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NAS CECIL FIELD, FL
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"REMEDIAL ACTION PLAN FOR BUILDING 46 FORMER TANKS 46R, 46D, 46SUL AND 46UL
NAS CECIL FIELD FL"
3/1/1999
TETRA TECH NUS INC

Remedial Action Plan
Building 46
Former Tanks 46R, 46D, 46SUL, and 46UL

for

Naval Air Station
Cecil Field

Jacksonville, Florida

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 065

March 1999

029924P

REMEDIAL ACTION PLAN
BUILDING 46, FORMER TANKS 46R, 46D, 46SUL, AND 46UL
FOR

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
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North Charleston, South Carolina 29406

Submitted by:
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CONTRACT NUMBER N62467-94-D-0888
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MARCH 1999

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ACRONYM LIST

ABB-ES	ABB Environmental Services, Inc.
AS	air sparging
BCT	BRAC Clean-up Team
bgs	below ground surface
BOD	biological oxygen demand
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylenes
cfm	cubic foot per minute
CLEAN	Comprehensive Long-term Environmental Action Navy
COC	chemical of concern
COD	chemical oxygen demand
CSR	Confirmation Sampling Report
Cu.Yd.	Cubic Yards
DO	dissolved oxygen
DPT	direct push technology
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
ft	feet
ft^2	square feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
GAC	granular activated carbon
GCAS	Granular Carbon Absorption System
GCTLs	Groundwater Cleanup Target Levels (FDEP)
HDPE	high-density poly ethylene
HLA	Harding Lawson & Associates
HP	horsepower
KAG	Kerosene analyte group
LTTD	low temperature thermal desorption
MCL	Maximum Contaminant Level
mg/kg	milligram per kilogram
MSDS	material safety data sheet

MTBE	methyl tert butyl ether
NA	natural attenuation
NAS	Naval Air Station
NPDES	National Pollulant Discharge Elimination System
O&M	operation and maintenance
ORC	oxygen releasing compound
ORP	oxidation/reduction potential
OVA	organic vapor analyzer
PAH	polycyclic aromatic hydrocarbon
P&ID	Piping and Instrumentation Diagram
ppm	part per million
ppmv	part per million per volume
PSIG	pound per square inch guage
PVC	polyvinyl chloride
RAP	Remedial Action Plan
SAR	Site Assessment Report
scfm	standard cubic foot per minute
scfh	standard cubic foot per hour
SCTLs	Soil Cleanup Target Levels (FDEP)
SVE	soil vapor extraction
SVOC	Semivolatile organic compound
TOC	total organic carbon
TRPH	total recoverable petroleum hydrocarbon
TSDF	transportation, storage, and disposal facility
TtNUS	Tetra Tech NUS, Inc.
µg/kg	microgram per kilogram
µg/L	microgram per liter
U.S. EPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
VOC	volatile organic compound
WWTP	wastewater treatment plant
yd^3	cubic yards

PROFESSIONAL CERTIFICATION

Remedial Action Plan
Naval Air Station Cecil Field
Building 46 Former Tanks 46R, 46D, 46SUL and 46UL
Jacksonville, Florida

This Remedial Action Plan has been prepared under my responsible supervision in conformance with standard engineering practices and principles to remediate this site to acceptable hydrocarbon concentrations as specified in Chapter 62-700 of the Florida Administrative Code.

Mark P. Speranza P.E.
Florida License No. 0050304

Mark P. Speranza

EXECUTIVE SUMMARY

This Remedial Action Plan (RAP) has been prepared by Tetra Tech NUS, Inc. (TtNUS) to select the most suitable remedy for soil and groundwater cleanup for Building 46 (Former Tanks 46R, 46D, 46SUL and 46UL) at Naval Air Station (NAS) Cecil Field, Jacksonville, Florida. This RAP has been prepared in accordance with the requirements of Chapter 62-770, Florida Administrative Code (FAC). This RAP is being submitted to the Naval Air Station (NAS) Cecil Field Base Realignment and Closure (BRAC) Clean-up Team (BCT) for approval.

TtNUS performed the following tasks during the RAP:

- Reviewed past pilot-scale treatability studies for relevant technologies from sites at NAS Cecil Field.
- Reviewed the Site Assessment Report (Harding Lawson Associates [HLA], 1998b).
- Conducted a site survey to identify utilities and to construct a site plan.
- Screened technologies for the remediation of soil and groundwater.
- Designed a remedial action plan that would remediate the contaminated soil and groundwater using air sparging and soil vapor extraction.
- Proposed a system start-up, operations, and maintenance plan to run the system.
- Specified a sampling plan to track the remediation status of the site.

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This Remedial Action Plan (RAP) has been prepared by Tetra Tech NUS (TtNUS) for the U.S. Navy (Navy) Southern Division Naval Facilities Engineering Command under Contract Task Order 0065, for the Comprehensive Long-term Environmental Action Navy (CLEAN III), Contract Number N62467-94-D-0888. The RAP has been prepared to select a remedy in accordance with requirements of FAC Chapter 62-770 for the contaminated soil and groundwater located at Building 46 (Former Tanks 46R, 46D, 46SUL, and 46UL), NAS Cecil Field in Jacksonville, Florida.

This RAP summarizes the findings of a site assessment report, presents the cleanup goals, evaluates potential technologies, selects the most suitable technology for cost effective and timely remediation and presents a preliminary design with operation and maintenance of the selected remedy.

1.2 SITE DESCRIPTION

Building 46, the former base gas station was located across "D" Avenue from the Bachelor Officers Quarters. The site currently consists of a grassy island along the east side of "D" Avenue and an asphalted parking lot between Buildings 903 and 904. Figure 1-1 illustrates the site plan and location.

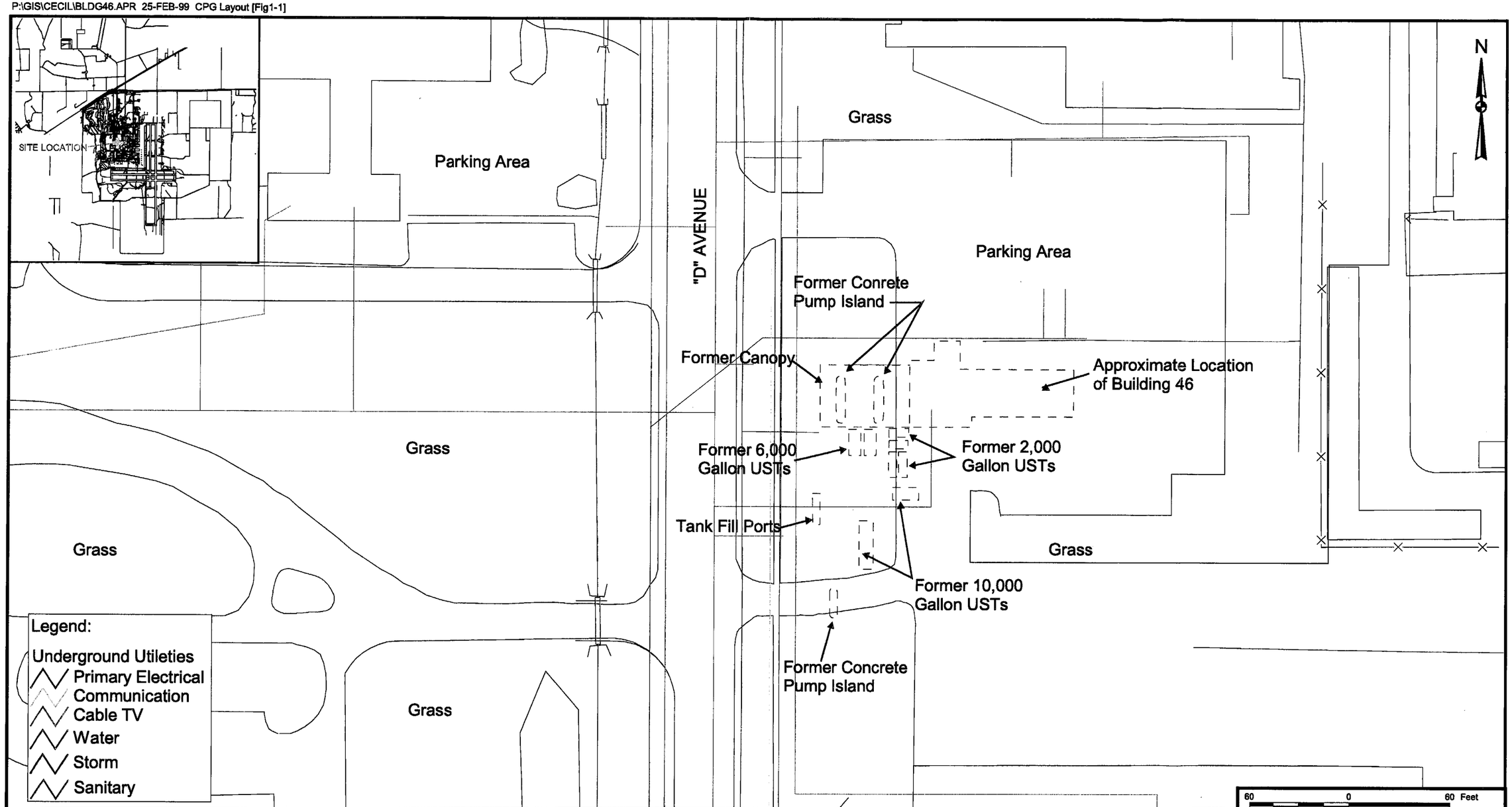
1.3 SITE HISTORY

Building 46 was in operation from 1946 to 1987 and featured eight underground storage tanks (USTs), all of which were removed in June 1988. Four of these tanks were in operation before 1970. These four tanks were unidentified and their contents unknown but facility drawings indicate that these tanks all had a 2,000-gallon capacity and were located just south of Building 46. The remaining four tanks, identified as 46R, 46D, 46SUL, and 46UL were installed in 1970 adjacent to Building 46 itself. Tanks 46R and 46UL both had a 10,000-gallon capacity and were used to store regular and unleaded gasoline, respectively. Tanks 46D and 46SUL both had a 6,000-gallon capacity and were used to store diesel and super unleaded gasoline, respectively.

1.4 PREVIOUS INVESTIGATION

A Contamination Assessment Plan was prepared to evaluate soil and groundwater (ABB Environmental Services [ABB-ES], 1996). Site sampling was conducted in June 1997. Figure 1-2 shows the location of the soil borings and Figure 1-3 shows the location of the drive point technology (DPT) sampling points

P:\GIS\CECIL\BLDG46.APR 25-FEB-99 CPG Layout [Fig1-1]



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CHAD P. GLICK DATE 2/25/99

CHECKED BY DATE 3/4

COST/SCHED-AREA

SCALE AS NOTED

SITE LAYOUT MAP
BUILDING 46, TANKS 46R, 46D, 46SUL, & 46UL
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895

APPROVED BY DATE 03/17/99

APPROVED BY DATE

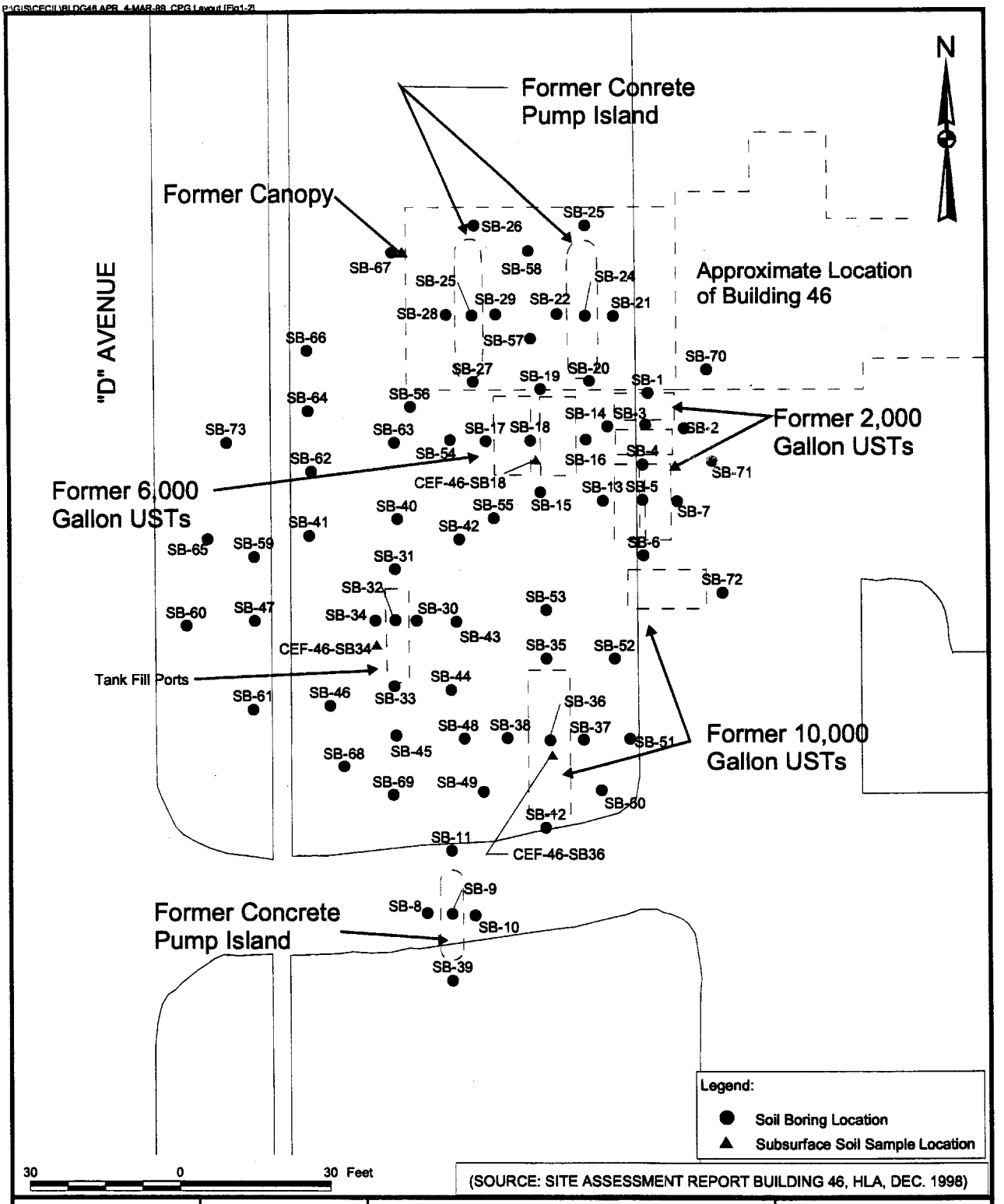
DRAWING NO. FIGURE 1-1 REV. 0

and monitoring wells. The subsequent Confirmation Sampling Report (CSR) recommended that a Site Assessment (SA) be performed to assess the extent of excessively contaminated soil and groundwater (HLA, 1998a). A Site Assessment Report (SAR) was submitted to the Base Realignment and Closure (BRAC) Clean-up Team (BCT) in December 1998 (HLA, 1998b).

1.5 REPORT ORGANIZATION

This report is organized into seven sections. Below is a list of these sections and a brief description of their purpose:

Section 1	Introduction	Presents the report's purpose, scope, site information, and report organization.
Section 2	Site Assessment Report Findings and Conclusions	Reviews the approved SAR and summarizes the SAR's findings and conclusions.
Section 3	Remedial Action Goals	Identifies the soil and groundwater treatment objectives for the remedial system / plan.
Section 4	Remedial Alternative Technology Screening	Presents the alternatives for remediation, determines the suitability for the site, presents budgetary costs for each, and selects the most suitable alternative.
Section 5	Remediation System Design	Discusses the preliminary design of an AS/SVE remediation system.
Section 6	Start-Up and Operations and Maintenance	Presents the procedures for starting up the system and proper maintenance duties/intervals.
Section 7	Monitoring of Remedial Progress	Identifies monitoring locations for the remediation system and sampling frequencies to evaluate the AS/SVE and natural attenuation effectiveness.
Appendix A	SAR Analytical Data	
Appendix B	State of Florida's Cleanup Target Concentrations	
Appendix C	Technology Screening Cost Estimates	
Appendix D	Design Calculations	
Appendix E	Vendor Catalog Cuts	



(SOURCE: SITE ASSESSMENT REPORT BUILDING 46, HLA, DEC. 1998)

DRAWN BY CHAD P. GLICK	DATE 3/4/99	SOIL BORING LOCATION MAP BUILDING 46, TANK 46R, 46D, 46SUL, 46UL NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 7895
CHECKED BY JPR	DATE 3/4		APPROVED BY	DATE 03/17/99
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-2	REV 0

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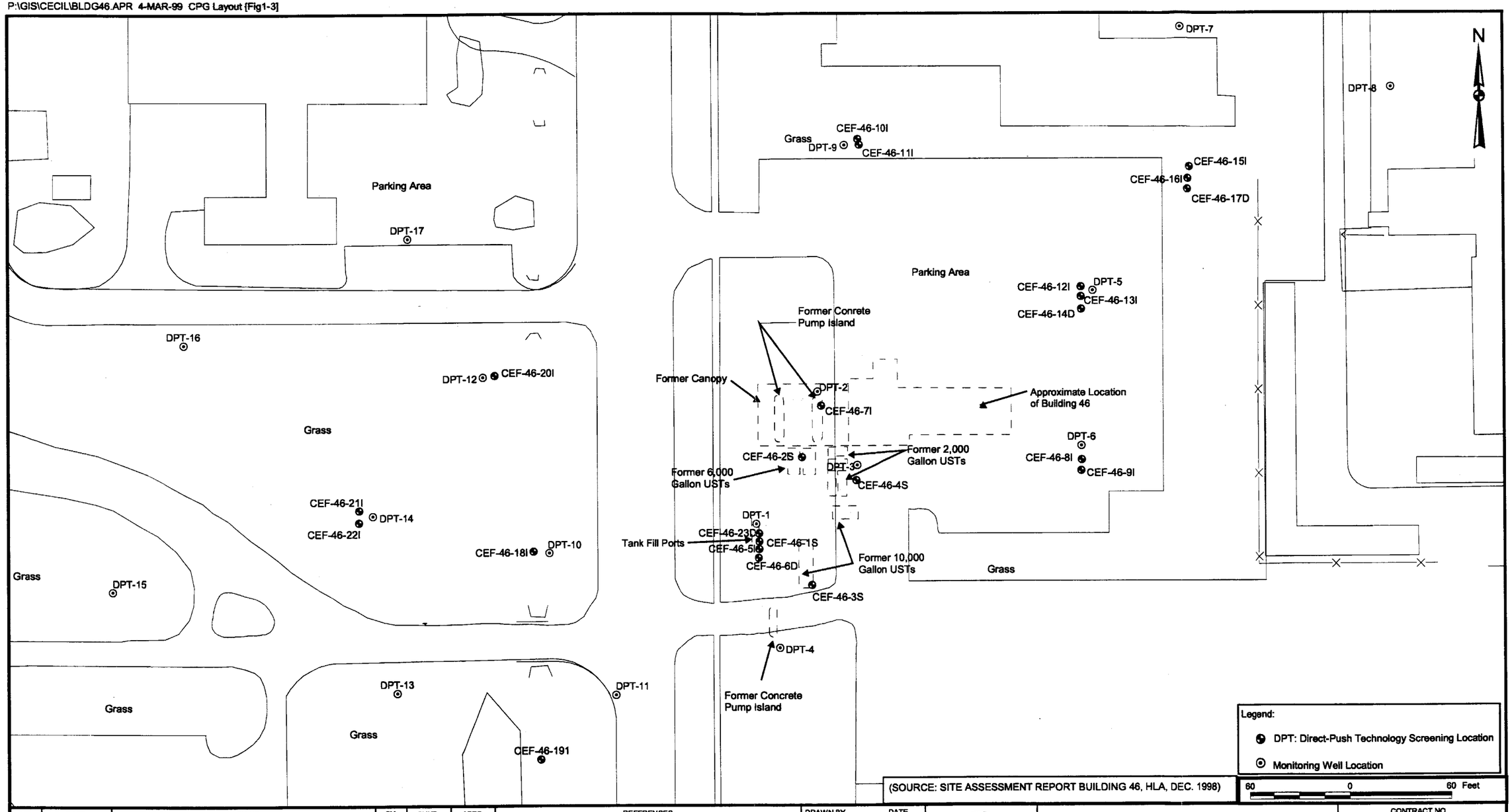

(SOURCE: SITE ASSESSMENT REPORT BUILDING 46, HLA, DEC. 1998)

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CHAD P. GLICK — DATE 3/4/99

CHECKED BY — DATE 3/14

COST/SCHED-AREA

SCALE AS NOTED

DPT AND MONITORING WELL LOCATIONS
BUILDING 46, TANKS 46R, 46D, 46SUL, 46UL
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7295

APPROVED BY — DATE 03/17/99

APPROVED BY — DATE

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2.0 SITE ASSESSMENT REPORT FINDINGS AND CONCLUSIONS

This section presents a summary of the SAR (HLA, 1998b).

