

4/28/94 - 01816

NAVAL BASE, NORFOLK
TECHNICAL REVIEW COMMITTEE MEETING
28 APRIL 1994
BREEZY POINT OFFICERS CLUB - NAVAL AIR STATION, NORFOLK

AGENDA

0930	Introduction	Mr. David Forsythe Installation Restoration Program Manager, Naval Base
0940	Welcome	Captain James L. Norton Deputy Commander, Naval Base
0950	Q-Area Drum Storage Yard (QADSY) RI/FS Summary	Environmental Science and Engineering, Inc (ESE)
1030	BREAK	
1040	QADSY -Remedial Action Plan	ESE
1200	LUNCH	
1300	QADSY - Group Discussion	ESE
1400	Formation of a Restoration Advisory Board	Mr. David Forsythe

TRC OUTLINE Q AREA DRUM STORAGE YARD

I. BACKGROUND

A. Location

1. Site is located on Norfolk Naval Base, part of the Sewells Point Naval Complex
2. Q Area located in northwestern corner of the complex
3. Located between Elizabeth River and Willoughby Bay

B. Site Description

1. Created by fill operation in early 1950s; disposal area of dredged materials excavated from Willoughby Bay
 - a) in use since 1950's
 - b) stored tens of thousands of drums
2. Originally covered much larger area than now

C. Regional Geology/Hydrogeology

1. Uppermost geological characterized by fill overlying the Tabb Formation
 - a) fine to coarse sand grading upward to sandy and clayey silt
 - b) average thickness is 20 feet
 - c) an unconfined water table aquifer (Columbia Aquifer) is associated with the strata
 - (1) aquifer can be used only for lawn watering and other similar uses due to water quality limitations
 - low pH, high iron content
 - has typically been contaminated by:
 - waste lagoons
 - landfills

- septic tanks below the water table
- municipal sludge application sites

(2) City of Norfolk Health Department prohibits use of water table aquifer for public or private water supplies by law

2. Yorktown Formation and aquifer

- a) underlies the Tabb Formation
- b) characterized by coarse sand and gravel beds; abundant, thick shell beds
- c) thickness ranges from 300 to 400 feet
- d) Yorktown aquifer generally under confined (artesian) conditions
 - (1) generally separated from overlying water table aquifer by confining beds of silt, clay, and sandy clay; 20 to 40 feet thick
 - (2) domestic, public, commercial, and industrial supply wells are drilled into Yorktown aquifer
 - (3) water quality generally suitable for potable and most other uses
 - occasionally see high iron concentrations
 - locally may have problems with brackish water (high chloride content)

3. Site - Specific Geology/Hydrogeology

- a) the site is underlain by fill consisting of yellow-brown, gray, and black silty sand with shell fragments
- b) water table generally around 8 feet below surface, elevation 2 to 5 feet above msl
- c) the Yorktown confining layer is not present at the QADSY, possibly result of channelization and meandering of Elizabeth River
 - (1) the Columbia and Yorktown are hydraulically connected
 - (2) unconfined, brackish, not used for potable water
 - (3) discharges into Elizabeth River and/or Willoughby Bay
- e) aquifer thickness was not confirmed during drilling, but expected to be 85 to 140 feet
- f) groundwater flow direction primarily to the west at very low gradients (less than one-thousandth of a foot per foot - 0.0006 ft/ft)
- g) average linear velocity approximately 23 feet per year

h) groundwater divide along eastern boundary

- (1) wells DW-2, DW-4, and SW-8 are located east of the divide, not hydraulically connected to remainder of site and were used for background wells

II. PREVIOUS STUDIES

A. Initial Abatement Study (February 1983)

1. Onsite phase conducted in May 1982 for Sewells Point Naval Complex
2. During the onsite IAS survey, evidence of considerable leakage and spillage of liquids was found
3. Recommendations were made for installation and quarterly sampling of 3 monitoring wells

B. IRP Interim RI (March 1988)

1. Sampled soils (3 rounds) and groundwater (4 rounds) for organics and inorganics
 - a) Conducted initial site investigation (soil and groundwater sampling) in November and December 1983;
 - b) Second round sampling of groundwater in August 1984
 - c) Third round in April 1986 included existing wells and 21 soil samples from 7 locations
 - d) Navy performed soil sampling in April 1986, following third round
 - (1) eight samples
 - (2) result: removal of the most contaminated soil was planned as part of FY-89 Military Construction project
 - e) Fourth round groundwater sampling June 1986
2. Groundwater

- a) Significant concentrations of organics in GW-01 in leaking drum storage area
 - b) Inorganic compounds found in all 4 wells
 - (1) considered concentrations to be higher than actual due to unfiltered samples
3. Soils
- a) trans 1,2 DCE and TCE found in soils in same area as one of the wells (GW-01)
 - b) phenol also found
 - c) several inorganics identified in soil samples (S-05, S-06, S-07, S-08)
 - d) found oil and grease concentrations (ranged from 4120 to 54,100 mg/kg in all eight Navy samples)
4. Conclusions:
- a) source of contaminants is damaged and leaking containers
 - b) organics leaching from soil into groundwater in that area
 - c) soil may be absorbing some of volatiles, but not inorganics
5. Recommendations
- a) need downgradient wells
 - b) install three additional nested wells and sample
 - c) collect additional soil samples
 - d) if not hazardous, cap entire drum storage yard
 - e) contain damaged/leaking drums
6. 750 cubic yards of soil excavated in 1987
- a) area now paved

III. FIELD WORK

A. Three Field Events for RI/FS

1. October 1990
 - a) 36 locations collected for soil
 - b) 10 borings converted into monitor wells and collected groundwater
2. January 1991
 - a) sample 5 wells for metals
 - b) surface water sampling from Elizabeth River
 - c) slug test
 - d) pumping test
3. December 1992 - January 1993
 - a) 8 borings converted into monitor wells and collected groundwater
 - b) 66 groundwater hydropunch samples, analyzed TCE, PCE, and DCA in field with portable GC
 - c) 8 locations collected for soil to delineated vertical TPH contamination
 - d) 2 sediment samples from storm drain
 - e) Tidal groundwater monitoring for 1 month
 - f) Vertical flow regime survey between the Elizabeth River and aquifer

IV. RI/FS Analytical Results

1. October 1990
 - a) Soil
 - (1) VOCs
PCE detected at 32,000 $\mu\text{g}/\text{kg}$ (below Federal Standards)
< 100 $\mu\text{g}/\text{kg}$, even for total VOCs
 - (2) TPH
>1/2 of samples in TA, PP, and HM areas exceed VDEQ
100 ppm TPH guideline for disposal in sanitary or industrial
landfills
>2/3 of samples in TA, PP, and HM areas exceed VDEQ 50
ppm TPH guideline for clean fill
TPH identified mostly as compressor oil, some lube oil, trace
of No. 6 fuel oil, motor oil, hydraulic oil

- (3) metals
 - none above TCLP standard
 - slightly higher than background
- b) Groundwater
 - (1) VOCs
 - PCE and carbon tetrachloride exceeded VDEQ Surface Water Standards
 - (2) TPH exceeded VDEQ groundwater standards
 - (3) metals
 - arsenic, cadmium, chromium, lead, mercury, and zinc exceeded VDEQ groundwater standards
- 2. January 1991
 - a) Groundwater
 - (1) metals - were below the detection limits for filtered and unfiltered.
 - b) Surface water
 - (2) metals - antimony was detected in filtered and unfiltered samples. No surface water standards exist for antimony
- 3. December 1992 - January 1993
 - a) Soil
 - (1) TPH - were detected below the VDEQ action levels for clean fill (50 mg/kg)
 - b) Groundwater
 - (2) VOCs - TCE was measured above the VDEQ surface water standard
 - c) Sediment
 - (1) TPH - exceed VDEQ action level for diesel and gasoline
 - (2) TCLP pesticide/PCB were measured although not in borings suggesting contaminants are coming from offsite sources.
 - (3) Metals - high levels but do not exceed TCLP standards

V. Aquifer Tests

- A. Slug test/pumping test
 - 1. T and K values as 1362 sf/day and 11 ft/day
 - 2. Typical T and K as 1070 to 2460 sf/day and 4 to 29 ft/day, respectively.
- B. Groundwater tidal survey - peak groundwater potentiometric level occurs approximately 50 minutes after high tide. A 1.9 feet elevation of groundwater allows dispersal of groundwater to the surface water

- C. Vertical flow regime survey between the Elizabeth River and site aquifer exhibited local groundwater is discharging into the Elizabeth River
- D. Groundwater model (MODFLOW, 3-D groundwater flow and INTERTRANS, particle) determined particles will reach and migrate below the bulkhead into the Elizabeth River

VI. Risk Assessment Results

Determined that the probability for exposure to above was very low as a result of:

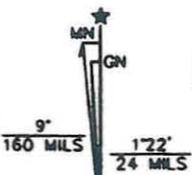
- Restricted access to site and remote location with respect to residential community
- State regulations prohibiting use of shallow groundwater for potable water supply
- Poor water quality of both shallow and deep portion of aquifer

VII. ARARS

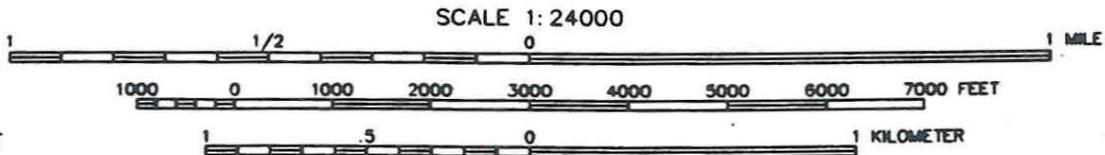
- A. MCLs are not applicable because:
 - Yorktown becomes brackish with depth adjacent to surface water bodies (e.g. Elizabeth River and Willoughby Bay)
 - Columbia and Yorktown aquifers are considered as the water table aquifer because the confining layer does not exist at the site
 - City of Norfolk prohibits the use of the water table aquifer for potable purposes by law
- B. Surface water standards are relevant and appropriate because of the following:
 - The groundwater model determine groundwater flows into the Elizabeth River
 - No VDEQ groundwater standards exist for TCE and PCE

VIII. Feasibility Study

- A. Four groundwater alternatives
- B. Six soil alternatives



UTM GRID AND 1984
MAGNETIC NORTH
DECLINATION AT
CENTER OF SHEET



SCALE 1:24000
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

SOURCE: USGS NORFOLK NORTH, VA. QUADRANGLE.



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DATE 3-29-94	SCALE SHOWN	TITLE SITE LOCATION AND TOPOGRAPHIC MAP Q AREA DRUM STORAGE YARD NORFOLK NAVAL BASE, NORFOLK, VA.	
DRAWN BY LAL	APPROVED BY	CLIENT NAVFAC - Q AREA	FIGURE 1-1
JOB NO. 4921150	DWG. NO./ REV. NO. 1 / -		

SYSTEM	SERIES	NORTH CAROLINA		VIRGINIA		DESCRIPTION OF HYDROGEOLOGIC UNITS		
		STRATIGRAPHIC UNITS	HYDROGEOLOGIC UNITS	STRATIGRAPHIC UNITS	HYDROGEOLOGIC UNITS			
QUATERNARY	RECENT PLEISTOCENE	POST-MIOCENE (UN-DIFFERENTIATED)	WATER TABLE OR QUATERNARY AQUIFER	TABB	FILL	Unconsolidated sand, silt and some gravel. Sand units yield quantities adequate for domestic and small industrial demands, used extensively for lawn watering. Unconfined aquifer.		
					LYNNHAVEN MEMBER			
TERTIARY	UPPER	YORKTOWN PUNGO RIVER	TERTIARY AQUIFER SYSTEM	SAND AQUIFER	YORKTOWN	YORKTOWN AQUIFER	Sand and shell beds main water-bearing units. Adequate for moderate public and industrial supplies. Artesian	
	MIDDLE					CONFINING UNITS		Silt and clay predominant, minor sand lenses.
	MIOCENE	EOCENE		CASTLE HAYNE LIMESTONE	LIMESTONE AQUIFER	NANJENDY	NOT FOUND IN STUDY AREA	
		PALEOCENE		BEAUFORT		MATTAPONI	EOCENE-UPPER CRETACEOUS AQUIFER	Glauconitic sand and interbedded clay and silt. Infrequently used as a water supply. Yields adequate for moderate supplies. Brackish in most of area. Artesian
CRETACEOUS	UPPER	PEEDEE	CRETACEOUS AQUIFER SYSTEM	UPPER UNIT	TRANSITIONAL BEDS	LOWER CRETACEOUS	Interbedded gravel, sand, silt, and clay. Yields are adequate for large industrial use. Brackish in most of area. Artesian	
	LOWER	BLACK CREEK UNNAMED		LOWER UNIT				PATUXENT



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DATE
4-7-93

SCALE
SHOWN

TITLE
STRATIGRAPHIC AND HYDROGEOLOGIC UNITS
SOUTHEASTERN VIRGINIA (FROM SIUDYLA, ET AL., 1981)
Q AREA DRUM STORAGE YARD
NORFOLK, VIRGINIA

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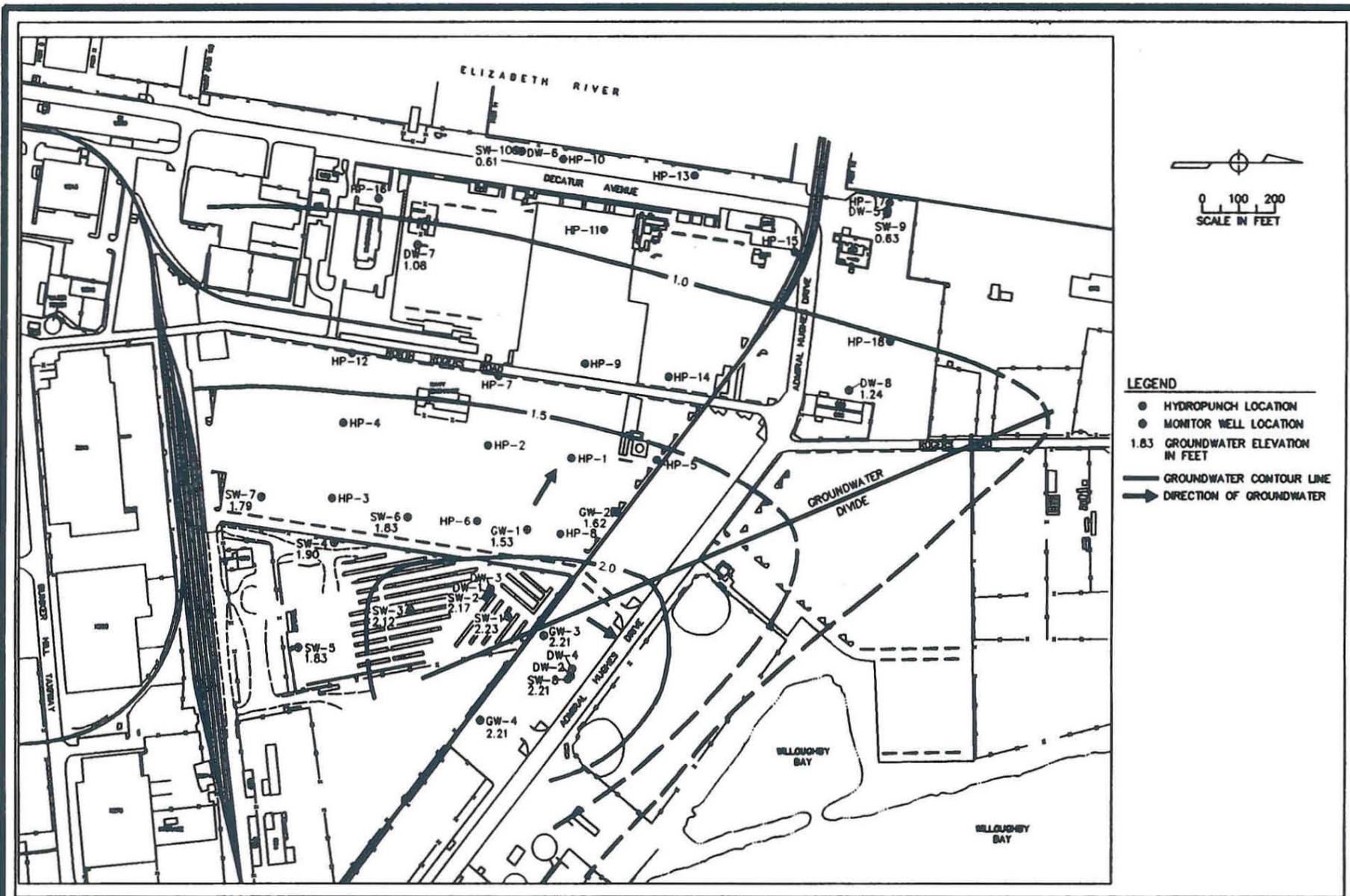
APPROVED BY

