger holes and trenches were reportedly used for waste burial. No records exist concerning what was buried at SWSA 1 nor the exact locations where burial occurred. However, it is suspected that only a relatively small amount of radioactivity (2000 to 4000 Ci) was buried here since fissionable material was conserved during this period and ORNL operations did not include isotope separation and concentration during its use.

   (b) Physical Description—The site is triangular in shape and encompasses approximately 1 acre. The portion south of Third Street slopes upward, while the northern section is relatively flat and seasonally marshy. It appears that the specific location was selected primarily on the basis of its proximity to the Laboratory with no consideration of the potential of waste leaking into nearby WOC. Groundwater occurs below the site at a comparatively shallow depth and, according to water table contour maps, moves in the general direction of WOC. This water is monitored via the ORNL Stream Monitoring System.

   (c) Current Condition—The site is now grassed, surrounded by a barbed wire fence with "Radiation Hazard—Keep Out" signs at regular intervals and does not show signs of unusual erosion. No subsided trenches have been discovered at the site.

   (d) Radiological Hazards—No surface contamination or radiation fields significant enough to warrant a "contamination" or "radiation" zone, per the ORNL *Health Physics Manual*, have been discovered at SWSA 1. The radionuclide inventory is reported to be in the range of 2000 to 4000 Ci, as discussed above.

6. SECURITY/PROTECTION SYSTEMS: Although located in BV, SWSA 1 is outside the main ORNL complex. It is accessible via Lagoon Road and Third Street and during nonworking hours is part of the ORNL limited access area. It is surrounded by a barbed wire fence with "Radiation Hazard—Keep Out" signs at regular intervals.

7. SURVEILLANCE ACTIVITIES: See Table A.1.1-1 for details of surveillance activities.

8. ROUTINE MAINTENANCE: See Table A.1.1-2 for details of maintenance activities.

Sam

Table A.1.1-1. Surveillance activities—SWSA 1

Activity	Frequency	Responsibility	Documentation	Staffing/ resource requirements
1. Routine site inspection	Weekly	WMRAD[a]	S&M checklist[b]	200 wh/y[c]
2. Radiological surveillance				
(a) Surveys for grounds maintenance	As required	EHP[d]	Radiation Protection data base	15 wh/y[e]
(b) Routine radiation survey	Semiannual	EHP	Radiation Protection data base	45 wh/y
3. Groundwater well sampling	Semiannual	EHP	Environmental Monitoring data base	*e*
4. Surface water monitoring	Continuous	EHP	WOCC data base[f]	*e*
5. Security patrol	Daily	LP[g]	Daily security report	*e*

[a]WMRAD = Waste Management and Remedial Action Division.
[b]S&M = surveillance and maintenance.
[c]wh/y = work-hours per year.
[d]EHP = Environmental and Health Protection.
[e]Costs are included in ORNL overhead charges. No WAG S&M funding is required.
[f]WOCC = Waste Operations Control Center.
[g]LP = Laboratory Protection.

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000288

Table A.1.1-2. Maintenance activities—SWSA 1

Activity	Frequency	Responsibility	Documentation	Staffing/ resource requirements
1. Routine maintenance				
(a) Vegetation maintenance	As required	WMRAD/P&E[a,b]	S&M log[c]	280 wh/y[d]
(b) Fence/gate repairs	As required	WMRAD/P&E		50 wh/y

[a]WMRAD = Waste Management and Remedial Action Division.
[b]P&E = Plant and Equipment.
[c]S&M = surveillance and maintenance.
[d]wh/y = work-hours per year.

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000290

UNIT NAME: Solid Waste Storage Area (SWSA) 2 - (4003)

Unit Number: 01.47

Project Status: Remedial Investigation Completed (Bechtel et al 1992)

Unit Location: SWSA 2 is located on the south side of a hill near the east entrance and main parking area of ORNL, northwest of Building 4500. ORNL grid coordinates are N 22,420 ft and E 32,310 ft. (ORNL 1990)

Approximate Dimensions and Capacity: The disposal area is a rectangular area of ~3.6 acres (1.4 ha). It is currently unfenced and has a grass cover. (ORNL 1990)

Dates Operated: Site commissioned: 1944. Taken out of service: 1946. (ORNL 1990)

Present Function: Not in operation.

Life Cycle Operation: The area was used for disposal of solid waste contaminated with beta or gamma activity, liquid waste contaminated with plutonium in stainless steel drums, and alpha-contaminated material from off-site locations. (Bechtel et al 1992)

Waste Characteristics: The burial site is reported to contain no waste. The burial waste and contaminated soil were moved to another site (SWSA 3) some time after the site was closed in 1946. There have been unsubstantiated reports that some wastes remain buried at the site. (Bechtel et al 1992)

Release Data: No significant migration of radionuclides has taken place from SWSA 2. Coring was conducted in 1976 on the site as a part of subsurface investigations for a new building. Analysis of these samples indicated that the soil and water from 25 locations around the site did not contain concentrations of tritium, gross beta, or gross alpha levels that were significantly higher than background samples collected throughout eastern and central Tennessee. (ORNL 1990)

Site Status: CERCLA (ORNL 1990)

Media of Concern:

Comments: This site was included in a CERCLA remedial investigation (Bechtel et al 1992) and will be remediated in accordance with the FFA.

References:

Bechtel National, Inc./CH2M Hill/Ogden/Peer, September 1992. *Site Characterization Summary Report for Waste Area Grouping 1 at Oak Ridge National Laboratory*, DOE/OR-1043/V1 & D1, Oak Ridge, Tennessee.

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

Date Prepared: December 1996

Photo: 06_22.JPG; 06_23.JPG; 26_08.JPG

A.1.2 Solid Waste Storage Area 2

1. SITE NAME: Solid Waste Storage Area 2.

2. LOCATION: SWSA 2 is located on the south side of a hill near the east entrance and main parking area of the Laboratory, northwest of Bldg. 4500. 200 ft north of Central Avenue and 135 ft west of 5th Street. ORNL grid coordinates are N 22,500 and E 32,500. An access road to a transformer station passes through the northwest corner of the SWSA.

3. SERVICE DATES: 1944 to 1946.

4. STATUS: Inactive; controlled by WMRAD (L. Holder, Jr.).

5. DESCRIPTION:

   (a) Operating History—SWSA 2 was opened shortly after the closing of SWSA 1 in 1944. The area was selected because of its proximity to the OGR and processing facilities to provide easier, all-weather access to the burial ground. There are no available records documenting the quantity or type of waste disposed of in SWSA 2. However, it has been established that beta- and gamma-contaminated solid waste was placed in black iron drums and buried in trenches. In addition, liquid waste contaminated with plutonium was placed in stainless steel drums and either buried in trenches or stored above ground in a ravine in the denuded slope. SWSA 2 was closed in 1946 when it was determined that it was not compatible with the long-range land-use planning at ORNL. Following closure of SWSA 2, the stainless steel drums containing the plutonium-contaminated liquid waste were removed and transferred to SWSA 3, but the iron drums containing beta- and gamma-contaminated solid waste had deteriorated. Because of this condition, the drums and surrounding soil in SWSA 2 were removed and reburied in SWSA 3. Sometime during the period 1946–1949, the hillside of SWSA 2 was bulldozed, contoured, and seeded.