2.1 LITHOLOGIC FINDINGS

The Building 46 site is primarily underlain by silty fine-grained sand, fine-grained sand, and clayey sand to a depth of 92 to 101 feet below ground surface (bgs), where dolomite is encountered. The dolomite represents the top of the geologic unit called the Hawthorne Group. A hardpan layer consisting of dense fine-grained sand is discontinuous throughout the site at depth ranging from 11 to 14 feet bgs. Boring logs are contained within the SAR and can be found in the BCT library.

2.2 GROUNDWATER AND AQUIFER CHARACTERISTICS

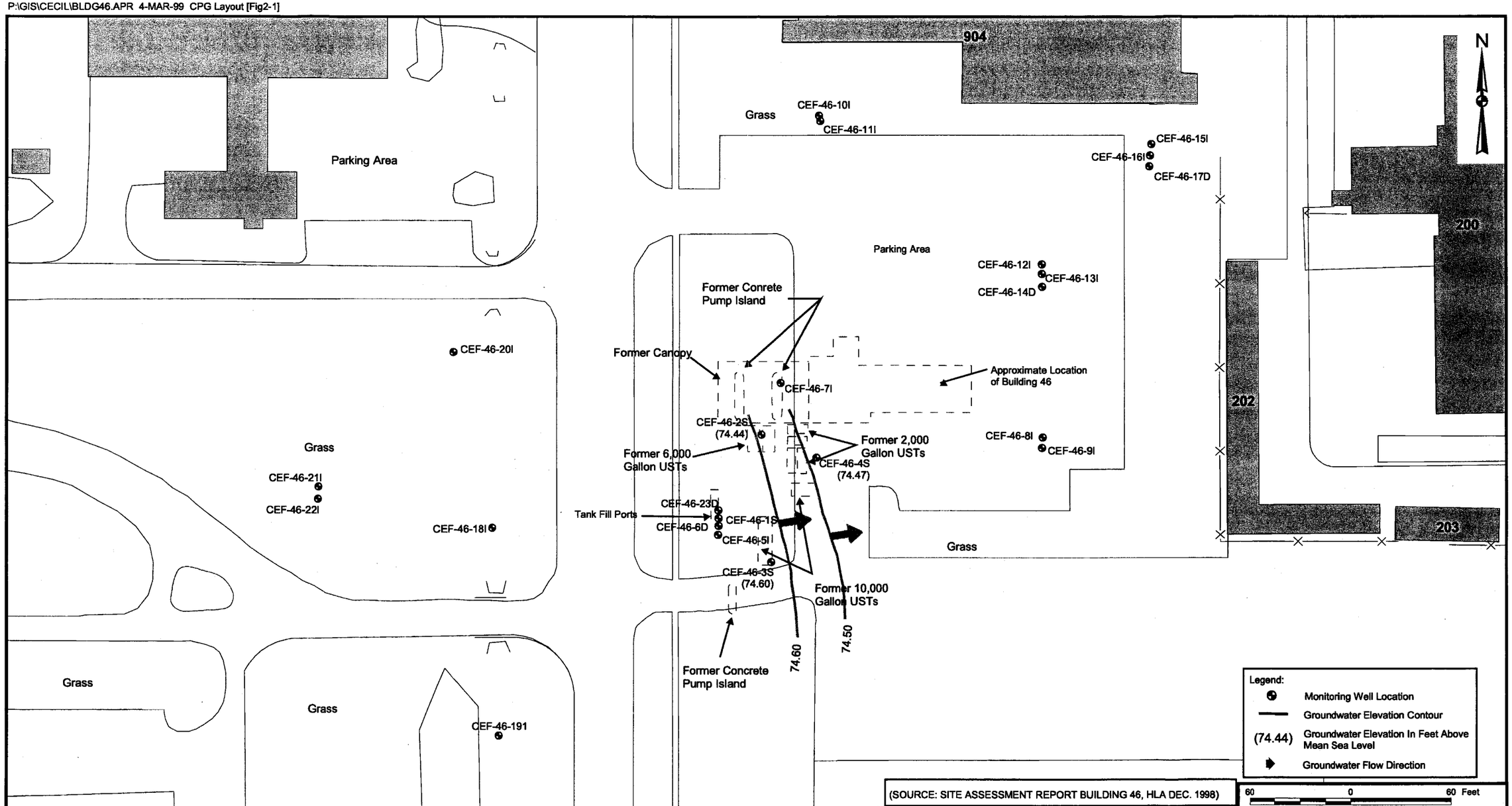
Depth to groundwater varies across the site from 4 to 7 feet bgs. The surficial aquifer where groundwater contamination is confined consists of three zones, including shallow, intermediate and deep. The shallow surficial aquifer extend from the water table to 25 feet bgs. The intermediate surficial aquifer extends from 25 to 50 feet bgs and is itself subdivided in a shallow intermediate zone extending from 25 to 30 feet bgs and a deep intermediate extending from 30 to 50 feet bgs. The deep surficial aquifer extends from 50 to 92 feet bgs.

Groundwater flow direction varies with depth. Building 46 is located above a divide where the groundwater of the surficial aquifer flows either to the west-southwest or east-northeast. Figures 2-1, 2-2, 2-3, and 2-4 show groundwater contours in the shallow, shallow intermediate, deep intermediate, and deep surficial aquifer, respectively.

The following hydrogeologic parameters were estimated for the surficial aquifer as a whole in the SAR (HLA, 1998b).

Hydraulic Conductivity	K	=	5.0 ft/day
Hydraulic gradient	i	=	0.004 ft/ft
Effective porosity	n_e	=	0.25 (unitless)

Using these parameters, the linear velocity of groundwater in the surficial aquifer (v) can be computed in accordance to the following formula:



(SOURCE: SITE ASSESSMENT REPORT BUILDING 46, HLA DEC. 1998)

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CHECKED BY	DATE 3/14
COST/SCHED-AREA	
SCALE AS NOTED	

SHALLOW SURFICIAL AQUIFER POTENTIOMETRIC SURFACE CONTOUR MAP
BUILDING 46, TANKS 46R, 46D, 46SUL, 46UL
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895	
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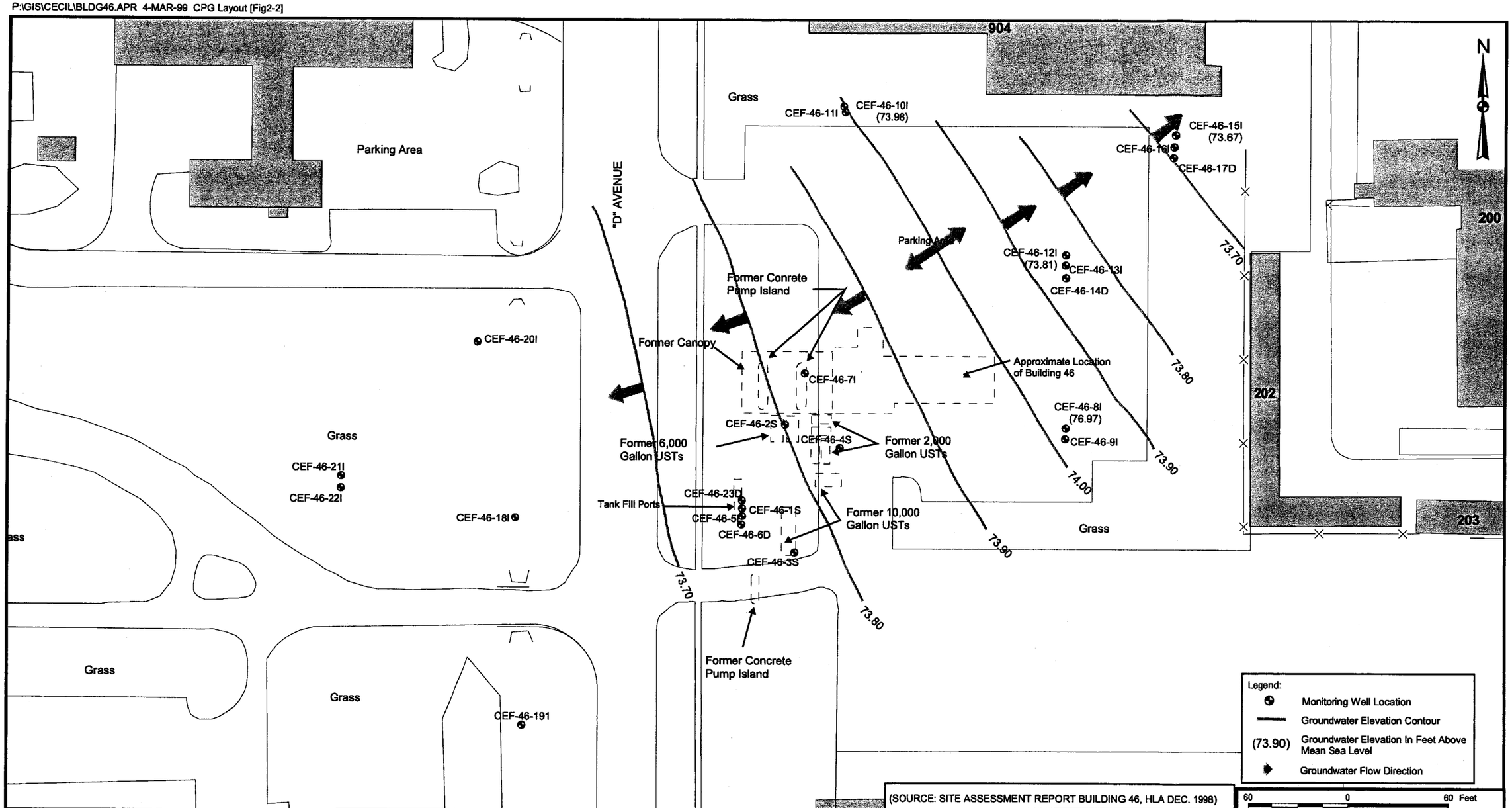
P:\GIS\CECIL\BLDG46.APR 4-MAR-99 CPG Layout [Fig2-2]



(SOURCE: SITE ASSESSMENT REPORT BUILDING 46, HLA DEC. 1998)

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CHAD P. GLICK	DATE 3/4/99
CHECKED BY	DATE 3/14
COST/SCHED-AREA	
SCALE AS NOTED	

INTERMEDIATE SURFICIAL AQUIFER
POTENTIOMETRIC SURFACE CONTOUR MAP
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895	
APPROVED BY	DATE 03/17/99
APPROVED BY	DATE
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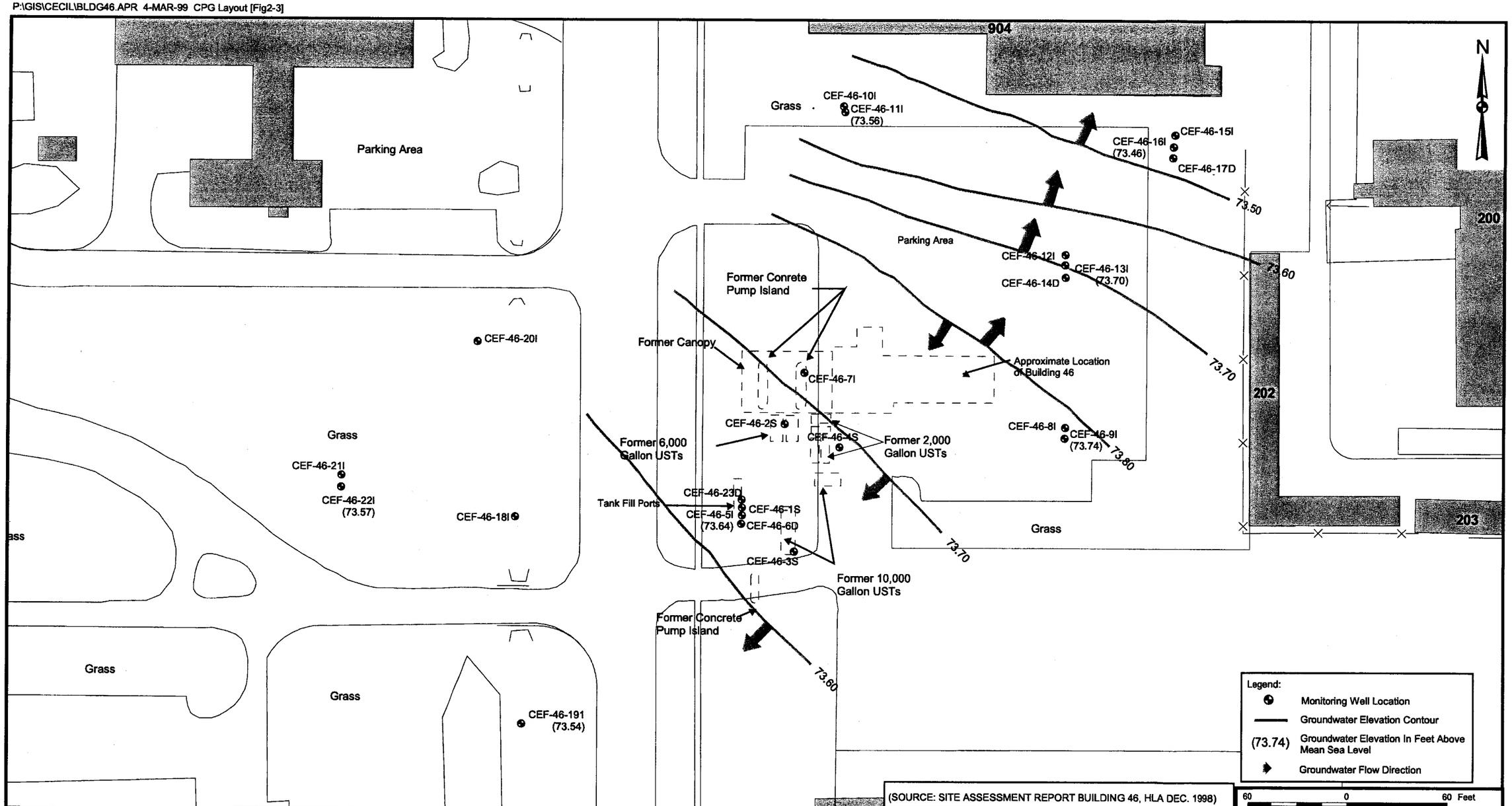
P:\GIS\CECIL\BLDG46.APR 4-MAR-99 CPG Layout [Fig2-3]



(SOURCE: SITE ASSESSMENT REPORT BUILDING 46, HLA DEC. 1998)

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CHAD P. GLICK DATE 3/4/99

CHECKED BY DATE 3/14

COST/SCHED-AREA

SCALE AS NOTED

DEEP INTERMEDIATE SURFICIAL AQUIFER POTENTIOMETRIC SURFACE CONTOUR MAP
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895

APPROVED BY DATE 03/17/99

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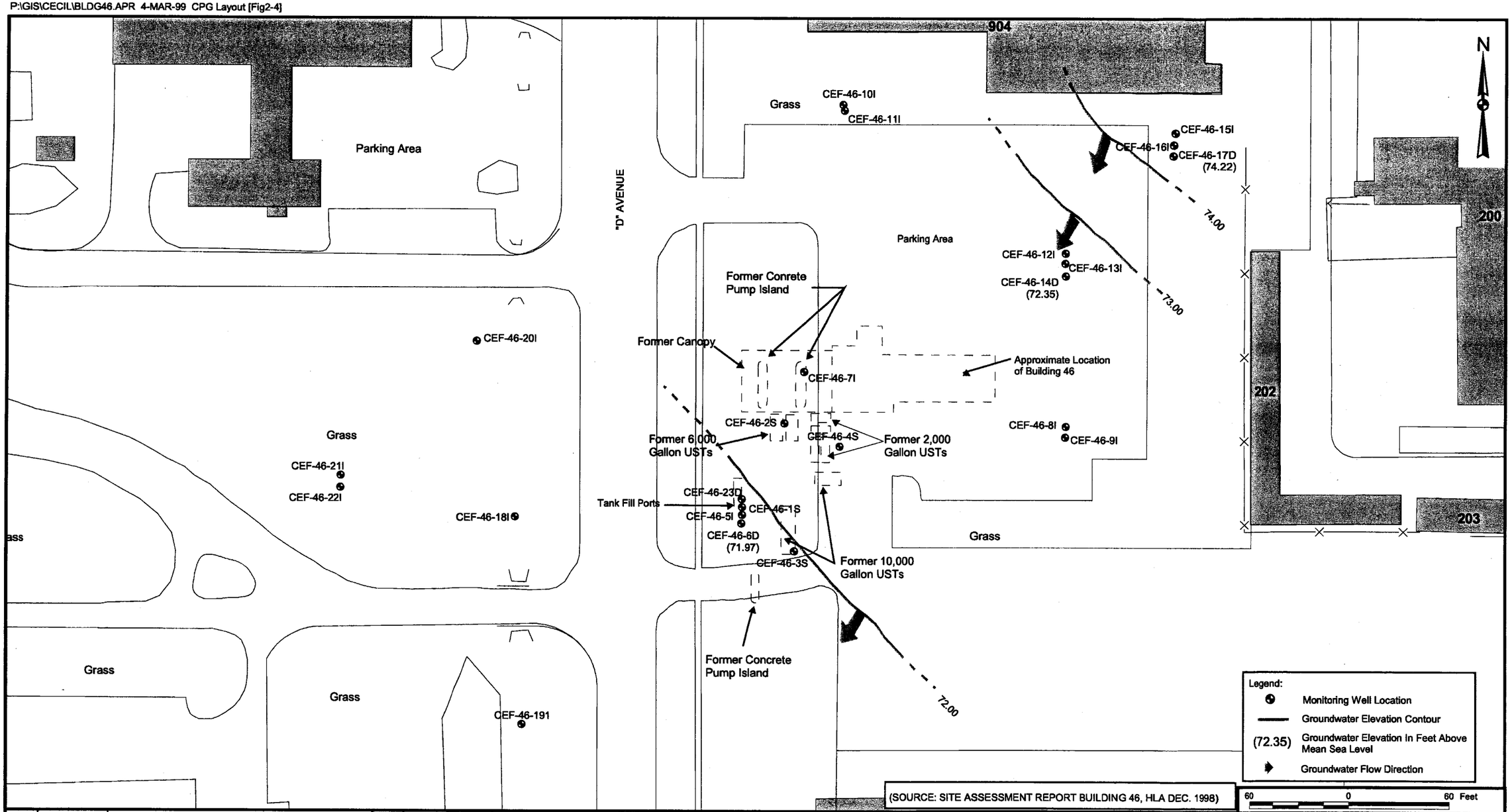

(SOURCE: SITE ASSESSMENT REPORT BUILDING 46, HLA DEC. 1998)

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CHAD P. GLICK DATE 3/4/99
CHECKED BY DATE 3/14
COST/SCHED-AREA
SCALE AS NOTED

DEEP SURFICIAL AQUIFER POTENTIOMETRIC
SURFACE CONTOUR MAP
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
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REV. 0

$$v = K \times i \div n_e$$

The average linear velocity is thus estimated at 0.08 ft/day or 29.2 ft/year.

2.3 CONTAMINATED SOIL ASSESSMENT

Soil samples were collected from 39 borings and screened for petroleum products content by using an Organic Vapor Analyzer (OVA) following the procedures for headspace measurement/analysis set forth in FAC 62-770. Figure 2-5 shows a summary of the soil screening results and the horizontal extent of the soil with OVA readings in excess of 5,000 parts per million by volume (ppmv) and in excess of 50 ppmv. In addition, three soil samples from locations with high (>5,000 ppmv), medium (1,000-5,000 ppmv), and low (<1,000 ppmv) OVA readings were collected and sent to a laboratory for analysis of the Kerosene analytical group (KAG) parameters. Detailed results of the OVA screening and additional analyses are included in Appendix A.