JOB NO.
4921150

DWG. NO./ REV. NO.
Q3-1 / 1

CLIENT
NAVFAC - Q AREA

FIGURE
3-1

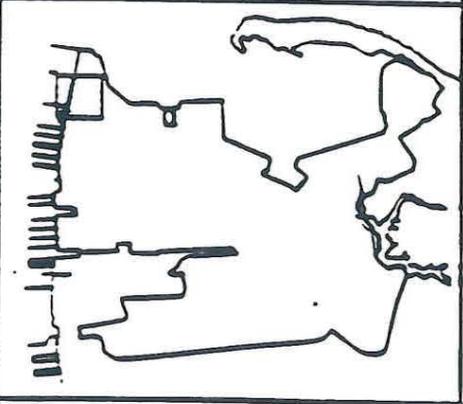
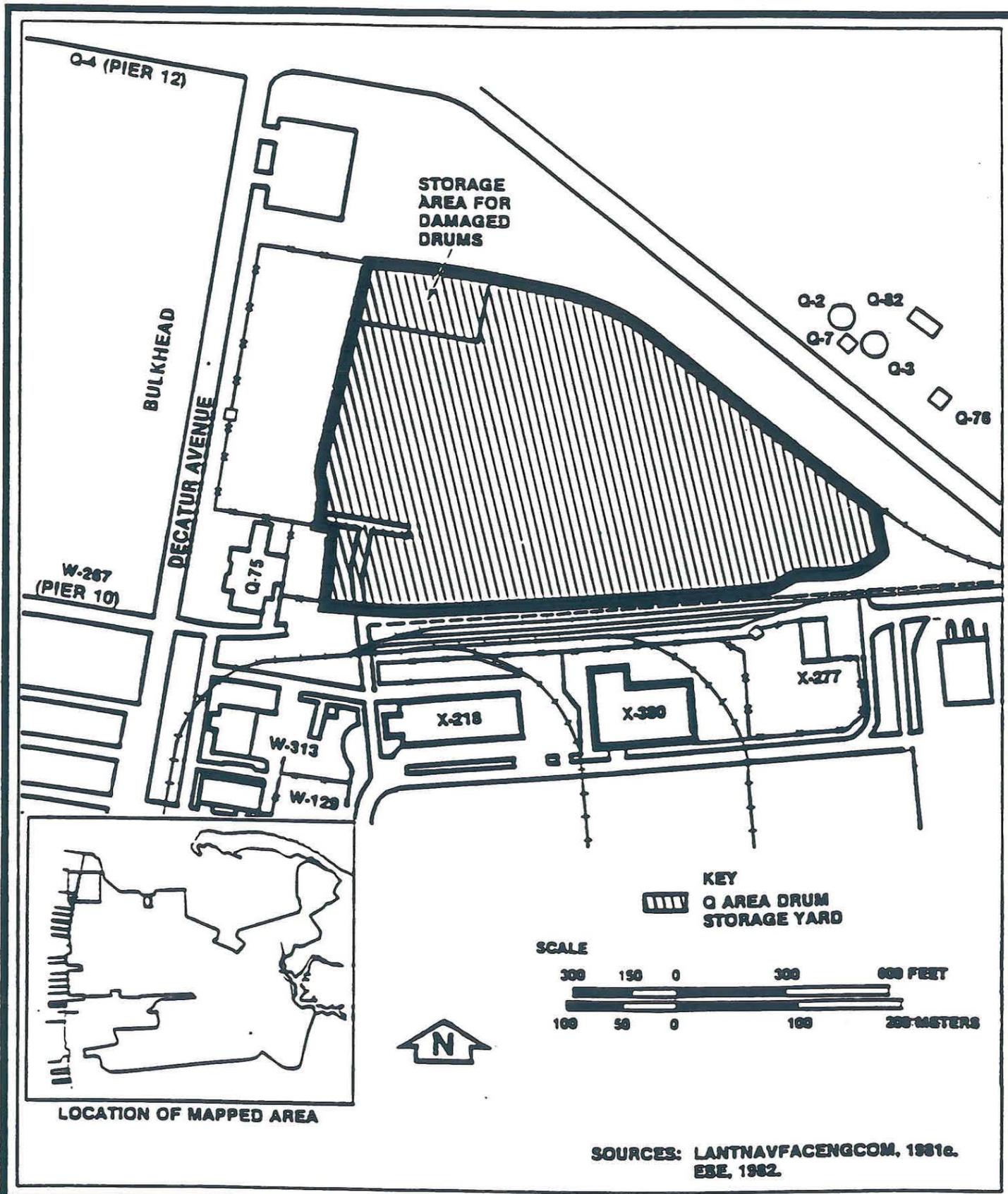


- LEGEND**
- HYDROPUNCH LOCATION
 - MONITOR WELL LOCATION
 - 1.83 GROUNDWATER ELEVATION IN FEET
 - GROUNDWATER CONTOUR LINE
 - ➔ DIRECTION OF GROUNDWATER



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DATE 3-14-94	SCALE SHOWN	TITLE GROUNDWATER CONTOUR MAP JANUARY 19, 1993 Q AREA DRUM STORAGE YARD NORFOLK, VIRGINIA	
DRAWN BY LAL/DN	APPROVED BY		
JOB NO. 4921150	DWG. NO./ REV. NO. PQD2 / -	CLIENT NAVFAC - Q AREA	FIGURE 3-4



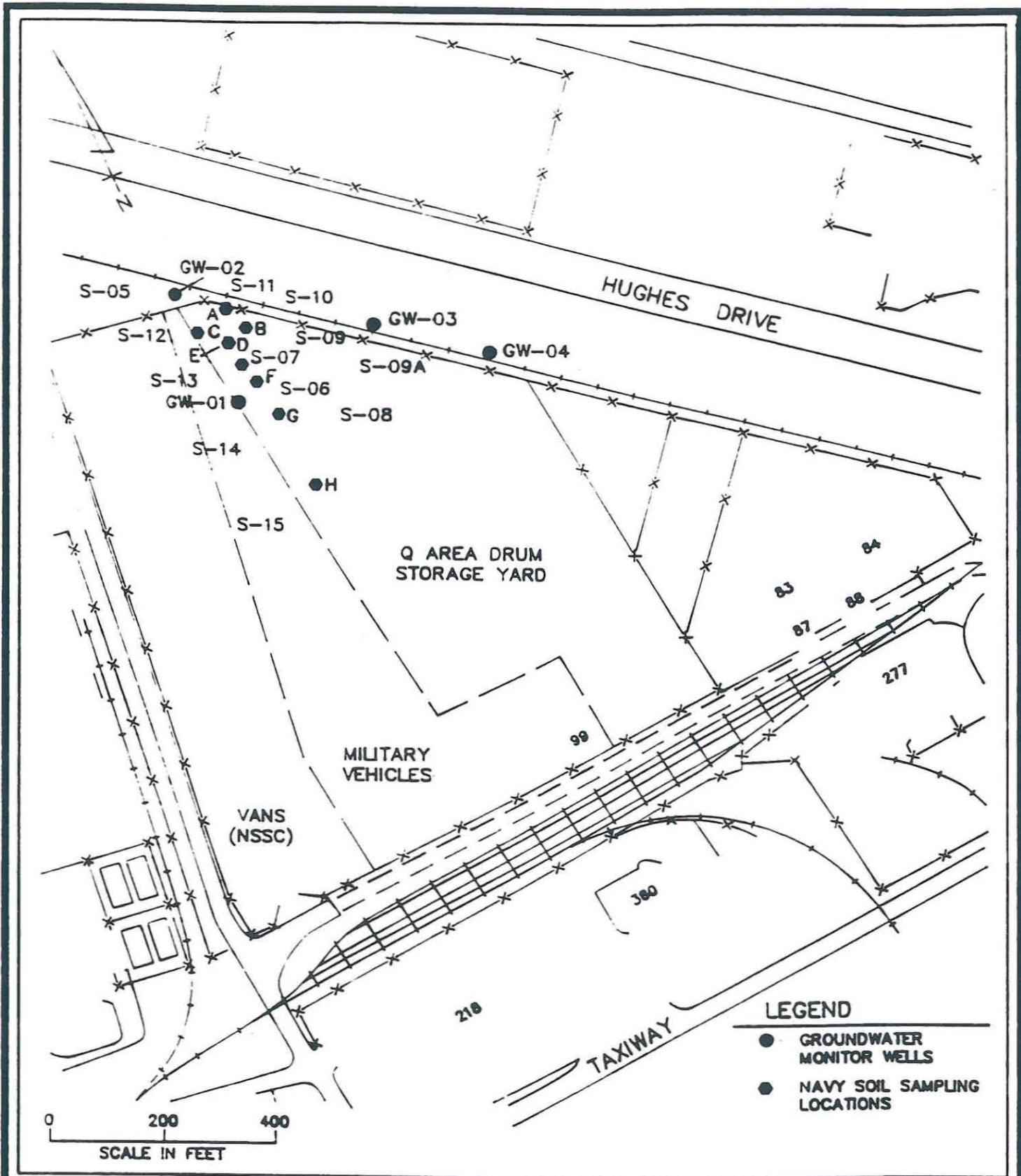
LOCATION OF MAPPED AREA

SOURCES: LANNAVFACENGCOM, 1981e.
ESE, 1982.



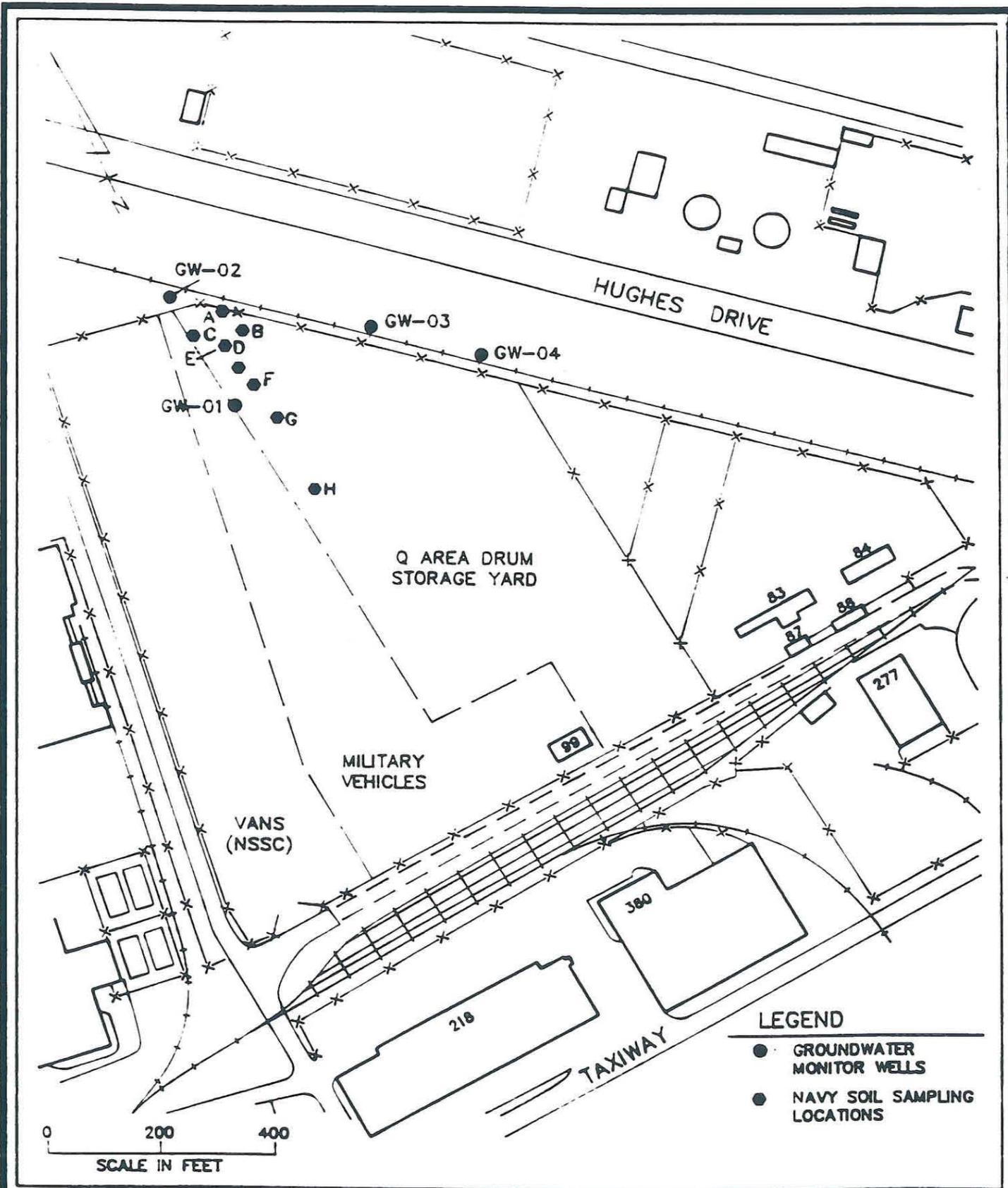
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DATE 6-3-91	SCALE SHOWN	TITLE Area of Investigation for Initial Assessment Study, May 1982, Q Area Drum Storage Yard, Norfolk Virginia	
DRAWN BY LAF	APPROVED BY		
JOB NO. 4901107	DWG. NO./ REV. NO. 2 -	CLIENT LANNAVFACENGCOM	FIGURE 1-2

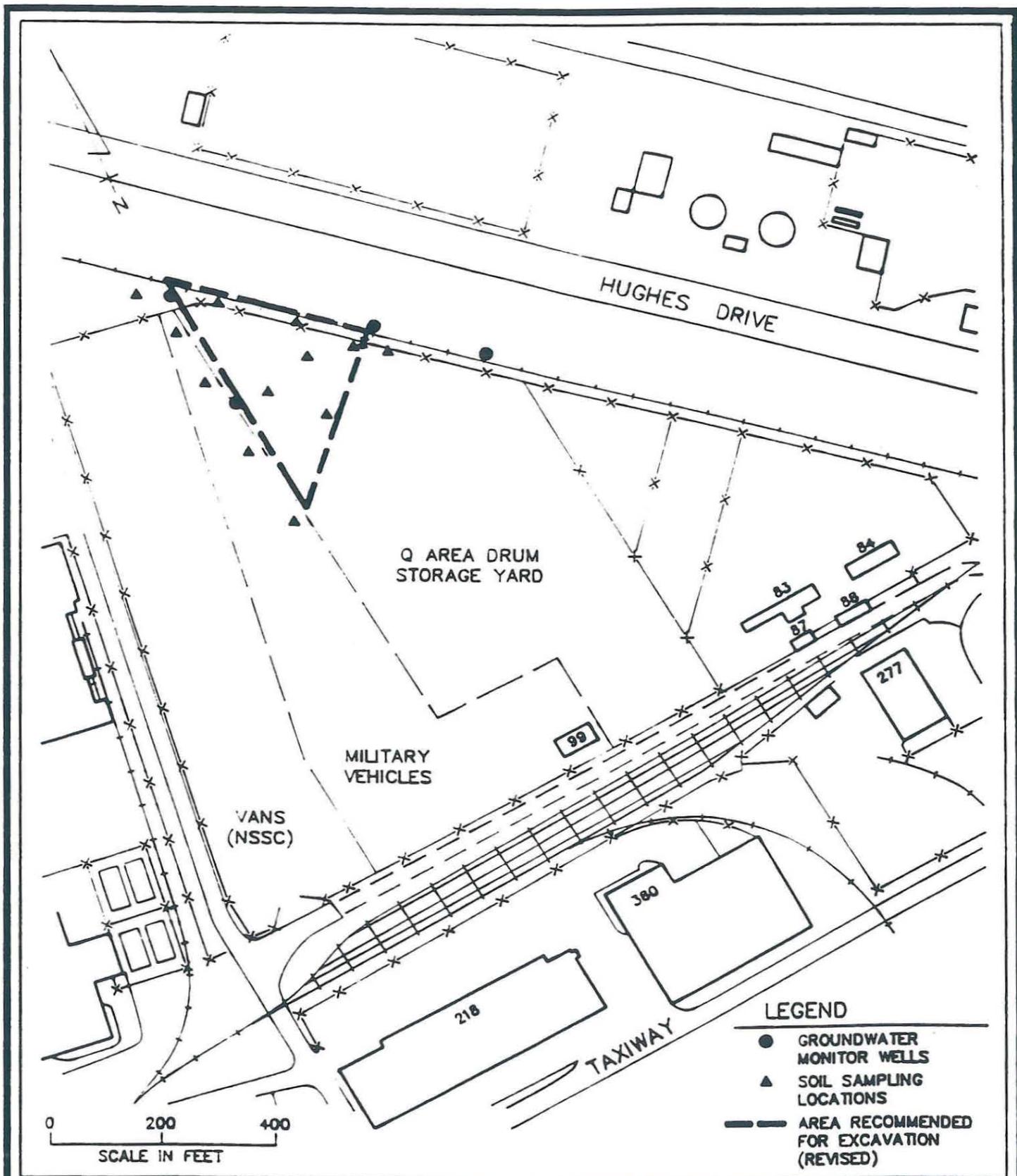


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DATE 6-4-91	SCALE SHOWN	TITLE Area of Investigation for the Remedial Investigation, November 1983-June 1986 Q Area Drum Storage Yard, Norfolk, Va	
DRAWN BY LAF	APPROVED BY	CLIENT LANTNAVFACENGCOM	FIGURE 1-3
JOB NO. 4901107	DWG. NO. / REV. NO. QBASE3 / -		