   (b) Physical Description—The site is rectangular in shape, 300 ft × 650 ft (3.5 acres).

   (c) Current Condition—The site is currently unfenced with a grass cover that has stabilized the soil. To further reduce erosion, a contour ditch was installed to direct runoff from points above the burial ground around the hillside without crossing the trench area. Surface water runoff from within the site is carried by another ditch to the storm sewer system.

   (d) Radiological Hazards—In 1977, core samples were taken at various points in SWSA 2 and water samples taken from the core holes. Soil was analyzed for uranium, plutonium, and ^{137}Cs; the results indicated lower levels than samples collected in 1976 from 16 sites throughout eastern and central Tennessee. Likewise, water samples that were analyzed for tritium, gross alpha, and gross beta activity had levels not significantly different from background samples.

→tm

6. SECURITY/PROTECTION SYSTEMS: SWSA 2 is within the ORNL BV secured area. Because historical accounts and environmental sampling efforts confirm that waste buried in SWSA 2 has been removed, no boundary fence or warning signs exist at this site.

7. SURVEILLANCE ACTIVITIES: No surveillance activities are conducted at SWSA 2 except routine monitoring well sampling and analysis as part of the ORNL/RAP WAG 1 monitoring effort funded by ORNL overhead.

8. ROUTINE MAINTENANCE: Grass in a portion of SWSA 2 is kept mowed because of an overhead power line. No additional site maintenance is required.

9. ANTICIPATED REPAIRS/IMPROVEMENTS: SWSA 2 is not anticipated to require any significant repairs or improvements.

10. COST AND SCHEDULE:

    (a) Annualized costs

    None anticipated.

    (b) Projected resource requirements

    None anticipated.

UNIT NAME: Former Waste Pile Area (South of NRWTP)

Unit Number: 01.58

Project Status: Remedial Investigation completed. (Bechtel et al 1992)

Unit Location: Directly south of the site of the Nonradiological Wastewater Treatment Plant. Approximate ORNL grid coordinates are N 20,780 ft and E 31,250 ft. (ORNL 1990)

Approximate Dimensions and Capacity: Irregularly shaped area of ~1.58 acres. (Bechtel et al 1992)

Dates Operated: Unknown. (ORNL 1990)

Present Function: Not in operation.

Life Cycle Operation: Apparently used for disposal of waste from construction operations and as a soil borrow area. (Bechtel et al 1992). May be an extension of SWMU 01.57 Nonradiological Wastewater Treatment Plant Site. (ORNL 1990)

Waste Characteristics: Construction trash and debris. (ORNL 1990)

Release Data: No releases reported. (ORNL 1990)

Site Status: CERCLA (ORNL 1990)

Media of Concern:

Comments: This site was included in a CERLCA remedial investigation (Bechtel et al 1992) and will be remediated in accordance with the FFA.

References:

Bechtel National, Inc./CH2M Hill/Ogden/Peer, September 1992. *Site Characterization Summary Report for Waste Area Grouping 1 at Oak Ridge National Laboratory*, DOE/OR-1043/VI & D1, Oak Ridge, Tennessee.

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

Date Prepared: December 1996

Photo: 13_01.JPG; 13_02.JPG

UNIT NAME: West End Dump Site

Unit Number: 0.61

Project Status: No planned activities.

Unit Location: Wooded area approximately 300 ft west of Building 1061. ORNL grid coordinates E 28180 ft and N 22330 ft. (ORNL 1990)

Approximate Dimensions and Capacity: 10 ft by 8 ft. (ORNL 1990)

Dates Operated: Unknown, not active at present. (ORNL 1990)

Present Function: Not in use. (ORNL 1990)

Life Cycle Operation: Not applicable.

Waste Characteristics: This area has several mounds of debris consisting of: rusted drums, a garbage can, different size drums (30 gal, 5 gal, etc.), tile, old porcelain fixtures, metal, galvanized, pipe, brick, possible tar buckets, incandescent light bulbs (base only), and asbestos. Part of the area is flagged off with tape stating: CAUTION: ASBESTOS - DO NOT ENTER. (ORNL 1990)

Release Data: Not applicable.

Site Status: RCRA (ORNL 1990)

Media of Concern: Surface water and groundwater. (ORNL 1990)

Comments: Reference for the information appearing on the Contaminated Site Summary Sheet is Surveillance Record, Control Number ORNL-95-X11.

A request has been made to analyze the debris for radioactive materials, hazardous waste constituents and PCBs. (ORNL 1990)

References:

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

Date Prepared: December 1996

Photo: No Photo Available.

UNIT NAME: Abandoned Burn Pit

Unit Number: 0.01

Project Status: No activity planned.

Unit Location: Located north of WAG 17 on Chestnut Ridge Road in the area of the Sanitary Waste Compactor. ORNL grid coordinates N 23,100 ft and E 37,950 ft. (ORNL 1990)

Approximate Dimensions and Capacity: No records of the exact dimensions exist. (ORNL 1990)

Dates Operated: Approximately 1959 - 1969. (ORNL 1990)

Present Function: Not in operation.

Life Cycle Operation: The site was used to burn combustible trash during early operation of the laboratory. The pit where trash was burned has been backfilled. (ORNL 1990)

Waste Characteristics: Wood, refuse, and combustible construction debris were burned in the pit. However, no records exist of the exact material burned. Reportedly, on two occasions laundry material contaminated with very low levels of radioactivity were burned in the pit. (ORNL 1990)

Release Data: There are no documented releases of hazardous or radioactive materials. However, sampling surveys reported elevated levels of Cd, Cu, Pb, and Zn. Cs-137 activity was detected at 5-15 times background. (ORNL 1990)

Site Status: CERCLA

Media of Concern: Soil

Comments: Previously designated as unit number OS-1. The Sanitary Waste Compactor is currently located at the site. (ORNL 1990)

References:

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

Date Prepared: December 1996

Photo: 12_13.JPG

WAG1 SCSR 1992

Chemical analysis of the sludge revealed barium at 693 mg/kg, cadmium at 26.4 mg/kg, chromium at 272 mg/kg, lead at 262 mg/kg, mercury at 21.9 mg/kg, and nickel at 65.0 mg/kg. Section 4 describes these samples and reports the analytical results.

3.5.3 Burial Grounds

During early operations at ORNL (1943 to 1946), radioactive solid wastes were buried at two sites within the WAG 1 boundary, SWSA 1 and SWSA 2. Another site (called the former waste pile area) was used as a borrow pit and for disposal of noncontaminated construction debris. The latter is included with WAG 1 although it lies just beyond the south WAG 1 boundary, east of SWSA 1 (Fig. 3.5.3).

Geophysical surveys (Johnson and Wagner 1991) were performed in these areas in 1990 using electromagnetic (EM) terrain conductivity and ground magnetometer survey techniques to collect information regarding buried waste that might be present at all three locations. These surveys are discussed in Sect. 2.4, and the extent of the areas surveyed is shown in Fig. 2.4.1.