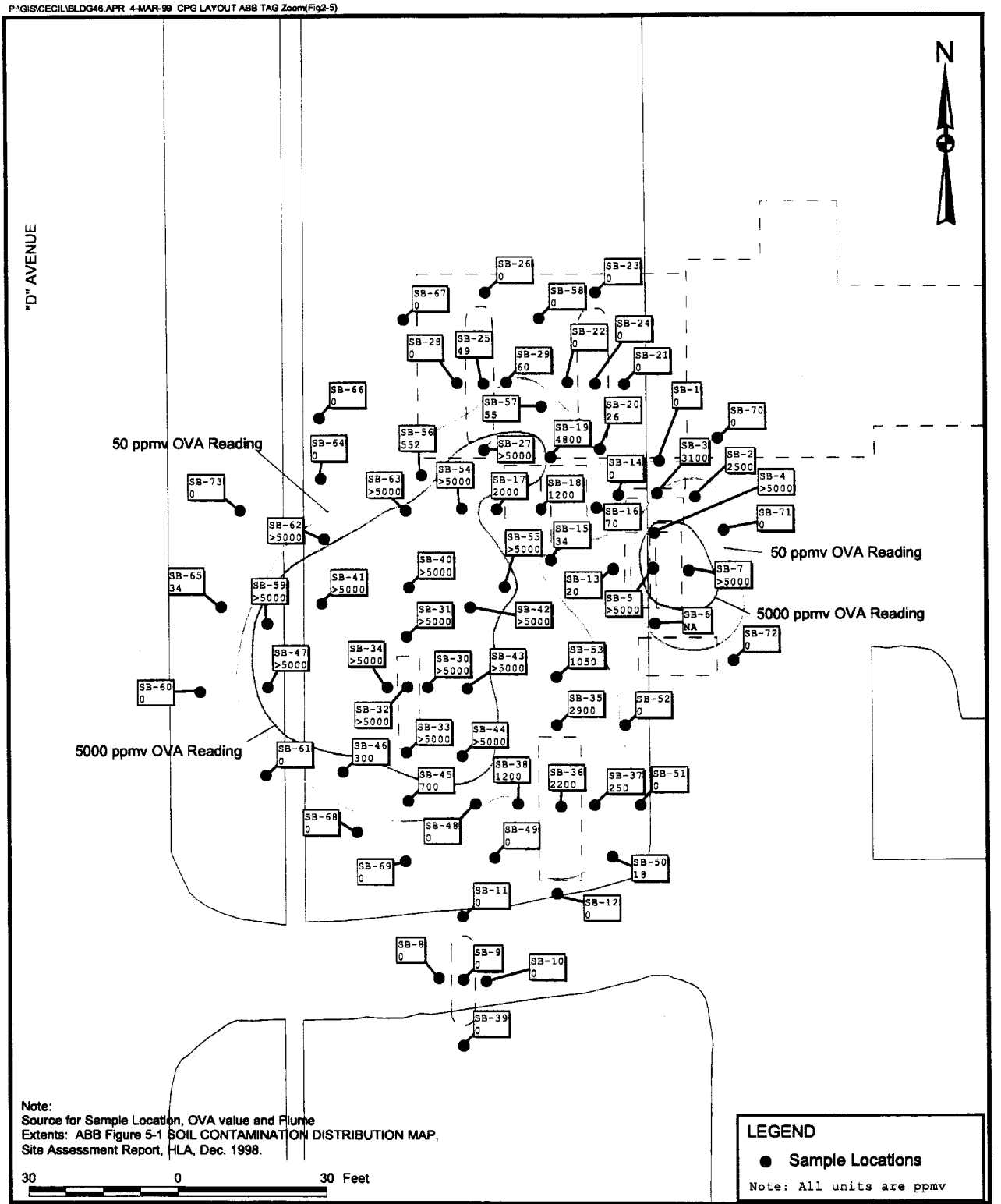
Results from both the OVA screening and additional analyses indicated that there are petroleum-impacted soils at the site and that the horizontal extent of soil with OVA readings in excess of 50 ppmv is approximately 5,500 square feet (ft^2). Allowing for two feet of over-excavation (outside the 50 ppmv contour), with the soil contamination vertically delineated to a depth of 7 ft, yields a total estimated volume of 1,436 cubic yards (yd^3) of contaminated soil.

Based upon the analytical results from the three above-mentioned soil borings, as presented on Table 5-1 of the SAR which is included in Appendix A, the average total recoverable petroleum hydrocarbon (TRPH) concentration of the contaminated soil is estimated at 2,150 pounds (980 kilograms).

2.4 CONTAMINATED GROUNDWATER ASSESSMENT

Groundwater samples were collected from 23 monitoring wells and 15 DPT sampling locations and analyzed for KAG parameters. Detailed analytical results are included in Appendix A. These results indicate that petroleum constituents have impacted the groundwater. Figure 2-6 shows the horizontal extent of groundwater contamination which exceeds target cleanup levels. Horizontal extent of groundwater contamination in the shallow, intermediate, and deep surficial aquifer is estimated at approximately 25,300 ft^2,. 95,700 ft^2 and 31,000 ft^2, respectively. Vertical extent of groundwater contamination is estimated at approximately 80 feet bgs as shown on Figure 2-7..

P:\GIS\CECIL\BLDG46.APR 4-MAR-99 CPG LAYOUT ABB TAG Zoom(Fig2-5)



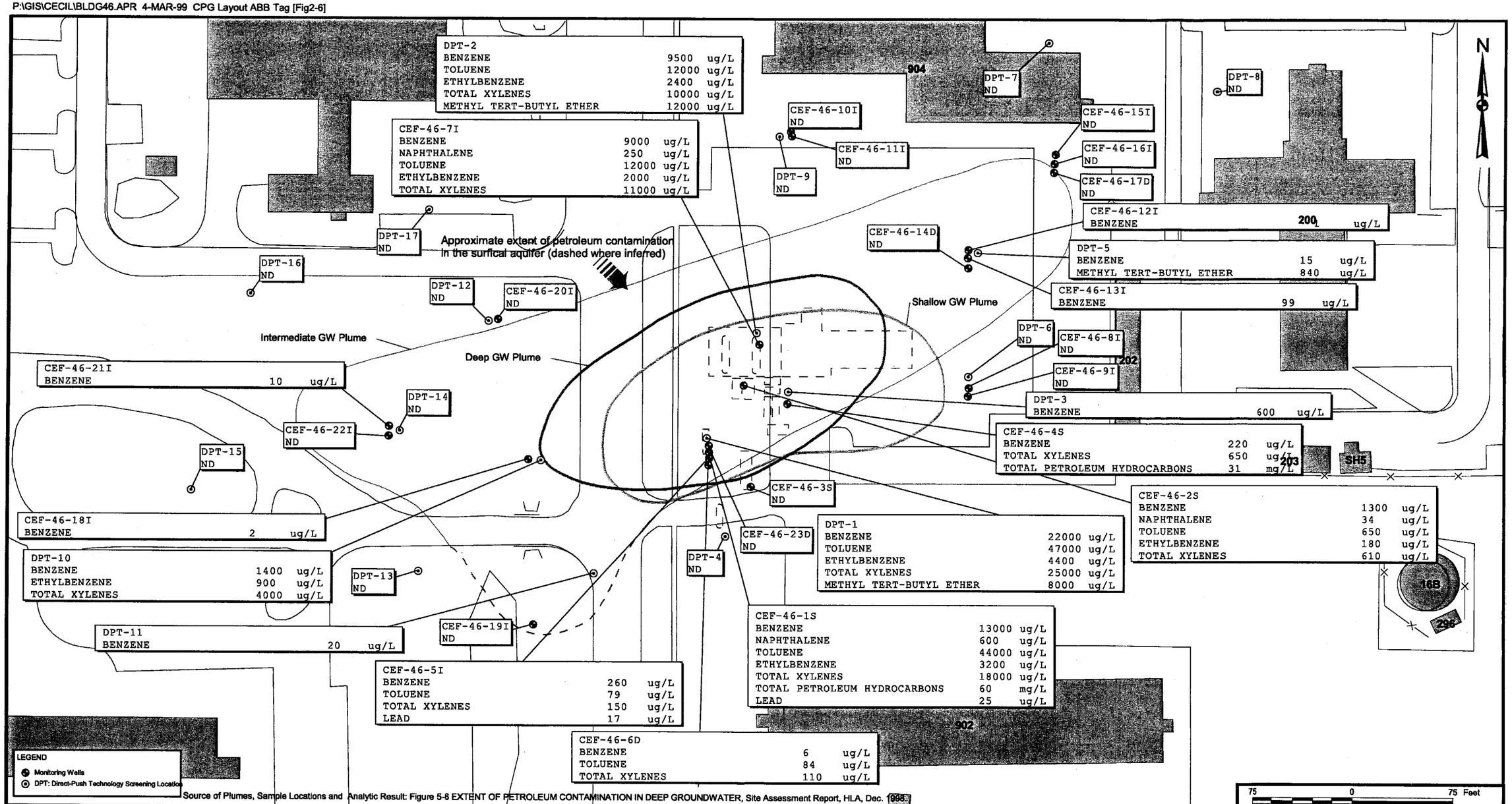
Note:
Source for Sample Location, OVA value and Plume Extents: ABB Figure 5-1 SOIL CONTAMINATION DISTRIBUTION MAP, Site Assessment Report, HLA, Dec. 1998.

30 0 30 Feet

LEGEND
● Sample Locations
Note: All units are ppmv

DRAWN BY CHAD P. GLICK	DATE 3/4/99	VOA CONTAMINATION DISTRIBUTION FROM SOIL SCREENING BUILDING 46 NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 7895
CHECKED BY	DATE 3/14		APPROVED BY	DATE 03/12/99
COST/SCHEDULE-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2-5	REV 0

P:\GIS\CECIL\BLDG46.APR 4-MAR-99 CPG Layout ABB Tag [Fig2-6]



Source of Plumes, Sample Locations and Analytic Result: Figure 5-8 EXTENT OF PETROLEUM CONTAMINATION IN DEEP GROUNDWATER, Site Assessment Report, HLA, Dec. 1998.

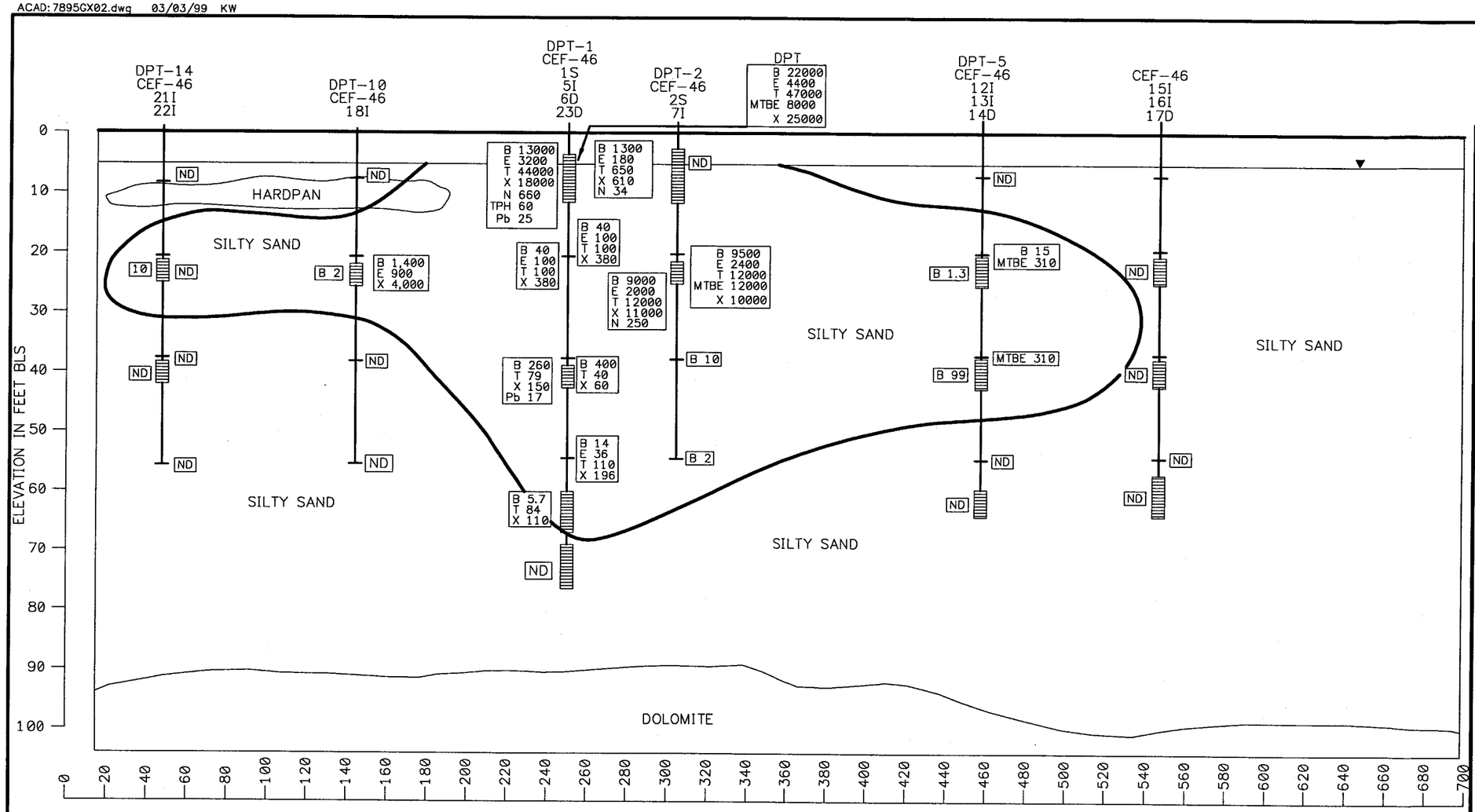
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CPG DATE 3/4/99
CHECKED BY DATE 3/4
COST/SCHED-AREA
SCALE AS NOTED

PETROLEUM CONTAMINANTS EXCEEDING CLEANUP TARGET LEVELS IN THE SURFICIAL AQUIFER BUILDING 46 NAS CECIL FIELD JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
APPROVED BY DATE
DRAWING NO. FIGURE 2-6 REV. 0

ACAD:7895GX02.dwg 03/03/99 KW



LEGEND

B	BENZENE
T	TOLUENE
E	ETHYLBENZENE
X	XYLENES
TPH	TOTAL PETROLEUM HYDROCARBONS
Pb	LEAD
N	NAPHTHALENE
MW	MONITORING WELL
DPT	DIRECT-PUSH TECHNOLOGY
BLS	BELOW LAND SURFACE
ND	NOT DETECTED OR DETECTED CONCENTRATIONS ARE BELOW THE CLEANUP TARGET LEVELS
MTBE	METHYL TERT-BUTYL ETHER
ug/L	MICROGRAMS PER LITER
CEF-46	MONITORING WELL LOCATION
DPT-2	DPT GROUNDWATER SCREENING LOCATIONS
▼	WATER TABLE ELEVATION (BLS)
—	DPT GROUNDWATER SAMPLE LOCATION
B 99	REPORTED CONCENTRATION OF COMPOUND IN SAMPLE
▤	SCREENED INTERVAL

NOTES

ALL CONCENTRATIONS IN ug/L

MONITORING WELL CONCENTRATIONS SHOWN TO LEFT AT GIVEN SCREEN INTERVALS. DPT RESULTS SHOWN TO THE RIGHT OF THE MARKED LOCATIONS.

SOURCE: SITE ASSESSMENT REPORT, HLA, DEC 1998

0 20 40
VERTICAL SCALE IN FEET

0 60 120
HORIZONTAL SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 2/26/99
CHECKED BY DATE 3/14
COST/SCHED-AREA
SCALE AS NOTED

DEPARTMENT OF THE NAVY · SOUTHERN DIV FACILITIES ENGINEERING COMD

VERTICAL DISTRIBUTION OF PETROLEUM CONTAMINANTS ALONG FLOWPATH
REMEDIAL ACTION PLAN
BUILDING 46, TANKS 46R, 46D, 46SUL, 46SUR
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
APPROVED BY DATE
DRAWING NO. FIGURE 2-7
REV. 0

FORM CADD NO. SDIV_BH.DWG – REV 0 – 1/20/98

Based upon the calculations presented in Appendix F of the SAR (HLA, 198b), the total mass of volatile organic compounds (VOCs) in the contaminated groundwater is estimated at 540 pounds (245 kilograms).

2.5 SITE ASSESSMENT REPORT CONCLUSIONS

In accordance with FAC 62-770, the SAR determined that contamination exists in the soil and groundwater at the Building 46 Site at levels exceeding cleanup target levels and therefore recommended that a RAP be prepared and implemented.

3.0 REMEDIAL ACTION GOALS

The purpose of this RAP is to design a selected remedy to reduce both the soil and groundwater contaminant concentrations to below state mandated target cleanup levels. The following paragraphs list the target levels for site-specific chemicals of concern (COCs) for each of the contaminated media.

3.1 SOIL REMEDIAL ACTION GOALS

This RAP recognizes selected Soil Cleanup Target Levels (SCTLs) as listed in Table 2 of the University of Florida Soil Cleanup Target Level Development Web Site (University of Florida [UFL], 1999) as the soil remedial action goals in accordance with FAC 62-777. A complete list of these SCTLs is presented in Appendix B. Soil remedial action goals for the Building 46 site-specific COCs are presented in Table 3-1.

TABLE 3-1

SOIL REMEDIAL ACTION GOALS
BUILDING 46
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Site-Specific COC	Remedial Action Goal (mg/kg)
Benzene	0.007
Toluene	0.5
Ethylbenzene	0.6
Total Xylenes	0.2
MTBE	0.20
Naphthalene	1.7
TRPH	340

3.2 GROUNDWATER REMEDIAL ACTION GOALS

This RAP recognizes selected Groundwater Cleanup Target Levels (GCTLs) as listed in Table 1 of the University of Florida Soil Cleanup Target Level Development Web site (UFL, 1999a) as the groundwater remedial action goals. A complete list of these GCTLs is presented in Appendix B. Groundwater remedial action goals for site-specific COCs are listed in Table 3-2.

TABLE 3-2

GROUNDWATER REMEDIAL ACTION GOALS
BUILDING 46
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Site-Specific COCs	Remedial Action Goal (µg/L)
Benzene	1
Ethylbenzene	30
Toluene	40
Total Xylenes	20
MTBE	50
Naphthalene	20
TRPH	5,000

4.0 REMEDIAL ALTERNATIVE TECHNOLOGY SCREENING

The following potentially applicable technologies were screened in order to determine the best remedial alternative for the Building 46 site:

- For soil:
  - -- Excavation and offsite treatment and disposal
  - -- Soil vapor extraction (SVE)
- For groundwater:
  - -- Natural Attenuation (NA)
  - -- Chemically-enhanced NA
  - -- Air sparging and vapor extraction (AS/VE)
  - -- Extraction and treatment (pump and treat)

4.1 SOIL REMEDIAL TECHNOLOGIES

4.1.1 Excavation and Offsite Treatment and Disposal

This technology would consist of excavating soil currently estimated to be contaminated with OVA readings in excess of 50 ppmv and transporting this soil to a permitted treatment, storage and disposal facility (TSDF) for treatment and disposal. The most likely offsite treatment technology would be thermal treatment through either low-temperature thermal desorption (LTTD) or incineration and the most likely offsite disposal technology for the treated soil would be reuse as road construction material. Pre- and post-excavation soil sampling would be performed to further delineate the area(s) to be excavated, provide waste characterization data for the TSDF, and verify that all contaminated soil has been removed.

Effectiveness

Excavation and offsite treatment and disposal would be a very effective technology for the remediation of contaminated soil as it would permanently remove contaminants from the site. Thermal treatment through either LTTD or incineration is a proven technology for the irreversible removal and destruction of petroleum hydrocarbons which are the main contaminants concern in the soil of the Building 46 site. Use of this type of treatment technology would allow disposal of the treated soil through beneficial reuse.

It is anticipated that excavation and offsite treatment and disposal would achieve soil remediation within approximately one month.

Implementability

Excavation and offsite treatment and disposal would be relatively easy to implement and is typically the approach of choice for relatively small volume of contaminated soil such as that present at the Building 46 site (1,400 cubic yards) Numerous competent contractors could provide on-site excavation and offsite transportation services. Permitted TSDFs would be readily available for the offsite treatment and reuse of the excavated soil. Some site disruption would occur during excavation of the contaminated soil but, since most of it is located in undeveloped grassy areas, this disruption would be minimal. Care would have to be taken during excavation not to disrupt or damage the utility lines which criss-cross the area.