 Environmental Science & Engineering	DATE 6-4-91	SCALE SHOWN	TITLE Navy Sampling Locations, April 1986 - Q Area Drum Storage Yard - Norfolk, VA	
	DRAWN BY LAF	APPROVED BY		
	JOB NO. 4901107	DWG. NO. / REV. NO. QBASE1 / -	CLIENT LANTNAVFACENGCOM	FIGURE 1-4



LEGEND

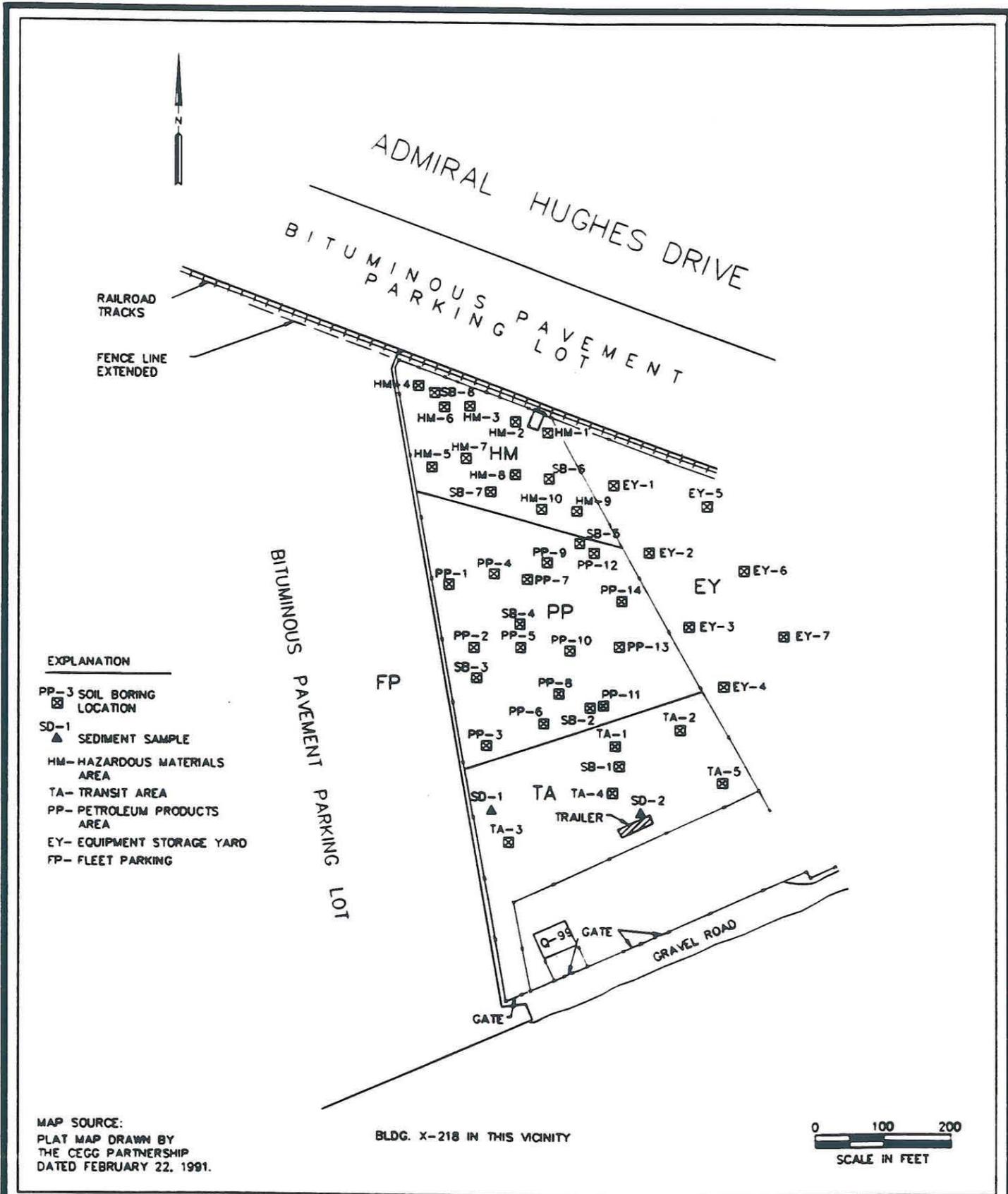
- GROUNDWATER MONITOR WELLS
- ▲ SOIL SAMPLING LOCATIONS
- AREA RECOMMENDED FOR EXCAVATION (REVISED)

0 200 400
SCALE IN FEET



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DATE 6-4-91	SCALE SHOWN	TITLE Area Recommended for Contaminated Soil Removal Q Area Drum Storage Yard, Norfolk, Va	
DRAWN BY LAF	APPROVED BY	CLIENT LANTNAVFACENGCOM	FIGURE 1-5
JOB NO. 4901107	DWG. NO./ REV. NO. QBASE2 / -		

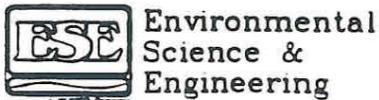


EXPLANATION

- PP-3 SOIL BORING LOCATION
- SD-1 SEDIMENT SAMPLE
- HM- HAZARDOUS MATERIALS AREA
- TA- TRANSIT AREA
- PP- PETROLEUM PRODUCTS AREA
- EY- EQUIPMENT STORAGE YARD
- FP- FLEET PARKING

MAP SOURCE:
 PLAT MAP DRAWN BY
 THE CEGG PARTNERSHIP
 DATED FEBRUARY 22, 1991.

BLDG. X-218 IN THIS VICINITY



DATE 4-16-93	SCALE SHOWN	TITLE SOIL AND SEDIMENT SAMPLE LOCATIONS Q AREA DRUM STORAGE YARD NORFOLK, VIRGINIA	
DRAWN BY LAF	APPROVED BY		
JOB NO. 4921150	DWG. NO./ REV. NO. SOILB / -	CLIENT NAVFAC - Q AREA	FIGURE ES-3



- LEGEND**
- HYDROPUNCH LOCATION
 - MONITOR WELL LOCATION



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TITLE

MONITOR WELL AND HYDROPUNCH
LOCATIONS
Q AREA DRUM STORAGE YARD
NORFOLK NAVAL BASE, NORFOLK, VA.

CLIENT

NAVFAC - Q AREA

FIGURE

ES-2

Slide 12. RI/FS Soil Analytical Results (µg/kg)

	Range	Mean	Background
Methylene Chloride	U - 110	12	7 - 12
Acetone	U - 650	65	U
1,1-DCE	U - 5*	0	U
1,1-DCA	U - 1500*	25	U
1,2-DCE	U - 20	1	U
TCE	U - 29*	0	U
PCE	U - 32,000	550	U
TPH (ppm)	ND - 4400	514	74 - 92

* Detected in one sample only.

U = Undetected

ND = Not detected

Table 5-5. (Continued)

Constituent	VDEQ Groundwater Standard	VDEQ Surface Water Standard				Samples Exceeding Standard	Sample Concentration
		Freshwater Aquatic Life		Human Health			
		Acute Toxicity	Chronic Toxicity	Public Water Supplies	All Other Surface Waters		
METALS (µg/l)							
Antimony	--					N/A	
Arsenic	50	360	190	50		SW-2-2 SW-5-2	171 337
Cadmium	0.4	$e^{(1.128[\ln(\text{hardness}) - 3.828])}$	$e^{(0.7852[\ln(\text{hardness}) - 3.490])}$	10		SW-2-2 SW-4-2 SW-5-2 GW-4-2 DW-2 FD (U)	281 206 1120 63 0.5
Chromium	60	16 ²	11 ²	170 ²	3400 ²	SW-2-2 SW-4-2 SW-5-2 GW-4-2	281 206 1120 63
Lead	50	$e^{(1.273[\ln(\text{hardness}) - 1.460])}$	$e^{(1.273[\ln(\text{hardness}) - 4.705])}$	50		SW-2-2 SW-4-4 SW-5-2	116 102 516
Mercury	0.05	2.4	0.012	0.144	0.146	SW-2-2 GW-4-2 SW-5 (F)	0.140 0.3
Zinc	50	$e^{(0.8473[\ln(\text{hardness}) + 0.8604])}$	$e^{(0.8473[\ln(\text{hardness}) + 0.7614])}$			SW-2-2 SW-4-2 SW-5-2 GW-4-2	354 416 1580 101

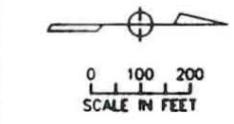
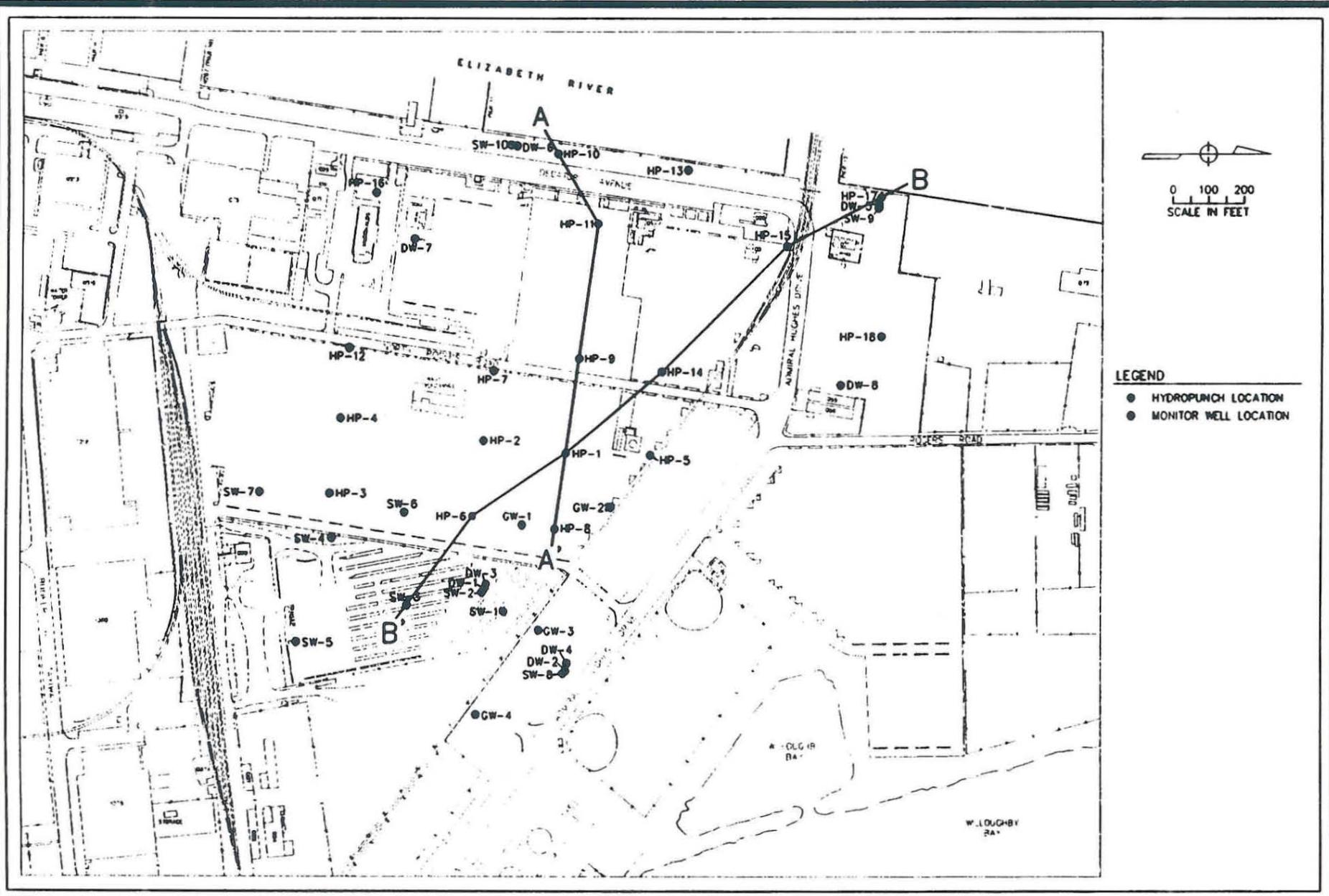
¹Drinking water and fish consumption
²Fish consumption

*Hardness as calcium carbonate mg/e CaCO₃
^aChromium VI

FD = Field Duplicate
 U = Unfiltered
 F = Filtered

Table 5-5. Groundwater Samples Exceeding VDEQ Standards

Constituent	VDEQ Groundwater Standard	VDEQ Surface Water Standard				Samples Exceeding Standard	Sample Concentration
		Freshwater Aquatic Life		Human Health			
		Acute Toxicity	Chronic Toxicity	Public Water Supplies	All Other Surface Waters		
VOCs (µg/l)							
PCE	--	--	--	317	3519	SW-2-1 SW-2-2	4800 3700
TCE	--	--	--	2.7	807	HP-15-35 HP-11-35	1371 866
1,1,1-TCA	--	--	--	3100	--	N/A	--
1,2-DCA	--	--	--	3.8	990	NONE	--
1,2-DCE	--	--	--	--	--	N/A	--
1,1-DCA	--	--	--	--	--	N/A	--
Acetone	--	--	--	--	--	N/A	--
1,1-DCE	--	--	--	--	--	--	--
Carbon Tetrachloride	--	--	--	2.5	45	SW-1-1 SW-1-1 FD SW-1-2	120 72 84
Methylene Chloride	--	--	--	--	--	N/A	--
Chloroform	--	--	--	57	4700	NONE	--
Bromodichloro-methane	--	--	--	--	--	N/A	--
TPH mg/l	1	--	--	--	--	SW-1-2	1-5