3.5.3.1 SWSA 1

SWSA 1 is a triangular area of approximately 1 acre 25 ft south of WOC (Fig. 3.5.1). In 1944, contaminated solid wastes were buried in SWSA 1 in trenches using earthen cover. The area is fenced and covered with grass. The geophysical surveys indicated five discrete areas of possible buried solid wastes in SWSA 1, all of which were located by the magnetometer survey and three of which were located by both the magnetometer and EM surveys (Fig. 3.5.14). Overhead power lines and the metal fence surrounding the area interfered with data collection and may have masked additional areas of buried waste (Johnson and Wagner 1991). The feature on Fig. 3.5.14 shown as "interpreted underground utility" (a straight line shown diagonally from southwest to southeast in the northwest portion of the WAG) is believed to be an abandoned section of LLLW pipeline that may have leaked in the late 1950s (Trabalka 1992).

3.5.3.2 SWSA 2

SWSA 2 is a rectangular area of approximately 3.6 acres near the eastern entrance of ORNL, adjacent to the main parking area (Fig. 3.5.3). The area was used from 1944 to 1946 to dispose of contaminated solid waste with gamma and beta activity, liquid waste contaminated with plutonium in stainless steel drums, and alpha-contaminated material from off site. The waste and contaminated soil reportedly were removed and reburied in SWSA 3 some time after 1946, although there have been unsubstantiated reports that some waste (mainly storage tanks and vehicles) remain buried at the site (Bates 1983). The site was backfilled with clean soil and is covered with grass and unfenced (but it is within the greater fenced and secured portion of the main plant area). The geophysical surveys indicated 17 discrete anomalies, 9 of which correspond to locations marking a previous soil boring program (Fig. 3.5.15). Magnetometer data indicated ferrous metal at 15 of the locations, and EM data identified the other 2 locations, neither of which correlated to the soil boring program.

3.5.3.3 Former waste pile area

The former waste pile area is an irregularly shaped area of approximately 1.58 acres located south of the nonradiological wastewater treatment facility (Fig. 3.5.3). Interviews with ORNL staff indicate that the site was used as both a soil borrow area and a disposal area for construction debris (Nix 1989). Excavation for installation of a pipeline uncovered metal and glass containers, transite (asbestos), and miscellaneous metal piping and scrap.

The geophysical (EM and magnetometer) surveys indicated four discrete anomalies (Fig. 3.5.16). One location was influenced by a large steel culvert pipe on the surface within the boundaries of the area; additional ferrous material may be buried east of the culvert pipe. Three buried pipelines were indicated in the northern corner of the area, two trending northwest to southeast, with another crossing the entire waste disposal area from southwest to northeast. One of the suspected pipelines in the northern corner correlates with the location of a double-walled, 2-in. stainless steel pipeline that connects tank W-33 near Building 2531 with the Melton Valley tanks (Binford and Orfi 1979). The other pipelines do not appear on the ORNL Atlas drawings (sheet 28).

FACILITY CONTACT CHECKLIST

Unit Name: Buried Waste at Nonrad Water Treatment Site
SWMU Number: 1.57

Facility Manger/Contact: Jay Story, 574-8769
Bill Alexander, 574-8770
John Murphy, 576-7929
Robert Dean, 574-7951
David Drake, 241-3694
Brad Patton, 576-0603

Date: 3/31/97 - 4/7/97

Historic Use/Purpose: Waste was excavated during the construction of Building 3608 (Nonrad Waste Water Treatment Facility.

Current Status: inactive

Facility Fate: **unknown**

Approximate Dimensions and Capacity: unknown

Dates Operated: Construction occurred between 1988 and 1990.

Waste Inventory/Characteristics: Undetermined quantities of metal shavings, carbon blocks, glass bottles, empty mercury flasks, transite.

Known Releases: Soil sampling results showed lead contamination (analytical results may be available through John Murphy. Contaminated soil was removed.

S&M Responsibilities: **NA**

Database availability/contact: **NA**

Comments: According to the sources contacted, it is suspected that not all of the buried waste has been excavated. Additional material (transite) was discovered during installation of telephone lines in 1996 (personal communication with W. Alexander). Also, the Former Waste Pile Area (SWMU 1.58) is thought to be an extension of this area.

References: personal communication

Date Prepared: 4/8/97

WAG 1 SCSR (1992)

2.3.3.5 USRADS soil sampling

The final phase of this investigation involved soil sampling at 41 locations representing all 4 categories of sampling locations (see Appendix A for sampling locations). Samples were collected in discrete 2-ft intervals using a truck-mounted drill rig, skid rig assembly, or hand auger. Borings were drilled or augered to auger refusal, the water table, an obstruction, or (in the case of hand augering) the practical limit of the method. Samples collected from each 2-ft interval were analyzed for Target Compound List (TCL) VOCs, radiological constituents, metals, base/neutral/acid-extractable (BNAE) constituents, pesticides and polychlorinated biphenyls (PCBs), and cyanide.

Those samples collected with a drill rig or skid rig assembly were collected with a 2-ft stainless steel split spoon sampler. Continuous 2-ft intervals were sampled with clean samplers to auger refusal, and soil lithology and radiation field instrument readings were recorded.

Hand augering was necessary when underground pipelines or utilities were thought to be present. The practical depth for most hand-augered boreholes was 6 to 8 ft. Samples were collected in clean stainless steel buckets from continuous 2-ft intervals. Descriptions of disturbed soil samples were recorded. Trip blanks, equipment rinsate samples, and duplicate samples were taken in accordance with the RI/FS Project Quality Assurance Plan.

2.4 SURFACE GEOPHYSICAL SURVEYS

2.4.1 Scope

Electromagnetic (EM) terrain conductivity and ground magnetometer surveys were performed at SWSA 1, SWSA 2, and the former waste pile area as part of the WAG 1 RI (see Fig. 2.4.1). The ground magnetometer survey detects buried objects containing ferrous metal, and the EM terrain conductivity survey locates low-density areas of disturbed soils possibly containing buried wastes. Both methods were used because each detects different physical properties, which will aid in identifying the nature of the waste. Survey data, methods, and results are reported in Johnson and Wagner (1991); survey results are discussed in more detail in Sect. 3.5 of this report. Raw data are stored in the project environmental data base. [illegible] and slowly moved side to side while the [illegible]