Cost

The total estimated cost of this technology would be approximately $293,000. A detailed breakdown of this cost is included in Appendix C.

The following assumptions were made to prepare this budget-type estimate:

- The total areal extent of soil contamination is approximately 5,500 ft^2.
- Existing pavement would have to be removed from an area of approximately 750 ft^2, including 600 ft^2 of parking lot immediately south of the location of former Building 46 and 60 feet of sidewalk along "D" Avenue.
- Soil would be excavated to a depth of 7 feet, which includes an anticipated 2 feet of over-excavation, for a total excavated soil volume of approximately 1,400 yd^3.
- Excavated soil would be transported offsite for thermal treatment and reuse as road construction material.
- A total of 40 soil samples would be collected, including 10 samples to delineate the area to be excavated, 14 samples to characterize the excavated soil, and 16 samples to verify that all contaminated soil has been excavated. These samples would be analyzed for KAG.
- The excavated areas would be backfilled with imported clean fill material, compacted, and graded to match pre-excavation elevations.

- The site would be restored to its pre-excavation conditions, including re-paving of the originally paved areas and seeding and mulching of the originally grassy areas.

- A post-removal action report would be prepared to document remedial activities and analytical results.

4.1.2 Soil Vapor Extraction

Soil vapor extraction (SVE) would consist of applying a vacuum to the area of contaminated soil above the groundwater table (vadose zone) to induce a current of air through the pores of the soil thus promoting the volatilization of contaminants attached to soil particles and their transport and removal into the air current which can then be captured and treated prior to venting to atmosphere. Vacuum would be applied through a network of vertical wells installed just above the groundwater table and screened throughout the contaminated vadose zone. The extracted vapors would be collected and treated through gas-phase granular activated carbon (GAC) adsorption prior to venting to atmosphere. When saturated the GAC would be replaced and sent offsite for regeneration or incineration. Soil samples would be regularly collected and analyzed to monitor the progress of the remedial action. Offgas samples would be collected and analyzed to verify the performance of the extracted vapor treatment system.

Effectiveness

SVE has proven to be an effective technology to remediate soil contaminated with VOCs, such as benzene, toluene, ethylbenzene, and xylenes (BTEX), which are the main contaminants of concern at the Building 46 site. SVE has also proven particularly effective when applied to soil with good porosity, such as is the case at NAS Cecil Field. SVE would not volatilize and directly remove SVOCs, including the polycyclic aromatic hydrocarbons (PAHs) which slightly exceed cleanup criteria, such as naphthalene, dibenzo(a,h)anthracene, and benzo(a)pyrene. However, by thoroughly aerating the soil in the unsaturated zone, SVE would foster conditions favorable to the long-term biodegradation of these PAHs.

Gas-phase GAC adsorption would effectively capture volatilized BTEX from the extracted vapor and regeneration or incineration of the saturated GAC would permanently and irreversibly remove or destroy the adsorbed compounds.

It is anticipated that SVE would achieve soil remediation within approximately two years.

Implementability

SVE would be relatively easy to implement. Numerous competent contractors could install such a system and equipment and materials are readily available. Some site disruption would occur during the installation of the SVE system but, since most of it would be located in undeveloped grassy areas, this disruption would be minimal. Care would have to be taken during the installation of the SVE system not to disrupt or damage the utility lines which criss-cross the area. Personnel would be required to operate the SVE system and monitor its performance. However, it would be relatively simple to train such personnel or subcontract these activities.

Cost

The total estimated cost of this technology would be approximately $290,000. A detailed breakdown of this cost is included in Appendix C.

The following assumptions were made to prepare this budget-type estimate:

- Based on the results of pilot tests conducted at similar NAS Cecil Field sites, it is anticipated that the radius of influence of vertical vapor extraction wells with a design vacuum of 45 inches of water and a vapor flow of 10 cubic feet per minute (cfm) would range from 15 feet in non-paved areas to 30 feet in paved areas.

- A total of 6 vertical vapor extraction wells would be installed to a depth of 7 feet over in the same area of contaminated soil as defined in Section 4.1.1 (i.e., 5,500 ft^2). These wells would be arranged along three horizontal pipelines which would convey the extracted vapors to a central location.

- A vapor extraction and treatment system would be installed at a central location. This system would feature a 60 cfm (2 HP) vacuum pump, a moisture separator (55-gallon), and two off-gas treatment canisters operating in series and each holding 1,000 pounds of GAC for the treatment of extracted vapors.

- Areas disturbed by the installation of the vapor extraction wells and conveying pipelines would be restored to original conditions, i.e., backfilled, graded and either re-paved or seeded and mulched.

- The vapor extraction and treatment system would be operated for a period of two years, during which the lead GAC canister would have to be replaced approximately seven times.

- To monitor the progress of the remedial action, three soil samples would be collected quarterly during the first year of SVE operation and semi-annually thereafter. These samples would be analyzed for KAG.

- One sample of treated offgas would be collected monthly to verify the performance of the extracted vapor treatment system. This sample would be analyzed for VOCs

- Following installation and initial operation of the SVE system, a post-removal action report would be prepared to document remedial activities. This report would then be updated quarterly to include performance monitoring results.

4.2 GROUNDWATER REMEDIAL TECHNOLOGIES

4.2.1 Natural Attenuation

Natural Attenuation (NA) would consist of monitoring groundwater quality to determine the extent to which indigenous microorganisms and natural biodegradation processes would break down petroleum hydrocarbons over time. For this purpose, new monitoring wells would be installed as required and samples from these new wells and existing wells would be regularly collected and analyzed for natural attenuation parameters as detailed in the costing assumptions.

Effectiveness

NA would only be effective if the source of groundwater contamination, i.e., the contaminated soil, has been previously removed or remediated. NA would also be more effective if the highly-contaminated groundwater in the source area had been previously remediated to levels that are amenable to biodegradation, because the high contaminant concentrations could impair naturally occurring biodegradation.

Indigenous microorganisms and naturally-occurring biological processes have been shown to be capable of breaking down petroleum hydrocarbons over time, especially lighter fraction hydrocarbons, such as the BTEX which are the main contaminants of concern at the Building 46 site. Methyl tert butyl ether (MTBE) is less amenable to natural biodegradation than BTEX. Heavier fraction hydrocarbons, such as PAHs, would also be less amenable then BTEX to natural biodegradation, but some breakdown would still be likely to occur over time and these contaminants are not as prevalent as BTEX at the Building 46 site. NA processes are also favored by relatively porous soil, such as is the case at NAS Cecil Field. If monitoring determines that either no attenuation is occurring or that unacceptable risks are likely to develop in spite of natural attenuation, a more aggressive remedial approach would be taken.

It is anticipated that NA would achieve groundwater remediation within approximately 15 years if the highly-contaminated groundwater of the source area has been previously remediated to levels that are amenable to biodegradation or up to 30 years if it has not. It should be noted that the high contaminant concentrations in the source area groundwater could result in a much longer remedial duration.

Implementability

NA would be very simple to implement. Numerous competent contractors could install the new monitoring wells which may be required. Personnel would be required to regularly collect groundwater samples. However, it would be relatively simple to train such personnel or subcontract this activity. Numerous competent laboratories could provide the necessary analytical services.

Cost

The total estimated cost of this technology would be approximately $324,000 if the source area groundwater has been previously remediated and $394,000 if it has not. A detailed breakdown of this cost is included in Appendix C.

The following assumptions were made to prepare this budget-type estimate:

- A total of three new monitoring wells would be installed, including two intermediate (50 feet) and one deep (90 feet). These wells would be located southwest of the site, immediately ahead of the leading edge of the intermediate and deep contamination plume to monitor potential contaminant migration.

- An initial round of groundwater samples would be collected and to establish baseline conditions. For this purpose, samples would be collected from the three new wells and 11 existing wells at and around the Building 46 site. These samples would be analyzed for KAG.

- Groundwater samples from the three new wells and 11 existing wells would be collected over a period of 15 to 30 years. For the first year, sampling frequency would be quarterly and semi-annually thereafter. These samples would be analyzed for KAG. Samples would also be analyzed semi-annually during the first five years and annually thereafter for natural attenuation indicator parameters, such as oxidation-reduction potential (ORP), dissolved oxygen (DO), pH and alkalinity, temperature, conductivity, biological and chemical oxygen demand (BOD and COD), total organic carbon (TOC), ferrous and total iron, sulfur compounds (sulfates, sufides, hydrogen sulfide), nitrogen compounds (nitrates, nitrites), orthophosphates, chlorides, and metabolic gases (methane, ethane, ethene, carbon dioxide).

- Monitoring reports would be prepared to document each sampling event.

4.2.2 Chemically-Enhanced Natural Attenuation

Chemically-enhanced NA would consist of using an oxygen-releasing compound to enhance the growth of indigenous microorganisms and natural biodegradation processes, with monitoring groundwater quality to determine the extent to which these microorganisms and processes would break down petroleum hydrocarbons over time. For this purpose, an oxygen releasing compound, such as magnesium peroxide, would initially be seeded throughout the contaminant plume using DPT, after which a maintenance dosage would be periodically fed into monitoring wells. New monitoring wells would be installed as required and samples from these new wells and existing wells would be regularly collected and analyzed

Effectiveness

As with NA, chemically-enhanced NA would only be effective if the source of groundwater contamination, i.e., the contaminated soil, has been previously removed or remediated.

The effectiveness of chemically-enhanced NA would be the same as that of NA with the difference that, since natural biodegradation of hydrocarbons is typically an aerobic process, the addition of an oxygen releasing compound would accelerate this process. It is thus anticipated that chemically-enhanced NA would be more effective for the biodegradation of MTBE and would require significantly less time to achieve the same degree of contaminant removal. As with NA, if monitoring determines that either no attenuation is occurring or that unacceptable risks are likely to develop in spite of natural attenuation, a more aggressive remedial approach would be taken.

It is anticipated that chemically-enhanced NA would achieve groundwater remediation within the source area and outer plume within approximately 15 years.

Implementability

Chemically-enhanced NA would be very simple to implement. Numerous competent contractors could perform the initial seeding and maintenance dosage of oxygen releasing compound and install the new monitoring wells which may be required. Personnel would be required to regularly collect groundwater samples. However, it would be relatively simple to train such personnel or subcontract this activity. Numerous competent laboratories could provide the necessary analytical services.

Cost

The total estimated cost of this technology would be approximately $781,000. A detailed breakdown of this cost is included in Appendix C.

The following assumptions were made to prepare this budget-type estimate:

- A total of three new monitoring wells would be installed, including two intermediate (50 feet) and one deep (90 feet). These wells would be located southwest of the site, immediately ahead of the leading edge of the intermediate and deep contamination plume to monitor potential contaminant migration.

- An initial round of groundwater samples would be collected to establish baseline conditions. For this purpose, samples would be collected from the three new wells and 11 existing wells at and around the Building 46 site. These samples would be analyzed for KAG.

- The initial seeding of the groundwater contaminant plume would consist of injecting five pounds of oxygen releasing compound at each of approximately 400 DPT points. Maintenance dosage would consist of feeding 10 pounds of oxygen releasing compound in each of 14 existing monitoring wells on a quarterly basis for a period of 15 years.

- Groundwater samples from the three new wells and 11 existing wells would be collected over a period of 15 years. For the first year, sampling frequency would be quarterly and semi-annually thereafter. These samples would be analyzed for KAG. Samples would also be analyzed semi-annually during the first five years and annually thereafter for natural attenuation indicator parameters, such as ORP, DO, pH and alkalinity, temperature, conductivity, BOD and COD, TOC, ferrous and total iron, sulfur compounds (sulfates, sufides, hydrogen sulfide), nitrogen compounds (nitrates, nitrites), orthophosphates, chlorides, and metabolic gases (methane, ethane, ethene, carbon dioxide).

- Monitoring reports would be prepared to document each sampling event.

4.2.3 Air Sparging and Soil Vapor Extraction (AS/SVE)

Air sparging and soil vapor extraction would consist of injecting compressed air in the groundwater contaminant plume and applying a vacuum in the vadose zone above that plume. This would induce an air current through the groundwater and soil which would promote short-term stripping of VOCs and long-term biodegradation of SVOCs in both groundwater and soil. Compressed air would be injected through a network of vertical wells screened at various depths (mostly intermediate/deep) within the contaminant

plume. Vacuum would be applied through a network of vertical wells screened in the vadose zone above the contaminant plume. The extracted vapors would be collected and treated through gas-phase GAC adsorption prior to venting to atmosphere. When saturated, the GAC would be replaced and sent offsite for regeneration or incineration. Groundwater and soil samples would be regularly collected and analyzed to monitor the progress of the remedial action and offgas samples would be collected and analyzed to evaluate the performance of the extracted vapor treatment system and verify its compliance with regulatory emission requirements.

To minimize cost and disruption associated with installation, the proposed AS/SVE system would be designed to remediate only the highly-contaminated soil and groundwater in the source area.

Effectiveness

AS/SVE would be effective for the remediation of both groundwater and soil, meaning that it could be designed to effectively remediate groundwater even if the source of groundwater contamination, i.e., the contaminated soil, has not been previously removed or remediated. However, as previously mentioned, the design of the proposed system would be limited to the remediation of the contaminant source area and, therefore, additional groundwater remediation would be required through natural attenuation or other means, to address the destruction of contaminants outside the source area.

AS/SVE has proven to be an effective technology for the removal of VOCs, such as the BTEX which are the main contaminants of concern at the Building 46 site. AS/SVE has also proven particularly effective when applied in areas with soil of good porosity, such as is the case at NAS Cecil Field. AS/SVE would not volatilize and directly remove SVOCs, such as the PAHs, including in particular naphthalene, which also exceed cleanup groundwater criteria. However, by thoroughly aerating the groundwater, AS/SVE would foster conditions favorable to the long-term biodegradation of these PAHs. It is also anticipated that the combination of insitu volatilization and biodegradation provided by AS/SVE would result in adequate removal of MTBE from groundwater.

Gas-phase GAC adsorption would effectively capture volatilized BTEX from the extracted vapor and regeneration or incineration of the saturated GAC would permanently and irreversibly remove or destroy the adsorbed compounds.

It is anticipated that AS/SVE would achieve remediation of the source area groundwater and soil within approximately 12 years. The required additional groundwater remediation would likely be achieved through natural attenuation within the same time frame.

Implementability

AS/SVE would be relatively easy to implement. Numerous competent contractors could install such a system and equipment and materials are readily available. Some site disruption would occur during the installation of the AS/SVE system. The network of air injection and vapor extraction wells would extend over an area approximately half an acre in size (the estimated size of the contaminant source area) centered around the location of the former Building 46 and its installation may temporarily interfere with traffic on "D" Avenue and require the fencing-off of a portion of the parking lot south of Building 904. Care would have to be taken during the installation of the AS/SVE system not to disrupt or damage the utility lines which criss cross over the area. Personnel would be required to operate the AS/SVE system and monitor its performance. However, it would be relatively simple to train such personnel or subcontract these activities. During excavation, adequate caution would be needed to not disrupt or damage the utility lines in the area.

Cost

The total estimated cost of this technology would be approximately $936,000. A detailed breakdown of this cost is included in Appendix C.

The following assumptions were made to prepare this budget-type estimate:

- This technology would be used to remediate both soil and groundwater in the contaminant source area.

- Based upon the results of pilot tests conducted at similar NAS Cecil Field sites, it is anticipated that the radius of influence of vertical injection wells with air flow of 10 scfm would each be 30 feet. As previously mentioned and also based upon pilot tests results, it is anticipated that the radius of influence of vertical extraction wells with a design vacuum of 45 inches of water and a vapor flow of 10 scfm would range from 15 feet in non-paved areas to 30 feet in paved areas.

- A total of 9 air injection wells and 16 vapor extraction wells would be installed. Six of the air injection wells would be installed and screened to a depth of 50 feet (intermediate surficial aquifer) and the remainder would be installed and screened to a depth of 90 feet (deep surficial aquifer). All vapor extraction wells would be installed and screened to a depth of five feet bgs. As previously mentioned, air injection and vapor extraction wells would be installed over an area approximately a half acre in size, which coincides with the estimated extent of the contaminant source area. Two horizontal pipelines would be used to convey compressed air from a central location to the injection wells and three horizontal pipelines would convey vapors from the extraction wells to the same central location.

- An air injection and vapor extraction and off-gas treatment system would be installed at a central location. The air injection component of this system would feature one 100 scfm (30 HP) air compressor and associated receiver tank (100-gallon). The vapor extraction and treatment component of this system would feature one 200 scfm (5 HP) vacuum pump and associated moisture separator (55-gallon) and two canisters operating in series and each holding 2,000 pounds of GAC for the treatment of extracted vapors. All of this equipment would be housed in a pre-engineered and pre-fabricated shelter.

- Areas disturbed by the installation of the air injection and vapor extraction wells and conveying pipelines would be restored to original conditions, i.e., backfilled, graded and either re-paved or seeded and mulched.

- A total of three new monitoring wells would be installed, including two intermediate (50 feet) and one deep (90 feet). These wells would be located southwest of the site, immediately ahead of the leading edge of the intermediate and deep contamination plume to monitor potential contaminant migration.

- An initial round of groundwater samples would be collected to establish baseline conditions. For this purpose, samples would be collected from the three new wells and 11 existing wells at and around the Building 46 site. These samples would be analyzed for KAG.

- The air injection and vapor extraction and treatment system would be operated for a period of 12 years. During this time, the lead GAC canister would have to be replaced approximately four times.

- Groundwater samples from the three new wells and 11 existing wells would be collected quarterly for the first year of AS/SVE operation and semi-annually thereafter. These samples would be analyzed for KAG.

- To monitor the progress of the remedial action three soil samples would be collected quarterly for the first year as AS/SVE operation and semi-annually for one additional year. These samples would also be analyzed for KAG.

- One sample of treated offgas would be collected quarterly to verify the performance of the extracted vapor treatment system. This sample would be analyzed for VOCs.

- Following installation and initial operation of the AS/SVE system, a post-removal action report would be prepared to document remedial activities. This report would then be updated to include performance monitoring results.

4.2.4 Extraction and Treatment (Pump and Treat)

Pump and treat would consist of intercepting the contaminated groundwater and conveying it to the surface for treatment and disposal. Contaminated groundwater would be intercepted through a network of vertical extraction wells screened in the shallow, intermediate, and deep surficial aquifer and equipped with individual pumps. The extracted groundwater would be treated through air stripping followed by liquid-phase GAC adsorption prior to discharge to existing storm sewers. The air stripper exhaust gases would be treated through gas-phase GAC adsorption prior to venting to atmosphere. When saturated, the liquid- and gas-phase GAC would be replaced and sent offsite for regeneration or incineration. Groundwater samples would be regularly collected and analyzed to monitor the progress of the remedial action and treated groundwater and air stripper offgas samples would be collected and analyzed to verify the performance of the pump and treat system.

Effectiveness

Pump and treat would only be effective if the source of groundwater contamination, i.e., the contaminated soil, has been previously removed or remediated.

Pump and treat is one of the longest-established technologies for groundwater remediation and it has been proven effective for the removal of a wide range of contaminants. Air stripping with offgas GAC adsorption would be effective for the removal of VOCs, such as the BTEX which are the main contaminants of concern at the Building 46 site. Liquid-phase GAC adsorption would be effective for the removal of SVOCs, such as the PAHs, including in particular naphthalene, which also exceed groundwater cleanup criteria. The combination of air stripping and liquid-phase GAC adsorption would also adequately remove MTBE.

Regeneration or incineration of the saturated liquid- and gas-phase GAC would permanently and irreversibly remove or destroy the adsorbed compounds.

It is anticipated that pump and treat would achieve groundwater remediation within approximately 15 years.

Implementability

Pump and treat would be relatively easy to implement. Numerous competent contractors could install such a system and equipment and materials are readily available. Some site disruption would occur during the installation of the pump and treat system. The network of groundwater extraction wells would extend over an area approximately two acres in size centered around the location of the former Building 46, which corresponds to the known extent of the groundwater contaminant plume in the intermediate surficial aquifer. System installation would probably require the temporary closure of "D" Avenue and fencing-off of a significant portion of the parking lot south of Building 904. Care would have to be taken during the installation of the pump and treat system not to disrupt or damage the utility lines which criss cross over the area. Personnel would be required to operate the pump and treat system and monitor its performance. However, it would be relatively simple to train such personnel or subcontract these activities.