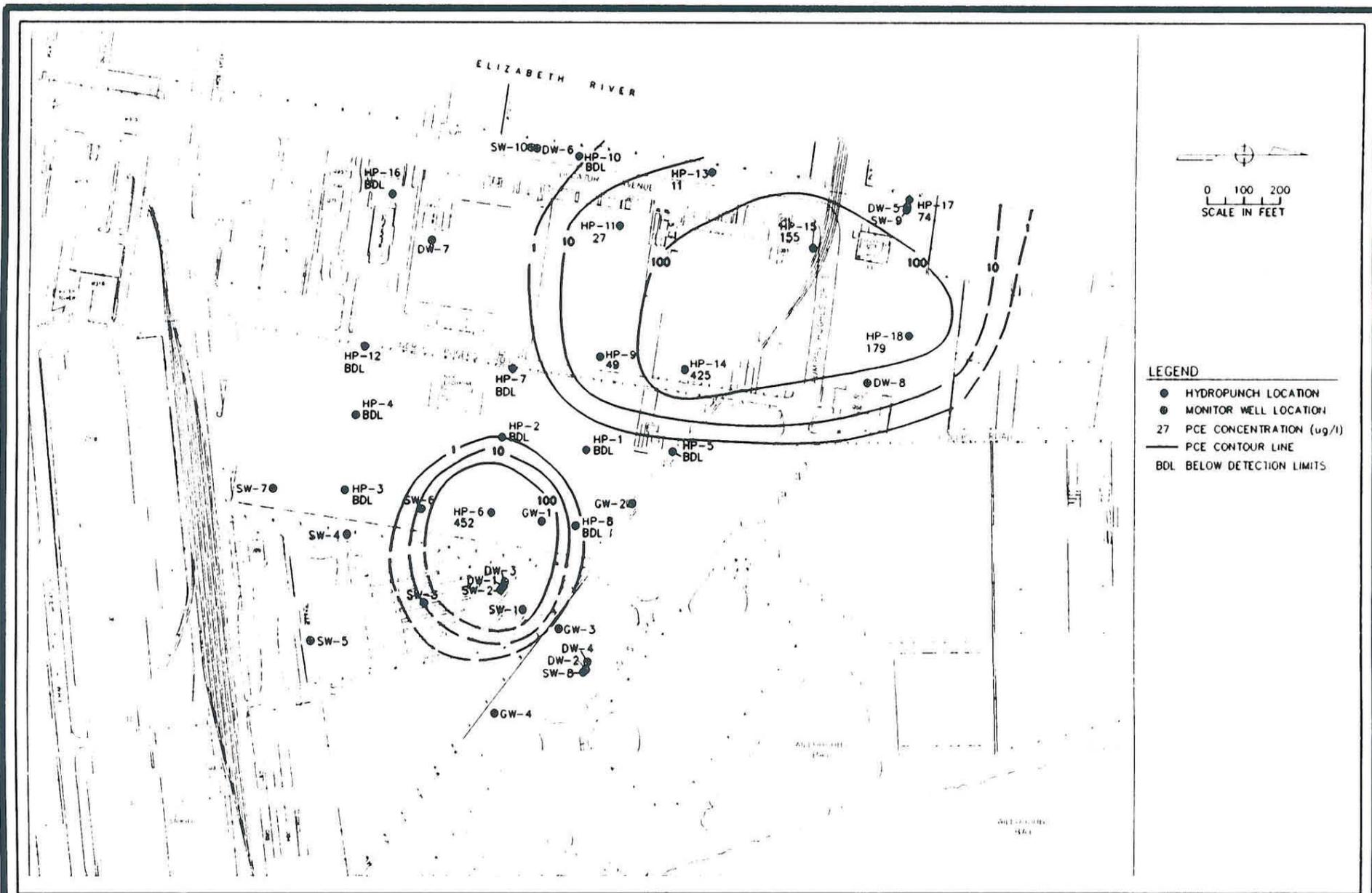
LEGEND

- HYDROPUNCH LOCATION
- MONITOR WELL LOCATION



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DATE 3-16-94	SCALE SH	TITLE MONITOR WELL, HYDROPUNCH AND TCE CONCENTRATION CROSS SECTION LOCATIONS A AREA DRUM STORAGE NORFOLK, VIRGINIA	
DRAWN BY LAL/DN	APPROVED BY		
JOB NO. 4921150	DWG. NO./ REV. NO. QDL / -	CLIENT NAVYFAC - Q AREA	FIGURE 5-6



LEGEND

- HYDROPUNCH LOCATION
- ⊙ MONITOR WELL LOCATION
- 27 PCE CONCENTRATION (ug/l)
- PCE CONTOUR LINE
- BDL BELOW DETECTION LIMITS



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DATE
3-16-94

SCALE
SHOWN

TITLE

PCE CONCENTRATION MAP
AT 15 FEET
Q AREA DRUM STORAGE YARD
NORFOLK NAVAL BASE, NORFOLK, VA.

DRAWN BY
LAL/DN

APPROVED BY

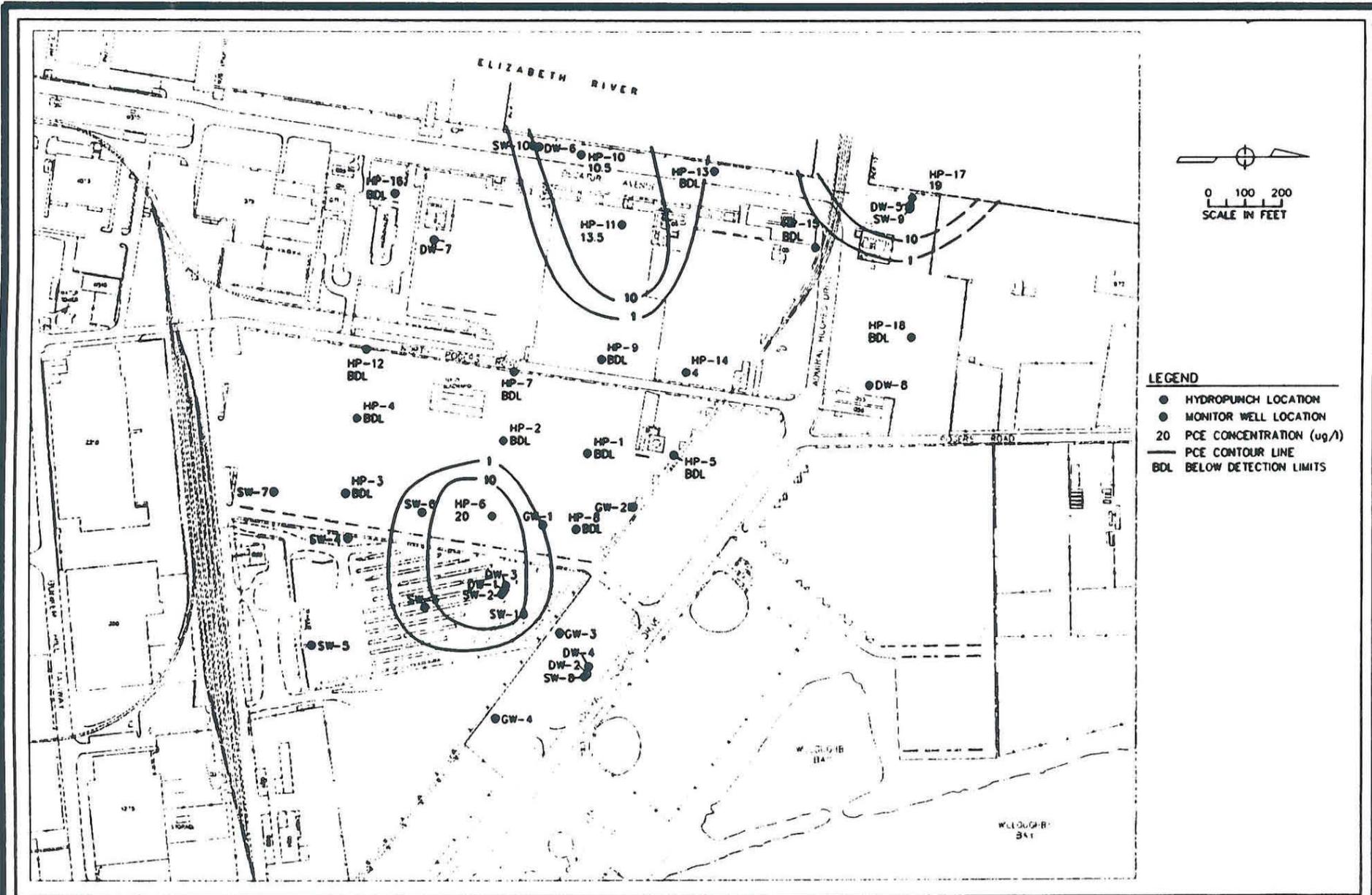
JOB NO.
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QDK / -

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NAVFAC - Q AEREA

FIGURE
5-29



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QDH / -

TITLE

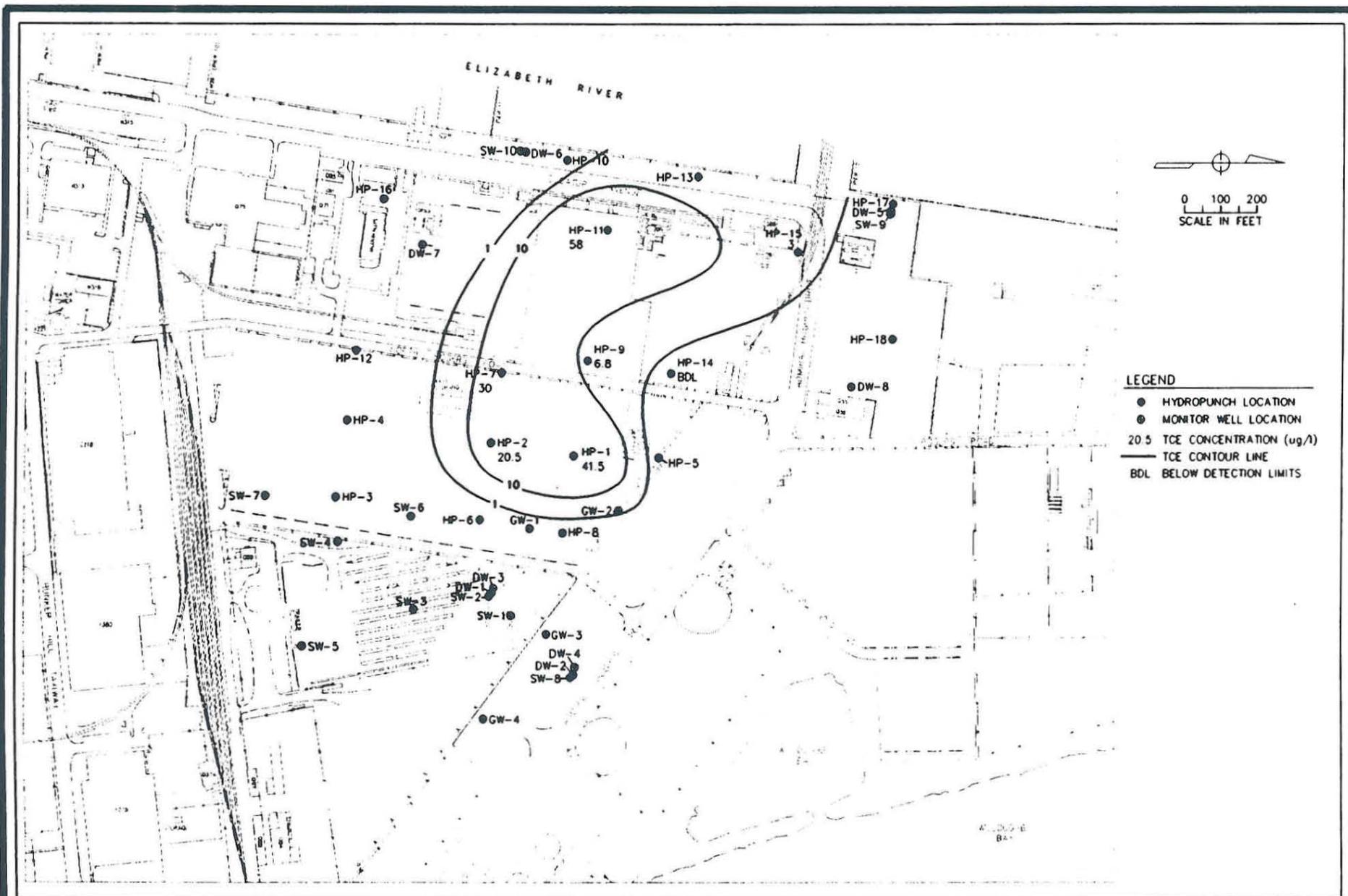
PCE CONCENTRATION MAP
AT 25 FEET
Q AREA DRUM STORAGE YARD
NORFOLK NAVAL BASE, NORFOLK, VA.

CLIENT

NAVFAC - Q AREA

FIGURE

5-31



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DN

JOB NO.
4921150

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SHOWN

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DWG. NO./ REV. NO.
QDE / -

TITLE

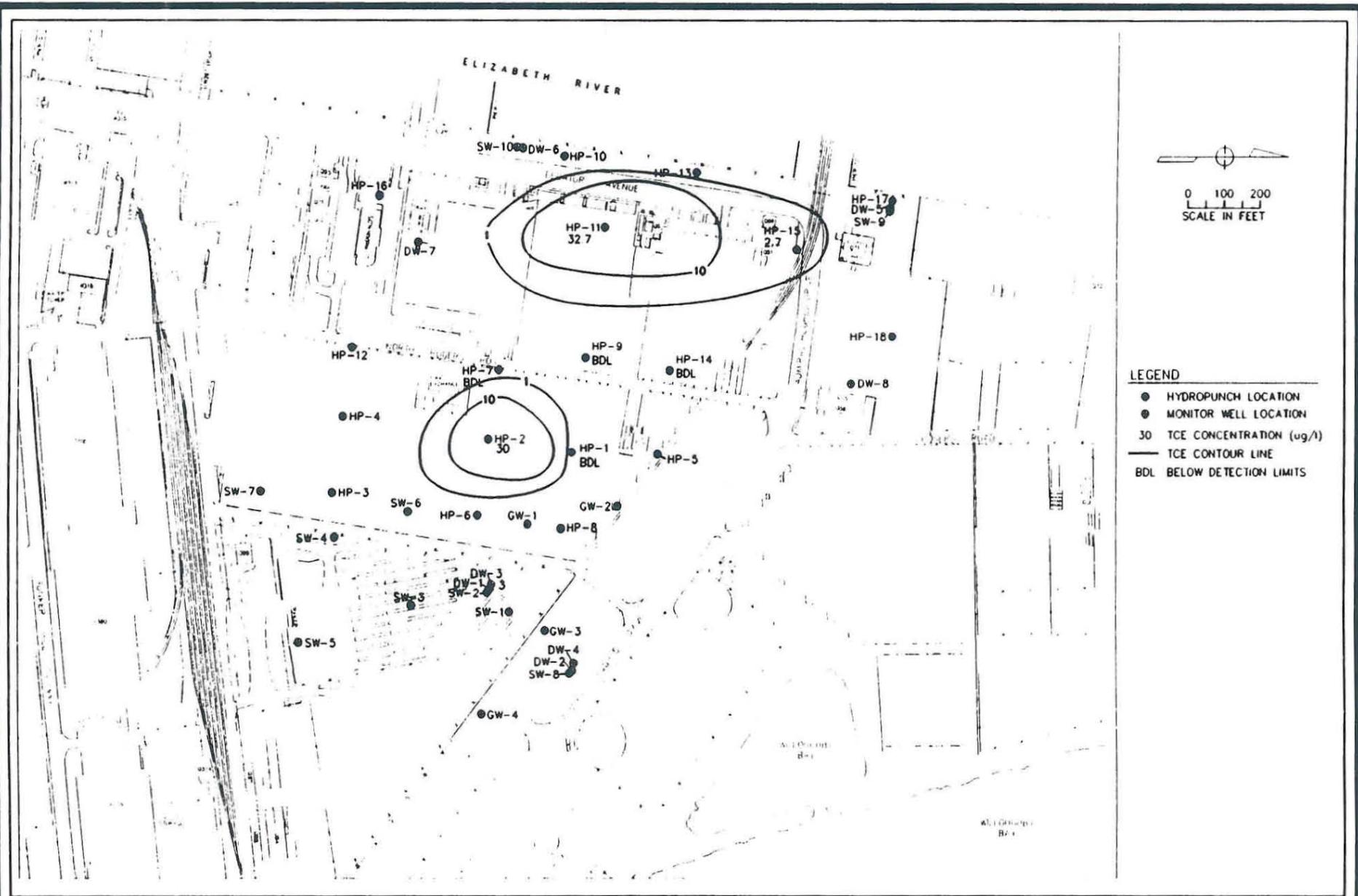
TCE CONCENTRATION MAP
AT 45 FEET
Q AREA DRUM STORAGE
NORFOLK NAVAL BASE, NORFOLK, VA.