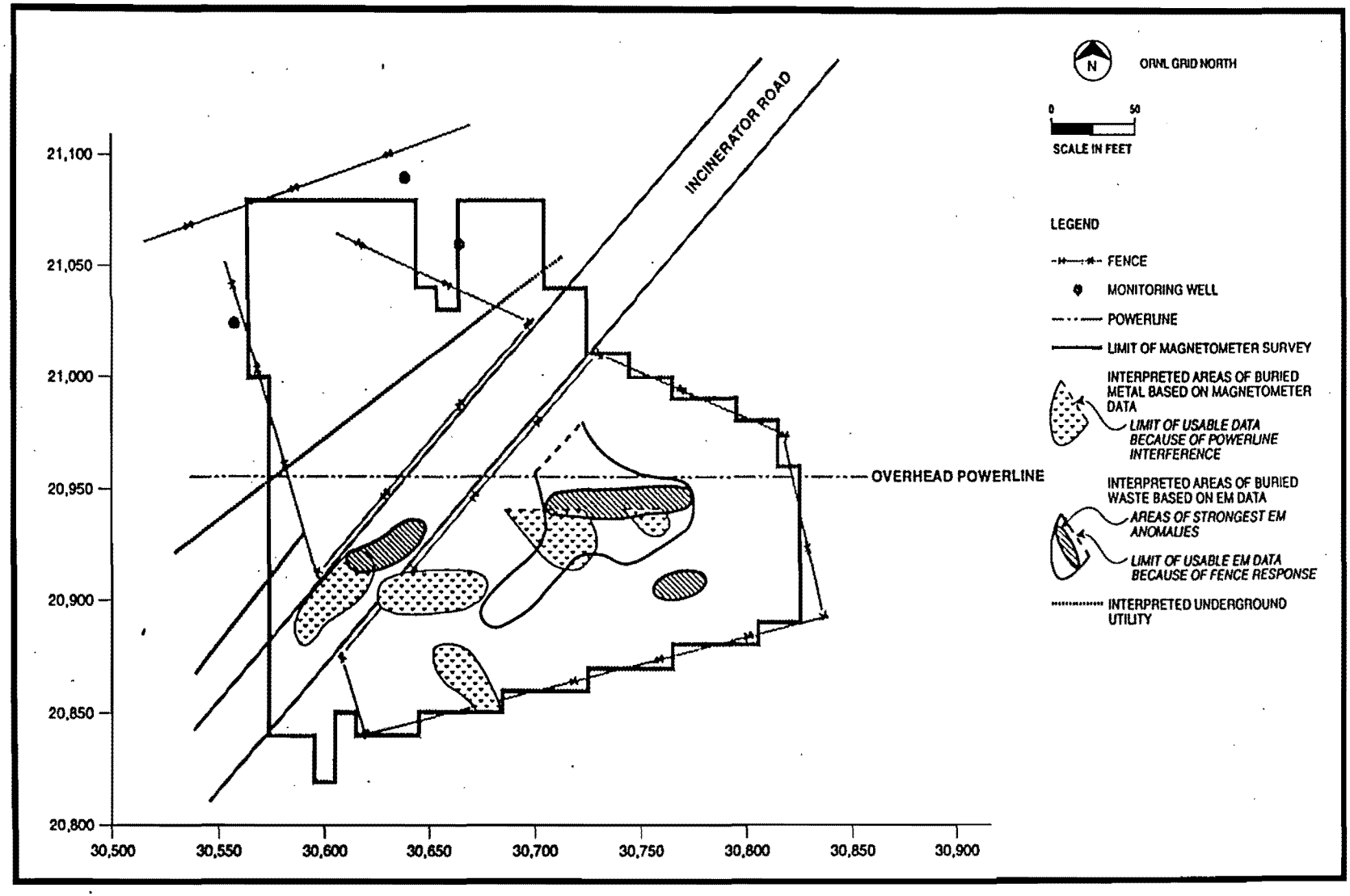

Fig. 3.5.14 Interpreted locations of buried wastes (SWSA 1), from geophysical survey data.

5.33A 6066.21

000313

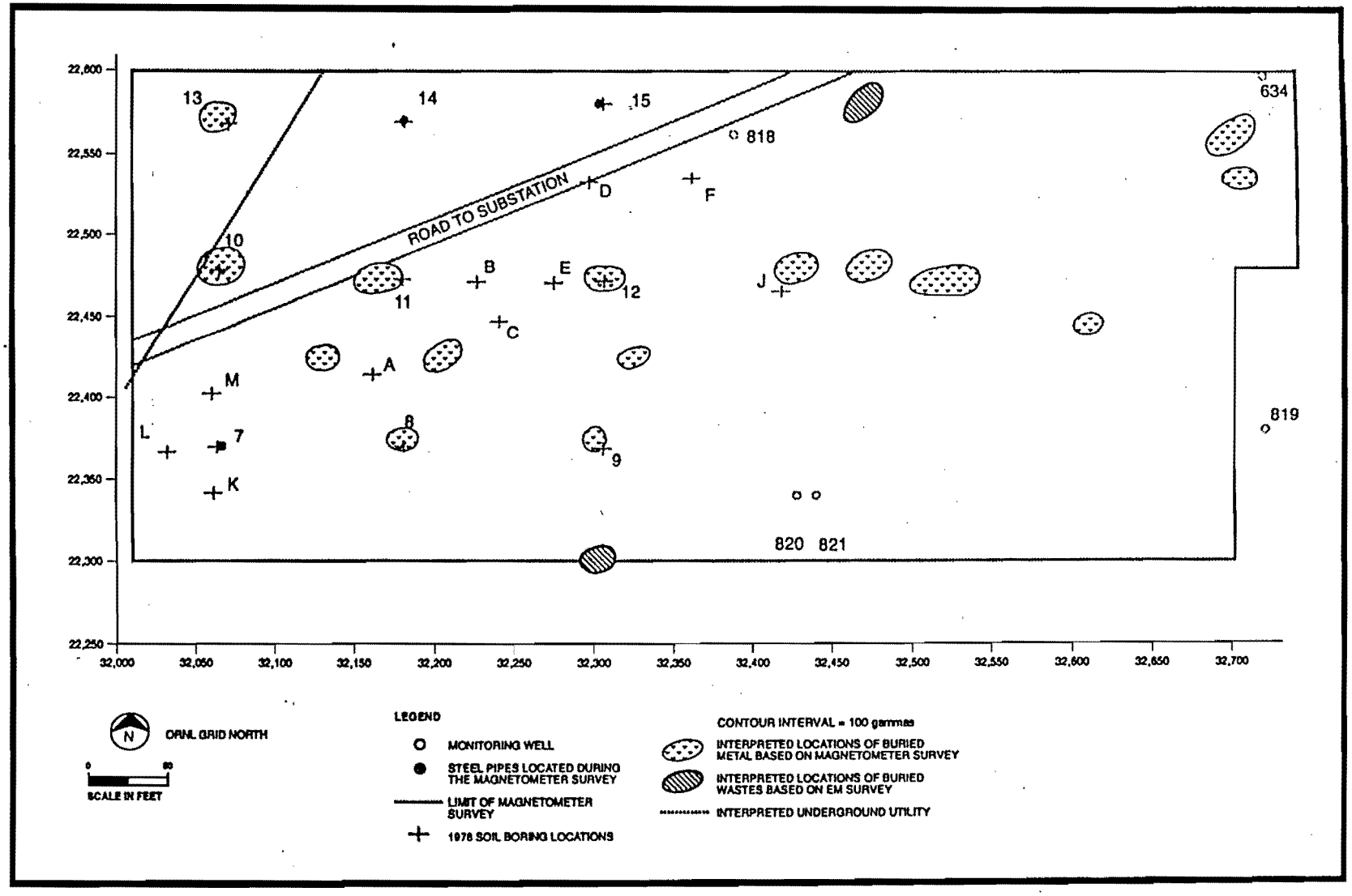

Fig. 3.5.15 Interpreted locations of buried wastes (SWSA 2), from geophysical survey data.