Since discharge of the treated groundwater to an existing industrial or sanitary wastewater treatment facility is not likely to be possible, this treated groundwater would have to be discharged directly or indirectly (i.e., via the storm sewer system) to surface water. Such discharge would require a National Pollutant Discharge Elimination System (NPDES) permit.

Cost

The total estimated cost of this technology would be approximately $882,000. A detailed breakdown of this cost is included in Appendix C.

The following assumptions were made to prepare this budget-type estimate:

- A total of five groundwater extraction wells would be installed, including one shallow (25 feet), three intermediate (50 feet) and one deep (90 feet). Groundwater would be extracted from each well at the rate of 4 gpm for a combined extraction rate of 20 gpm. As previously mentioned, groundwater extraction wells would be installed over an area approximately two acres in size. Three horizontal pipelines would be used to convey groundwater from the extraction wells to a central location.

- A groundwater treatment system would be installed at a central location. This system would feature an air stripper with offgas treatment and two liquid-phase GAC adsorbers operating in series. The air stripper would be of the low-profile tray-type with a 500 cfm (5 HP) air blower. Air stripper offgas treatment would consist of a 10 kilowatt (Kw) heater/dehumidifier and two canisters operating in series and each holding 2,000 pounds of GAC. Each of the liquid-phase GAC adsorbers would hold

1,000 pounds of GAC. All of this equipment would be housed in a pre-engineered and pre-fabricated shelter.

- Treated groundwater would be discharged to surface water without additional treatment. The Discharge point would be located approximately 500 feet from the central treatment facility. Discharge of the treated groundwater would necessitate an NPDES permit.

- Areas disturbed by the installation of the pump and treat would be restored to original conditions, i.e., backfilled, graded and either re-paved or seeded and mulched.

- A total of three new monitoring wells would be installed, including two intermediate (50 feet) and one deep (90 feet). These wells would be located southwest of the site, immediately ahead of the leading edge of the intermediate and deep contamination plume to monitor potential contaminant migration.

- An initial round of groundwater samples would be collected to establish baseline conditions. For this purpose, samples would be collected from the three new wells and 11 existing wells at and around the Building 46 site. These samples would be analyzed for KAG.

- The pump and treat system would be operated for a period of 15 years. During this time, the contents of the lead liquid-phase GAC adsorber would not have to be replaced and the lead GAC canister of the air stripper offgas treatment system would have to be replaced approximately twice.

- Groundwater samples from the three new wells and 11 existing wells would be collected for a period of 15 years. Sampling frequency would be quarterly for the first two years and semi-annually thereafter. Samples would be analyzed for KAG.

- One sample of treated groundwater and treated air stripper offgas would be collected quarterly to verify the performance of the groundwater treatment system. Treated groundwater would be analyzed for KAG. Treated offgas would be analyzed for VOCs.

- Following installation and initial operation of the pump and treat system, a post-removal action report would be prepared to document remedial activities. This report would then be updated to include performance monitoring results.

4.3 COMPARISON AND RECOMMENDATION

Table 4-1 provides a summary comparison of the evaluated remediation technologies for the Building 46 site.

This comparison shows that the cost of source area AS/SVE plus NA of the outer plume would not be as low as that of SVE for soil and NA for groundwater ($999,000 compared to $684,000) or as low as excavation/offsite treatment for soil and NA for groundwater ($999,000 compared to $687,000). However, as noted earlier, there is uncertainty as to the effectiveness of NA alone for the removal of the high contaminant concentrations in the source area groundwater. Therefore, the combination of AS/SVE for the remediation of the source area soil and groundwater with NA for the remediation of the outer plume groundwater would be the most cost-effective of all those capable to achieve complete remediation within a relatively practical time frame, i.e., 15 years. Source area AS/SVE plus NA would be slightly less expensive than chemically-enhanced NA plus SVE or plus excavation and offsite treatment and disposal and AS/SVE would be more effective and is better proven than chemically-enhanced NA for the remediation of the highly-contaminated source area groundwater. Source area AS/SVE plus NA would also be significantly less expensive than pump and treat plus SVE or plus excavation and offsite treatment and disposal.

Based upon this comparison, it is recommended to proceed with the design of an AS/SVE system for the remediation of the source area soil and groundwater, supplemented by NA to complete groundwater remediation.

TABLE 4-1

SUMMARY COMPARISON
SOIL & GROUNDWATER REMEDIATION TECHNOLOGIES
BUILDING 46 SITE
NAS CECIL FIELD – JACKSONVILLE, FLORIDA

Criteria	Excavation & Offsite Treatment & Disposal	SVE	NA	Chemically-Enhanced NA	AS/VE	Pump & Treat
Effectiveness	• Effective for soil • Requires groundwater remediation • Remediates soil within 2 month	• Effective for soil • Requires groundwater remediation • Remediates soil within 2 year	• May be effective for groundwater • Requires soil remediation • Remediates groundwater within 15 to 30 years	• Probably effective for groundwater • Requires soil remediation • Remediates groundwater within 15 years	• Effective for both groundwater and soil in source area • Require additional groundwater remediation • Remediates source area soil and groundwater within 12 year	• Effective for groundwater • Requires soil remediation • Remediates groundwater within 15 years
Implementability	• Easy to implement • Moderate site disruption	• Can be Implemented • Moderate site disruption	• Very easy to implement • No site disruption	• Easy to implement • Minimal site disruption	• Can be Implemented • Moderate site disruption	• Can be Implemented • Significant site disruption
Cost ($ x 1,000) Individual Technology Additional Remediation Total	$293 $394 to $882 $687 to $1,175	$290 $394 to $882 $684 to $1,172	$324 to $394 $290 to $675 $684 to $999	$781 $290 to $293 $1,081 to $1,084	$936 $ 63 $999	$882 $290 to $293 $1,172 to $1,175

5.0 REMEDIATION SYSTEM DESIGN

Following a presentation of applicable technologies, as discussed in Section 6.0, the BCT reached consensus on an integrated AS/SVE system as the remedial technology that will most effectively remediate the source area contaminated soil and groundwater followed by natural attenuation in the outer plume. This section discusses the AS/SVE system design, and Section 7.0 includes a discussion of the natural attenuation requirements.

5.1 PRE-CONSTRUCTION SOIL SAMPLING

In order to obtain the additional data necessary for a more accurate delineation of the source area soil contaminated at levels exceeding cleanup goals, additional sampling and analysis is recommended prior to construction of the AS/SVE system. Twelve soil borings will be advanced to the water table in a 20 to 25 ft grid size covering the currently assumed source area of 5,500 square feet. The soil samples will be analyzed for KAG. Based on these results, the design of the AS/SVE system presented below may require adjustment of vapor extraction well locations.

5.2 AS/SVE SYSTEM LAYOUT AND CONSTRUCTION

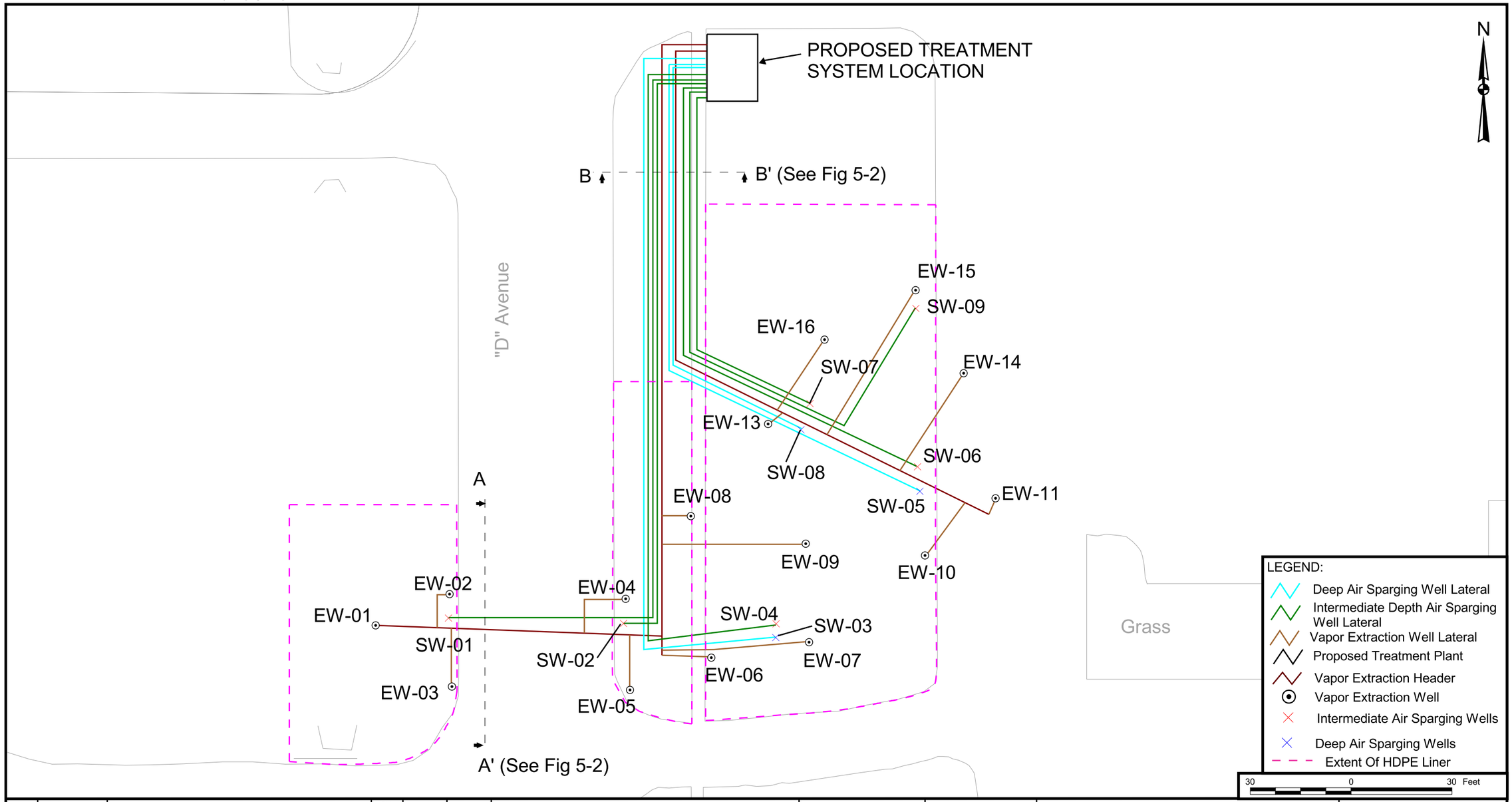
Figure 5-1A shows the air sparging and soil vapor extraction well layout and the proposed location of the treatment system. The treatment system is proposed to be located outside the area of AS/SVE treatment near the entrance to the parking lot.

5.2.1 Air Sparging Well Layout and Construction

Three deep air sparging wells (installed to depth of 90 feet bgs, screened from 85-90 ft bgs) and six intermediate depth wells (installed to a depth of 50 feet bgs, screened from 40-50 ft bgs) will be installed within the source area (previous UST locations) as shown on Figure 5-1B. The portions of the plume outside this zone of influence will be allowed to remediate through natural attenuation and the attainment of remedial action goals throughout the aquifer will be verified by monitoring.

Three pairs of intermediate/deep air sparging wells will be installed within the source area to achieve a thorough distribution of air throughout the depth of the contaminated zone. Wells SW-04, SW-06 and SW-07 are the intermediate air sparging wells and wells SW-03, SW-05 and SW-08 are the associated deep air sparging wells.

P:\GIS\CECIL\BLDG46.APR 4-MAR-99 CPG Layout [Fig5-1A]



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DRAWN BY CHAD P. GLICK DATE 2/26/99
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AIR SPARGING/VAPOR EXTRACTION SYSTEM LAYOUT, BUILDING 46, TANKS
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE
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DRAWING NO. FIGURE 5-1A
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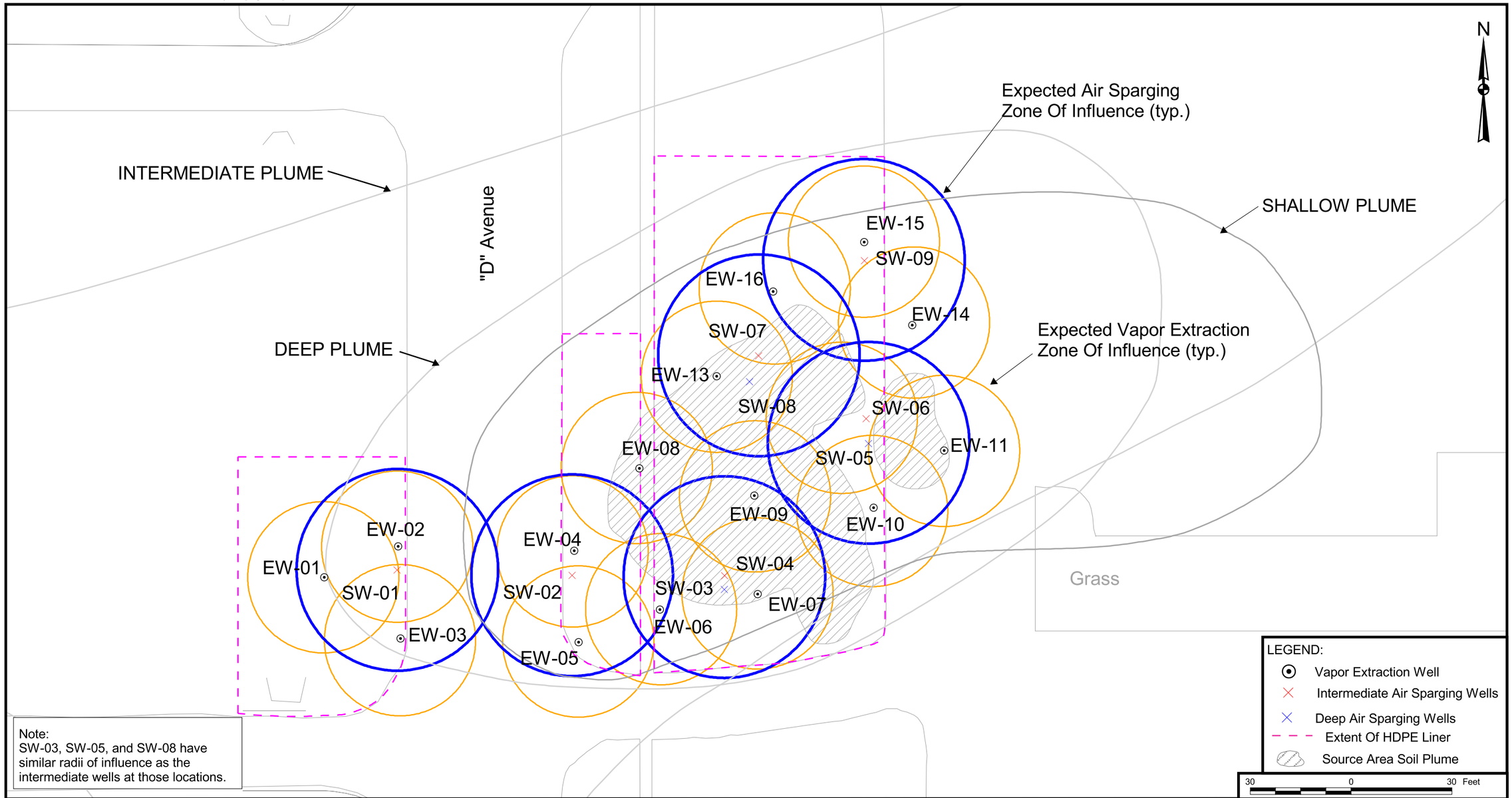
P:\GIS\CECIL\BLDG46.APR 4-MAR-99 CPG Layout [Fig5-1A]



Note:
SW-03, SW-05, and SW-08 have similar radii of influence as the intermediate wells at those locations.

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DRAWN BY: CHAD P. GLICK — DATE: 2/26/99
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ESTIMATED AIR SPARGING/VAPOR EXTRACTION ZONES OF INFLUENCE, BUILDING 46, TANKS
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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REV. 0

Two intermediate air sparging wells, SW-01 and SW-02 will be installed in the southwest portion of the plume downgradient of the source. One intermediate air sparging well, SW-09 will be installed in the northwestern portion of the plume downgradient of the source in the opposite direction.

Based on a pilot study conducted at Site 16 (which has similar site geology), an intermediate/deep well pair each injecting 10 scfm of air achieved a zone of influence with a minimum radius of 30 feet (TtNUS, 1998b). Similar radii of influence with intermediate air sparging wells were observed at Site 5 (AAB-ES, 1997). Therefore a radius of influence of 30 feet is expected for each of the six air sparging locations as shown on Figure 5-1B.

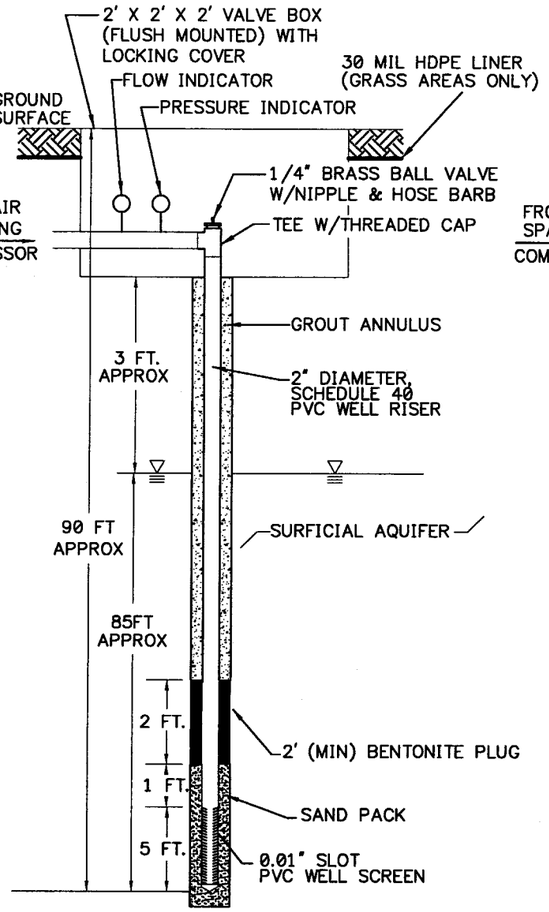
The wells will be constructed as illustrated on Figure 5-2. Because the minimum air pressure required to displace the water column in the deep air sparging wells SW-03, SW-06 and SW-08 will be approximately 37 pound per square inch gauge (psig), and the compressor to supply the air will be of higher pressure, all of the air sparging well laterals will be constructed of schedule 80 PVC. Air sparging wells will be constructed of Schedule 40 PVC. Air sparging well laterals will be connected directly to the air sparging headers within the treatment plant. The typical pipeline trench cross sections under grass-covered areas and asphalt-covered areas are also shown on Figure 5-2. The widths of the trenches can vary between 18 inches for single pipelines (such as vapor extraction laterals), up to 60 inches for multiple pipelines/headers.

The air sparging piping shall consist of both 2-inch galvanized steel piping and 2-inch schedule 80 PVC piping. All piping within the treatment system shall be 2-inch galvanized steel. All underground piping from the treatment system to the air sparging wells shall be 2-inch schedule 80 PVC. Each air sparging well head will be provided with a flow indicator, a pressure gauge and a sampling valve.

5.2.2 Soil Vapor Extraction Well Layout and Construction

Sixteen vapor extraction wells will be installed to remove the volatilized vapors from the source area vadose zone soil. The vapor extraction wells will be installed at the locations shown on Figure 5-1B. Extraction wells EW-04 and EW-05 must be installed off the paved area, preferably on the shoulder of "D" Avenue. Each vapor extraction well will be screened at a depth of 2.5-5.5 feet bgs. The screen is expected to be mainly present in the vadose zone, with approximately 0.5 feet below the water table. The extracted vapors will consist of VOCs from the vadose zone soil contamination present in the source area as well as volatilized VOCs carried by upward migrating air bubbles from groundwater air sparging. The intersection of the screen with the water table will ensure capture of vapors in the capillary zone.