CLIENT

NAVFAC - Q AREA

FIGURE

5-34



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4921150

SCALE
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DWG. NO./ REV. NO
QDD / -

TITLE

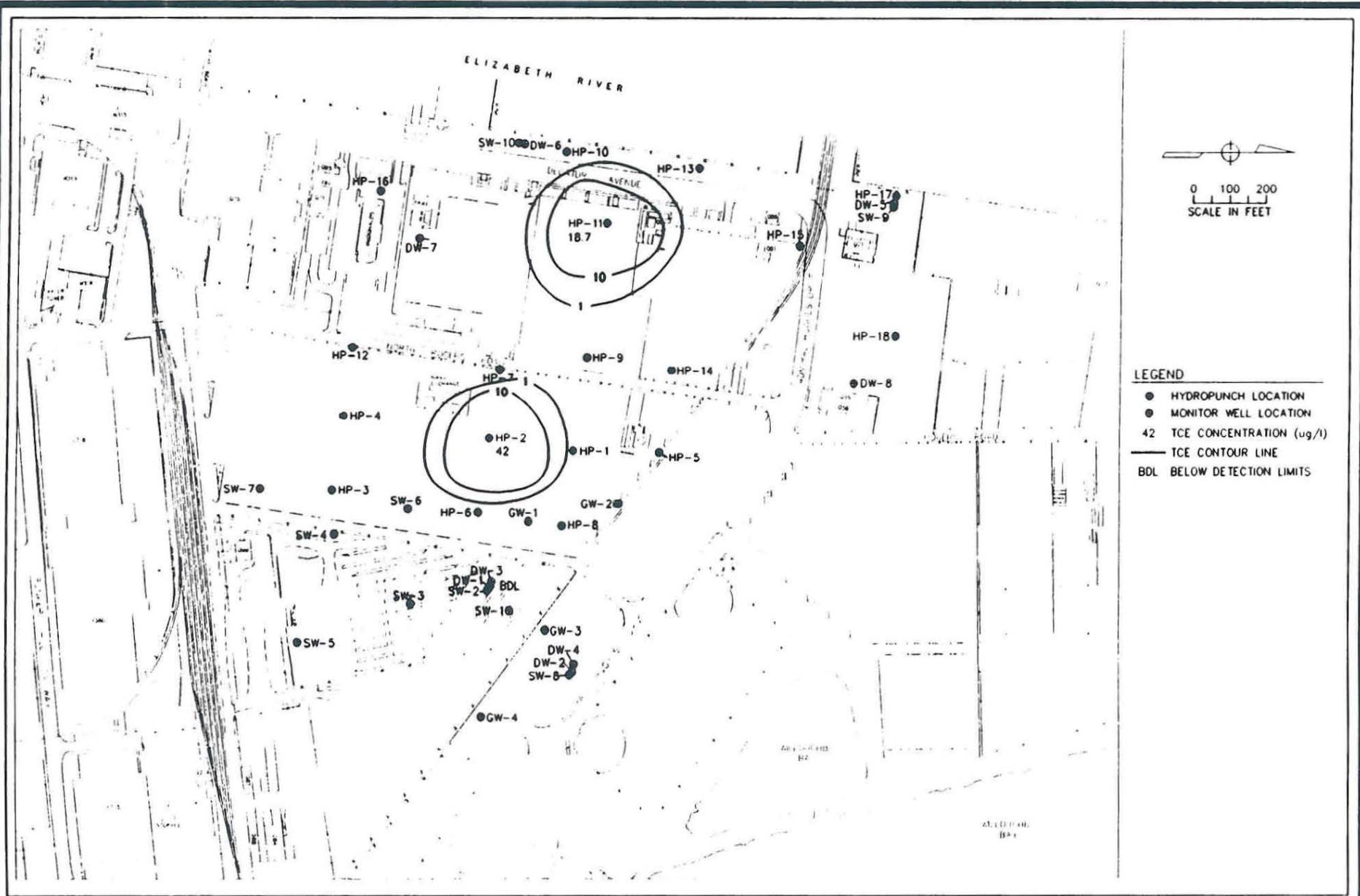
TCE CONCENTRAION MAP
AT 55 FEET
Q AREA DRUM STORAGE YARD
NORFOLK NAVAL BASE, NORFOLK, VA.

CLIENT

NAVFAC - Q AREA

FIGURE

5-35



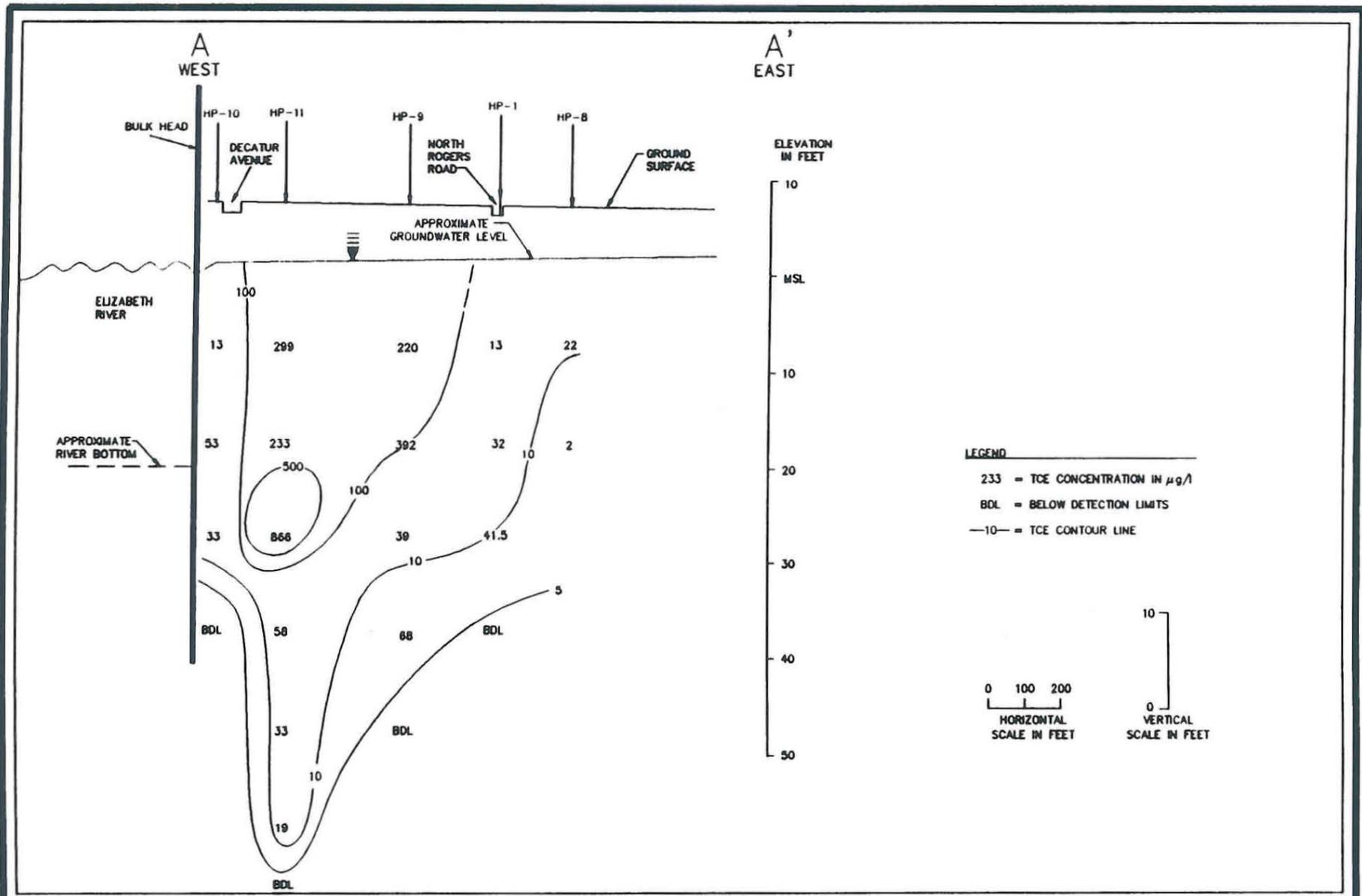
LEGEND

- HYDROPUNCH LOCATION
- MONITOR WELL LOCATION
- 42 TCE CONCENTRATION (ug/l)
- TCE CONTOUR LINE
- BDL BELOW DETECTION LIMITS



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DATE 3-16-94	SCALE SHOWN	TITLE TCE CONCENTRATION MAP AT 65 FEET Q AREA DRUM STORAGE YARD NORFOLK NAVAL BASE, NORFOLK, VA.	
DRAWN BY DN	APPROVED BY		
JOB NO. 4921150	DWG. NO. / REV. NO. QDC / -	CLIENT NAVFAC - Q AREA	FIGURE 5-36

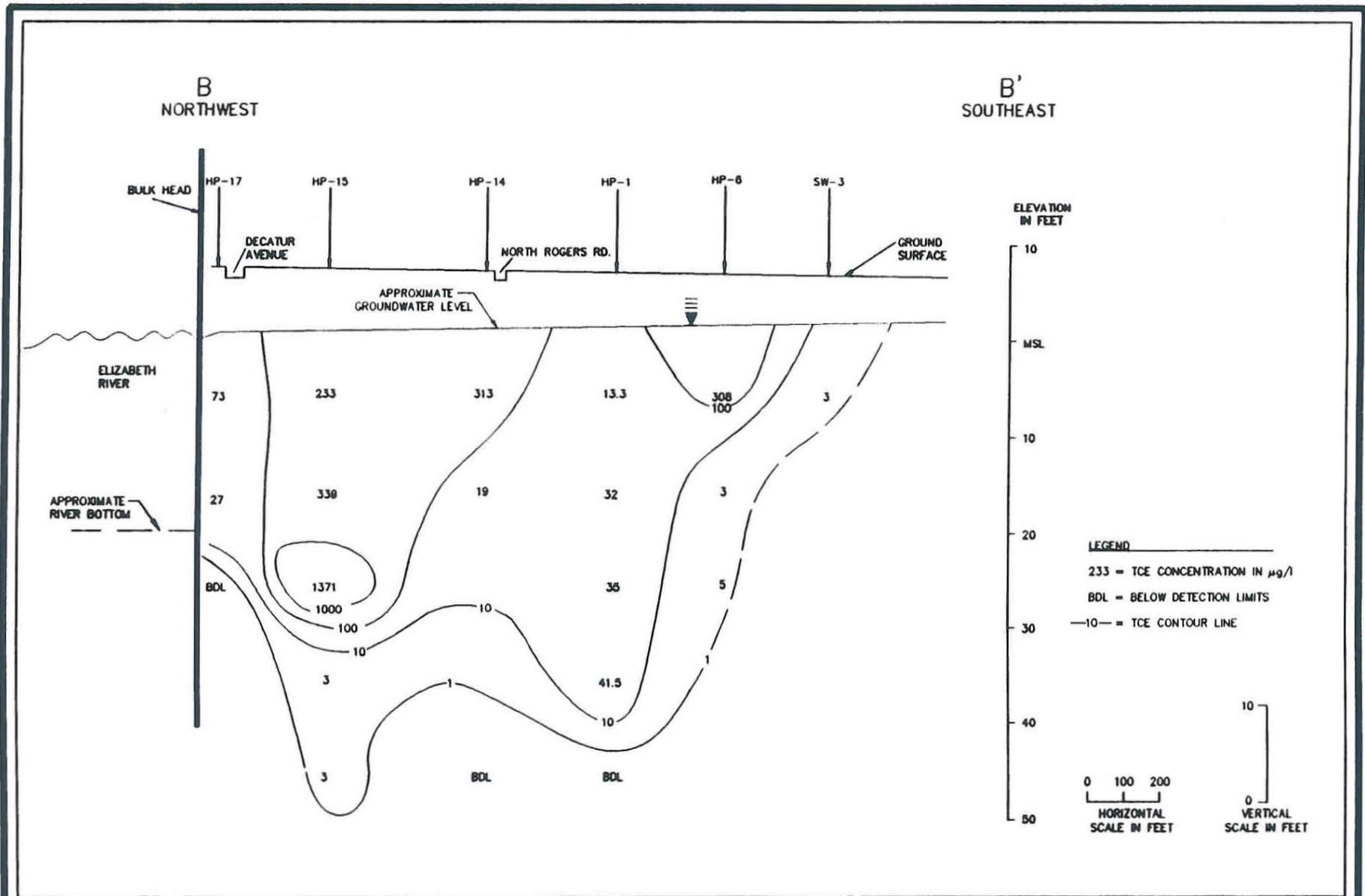


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DATE 3-16-94	SCALE SHOWN
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JOB NO. 4921150	DWG. NO./ REV. NO. QDO / -

TITLE TCE CONCENTRATION µg/l CROSS SECTION B-B Q AREA DRUM STORAGE YARD NORFOLK NAVAL BASE, NORFOLK, VA.
CLIENT NAVFAC - Q AREA

FIGURE
5-37



**Environmental
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DATE
3-16-94

SCALE
SHOWN

TITLE

TCE CONCENTRATION $\mu\text{g}/\text{l}$
CROSS SECTION B-B
Q AREA DRUM STORAGE YARD
NORFOLK NAVAL BASE, NORFOLK, VA.

DRAWN BY
DN

APPROVED BY

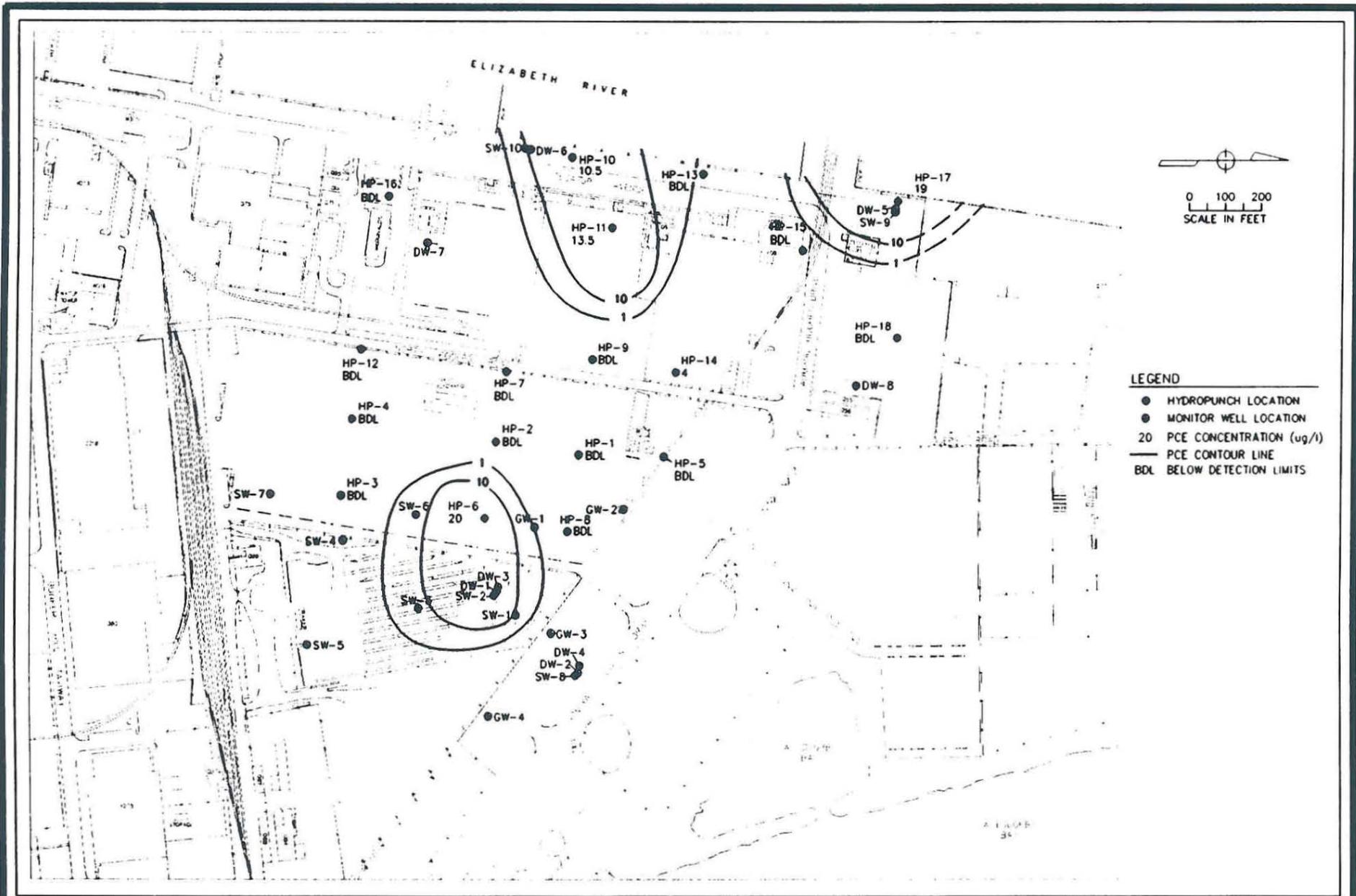
JOB NO.
4921150

DWG. NO./ REV. NO.
QDP / -

CLIENT

NAVFAC - Q AREA

FIGURE
5-38



**Environmental
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3-16-94

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4921150

SCALE
SHOWN

APPROVED BY

DWG. NO./ REV. NO.
QDH / -

TITLE

PCE CONCENTRATION MAP
AT 25 FEET
Q AREA DRUM STORAGE YARD
NORFOLK NAVAL BASE, NORFOLK, VA.