5.33A 6066.22

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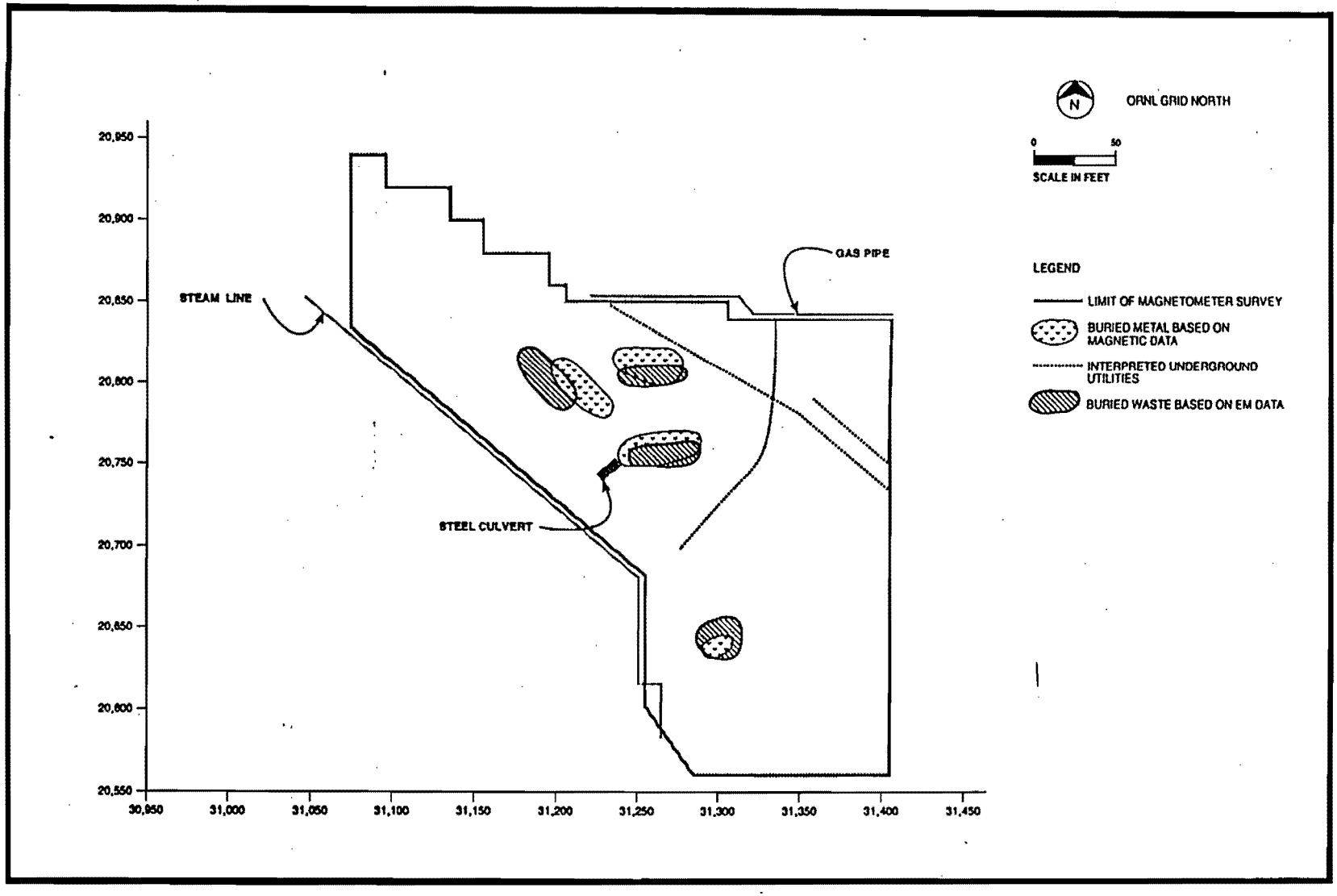

5.33A 6066.23

Fig. 3.5.16. Interpreted locations of buried wastes (waste pile area), from geophysical survey data.

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000318

6.5 ADDITIONAL INFORMATION NEEDS AND UNCERTAINTIES

There are a number of areas where additional information would contribute to a better understanding of the nature and extent of contamination or the fate and transport of contaminants. Addressing these topics would contribute to developing remedial action plans.

6.5.1 Waste Unit Characterization

6.5.1.6 SWSA 1

The presence of drummed waste buried in SWSA 1 is suspected on the basis of geophysical survey data. To support future remedial action decisions, sampling to identify the presence and nature of these wastes should be considered. Additional sampling of sediments and surface water in WOC would be useful in the characterization of potential releases of contamination from SWSA 1. There is also radiological contamination in groundwater near SWSA 1. If contamination is leaching from SWSA 1, portions of it may become strata-bound and migrate downdip (southward). A deep bedrock well south of SWSA 1 on the slopes of Haw Ridge is needed to evaluate whether this is occurring.

6.5.1.7 SWSA 2

Anomalies detected during the geophysical survey of SWSA 2 suggest the presence of isolated metallic objects. Some anomalies correspond to the sites of former drilling, suggesting that drilling pipe remains in the hole. Other anomalies do not correlate with former investigation locations and could indicate the presence of metallic wastes. A limited invasive sampling effort should be considered because, in other respects, SWSA 2 is a candidate for a "No-Further-Investigation" classification.

6.3 NATURE AND EXTENT OF CONTAMINATION

6.3.1 Groundwater

Several general areas of contamination were identified on the basis of results of the groundwater sampling program (see Fig. 4.3.26). Both radiological and chemical contaminants were identified in groundwater. The primary radionuclides found in groundwater at WAG 1 are strontium and tritium. Radionuclides found less frequently include radium-226/228, technetium-99, uranium-234, uranium-238, thorium-228/230/232, plutonium-238 and plutonium-239/240, americium-241, cobalt-60, nickel-63, iron-55, and cesium-137. Promethium-147 was also detected, but results are suspect because of the probable misidentification of this radionuclide.

There is evidence that strontium-90 is migrating from WAG 1 and seeping into First Creek. There is also limited evidence that some of this same plume may be underflowing First Creek and migrating westward. Other locations where groundwater may be impacting surface water quality are near the surface impoundments and near SWSA 1. Additional data are needed in these areas to confirm sources of contamination in surface water (see Sect. 6.5).

The most widespread organic compounds found in groundwater at WAG 1 are TCE and its degradation products 1,2-DCE and vinyl chloride. Benzene, toluene, xylene, and ethylbenze were found associated with a buried petroleum storage tank near the steam plant (Building 2519). This tank has since been removed. The metals silver, cadmium, chromium, lead, and mercury (one sample) were detected at concentrations exceeding MCLs in unfiltered groundwater samples from wells within and outside of WAG 1. Cadmium, chromium, and lead, in excess of their respective MCLs, tend to occur in the same wells. Cadmium, the most widespread metal at elevated concentrations, exceeded the MCL at the largest number of locations throughout WAG 1.