Based on a pilot study conducted at Site 16, the zone of influence is expected to have a minimum radius of 15 feet under unpaved or grass-covered areas. The radius of influence can be expected to extend up



DEEP AIR SPARGING WELL DETAIL
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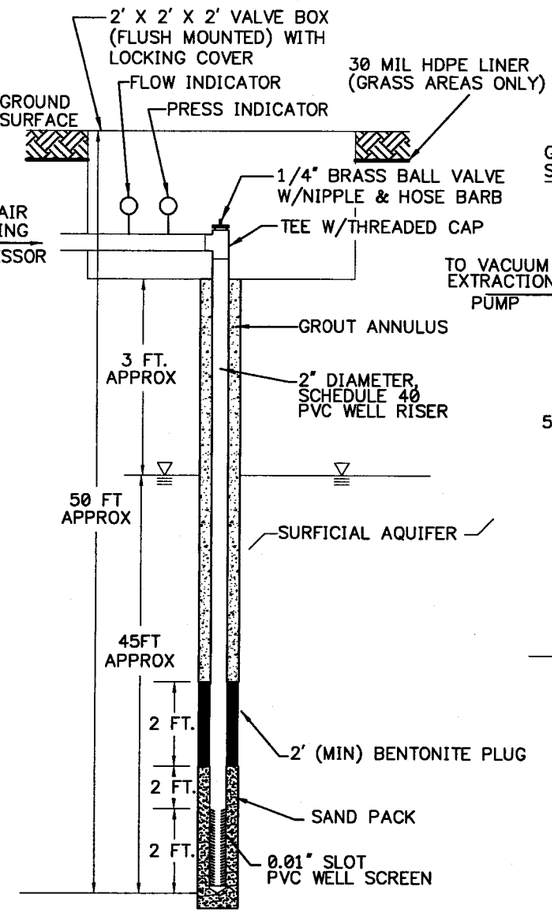

INTERMEDIATE AIR SPARGING WELL DETAIL
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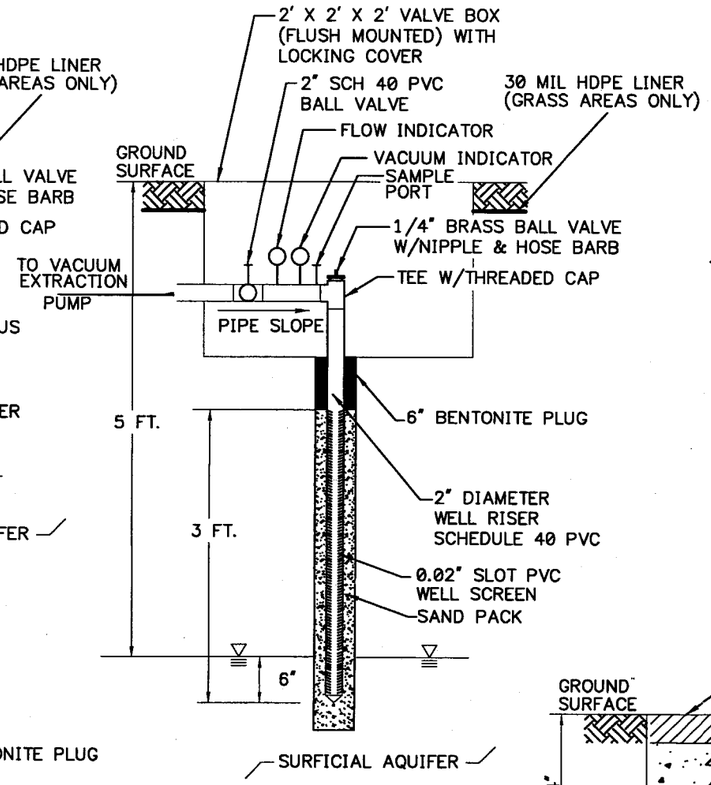

EXTRACTION WELL DETAIL
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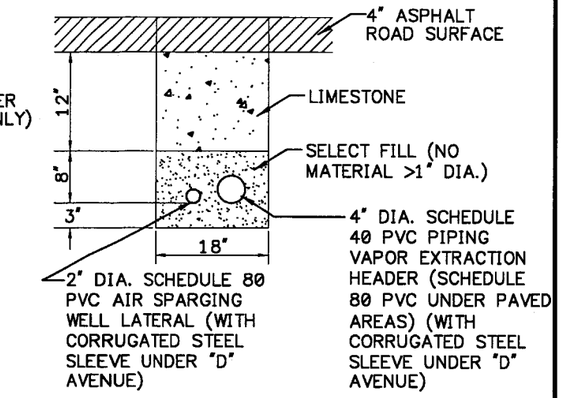

TRENCH CROSS SECTION A-A'
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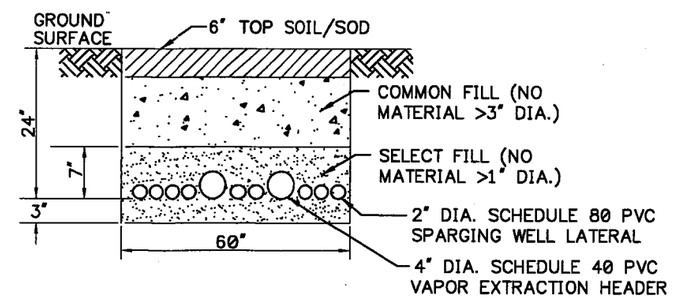

TRENCH CROSS SECTION B-B'
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WELL INSTALLATION & PIPING TRENCH DETAILS
REMEDIAL ACTION PLAN
BUILDING 46, TANKS 46R, 46D, 46SUL, 46UR
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
APPROVED BY DATE
DRAWING NO. FIGURE 5-2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

to 30 feet under paved areas or areas with less permeable surfaces. In order to minimize the number of vapor extraction wells, it is proposed that a 30-mil high-density polyethylene (HDPE) liner be installed over approximately 15,000 ft^2 of area being influenced by the SVE system. This liner will be installed on the soil underlying approximately 15,000 square feet of unpaved and grass-covered areas. The entire area will first be cleared and graded to drain towards a suitable drain location. The placement of the HDPE liner is expected to provide a conservative radius of influence of 22.5 feet per vapor extraction well.

Vapor extraction well construction details are shown on Figure 5-2. The wells will be constructed of Schedule 40 PVC. Each well will be provided with a flow controlling ball valve, flow indicator, a pressure gauge and a sampling valve.

5.2.3 Utilities

The underground utilities at the site are shown on Figure 1-1. The utilities consist of potable water, sanitary, electrical, communication and cable television. Prior to installation of the AS/SVE wells, headers and well laterals, the subcontractor must verify the exact locations of the utility lines and take measures to prevent disruption or damage to the lines. The AS/SVE well locations and trench locations may be adjusted by a few feet as necessary. The depths of the pipelines in the trenches may also be adjusted depending on the depths of the utilities, and if so, the penetrations of the pipelines in the vault boxes could vary.

5.2.4 Waste Management

The system installation wastes, such as drill cuttings, drillings muds, development water, contamination fluids, etc., generated during the installation of the air sparging wells vapor extraction wells, and monitoring wells will be managed (collected, stored, and treated/disposed) in accordance with the Base-wide Generic Work Plan (TtNUS, 1998a).

5.3 AIR SPARGING/VAPOR EXTRACTION TREATMENT SYSTEM EQUIPMENT AND CONTROLS

The treatment system equipment will be installed on a 6-inch concrete slab (approximately 20 feet long by 15 feet wide.) The treatment system will be enclosed by a 6-foot high fence with a gate at the corner adjoining the parking lot entrance. Figure 5-3 shows the layout of the treatment system.

5.3.1 Air Sparging Equipment

Figures 5-4 and 5-5 illustrate the air sparging system's Piping and Instrumentation Diagram (P&ID). The above-ground air sparging equipment consist of the following:

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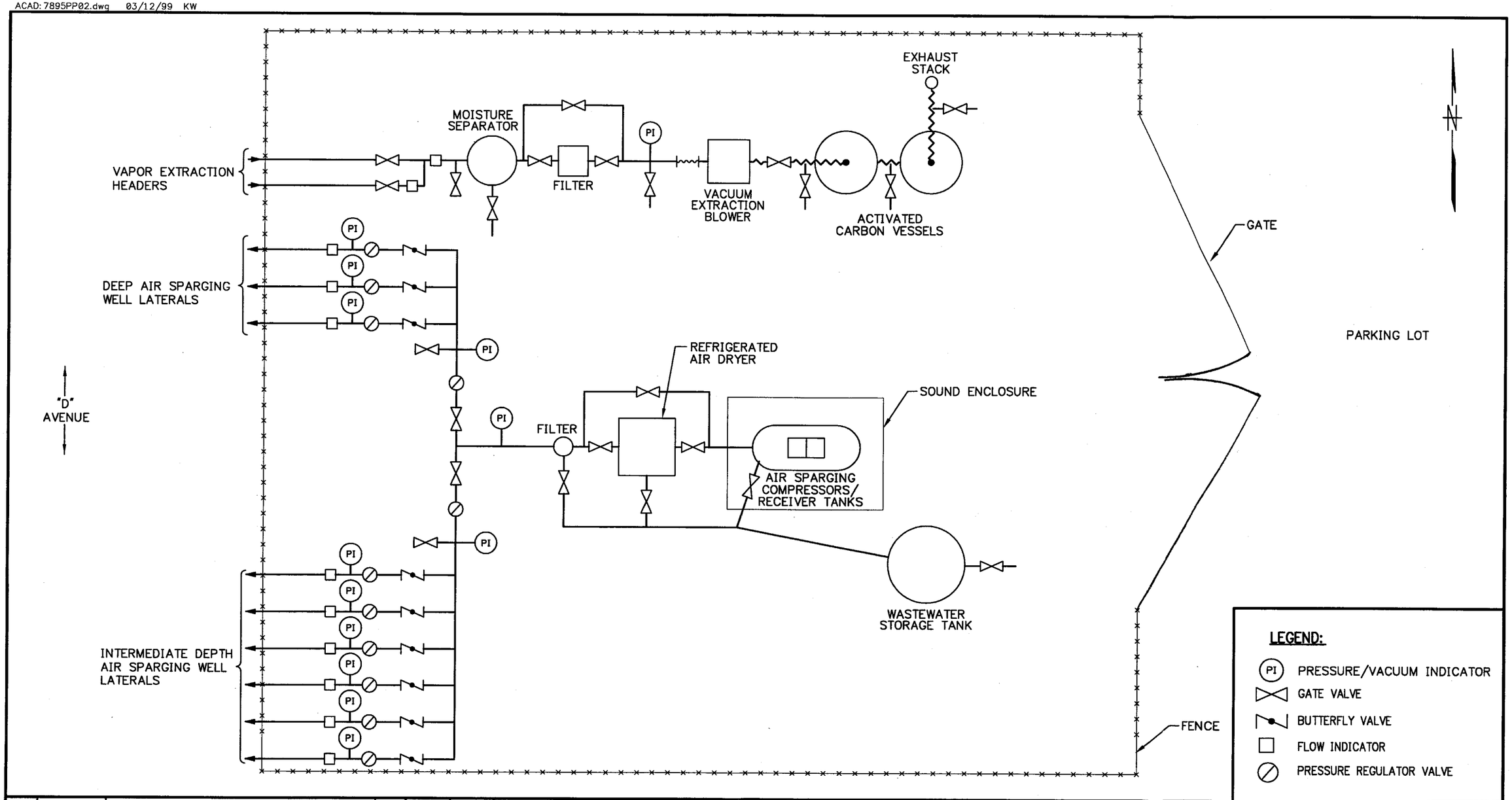

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SCALE NOT TO SCALE

CONCEPTUAL AIR SPARGING/VAPOR EXTRACTION TREATMENT SYSTEM LAYOUT
REMEDIAL ACTION PLAN, BUILDING 46, TANKS 46R, 46D, 46SUL, 46UR
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
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REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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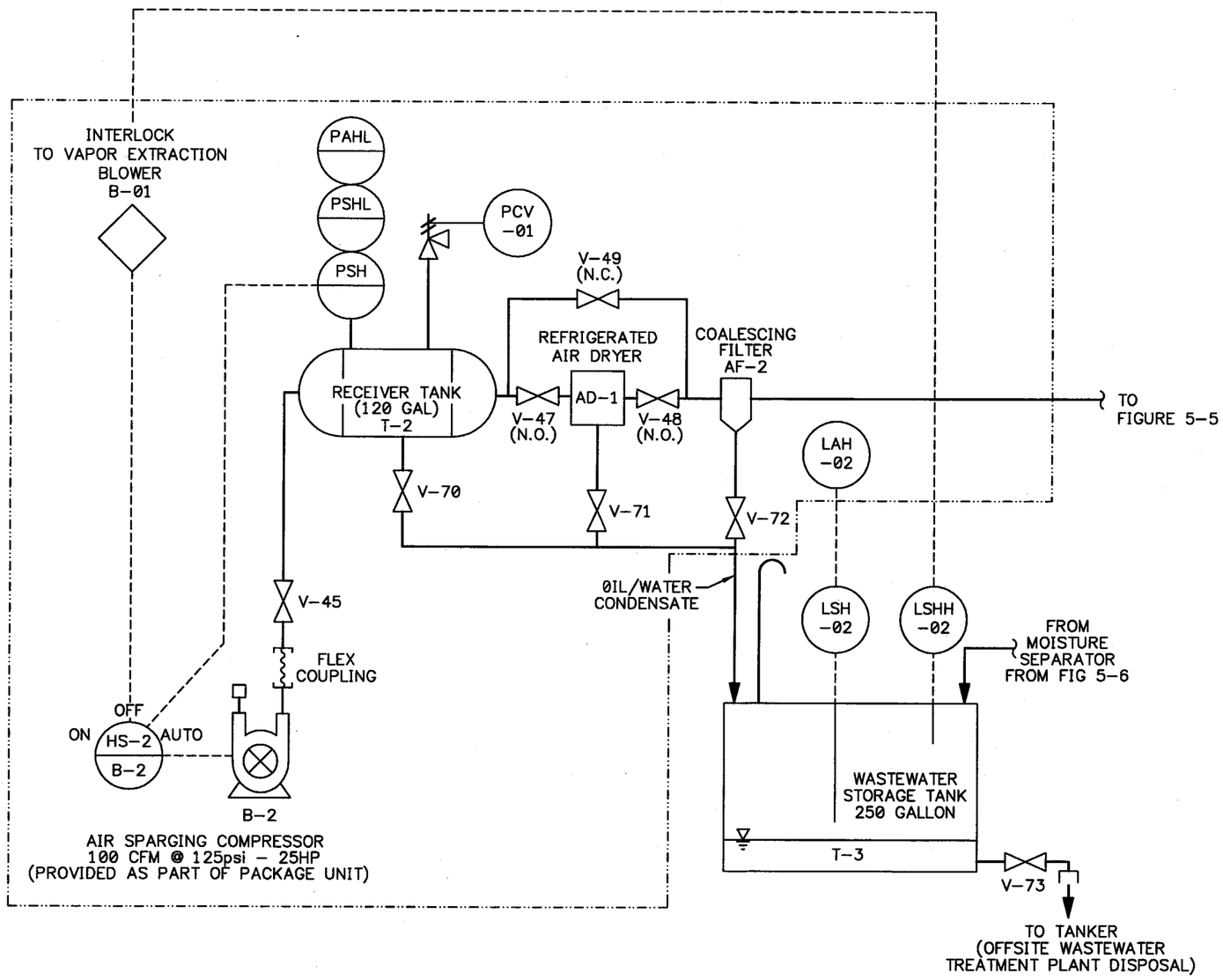

LEGEND:

AS	AIR SPARGE LINE
HS	HAND SWITCH
LAH	LEVEL ALARM HIGH
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH-HIGH
N.C.	NORMALLY CLOSED
N.O.	NORMALLY OPEN
PAHL	PRESSURE ALARM HIGH LOW
PCV	PRESSURE CONTROL VALVE
PSH	PRESSURE SWITCH HIGH
PSHL	PRESSURE SWITCH HIGH LOW
	GATE VALVE
	QUICK DISCONNECT COUPLING
	RELIEF VALVE

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AIR SPARGING SYSTEM
PROCESS AND INSTRUMENTATION DIAGRAM
REMEDIAL ACTION PLAN, BUILDING 46,
TANKS 46R, 46D, 46SUL, 46UR
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
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DRAWING NO. FIGURE 5-4 REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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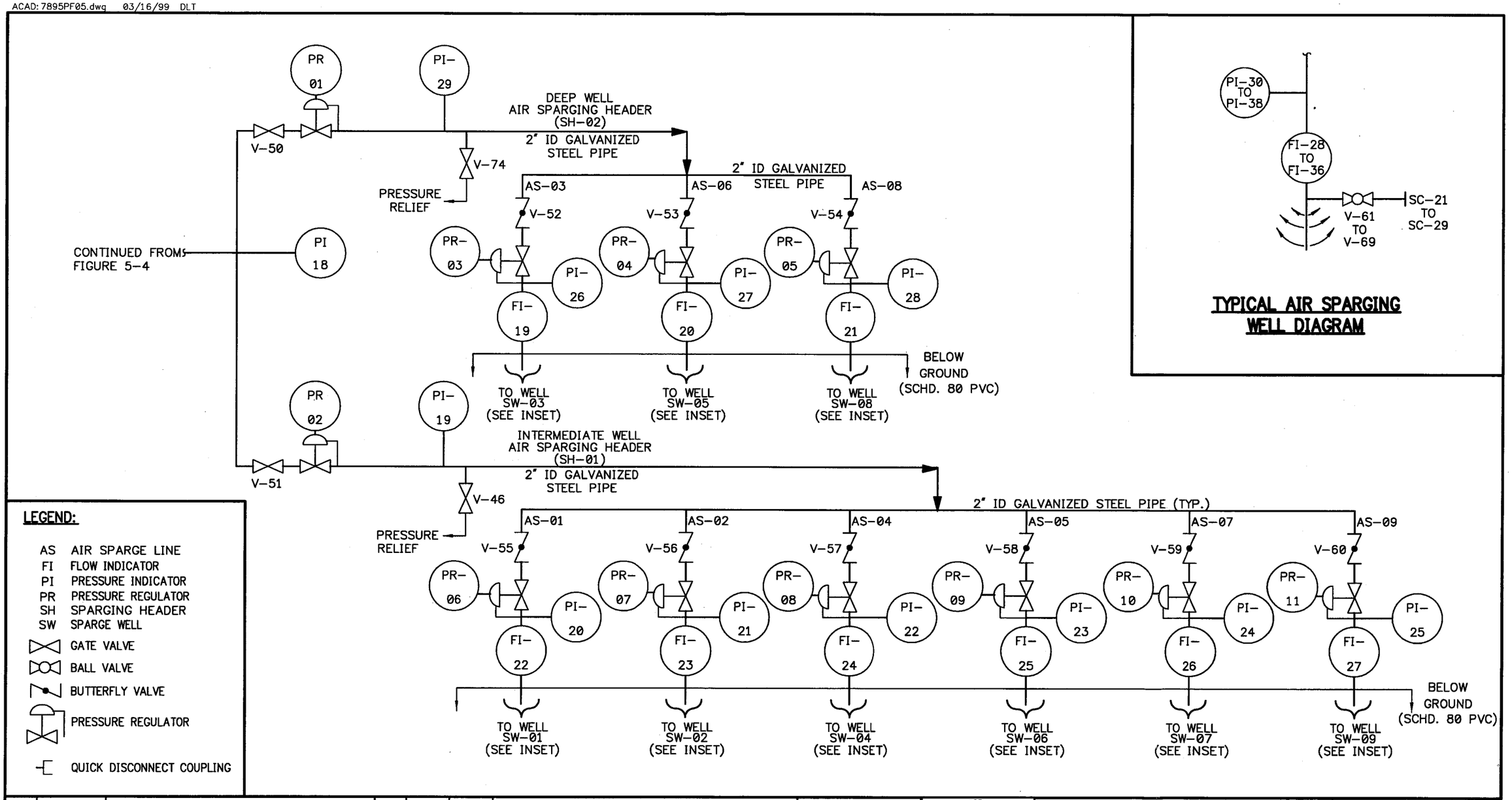

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CHECKED BY DATE 3/17
COST/SCHED-AREA
SCALE NOT TO SCALE

AIR SPARGING SYSTEM
PROCESS AND INSTRUMENTATION DIAGRAM (CONTD.)
REMEDIAL ACTION PLAN
BUILDING 46, TANKS 46R, 46D, 46SUL, 46UR
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
APPROVED BY DATE
DRAWING NO. FIGURE 5-5
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

- One (1) Air Sparging Compressor (B-2), with built-in after coolers and controls
- Receiver Tank (T-2)
- Refrigerated Air Dryer (AD-1)
- Coalescing Air Filter (AF-2)
- Pressure and flow-rate regulated air sparging well headers
- Pressure and flow-rate regulated air sparging lines

An air compressor rather than a blower will be required for air sparging because of the high pressures required for the deep air sparging wells. The Air Sparging Compressor will be of the rotary-vane type capable of providing a minimum of 90 scfm of flow rate (corresponding to 10 scfm per well for 9 air sparging wells) and a pressure rating of a minimum of 40 pounds per square inch gage (psig) (37 psig static head plus 3 psig friction losses). Based on commercially available compressors, a compressor capable of providing 100 scfm (at intake conditions) delivering a pressure of 125 psig will be used. The compressor motor will be rated for 25 horsepower (HP) and operate on a 480-volt, 3-phase electrical power supply.