CLIENT

NAVFAC - Q AREA

FIGURE

5-31

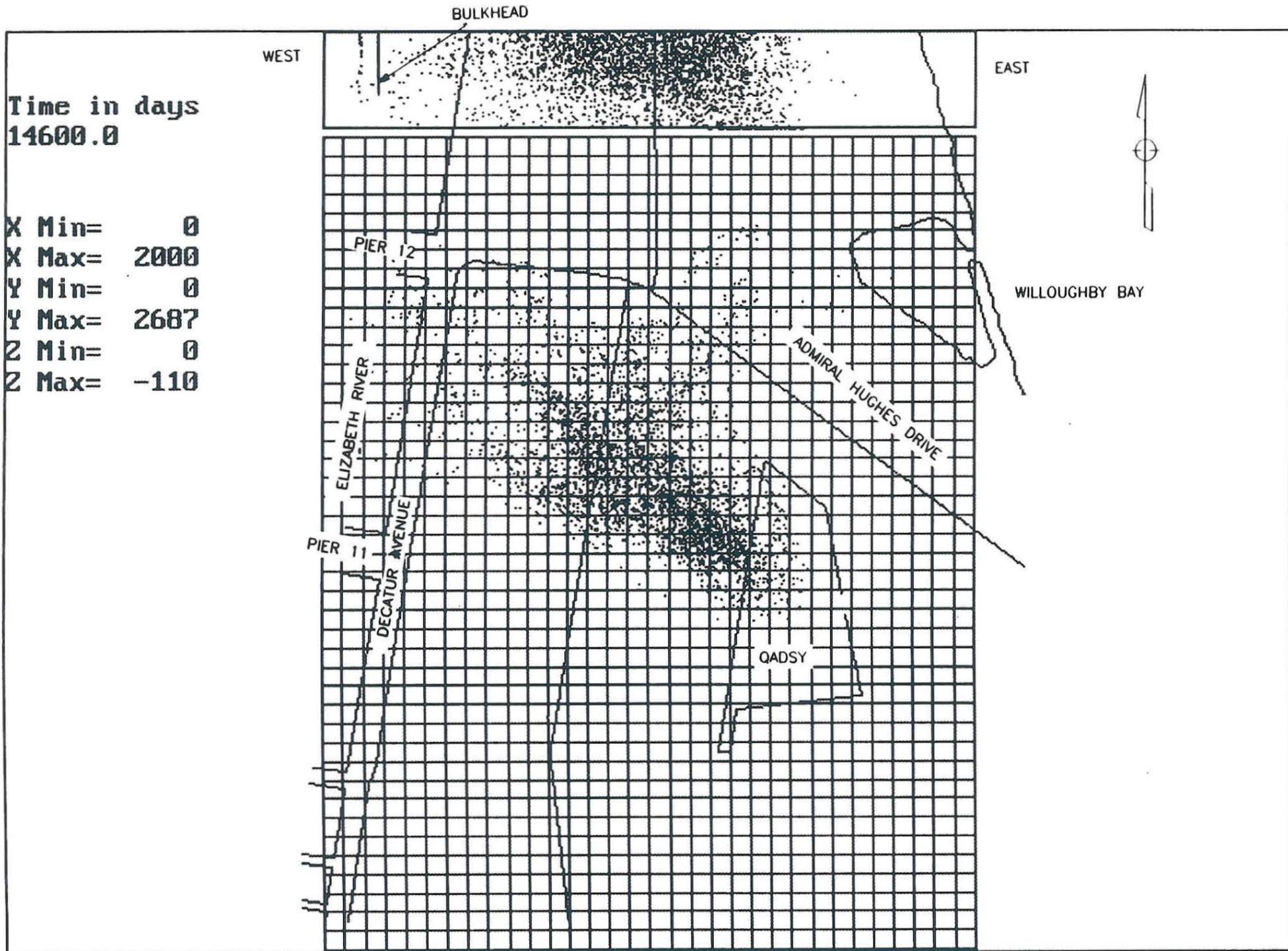


Figure 4-21

INTERTRANS Model - Simulation with 100 Particles

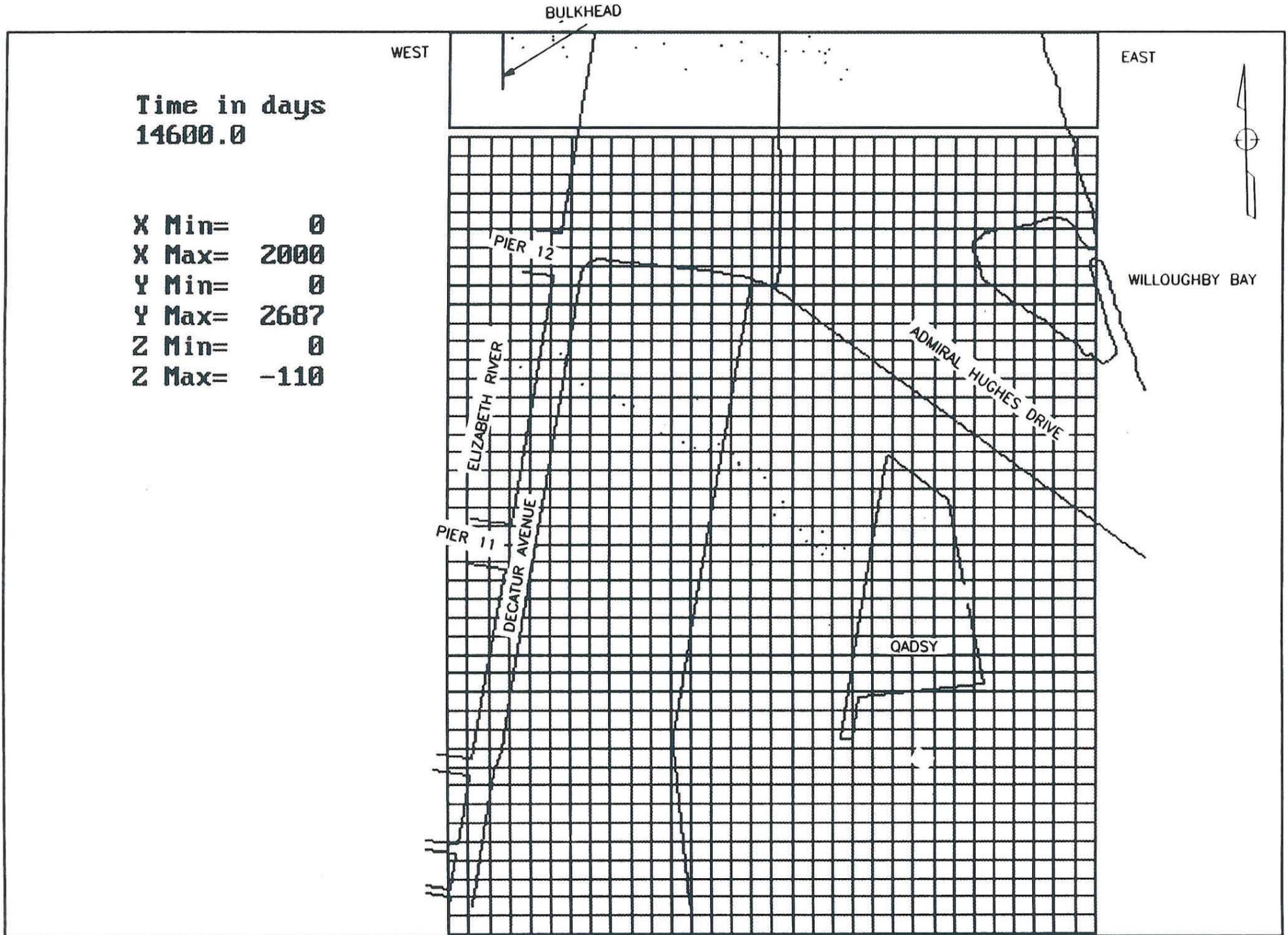


Figure 4-22

INTERTRANS Model - Simulation with 1 Particle

EXHIBIT 1-2
PART A: BASELINE RISK ASSESSMENT

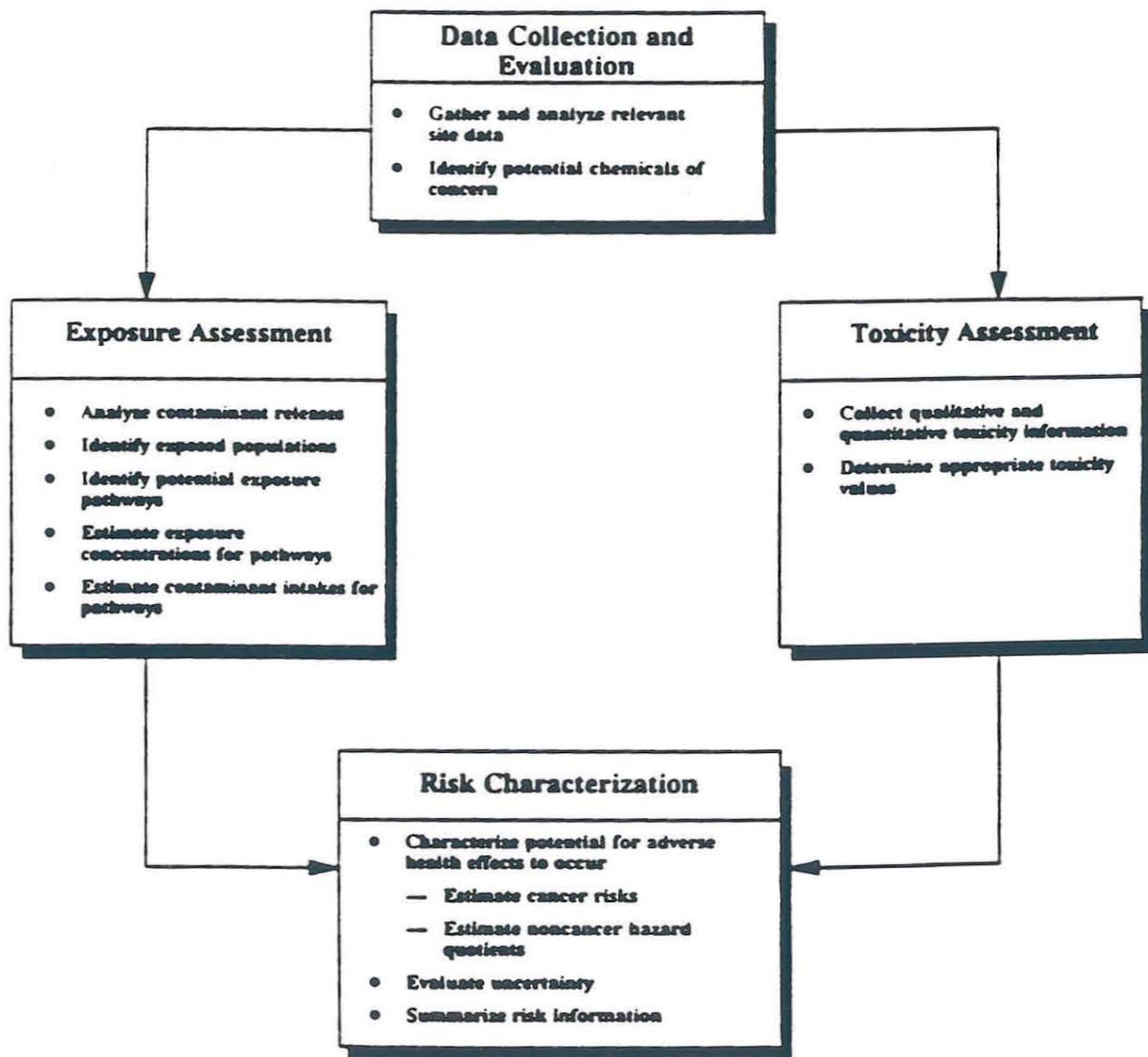
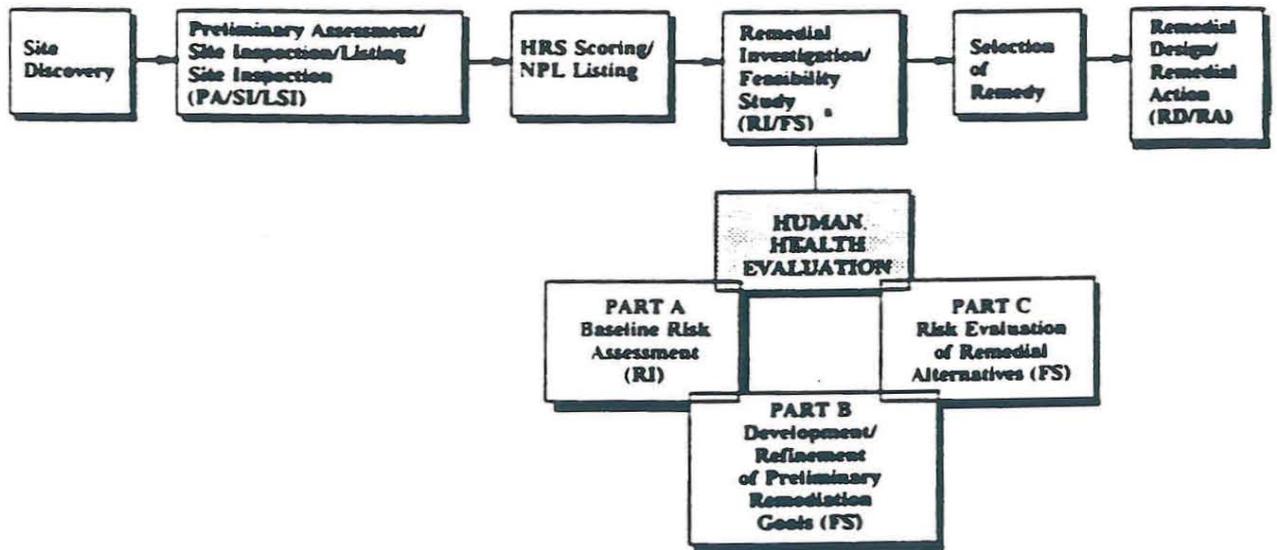