6.3.2 Soils

Both man-made and naturally occurring alpha-emitting radionuclides were detected in soil samples from WAG 1. Naturally occurring alpha-emitters detected include those from the thorium series [thorium-232, thorium-228, radium-224, and bismuth-212 (which emits both alpha and beta particles)], and the uranium series (uranium-238 and -234, thorium-230, and radium-226). Man-made alpha-emitters detected include americium-241, plutonium-238, and plutonium-239/240. Most of the contamination is found in the 3019 area, NTF, STF, isotope area, surface impoundments, Buildings 3503/3504 storage pad, floodplain soils, SWSA 1 and vicinity, and the thorium tank farm. Beta-emitting radionuclides commonly found in soils include cesium-137, strontium-90, and cobalt-60. A variety of other man-made radionuclides exceed reference levels (e.g., technetium-99, europium-152/154/155, nickel-63, calcium-45, and tritium) but were found less often and are not as widespread. Naturally

occurring beta-emitters detected above typical reference values include thorium-232/234 and radium-228.

Contamination in soil included 20 VOCs, 39 BNAEs, 7 pesticides, 2 PCBs, and cyanide. PCBs were detected in samples from the CH008 location, which is the site of a former coal storage area and near an associated former steam plant. Other borings that yielded samples containing PCBs were near Building 3529, south of STF (two borings), the surface impoundment (one boring), near the sewage impoundments, and along WOC and First Creek. Dioxins, furans, and herbicides were not detected.

All metals analyzed were detected in soil samples. The concentrations varied widely, possibly indicating both natural variability in the soils and the presence of contamination. Concentrations of individual metals in the main plant area and the floodplain soils varied by orders of magnitude. Metals that exceeded reference include beryllium, cadmium, chromium, cobalt, and mercury. The two highest concentrations of mercury were from samples near Building 3592 at a known mercury spill site; the third and fifth highest were found in the WOC floodplain soil near the Fifth Creek confluence with WOC.

6.3.3 Surface Water

Both man-made and naturally occurring radionuclides were detected during the Phase I investigation of WOC, First Creek, Fifth Creek, and Northwest Tributary. The most frequently detected were strontium-90 and tritium.

The highest concentrations of strontium were found in First Creek. Flux calculations indicate that during the low base sampling event, approximately half of the strontium in the WOC system above the 7500 bridge could be attributed to First Creek and Northwest Tributary. During the high base sampling event (including a storm episode), the total strontium loadings within First Creek and the rest of the WOC system increased but the relative amount of contamination contributed by First Creek and Northwest Tributary declined to approximately 25% of the total amount. Evidently there was a strontium source that discharged greater quantities to WOC during high base and high base storm flow conditions than during low base conditions. Potential sources may include a number of outfalls, SWSA 1 runoff or leachate, leaking LLLW lines, contaminated groundwater discharge from the main plant area, or seepage from the 3513/3524 surface impoundments.

Results of a screening survey performed in October 1991 indicated that elevated gross beta activity, presumably strontium, enters First Creek via a seep near the contact between Chickamauga Units D and E, and two storm water outfalls (341 and 342) west of Building 2500.

Concentrations of tritium detected in surface water were below the SDWA MCL of 20,000 pCi/L. Previous studies reported significantly higher concentrations at the 7500 bridge (i.e., up to 590,000 pCi/L), approximately 100 ft upstream of SW-6 in WOC. This suggests that there is a potential for high variability in the amount of tritium in WOC.

The highest concentration of cesium-137 was found in samples collected during low base conditions at a location near the surface impoundment and SWSA 1. Cesium-137 was not detected in filtered samples, indicating that it is transported through adsorption to suspended sediments. Potential sources of cesium-137 include seepage from waste management units along WOC (including the surface impoundments and SWSA 1), discharge from outfalls, and erosion/suspension from bottom sediments and floodplain soils.

No metals were detected at concentrations exceeding their respective MCLs. No organophosphorous pesticides, dioxins/furans, or chlorinated herbicides were detected in surface water samples. Of the few VOCs and BNAEs detected, only the VOCs pyridine and p-dioxane may be of concern, although they were detected in only one sample.

6.3.4 Sediment

Both man-made and naturally occurring radionuclides were detected in sediment samples from WAG 1. Radionuclides associated with the natural uranium and thorium decay series were detected at concentrations within reference ranges and are not considered site contaminants. All man-made radionuclides, including the transuranics americium-241, curium-242, and curium-243/244, were detected at concentrations exceeding reference levels, indicating that these are site contaminants. Cesium-137 was the most frequently detected man-made radionuclide in sediments. Sediment from three WOC locations between Third Street and First Creek contained cesium-137 at concentrations 1 to 2 orders of magnitude greater than reference concentrations.

VOC contamination in sediments was minimal. However, PAHs associated with coal combustion and parking lot runoff were detected in samples throughout WOC and in Fifth Creek. The metals cadmium, chromium, copper, lead, and mercury were detected above reference levels.

The concentrations of mercury detected were comparable to those reported in previous studies, although the maximum concentrations found in previous studies at locations associated with outfalls into Fifth Creek were not encountered. This difference is likely due to the selection of sampling locations and should not be viewed as an indication that the high concentrations of mercury detected in previous studies (e.g., 4874 to 7427 $\mu g/g$ near outfall 261 (Taylor 1990a) have dissipated.

6.5.1.6 SWSA 1

The presence of drummed waste buried in SWSA 1 is suspected on the basis of geophysical survey data. To support future remedial action decisions, sampling to identify the presence and nature of these wastes should be considered. Additional sampling of sediments and surface water in WOC would be useful in the characterization of potential releases of contamination from SWSA 1. There is also radiological contamination in groundwater near SWSA 1. If contamination is leaching from SWSA 1, portions of it may become strata-bound and migrate downdip (southward). A deep bedrock well south of SWSA 1 on the slopes of Haw Ridge is needed to evaluate whether this is occurring.

6.5.1.7 SWSA 2

Anomalies detected during the geophysical survey of SWSA 2 suggest the presence of isolated metallic objects. Some anomalies correspond to the sites of former drilling, suggesting that drilling pipe remains in the hole. Other anomalies do not correlate with former investigation locations and could indicate the presence of metallic wastes. A limited invasive sampling effort should be considered because, in other respects, SWSA 2 is a candidate for a "No-Further-Investigation" classification.

6.5.2 Groundwater, Surface Water, Soil, and Sediment

Surface water, sediment, and floodplain soil samples indicate that a significant amount of contaminant loading to WOC occurs in the vicinity of the impoundments and SWSA 1. Potential sources of this contamination include seepage from the surface impoundments and SWSA 1, outfalls, leaking waste or drain lines, and groundwater discharge. Additional characterization, including detailed sampling of surface water and sediments, is needed to further delineate the sources of contamination in this area.

A groundwater plume has been identified as extending from the corehole CH008 area to First Creek and possibly as far west as piezometer 535. This plume was identified only on the basis of CSL screening level analyses of groundwater and surface water samples, which did not include determinations of specific isotopes, but rather measured broader parameters (gross alpha and beta). Resampling of the First Creek seep location and piezometer 550 is justified to confirm the nature of contamination in the plume. In addition, flux rates of contaminated water from the plume into First Creek have not been computed. Two to three piezometers should be installed near the First Creek seep location; these piezometers and the seep should be sampled on a regular basis to provide data on the flux of contamination into First Creek. Water level measurements should also be made regularly, possibly using continuous water level recorders.