The Air Sparging Compressor will be equipped with a discharge muffler and mounted on a Receiver Tank of 120 gallon capacity. The compressor will be provided with an internal air-cooled oil cooler. The Receiver Tank will be equipped with a pressure regulating valve at the discharge and an adjustable pressure relief valve. The Refrigerated Air Dryer and Coalescing Air Filter will ensure that the air supplied for sparging is free of oil and moisture.

The Air Sparging Compressor, inlet filter, associated controls, discharge muffler, Receiver Tank and the Refrigerated Air Dryer and Coalescing Air Filter will be mounted on a single skid. A sound enclosure may be provided around the air compressors if required. A list of the all equipment to be installed (including this skid system) is provided in Table 5-1.

The wastewater accumulating in the Receiver Tank, dryer, and Coalescing Air Filter, will be periodically discharged under pressure using manual valves from the receiver tank, the dryer and filter to a 250-gallon Wastewater Storage Tank. This wastewater will consist of condensate from compression and cooling of humid ambient air and oil from the compressor's lubrication. It is estimated that under peak conditions in summer, approximately 18 gallons per day (gpd) of wastewater can be expected from the compressed air system, as shown in the calculations in Appendix D. Every 2 weeks the wastewater will be stored in the Wastewater Storage Tank and disposed of at the NAS Cecil Field wastewater treatment plant (WWTP) or other approved facility. Transfer of the wastewater will occur via suction using a vacuum truck.

TABLE 5-1

AIR SPARGING EQUIPMENT LIST AND PERFORMANCE SPECIFICATIONS
REMEDIAL ACTION PLAN, BUILDING 46 TANKS
NAVAL AIR STATION, CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 1 OF 2

ITEM	LOCATION/FUNCTION	PERFORMANCE SPECIFICATION
Air Sparging Compressor (B-2)	Treatment system/supplies pressurized air for sparging	One (1) 100 scfm inlet capacity, 125 psig discharge pressure, rotary-vane, 25 H.P. motor, 480-volt, 3 phase, 120 gal Receiver Tank, (T-2) refrigerated Air Dryer, (AD-1) Coalescing Air Filter (AF-2), pressure switch high and pressure alarm high/low.
Air Sparging Header (SH-01)	Treatment system/ intermediate depth air sparging header	2-inch ID galvanized steel
Air Sparging Header (SH-02)	Treatment system/ deep air sparging header	2-inch ID galvanized steel
Air Sparging Well Lateral (AS-01 to AS-09)	Treatment system and outside/ distributes air to sparging wells	2-inch ID galvanized steel (above ground) and Schedule 80 PVC (below ground)
Air Sparging Wells (SW-01, SW-02, SW-04, SW-06, SW-07 and SW-09)	Intermediate depth air sparging wells	2-inch ID, 50 feet in length, Schedule 40 PVC, with 0.010 inch slot size screens, 2 feet in length
Air Sparging Wells (SW-03, SW-05, SW-08)	Deep air sparging wells	2-inch ID, 50 feet in length, Schedule 40 PVC, with 0.010 inch slot size screens, 5 feet in length
Wastewater Storage Tank (T-3)	Treatment system/collects condensate and lubricating oil removed from receiver tank, dryer and filter	Vertical, closed-top cylindrical carbon steel tank, 250 gallon capacity, 3 ft dia x 3 ft ssh, 1-inch inlet, 1-inch drain, high level, high-high level switches, high-level alarm
Pressure Regulators (PR-01, PR-02)	SH-02 and SH-01, respectively/pressure reduction from compressor to air sparging headers	Spring-loaded diaphragm/valve with air aspirated secondary pressure adjustment to match dial-adjusted downstream pressure. Capable of reading 0 to 125 psig (5% accuracy) up to 100 scfm.
Pressure Regulators (PR-03, PR-04 and PR-05)	AS-03, AS-06 and AS-08, respectively/pressure reduction from deep air sparging header SH-02 to well laterals	Spring-loaded diaphragm/valve with air aspirated secondary pressure adjustment to match dial-adjusted downstream pressure. Capable of reading 0 to 50 psig (5% accuracy) up to 60 scfm.
Pressure Regulators (PR-06 through PR-11)	AS-01, AS-02, AS-04, AS-05, AS-07 and AS-09 respectively/ pressure reduction from intermediate air sparging header SH-01 to well laterals	Spring-loaded diaphragm/valve with air aspirated secondary pressure adjustment to match dial-adjusted downstream pressure. Capable of reading 0 to 50 psig (5% accuracy) up to 60 scfm.

TABLE 5-1

AIR SPARGING EQUIPMENT LIST AND PERFORMANCE SPECIFICATIONS
REMEDIAL ACTION PLAN, BUILDING 46 TANKS
NAVAL AIR STATION, CECIL FIELD
JACKSONVILLE, FLORIDA
PAGE 2 OF 2

ITEM	LOCATION/FUNCTION	PERFORMANCE SPECIFICATION
Pressure gauges (PI-18)	Junction of SH-01 and SH-02	Spiral/helical Bourdon type, capable of reading from 0 to 200 psig
Pressure gauges (PI-19, PI-29)	SH-01 and SH-02 respectively	Spiral/helical Bourdon type, capable of reading from 0 to 100 psig
Pressure gauges (PI-20 to PI-28)	AS-01 to AS-09 (see Figure 5-5 for match)	Spiral/helical Bourdon type, capable of reading from 0 to 60 psig
Flow meters (FI-19 to FI-27)	AS-01 to AS-09 (see Figure 5-5 for match)	Pitot-tube type automatic velocity-averaging sensor with differential pressure based flow gauge, capable of reading 0 to 100 scfm at operating pressures of 0 to 100 psig
Valves (V-45, V-46)	B-2/B-3 discharge/ Include or isolate air compressor(s)	2 inch ID gate or block valves
Valves (V-47, V-48)	Include or isolate refrigerated air dryer	2 inch ID gate or block valves
Valve (V-49)	Bypass refrigerated air dryer	2 inch ID gate or block valve
Valve (V-50, V-51)	SH-02 and SH-01 respectively/ control flow	2 inch ID gate or block valve
Valves (V-52 to V-60)	AS-01 to AS-09 (see Figure 5-5 for match)/control flow	2 inch ID butterfly valves
Valves (V-52 to V-60)	AS-01 to AS-09 (see Figure 5-5 for match)/control flow	2 inch ID butterfly valves
Valves (V-61 to V-69)	Air sparging wells/bleed or sample	1/2 inch ID ball valves
Valves (V-70, V-71 and V-72)	Receiver tank, dryer, filter drain valves	1/4 inch ID gate or block valves
Valve (V-73)	Wastewater Storage Tank drain	1 inch ID gate or block valve with quick disconnect coupling
Valves (V-74, V-75)	SH-02 and SH-01, respectively/bleed	2 inch ID gate or block valve
Pressure gauges (PI-30 to PI-38)	Air sparging well/pressure of air supplied	Spiral/helical Bourdon tube capable of reading 0-60 psig
Flow meters (FI-28 to FI-36)	Air sparging wells /flow rate of air supplied	Pitot-tube type automatic velocity-averaging sensor with differential pressure based flow gauge, capable of reading 0 to 100 scfm at operating pressures of 0 to 100 psig

The Wastewater Storage Tank will also receive a minimal volume of water from the Moisture Separator of the SVE system. Only during startup or when the water table elevations exceed the normally expected depth of 5 feet bgs, the Moisture Separator may collect as much as 5 gpd of water. Water from the Moisture Separator will be transferred into the Wastewater Storage Tank using a portable pump and flexible hose.

5.3.2 Air Sparging System Controls

The AS system controls will available on a main control panel. This control panel will house On-Off-Auto switches, motor starters, and control relays for the entire AS/SVE system. The motor starters shall be equipped with a thermal overload and three phase protection. A ground-fault protected 120-volt electrical outlet shall also be provided for operation of portable equipment. The following alarms and failsafes shall be installed in the main control panel:

- Moisture Separator high water-level (HI) alarm
- Wastewater Storage Tank high water-level (HI) alarm
- Moisture Separator high-high water-level (HI-HI) failsafe
- Wastewater Storage Tank high-high water-level (HI-HI) failsafe

The Receiver Tank shall be equipped with pressure switches for high- (HI-), low- (LO-) and alarm for high- (HI-) or low- (LO-) pressure conditions.

The main control panel shall also have an On-Off-Auto with manual override switch so that the operator may override the interlock condition during start-up or testing. The main control panel shall also contain an interlock between the AS system and SVE system such that the Air Sparging Compressor will be shut down if the Vapor Extraction Blower is de-energized. The Moisture Separator and the Wastewater Storage Tank will each be equipped with "HI" level switches to trigger alarms in the event of high water level and "HI-HI" level switches to shut down the AS/SVE system in the event of excessively high water levels. In lieu of alarms, a warning light (flashing or rotating beacon) may be used. Depending on the future ownership of the site, a telemetric communication of alarm conditions to a system attendant may also be considered.

5.3.3 Vapor Extraction Equipment

The Vapor Extraction Blower (B-1) will be of the positive displacement type. The Vapor Extraction Blower shall be capable of 160 scfm inlet capacity with a vacuum of 6 inches of mercury. A total pressure loss (calculations shown in Appendix D) of approximately 2-8 psig (5.7 inches of mercury) is expected. The

blower motor will be rated for 3 HP and operate on a 480-volt, 3-phase electrical power supply. The pump-to-motor coupling will be of the belt type with multiple sheaves to allow for adjustments in the vapor extraction rate that may be required by evolving conditions during the remedial action. The blower inlet will be equipped with a cartridge-type filter for protection against abrasive solid particles. A Moisture Separator with capacity of at least 55 gallons will be provided. This Moisture Separator will be supplied with both an adjustable vacuum relief valve and a vacuum gauge to determine the vacuum on vapor extraction headers.

The Vapor Extraction Blower, inlet filter, Moisture Separator, discharge muffler, and associated controls will be mounted on a single skid. A list of the all equipment to be installed (including this skid system) is provided in Table 5-2.

5.3.4 Soil Vapor Extraction System Controls

The SVE controls will be available on the main control panel. This control panel will house the motor On-Off-Auto switches, motor starters, and control relays for the system. The motor starter shall be equipped with a thermal overload and 3-phase protection. The Vapor Extraction Blower will be interlocked with the Air Sparging Compressor as described in 5.3.2. The SVE system P&ID is presented in Figure 5-6. Figure 5-7 presents the single line electrical diagram for the AS/SVE motors.

Although a majority of the soil-gas readings as reported in the SAR were high (> 5,000 ppmv), the combined AS/SVE vapor concentrations of BTEX and MTBE are expected to be less than 300 ppmv. Therefore, the vapor are unlikely to be flammable (i.e. exceed the Lower Explosive Limit for BTEX & MTBE). Consequently, the vapor extraction and treatment equipment need not be intrinsically safe or explosion proof.

5.3.5 Off-gas Treatment

The Florida Department of Environmental Protection (FDEP) requires blower off-gas treatment for at least thirty (30) days, and until the blower's total VOC effluent discharge is less than 13.7 pounds per day (lbs/day). Currently, the estimated emission rate is 11 lbs/day based on theoretical estimates of air sparging emissions and soil vapor extraction emissions, presented in Appendix D. Because of the potential for a higher VOC emission rate, especially during the initial phase of operation, and to comply with FDEP regulations a temporary off-gas treatment system is proposed.

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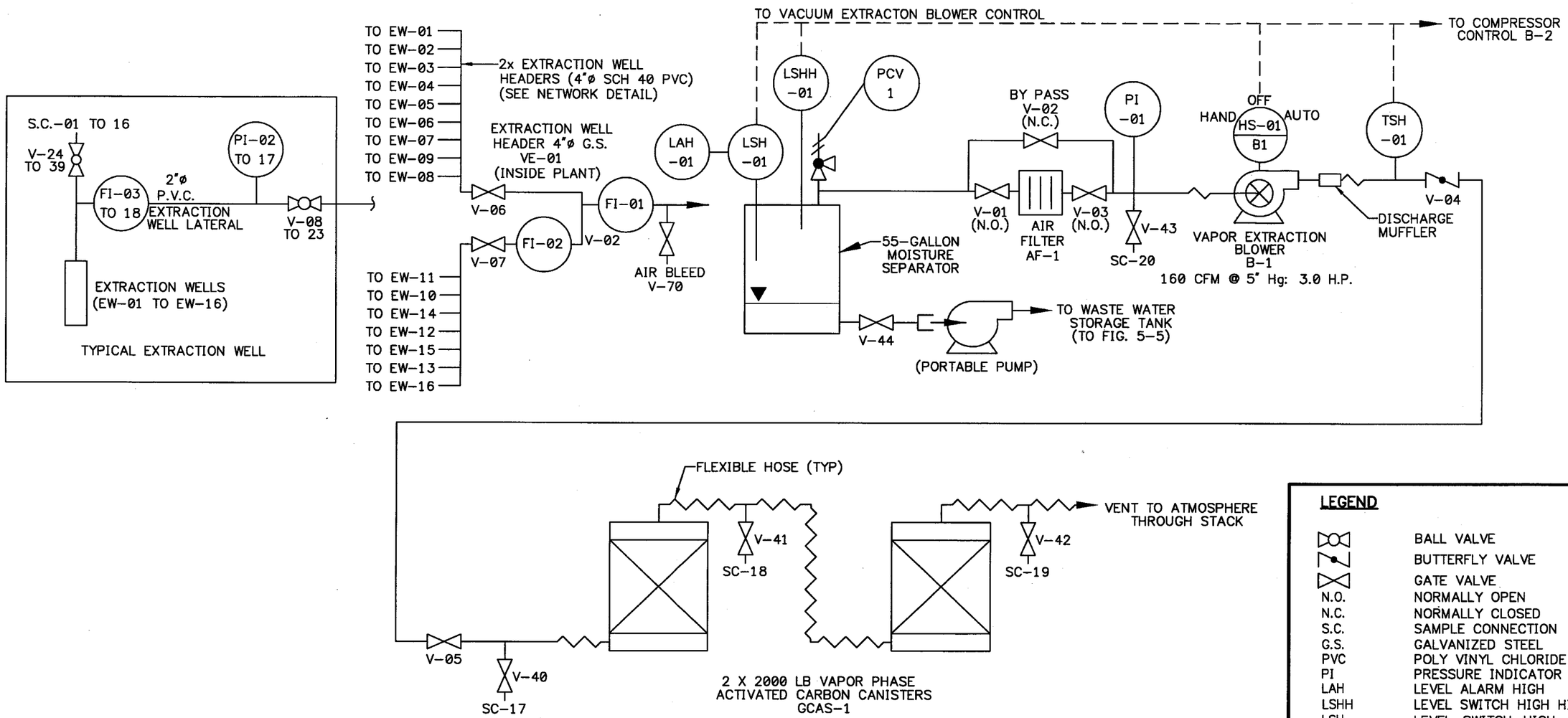

LEGEND

	BALL VALVE
	BUTTERFLY VALVE
	GATE VALVE
N.O.	NORMALLY OPEN
N.C.	NORMALLY CLOSED
S.C.	SAMPLE CONNECTION
G.S.	GALVANIZED STEEL
PVC	POLY VINYL CHLORIDE
PI	PRESSURE INDICATOR
LAH	LEVEL ALARM HIGH
LSHH	LEVEL SWITCH HIGH HIGH
LSH	LEVEL-SWITCH-HIGH
TSH	TEMPERATURE-SWITCH-HIGH
FI	FLOW INDICATOR
V	VALVE
HS	HAND SWITCH
B	BLOWER
	QUICK DISCONNECT COUPLING

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

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DEPARTMENT OF THE NAVY · SOUTHDIV NAVAL FACILITIES ENGINEERING COMD

VAPOR EXTRACTION AND TREATMENT PROCESS AND INSTRUMENTATION DIAGRAM
REMEDIAL ACTION PLAN
BUILDING 46, TANKS 46R, 46D, 46SUL, 46SUR
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
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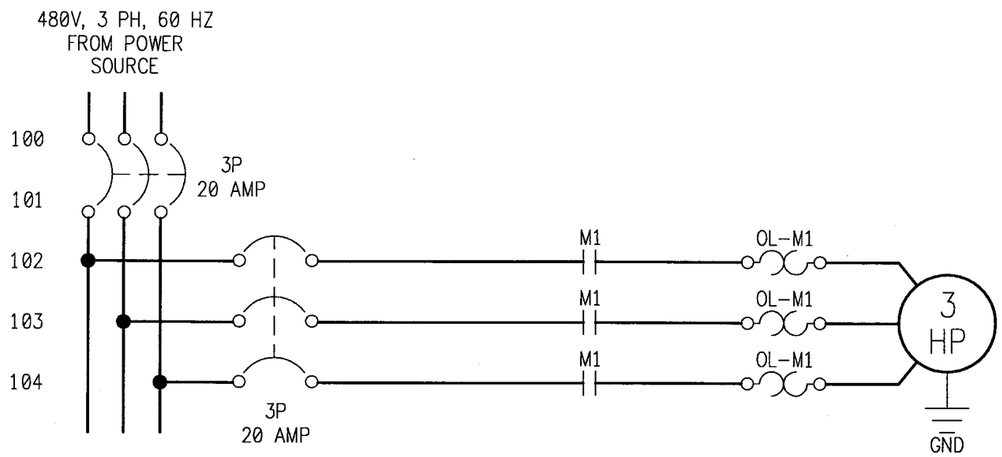
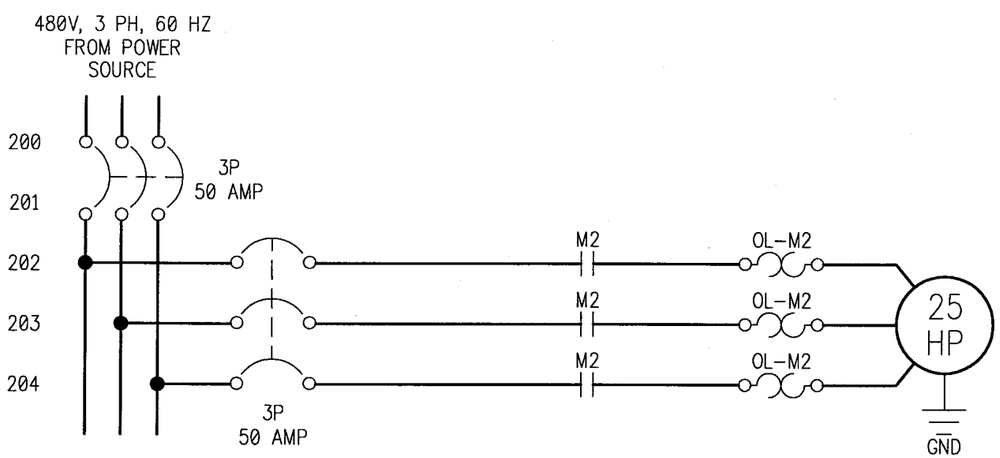
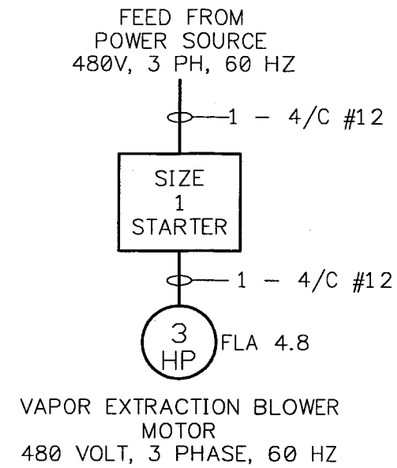
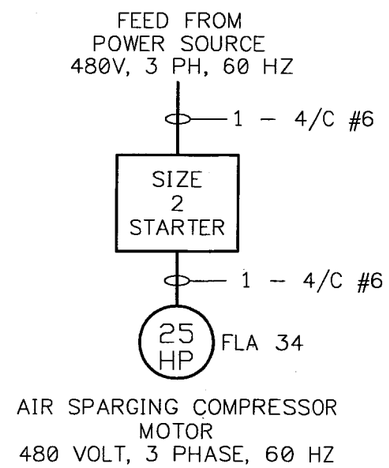


VAPOR EXTRACTION BLOWER SCHEMATIC DIAGRAM



AIR SPARGING COMPRESSOR SCHEMATIC DIAGRAM TYPICAL OF 2





SINGLE LINE DIAGRAM

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 2/25/99
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SCALE N.T.S.