EXHIBIT 2-2

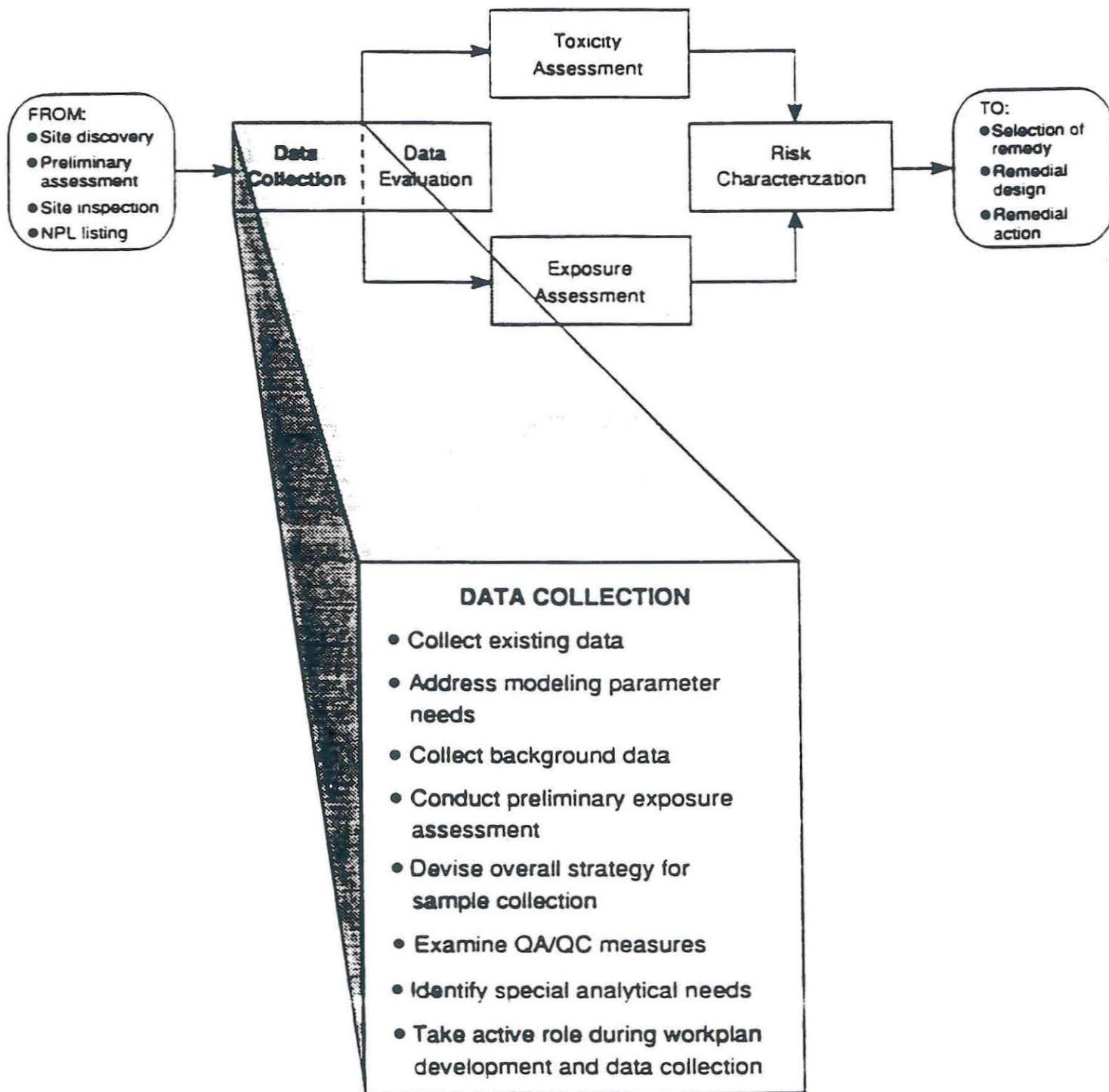
ROLE OF THE HUMAN HEALTH EVALUATION IN THE SUPERFUND REMEDIAL PROCESS



* The RI/FS can be undertaken prior to NPL listing.

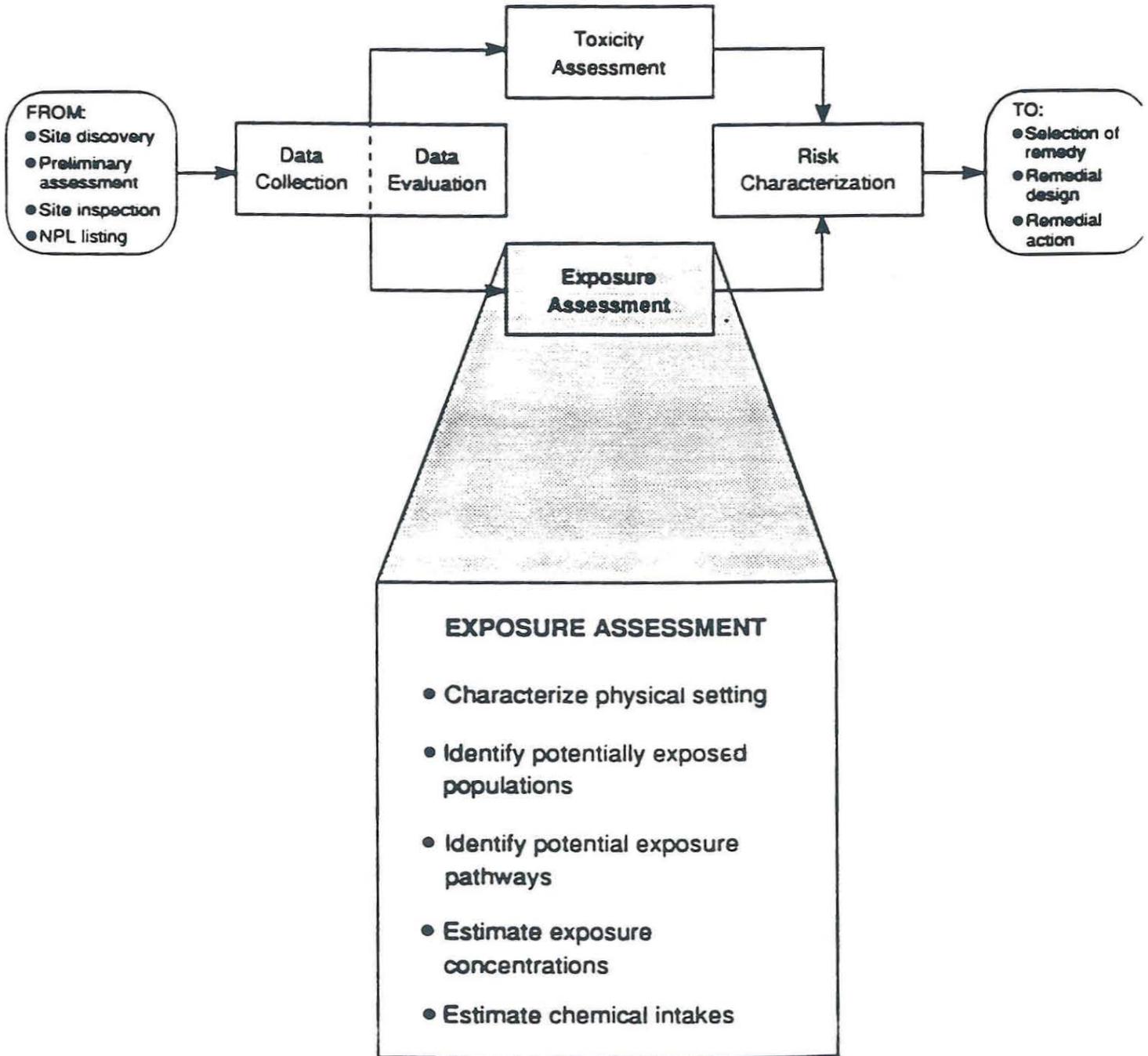
CHAPTER 4

DATA COLLECTION



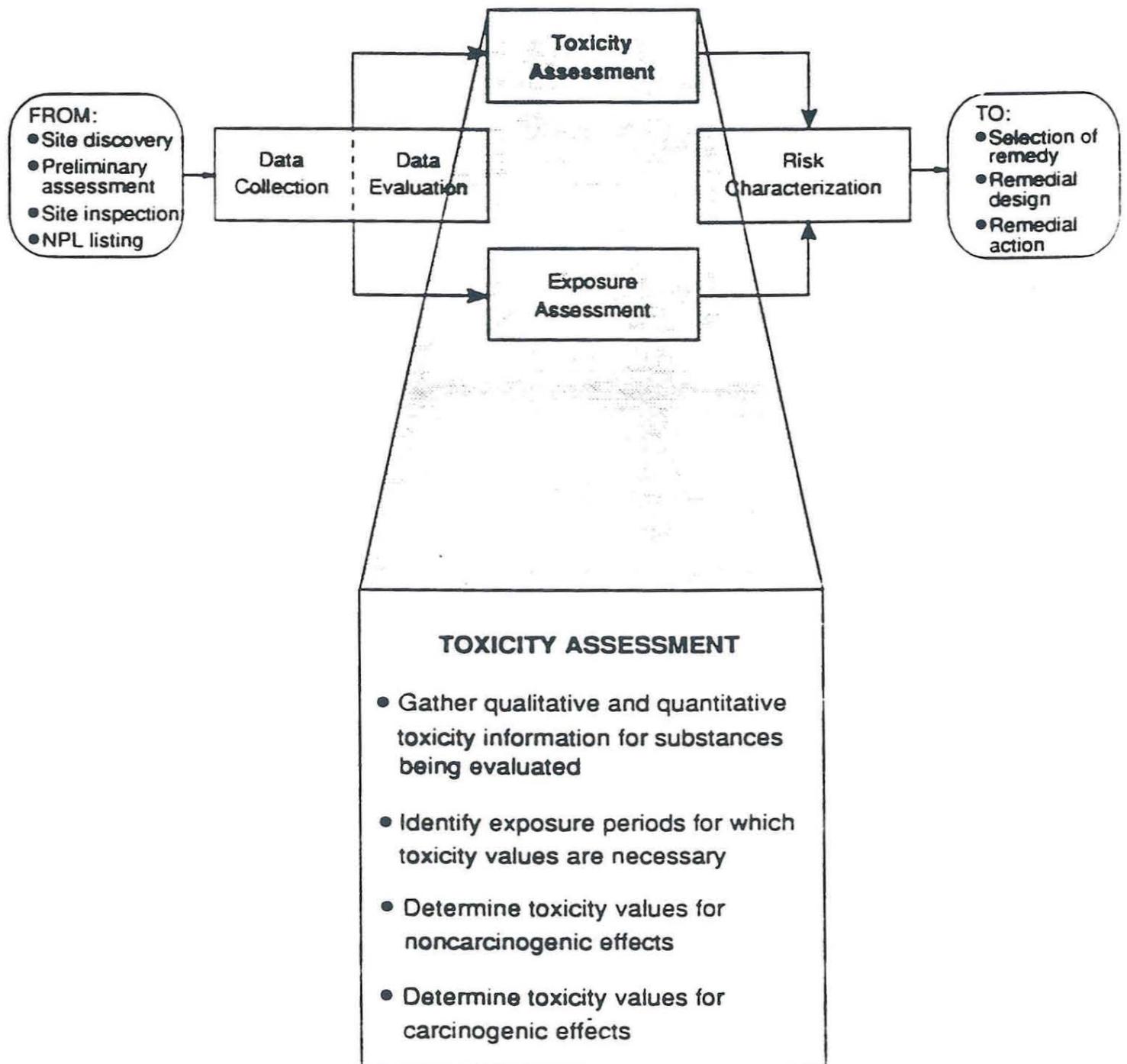
CHAPTER 6

EXPOSURE ASSESSMENT



CHAPTER 7

TOXICITY ASSESSMENT



CHAPTER 8

RISK CHARACTERIZATION

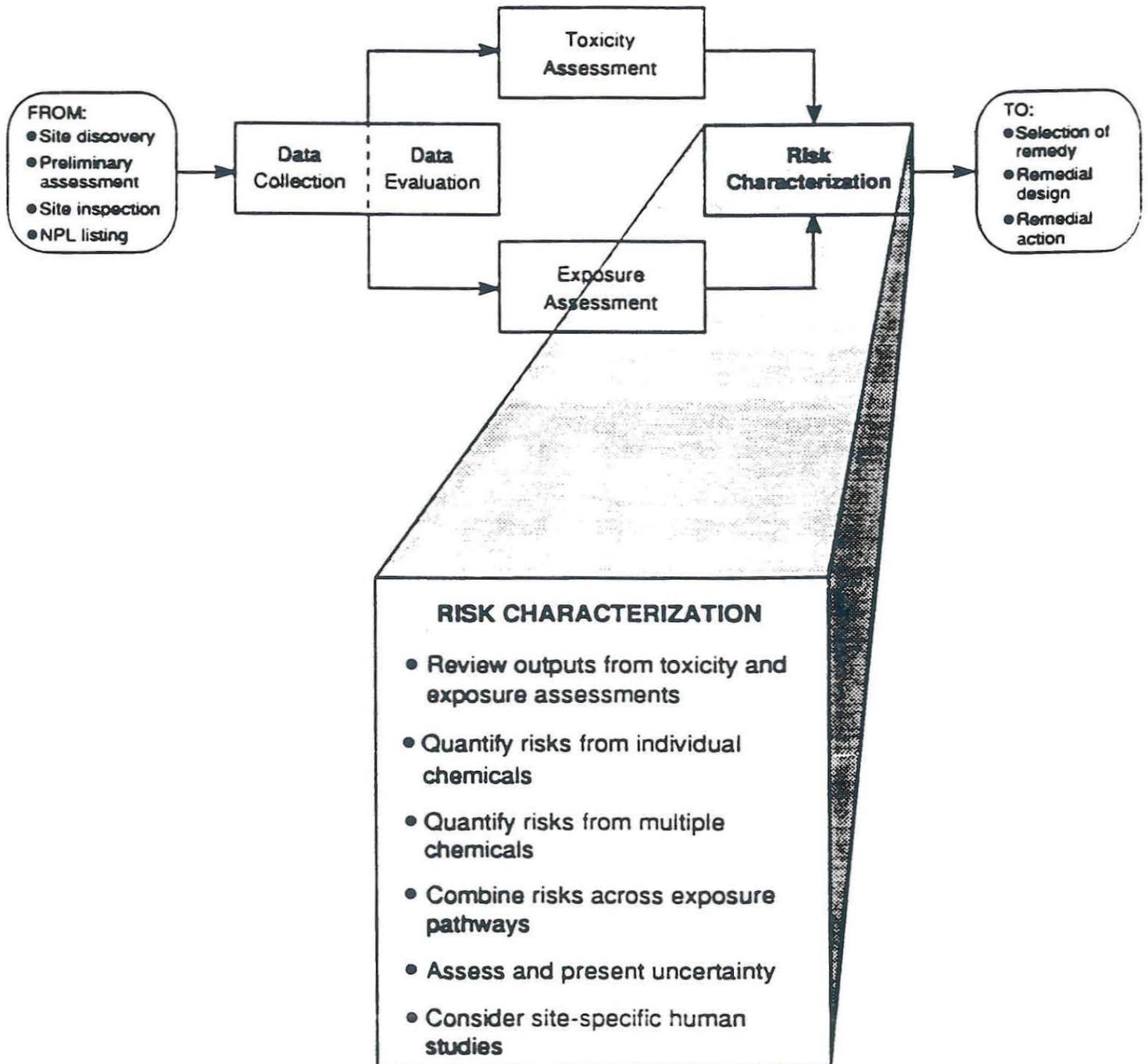
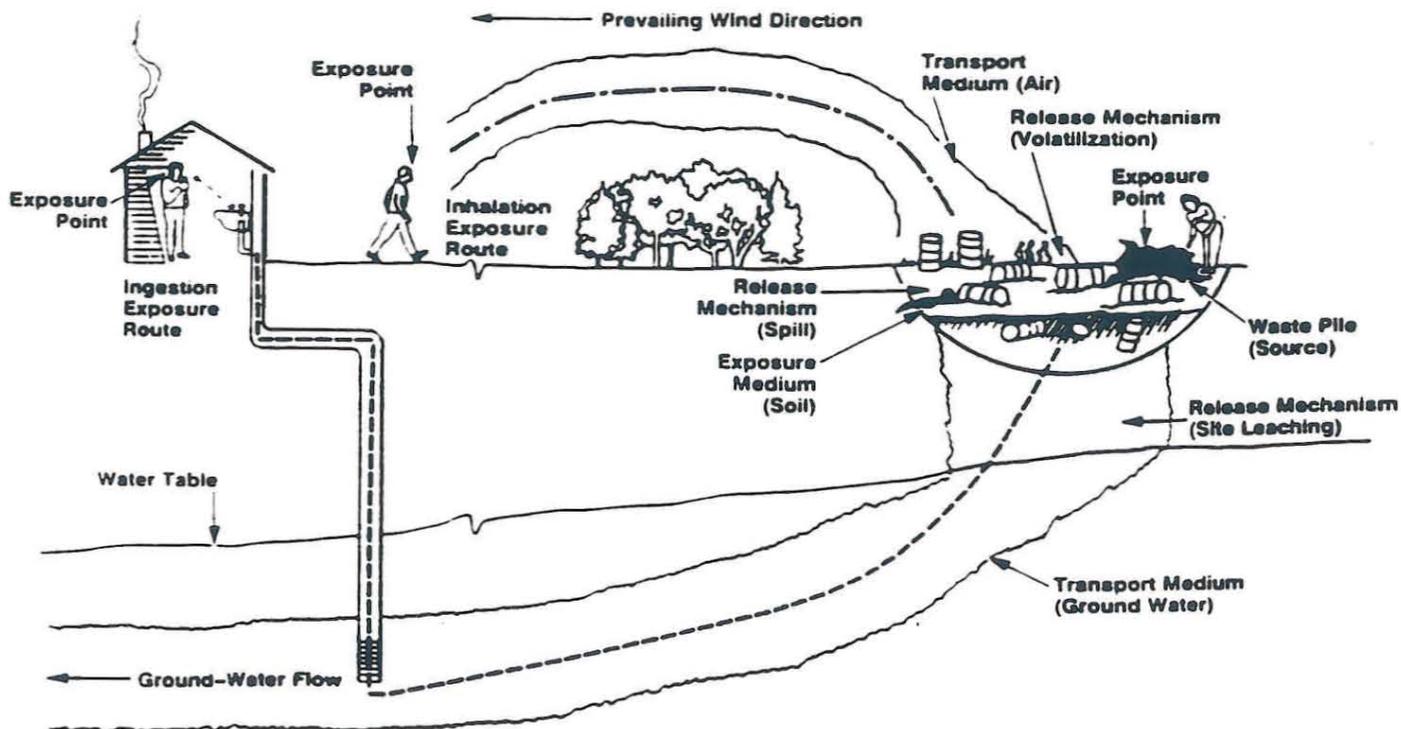