The depth and western extent of the plume (presumed to be predominantly strontium-90) also have not been determined. Additional multiport monitoring wells and piezometers would assist in defining the depth and extent of the plume. In addition, the source of the plume is not known; additional wells near NTF and in the hilltop area are needed to identify the source.

Contaminated sediments (mostly cesium-137 and mercury) were widely detected in WOC, and the transport mechanisms for these sediments are not well understood. Because these sediments represent potentially significant pathways for off-WAG migration to White Oak Lake, data on transport mechanisms and levels of contamination are needed to support future evaluations of remedial alternatives. Numerical modeling of sediment transport would be useful.

A significant number of surface water and sump samples exceeded holding time guidelines for mercury analysis. Due to the volatility of mercury and its confirmed presence in sediment samples, it is possible that reported concentrations for surface water and sump samples could be biased low or could represent false negative results. Additional sampling of surface water and sump locations to confirm the presence or absence of mercury may be warranted.

Significant radiological contamination was detected in floodplain soils; additional data on the vertical and areal extent of contamination are needed to evaluate the need for remediation. Data on the erodibility of the floodplain soils and other geotechnical parameters are also needed to evaluate the need for and selection of remedial actions. Numerical modeling of surface water processes and the erosion and transport of the floodplain soils would be useful.

SCSR

At SWSA 1, five discrete areas of possible buried solid wastes were identified on the basis of geophysical evidence. At SWSA 2, the geophysical surveys indicated 17 discrete anomalies, 9 of which correspond to locations marking a previous soil boring program. Magnetic data indicated the presence of ferrous metal at 15 of the locations, and EM data identified the other 2 locations, neither of which correlated to the soil boring program.

The old LLLW piping system has been a significant potential source of contaminants, and the interconnecting utility trench system has the potential to provide preferred pathways for contaminant transport. The original LLLW system piping consists of single-walled, stainless steel pipe; past leaks from these pipes are responsible for 23 SWMUs identified in

WAG1 GWOU

SWSAs 1 and 2. The relatively complete set of historical data for many wells located in SWSA 1 indicates generally stable contaminant concentrations over time and between high and low base flow groundwater conditions. Gross alpha and beta concentrations were found to be generally below reference levels, and tritium values ranged between ~37 and 92 Bq/L. The higher tritium activities in bedrock wells suggest the possibility of flow paths below the water table surface. In addition, several radionuclides (^{239}Pu, ^{240}Pu, and ^{228}Ra) detected in a piezometer may suggest westward migration of contaminants from SWSA 1.

Groundwater samples collected from wells in SWSA 2 indicate that tritium contamination is prevalent throughout much of the area, with the highest concentrations occurring within and southwest of SWSA 2. This finding suggests that contamination may be migrating southwestward from SWSA 2. Slightly higher gross alpha and beta detected in a downgradient piezometer also suggests minor migration of these contaminants. This is corroborated by the presence of radiological contamination in Fifth Creek outfall 165, which serves a small segment of a storm sewer from Fifth Street. Because no other source for the outfall 165 contamination is apparent, it is presumed to be coming from discharging groundwater from SWSA 2. Data from an adjacent pair of bedrock wells drilled to depths of 6.1 and 24.4 m (20 and 80 ft) indicate that contamination decreases with depth.

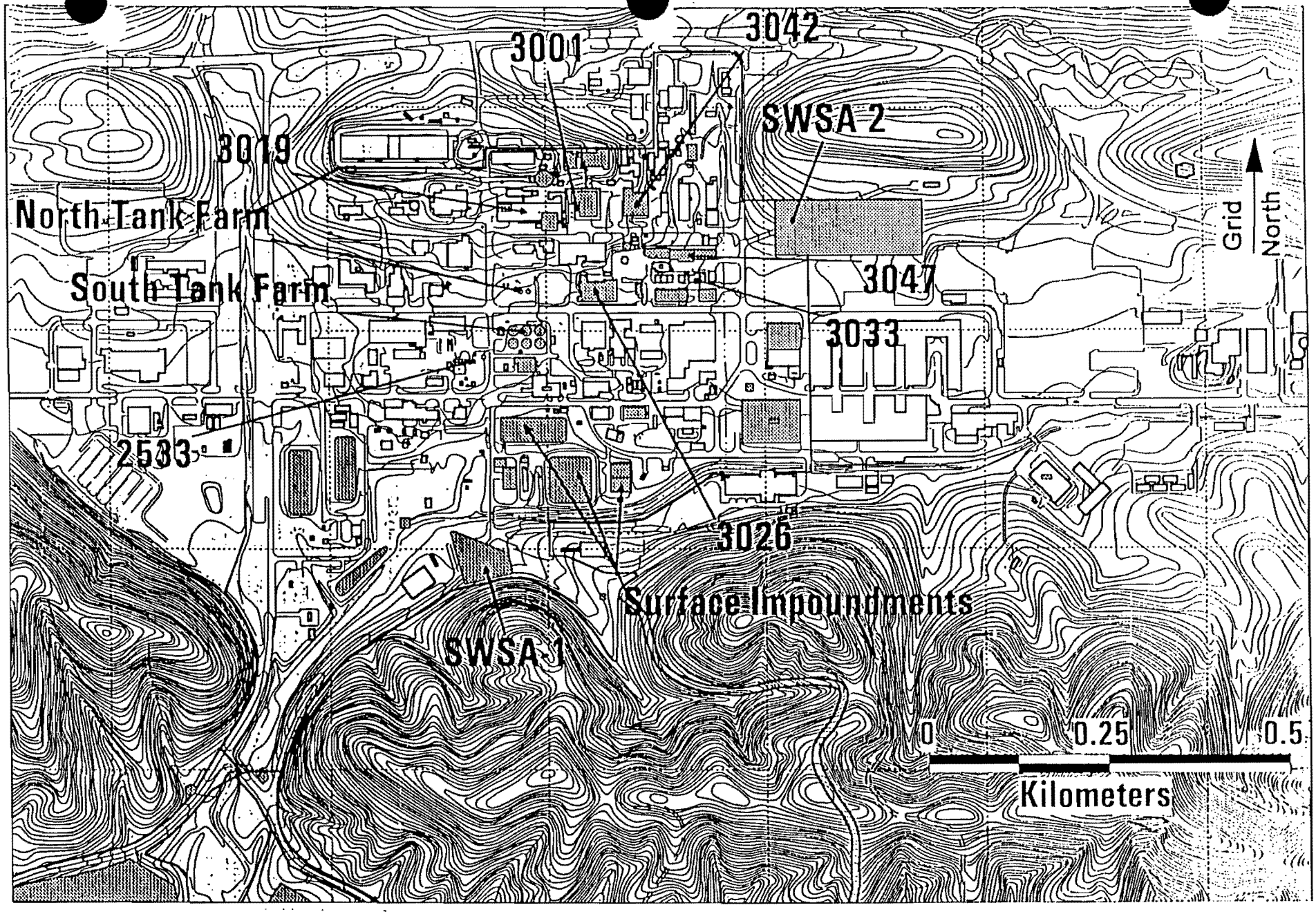

Fig. 3.6. Locations of buildings or other facilities associated with groundwater contamination within WAG 1.

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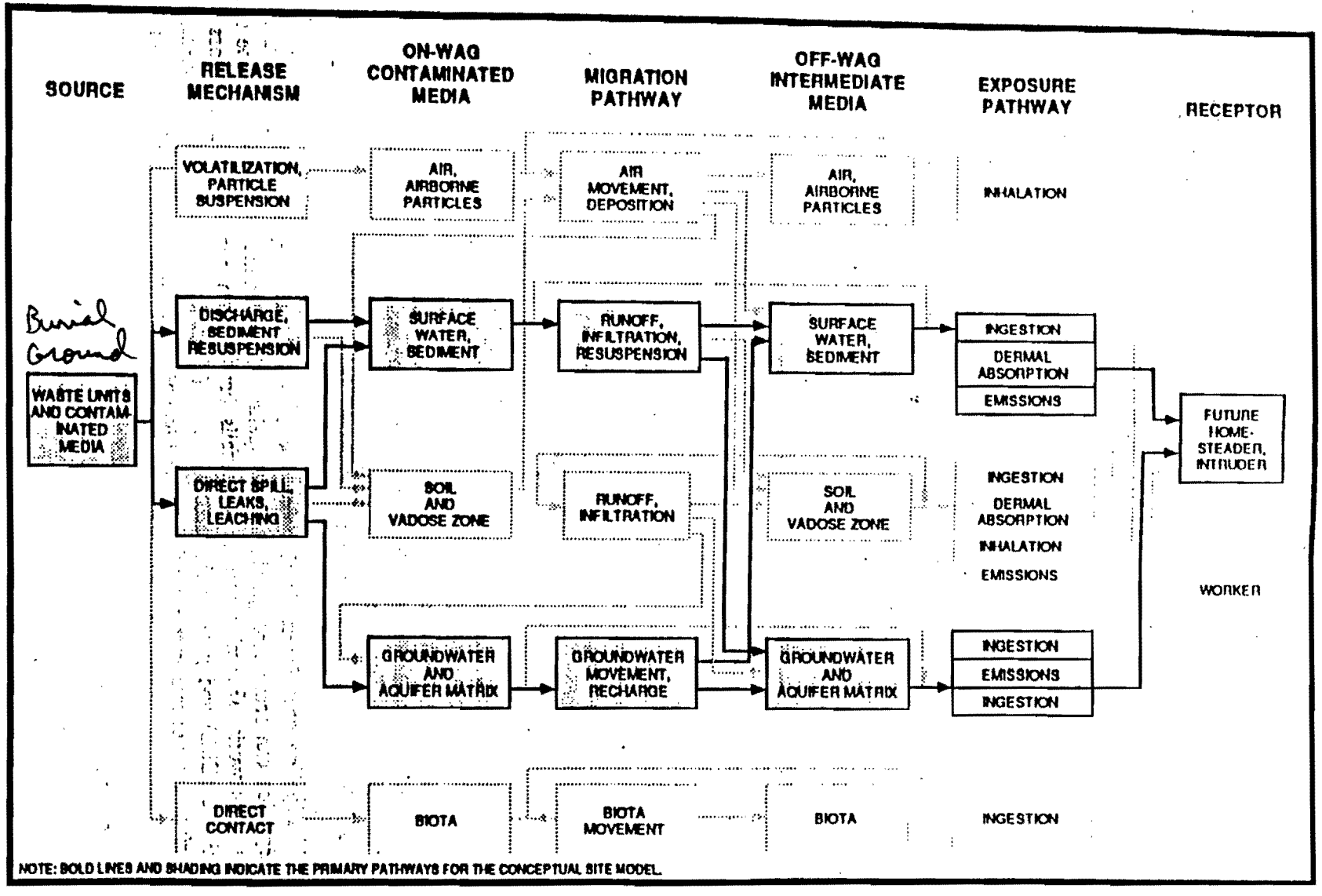

Fig. 3.3. Conceptual site model for Category II: Current off-WAG migration with potential for exposure to future off-WAG receptors.

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NO ADDITIONAL INFORMATION IS AVAILABLE

ORNL/ER-391

Energy Systems Environmental Restoration Program

Site Descriptions of Environmental Restoration Units at Oak Ridge National Laboratory, Oak Ridge, Tennessee

A. J. Kuhaida, Jr.
A. F. Parker

Date Issued—February 1997

Prepared by
Advanced Sciences, Inc.
Oak Ridge, Tennessee
under subcontract 9128.X01

Prepared for the
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Environmental Management Activities at
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Oak Ridge, Tennessee 37831
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Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

Remedial Investigation Work Plan for the Groundwater Operable Unit at Oak Ridge National Laboratory, Oak Ridge, Tennessee

Date Issued—March 1994

Prepared by
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DOE/OR-1043/V1&D1
ORNL/ER-131/V1&D1
ORNL/ER/Sub/87-99053/59/V1

Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

Site Characterization Summary Report for Waste Area Grouping 1 at Oak Ridge National Laboratory, Oak Ridge, Tennessee

Volume 1
Sections 1 Through 3

Date Issued—September 1992

Prepared by
Bechtel National, Inc./CH2M Hill/Ogden/PEER
Oak Ridge,Tennessee
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ORNL/ER-131/V2&D1
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Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

Site Characterization Summary Report for Waste Area Grouping 1 at Oak Ridge National Laboratory, Oak Ridge, Tennessee

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ORNL/ER-39

Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

Surveillance and Maintenance Plan for Waste Area Groupings at Oak Ridge National Laboratory, Oak Ridge, Tennessee, for FY 1993–2002

M. K. Ford
L. Holder, Jr.
R. G. Jones

Date Issued—December 1992

Prepared by
Waste Management and Remedial Action Division
Oak Ridge National Laboratory

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000347

ORNL/ER-345

Energy Systems Environmental Restoration Program

Annual Summary Report on the Surveillance and Maintenance Activities for the Oak Ridge National Laboratory Environmental Restoration Program for Fiscal Year 1995

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The S. M. Stoller Corporation
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Environmental Management Activities at the
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NO ADDITIONAL INFORMATION IS AVAILABLE

VII. ACTIVE FACILITIES

Many existing facilities within WAG 1 will remain part of on-going ORNL operations indefinitely and are not included in the Bethel Valley RI/FS. This includes buildings and laboratories as well as pipelines, tanks, and other areas (*e.g.* the garage and maintenance complex) that are part of the ORNL infrastructure. All active facilities not currently in transition to the D&D program will be excluded from consideration in the Bethel Valley RI/FS. In addition, certain inactive facilities which have already been remediated will also be excluded from consideration in the Bethel Valley RI/FS. For example, one site currently being remediated is the waste accumulation area at building 1503—bottles of chemicals left over from past research activities and stored under a laboratory hood. These chemicals and associated wastes are currently being removed for disposal.

Additional information on active facilities will be available at the Bethel Valley DQO meeting.