EXHIBIT 6-2 ILLUSTRATION OF EXPOSURE PATHWAYS



Risk Assessment

Determined that the probability for exposure to above was very low as a result of:

- Restricted access to site and remote location with respect to residential community
- State regulations prohibiting use of shallow groundwater for potable water supply
- Poor water quality of both shallow and deep portion of aquifer

ARARS

MCLS are not applicable because:

- **City of Norfolk prohibits the use of the water table aquifer for potable purposes by law**
- **Columbia and Yorktown aquifers comprise the water table aquifer because no confining layer exists at the site**
- **Yorktown becomes brackish with depth adjacent to surface water bodies (e.g., Elizabeth River and Willoughby Bay) and is not suitable for consumption**

Surface Water Standards are relevant and appropriate because of the following:

- **No VDEQ groundwater standards exist for TCE and PCE**
- **The groundwater model determines groundwater discharges into the Elizabeth River, hence no downgradient receptors**

Table 11-1. Remedial Action Goals

INDICATOR CHEMICAL	GROUNDWATER (µg/L)	SURFACE SOIL (mg/L)
Tetrachloroethene (PCE)	3519 ^a	0.7 ^b
Trichloroethene (TCE)	807 ^a	0.5 ^b
1,1,1-Trichloroethane (TCA)	NA	NA
1,2-Dichloroethene (DCE)	NA	NA
1,2-Dichloroethane (DCA)	990 ^a	NA
Acetone	NA	NA
1,1-Dichloroethene (DCE)	NA	0.7 ^b
Carbon Tetrachloride	45 ^a	0.5 ^b
Methylene Chloride	NA	NA
Chloroform	4700 ^a	6.0 ^b
Bromodichloromethane	NA	NA
Total Petroleum Hydrocarbons (TPH)	1000 ^c	50 mg/kg ^d
Arsenic	50 ^c	5.0 ^b
Cadmium	0.4 ^c	1.0 ^b
Chromium	50 ^c	5.0 ^b
Lead	50 ^c	5.0 ^b
Mercury	0.05 ^c	0.2 ^b
Zinc	50 ^c	NA

NA = not available

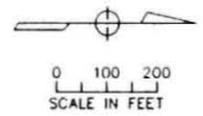
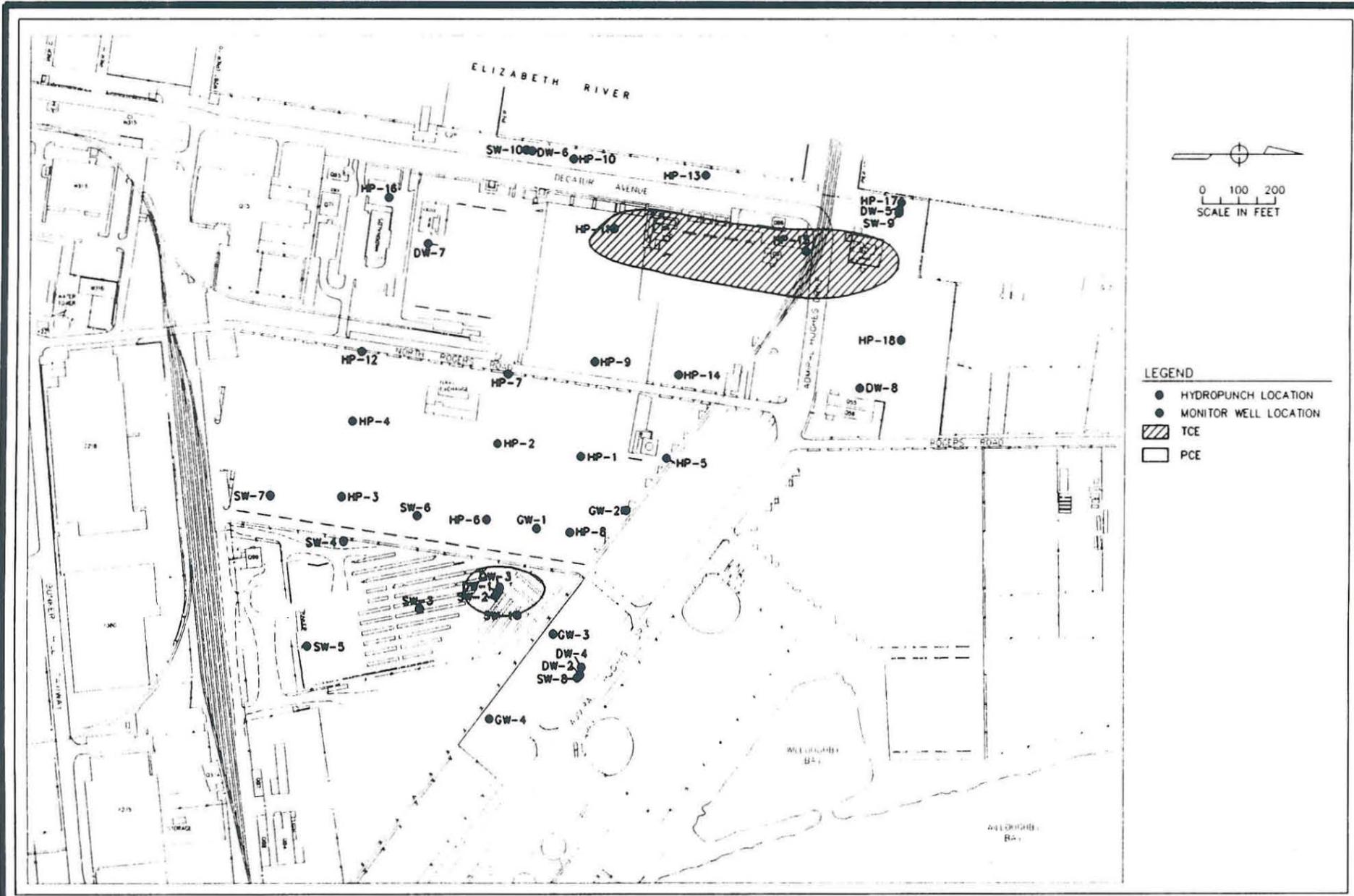
ARAR exceeded by 1992 or 1993 QADSY sample(s)

^a Derived from VWCB Water Quality Standards for surface water: protection of human health, non-public water supplies (VR 680-21-00).

^b Derived from EPA's TCLP final rule.

^c Derived from VWCB Water Quality Standards for groundwater (VR 680-21-00).

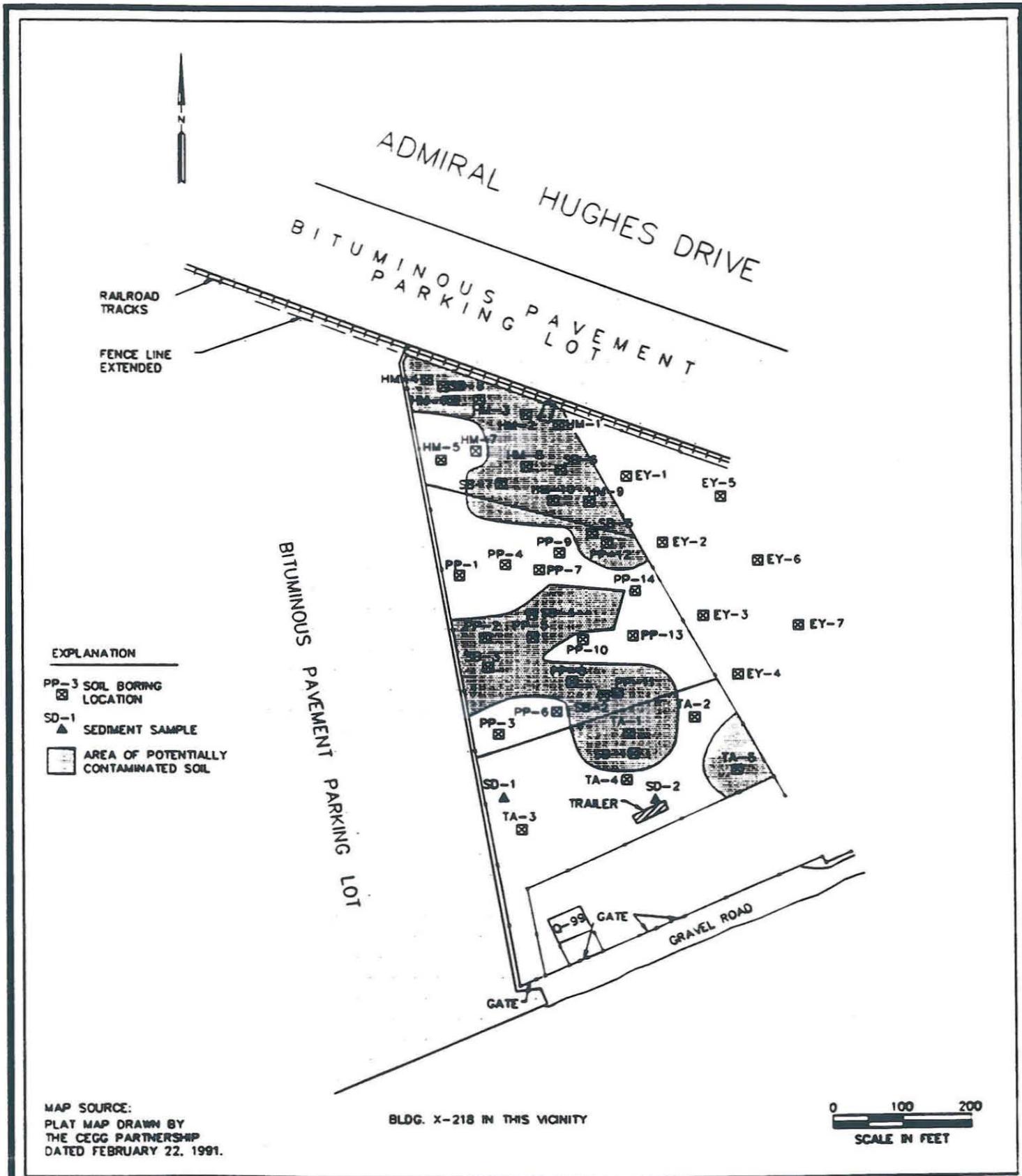
^d Derived from VWCB guidelines for disposal of petroleum-contaminated soil, exemption for use of petroleum-contaminated soil as clean fill.



- LEGEND**
- HYDROPUNCH LOCATION
 - MONITOR WELL LOCATION
 - ▨ TCE
 - PCE



DATE 3-16-94	SCALE SHOWN	TITLE AREA USED FOR CONTAMINATED GROUND WATER VOLUME CALCULATION Q AREA DRUM STORAGE YARD NORFOLK NAVAL BASE, NORFOLK, VA.	
DRAWN BY LAL/DN	APPROVED BY		
JOB NO. 4921155	DWG. NO./ REV. NO QDN / -	CLIENT NAVFAC - Q AREA	FIGURE 11-1



**Environmental
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DATE 4-14-93	SCALE SHOWN	TITLE AREAS USED FOR CONTAMINATED SOIL VOLUME CALCULATIONS (DEEP INTERVAL) Q AREA DRUM STORAGE YARD NORFOLK, VIRGINIA	
DRAWN BY LAF	APPROVED BY	CLIENT NAVFAC - Q AREA	FIGURE 11-3
JOB NO. 4921150	DWG. NO./ REV. NO. SOILA / -		

Groundwater Alternatives: Comparative Analysis

Alternative Number	Alternative Description	Short Term Effectiveness	Long Term Effectiveness	Restoration Time-frame	Cost
GW-1	No remedial action, water use restrictions, and long term monitoring	Worst, relies on natural degradation and groundwater flow to dissipate contaminants.	Average, the contaminant concentration will eventually drop. Strict monitoring and management of the site will be required for a long period of time.	30 years	PW = \$590,600
GW-2	Groundwater extraction, VOC's removal & discharge to storm drain.	Good, the water will be fully treated before it is discharged.	Good, contaminants are fully removed from the groundwater.	3 to 12 years	PW = \$1,362,774
GW-3	Groundwater extraction, VOC's removal, & discharge to WTP.	Good, the water will be fully treated before it is discharged to WTP.	Good, contaminants are fully removed from the groundwater.	3 to 12 years	PW = \$1,487,524
GW-4	Groundwater extraction, infiltration gallery, & microbial degradation.	Good, the water will be fully treated before it is discharged to the infiltration gallery.	Better, contaminants are fully removed from the groundwater faster due to enhanced microbial degradation and increase of groundwater gradient.	3 to 12 years	PW = \$1,413,387

Soil Alternatives: Comparative Analysis

Alternative Number	Alternative Description	Short Term Effectiveness	Long Term Effectiveness	Restoration Time-frame	Cost
S-1	No remedial action, land use restrictions, & surface water monitoring	Worse, relies on natural degradation and could lengthen the remediation time of the groundwater due to the leaching of contaminants for a long period of time.	Average, the contaminant concentration will eventually drop. Strict monitoring and management of the site will be required for a long period of time.	30 years	PW = \$842,421
S-2	Source containment	Average, relies on natural degradation. Potential for minor mobility of contaminants from the soil to the underlying groundwater due to groundwater fluctuations.	Average, the contaminant concentration will eventually drop. Strict monitoring and management of the site will be required for a long period of time.	3 months Cap life for 30 years	PW = \$1,387,927
S-3	Soil removal and landfill disposal	Average, contaminated soil will be excavated and removed from the site. Contamination will not be destroyed.	Average, contaminated soil will be excavated and removed from the site. Contamination will not be destroyed.	3 months	PW = \$4,258,143
S-4	Soil removal and offsite low temperature thermal treatment	Better, contaminated soil will be excavated and removed from the site for thermal treatment	Better, contaminated soil will be excavated and removed from the site for thermal treatment	3 months	PW = \$5,156,388
S-5A	Soil removal, low temperature thermal treatment, and backfill of treated soil	Better, contaminated soil will be excavated and remediated onsite by thermal treatment. The clean soil will be spread across the excavated area.	Better, contaminated soil will be excavated and remediated onsite by thermal treatment. The clean soil will be spread across the excavated area.	6 months - 12 months	PW = \$4,973,348
S-5B	Soil removal, solvent extraction, and backfill of treated soil	Better, contaminated soil will be excavated and remediated onsite by thermal treatment. The clean soil will be spread across the excavated area.	Better, contamination will be concentrated and recycled. The contamination will be removed from the environment.	6 months - 12 months	PW = \$10,508,066
S-6	Soil removal, stabilization, solidification, and offsite disposal of materials	Better, contaminated soil will be excavated and removed from the site for solidification and offsite disposal.	Better, contaminated soil will be excavated and removed from the site for solidification and offsite disposal.	6 months - 12 months	PW = \$7,670,266

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