DEPARTMENT OF THE NAVY ★ SOUTHERN DIV FACILITIES ENGINEERING COMD ★

SINGLE LINE DIAGRAM AND ELECTRICAL SCHEMATIC DIAGRAM REMEDIAL ACTION PLAN BUILDING 46, TANKS 46R, 46D, 46SUL, ~~46UR~~ NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 03/17/99
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DRAWING NO. FIGURE 5–7 REV. 0

FORM CADD NO. SDIV_BH.DWG – REV 0 – 1/20/98

TABLE 5-2

VAPOR EXTRACTION/TREATMENT EQUIPMENT LIST AND PERFORMANCE SPECIFICATIONS
REMEDIAL ACTION PLAN, BUILDING 46 TANKS
NAVAL AIR STATION, CECIL FIELD
JACKSONVILLE, FLORIDA

ITEM	LOCATION/FUNCTION	PERFORMANCE SPECIFICATION
Vapor Extraction Blower (B-1)	Treatment system/provides vacuum for extraction of vapors	160 scfm @ 6 inches mercury vacuum, 3.0 H.P., rotary lobe, 3.0 H.P. motor, 480-volt, 3 phase, cartridge-type 1-micron inlet filter (AF-1), high-temperature switch.
Moisture Separator (T-1)	Treatment system/ removes entrained water from extracted vapors	Closed-top, vertical cylindrical tank, 55-gallon capacity, 1.75 ft dia x 3 ft SSH, 4-inch inlet, 4-inch outlet, 1-inch drain, with high level, high-high level switches and high-level alarm
Granular Activated Carbon Adsorption System (GCAS-1)	Treatment system/ treats off-gas discharge from vapor extraction blower	Two (2) 2,000 lb carbon capacity canisters, fork-lift skid-mounted, 4-inch inlet, 4-inch outlet, quick-disconnect coupling.
Vapor Extraction Headers (VE-01, VE-02)	Treatment system and outside/ evacuates vapor extraction wells (See Fig 5-6 for match)	4-inch ID galvanized steel (above ground) and Schedule 40 PVC (below ground)
Vapor Extraction Wells (EW-01 to EW-16)	Vapor extraction wells	2-inch ID Schedule 40 PVC, with 0.020 slot-size screens of 3 ft length
Valves (V-01, V-03)	Treatment system/vapor extraction blower intake filter	4-inch block/gate valve
Valves (V-02)	Treatment system/bypass of air intake filter	4-inch block/gate valve
Valves (V-04)	Discharge of B-1	4-inch butterfly valve
Valves (V-05)	Off-gas treatment system inlet	4-inch block/gate valve
Valves (V-06,V-07)	Vapor extraction well headers (VE-01 and VE-02, respectively)	4-inch block/gate valve
Valves (V-08 to V-23)	Vapor extraction wells (EW-01 to EW-16)	4-inch ball valves
Valves (V-24 to V-39)	Vapor extraction wells (EW-01 to EW-16)	2-inch ball valves with sampling connection
Valves (V-40, V-41, V-42)	Off-gas treatment system	2-inch gate valve with sampling connection
Valves (V-43)	Intake of B-1	2-inch gate valve with sampling connection
Valve (V-44)	Discharge valve for moisture separator	1-inch ID gate valve
Pressure gauges (PI-2 to PI-17)	Extraction wells (EW-01 to EW-16)	Differential-pressure membrane type, capable of reading from 0 to 60 inches w.g.
Flow meters (FI-01, FI-02)	VE-01, VE-02 respectively	Pitot-tube type, automatic velocity averaging sensor, with differential-pressure based flow gauge, capable of reading from 0 to 200 scfm at operating vacuum up to 6" mercury
Flow meters (FI-03 to FI-18)	Vapor extraction well laterals	Variable area in-line rotameters capable of measuring up to 1,000 scfm at operating conditions

The temporary off-gas treatment system will consist of rental of a vapor-phase Granular Carbon Adsorption System (GCAS-1) consisting of two 2,000 pound Granular Activated Carbon (GAC) canisters connected in series on the discharge end of the vapor extraction blower. The discharge piping shall consist of a 4" diameter flexible rubber hose equipped with quick disconnects. This set-up will allow for expedient change outs or removal of the GAC canisters. After the 30-day period is completed, future off-gas treatment will only be needed if the total VOC's emitted are greater than 13.7 lbs/day.

Sampling ports with valves will be installed before, after, and in between the carbon vessels. Air samples from these ports will be sampled to evaluate the future need for off-gas treatment or to determine when the GAC canisters need to be changed. Using the estimated VOC emission rate of 11 lbs/day, GAC usage is conservatively estimated to be 50 lbs/day initially.

6.0 START UP AND OPERATION AND MAINTENANCE

The following sections establish procedures for the start-up of the AS/SVE system, the routine operation and maintenance (O&M) of the remediation equipment, and monitoring of operating parameters. The final sub-section establishes the procedures for final system deactivation, after the remedial action objectives for the site have been met.

6.1 SYSTEM START-UP

Following final inspection, and acceptance by the Navy, the AS/SVE system will be set for initial start-up. Approximately one week prior to start-up, a full round of water levels and dissolved oxygen levels will be collected. During this action the air sparging and soil vapor extraction wells in the area will also be surveyed with reference to elevation to establish the top of casing elevation for each well. Following collection of water levels, all of the monitoring wells will be sampled and analyzed as discussed in Section 7.0. This round of sampling will set the baseline contaminant profiles and provide comparable operating parameters (i.e. dissolved oxygen, water levels, etc.), for further monitoring of the remedial action.

System start-up will commence approximately one week following the initial round of sampling. The following steps outline the start-up procedures.

1. Inspect all the equipment and ensure that all moving parts are free from obstructions. Then "bump test" the Vapor Extraction Blower.

2. Energize the control panel disconnect switch. Confirm that the voltage supplied to the panel is 480 volt.

3. Open air bleed valve (V-70) wide open and start Vapor Extraction Blower. Gradually close air bleed valve to obtain a vacuum of approximately 45 inches of water or until significant water uptake is observed.

4. Adjust the ball valves from each vapor extraction well such that the air-flow in each well lateral is balanced (approximately the same) at a rate of approximately 10 scfm.

5. Let the Vapor Extraction Blower operate for at least two hours. During this two-hour period monitor the amount of water accumulated in the Moisture Separator. Gradually increase the vacuum applied

to the Moisture Separator until the maximum vacuum is applied. However if water accumulation in the Moisture Separator is significant, open air bleed valve to reduce vacuum levels until water take up is minimized.

6. After the vapor extraction system has stabilized and is operating normally, energize the compressed air system consisting of the Air Sparging Compressor and Refrigerated Air Dryer.

7. Adjust the pressure regulators on the air sparging headers to supply approximately 50 psig to the air sparging well laterals. Adjust the pressure regulators on the air sparging well laterals to equal the water column drop as calculated from the above referenced water levels.

8. Once the pressure in each of the air sparging wells is recorded for future use, record the flow of air to each of the air sparging wells. A flow of 10 scfm per air sparging well has been estimated for this system. Adjust the ball valves at the air sparging laterals such that a maximum of 10 scfm is injected into each well. Because of potential variations in the lithology of the locations of each of the wells, the 10 scfm flow rate is only a target level and may not be readily achievable, in which case, open the ball valves to their maximum output, and then record the reading. Note that when a rotameter is used for flow rate measurement, its reading may need to be converted using a calibration factor provided by the manufacturer, in order to obtain the flow rate in standard cubic feet per minute.

9. Allow the system to operate for approximately two hours without adjustment, and then record the readings on each of the pressure gauges and flowmeters. Compare these with the initial start-up.

10. Adjust the ball valves and pressure regulators to match as closely as possible those readings in the beginning. Verify that the vapor extraction flow rates continue to be stable and excessive moisture entrainment is not occurring, otherwise adjust the ball valves at the vapor extraction wells as required. Check for moisture entrainment at individual vapor extraction wells using the sampling valves and collecting the vapors in tedlar bags.

11. Allow the system to operate another hour, and then repeat steps Nos. 8, 9 and 10 until pressure, vacuum and flow readings have stabilized to within +/- 10 percent or some other acceptable variation.

12. The AS/SVE system is now in normal operation. Record all pressures, vacuums, and flows for comparison at weekly visits during start up and monthly visits thereafter.

13. From inside the control panel, record the voltage across the Air Sparging Compressor and Vapor Extraction Blower motors. Measure the amperage draw on each of the motors and record. Compare these values to those supplied in the manufacturer's manual for each and confirm that they are within normal operating parameters.

6.2 SYSTEM OPERATION AND MAINTENANCE

O&M for all mechanical equipment will be conducted in accordance with the manufacturers' suggested practices as supplied with the purchase of the equipment. The following O&M activities will be conducted at monthly visits to the site:

1. While the system is in operation, collect a full round of water levels.

2. While the system is in operation record the air sparging flowrates and pressures, soil vapor extraction system vacuums and flow rates, and the amount (if any) of water collected in the Moisture Separator and Wastewater Storage Tank.

3. While the system is in operation, collect an air sample from sampling valves located before, after, and in-between the canisters of the Granular Carbon Absorption System. The samples will be collected in Summa canisters for analysis of VOCs with U.S. EPA Method TO-14.

4. If excessive water builds up in the Moisture Separator or Wastewater Storage Tank (as indicated by the high water alarms), or a minimum at each monthly visit as a precaution against storm events use a portable diaphragm pump to transfer this water to a tanker truck through the drain valve using a flexible hose connected through the quick-disconnect coupling. Transport the water to the NAS Cecil Field WWTP or other approved facility for disposal.

5. Test the Wastewater Storage Tank and Moisture Separator HI-HI water level failsafe and alarms using a jumper within the control panel. While the failsafe and alarms are tripped, the Vapor Extraction Blower should denergize and the interlocks should also de-energize the compressed air system.

6. Add lubricating oil to the Vapor Extraction Blower and Air Sparging Compressor per manufacturers' recommendations. Grease the blower's bearings per manufacturer's recommendations. Visually check the particle filter for signs of dust or debris accumulation and replace if necessary. Record the amount of lubricating oil added and the condition of the filter. Periodically replace the lubricating oil in

the compressor and blower per manufacturer's instructions. Fully inspect the condition of the entire blower unit (belt tension, rust, etc.). Then reset the failsafe and energize the AS/SVE System.

7. While the Air Sparging Compressor is in operation record all of the pressures and flows in each of the air injection and vapor extraction wells.

8. Test the Air Sparging Compressor Receiver Tank's high pressure failsafe and alarm using a jumper within the control panel. When the compressor's failsafe and alarm are tripped the compressor circuit must deenergize. Drain condensate water out of the Receiver Tank, the Refrigerated Air Dryer and Coalescing Air Filter and transfer the water under air pressure to the Wastewater Storage Tank for disposal. Inspect the condition of the entire unit (belt tension, rust, etc.). Then reset the failsafe and energize the compressed air system.

9. Adjust the pressures, vacuums, and flowrates to the original operational levels as established during startup.

10. If excessive pressure differentials are observed within the vapor extraction hears or well laterals, then the vapor extraction headers and well laterals may need to be purged. To accomplish this task, disconnect the Vapor Extraction Blower's intake line and inject pressurized air into the pipelines in the direction of the headers and laterals. Pressurized air may be obtained from the operating compressor through one of the pressure relief valves on one of the air sparging headers after ensuring that the three (3) butterfly valves controlling flow to the air sparging laterals of the selected header are shut off.

11. Maintain good house-keeping measures for the entire system, picking up trash, and taking landscaping measures as necessary.

Two 5-gallon buckets shall be provided within the treatment system. One of these buckets will be used for the storage of spent blower oil. This bucket will be labeled as such, and a copy of the material safety data sheet (MSDS) maintained on site. The second 5-gallon bucket will contain sorbent pads and other miscellaneous spill containment items. Both of these buckets will be periodically sent for off-site recycle/ disposal as appropriate.

6.3 SYSTEM DE-ACTIVATION

Upon notification from the partnering team that the site is going into either a "No Further Action" or "Monitoring Only" status, the system will be de-activated. The following steps shall be followed during the system de-activation:

1. De-energize the Air Sparging Compressor and allow to cool down.

2. Bleed the Air Sparging Compressor's Receiver Tank, the Refrigerated Air Dryer and Coalescing Air Filter of excess pressure and condensate.

3. Allow the Vapor Extraction Blower to operate alone for three hours. The purpose of this is to allow remaining contaminant vapors (if any) time to migrate into the soils and be removed via the blower.

4. De-energize the Vapor Extraction Blower and allow to cool down.

5. Bleed the Moisture Separator of excess vacuum and condensate.

6. Seal the tops of the carbon canisters of the Granular Carbon Absorption System.

7. De-energize the control panel via the service disconnect.

8. Transport and dispose of the wastewater collected at the NAS Cecil Field WWTP or other permitted wastewater treatment plant.

Depending on the final site disposition, additional actions such as removal and/or abandonment of wells, dismantling and disposal/recycling of mechanical equipment, piping, valves, etc., must be determined.

6.4 REMEDIAL CLEANUP TIME

The estimated remedial duration using AS/SVE within the source area is 12 years, as calculated in Appendix D. Because this estimate is based on theoretical modeling which uses several conservative assumptions, the data collected during the first year of operation will be used to estimate remedial duration more precisely. At that time, quarterly monitoring data will be used to calculate a site-specific removal rate constant rather than the theoretical rate constant presented in Appendix D and it is anticipated that this new constant will yield a significantly shorter remedial duration estimate.

Another approach which could be used to shorten the operation time of the AS/SVE system would be to only operate that system for the time needed to decrease contaminant concentrations in the source area groundwater down to levels where NA could be depended upon to complete remediation. For example, the AS/SVE system could be operated until benzene concentrations in the source area groundwater reaches 100 µg/L (UFL, 1991b) (instead of the 1.0 µg/L cleanup goal) which would only require 6 years.

7.0 MONITORING OF REMEDIAL PROGRESS

7.1 OVERVIEW

This section describes the sampling and analysis program which will be conducted to monitor the progress of the remedial action and verify that no further migration of contaminated groundwater is occurring.

To achieve these objectives, this program will include sampling and analysis of soil and groundwater within the area of known contamination and sampling and analysis of groundwater downgradient from this area.

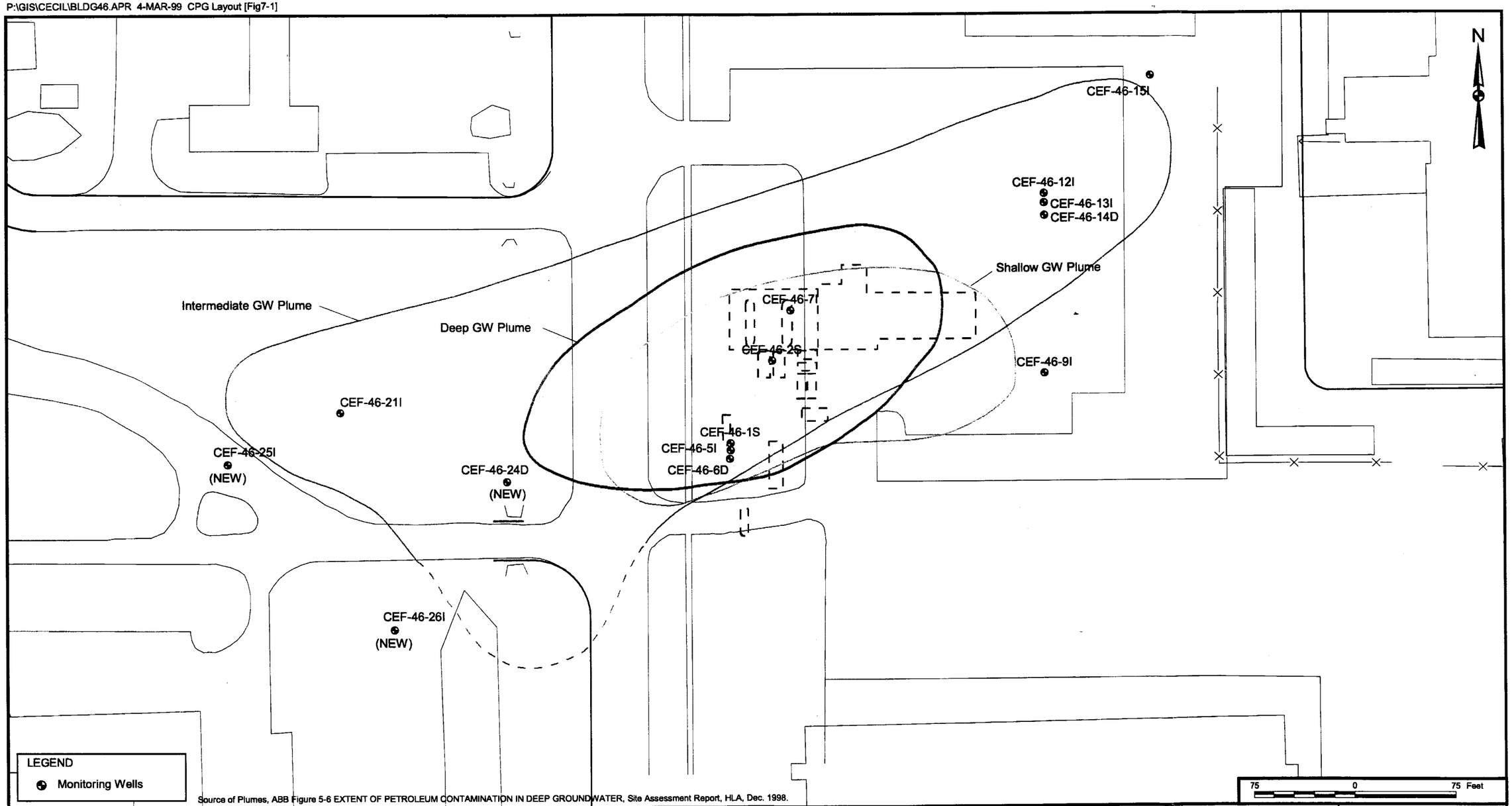
7.2 NEW MONITORING WELL INSTALLATION

Sufficient number of existing monitoring wells are available to evaluate the progress of the remedial action within the area of known contamination. Sufficient existing monitoring wells are also available to verify that the groundwater contaminant plume is not further expanding in a northeasterly direction from the source area. To verify that the groundwater contaminant plume is not further expanding in a southwesterly direction from the source area, one new deep monitoring well and two new intermediate monitoring wells will be installed in the surficial aquifer at the locations shown on Figure 7-1.

These wells will be designated as CEF-46-24D, and CEF-46-25I and CEF-46-26I, respectively. Well CEF-46-24D will be installed to a depth of 90 feet bgs and screened at a depth interval of 80 to 90 feet bgs. Wells CEF-46-25I and CEF-46-26I will be installed to a depth of 50 feet bgs and screened at a depth interval of 40 to 50 feet bgs.

The new monitoring wells will be installed and developed in accordance to the Southern Division, Naval Facilities Engineering Command's (SOUTHDIVNAVFACENGCOM's) "Monitoring Well Design, Installation, Construction, and Development Guidelines" (SOUTHDIVNAVFACENGCOM, 1997), U.S. EPA's "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells" (U.S. EPA, 1990), and U.S. EPA Region IV Science and Ecosystem Support Division "Environmental Investigation Standard Operating Procedures and Quality Assurance Manual" (U.S. EPA Region IV, 1996). New monitoring well construction detail is illustrated on Figure 7-2.

P:\GIS\CECIL\BLDG46.APR 4-MAR-99 CPG Layout [Fig7-1]



Source of Plumes, ABB Figure 5-6 EXTENT OF PETROLEUM CONTAMINATION IN DEEP GROUNDWATER, Site Assessment Report, HLA, Dec. 1998.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CHAD P. GLICK	DATE 3/4/99
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PROPOSED GROUNDWATER SAMPLING LOCATIONS
REMEDIAL ACTION PLAN
BUILDING 46 RAP
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 7895	
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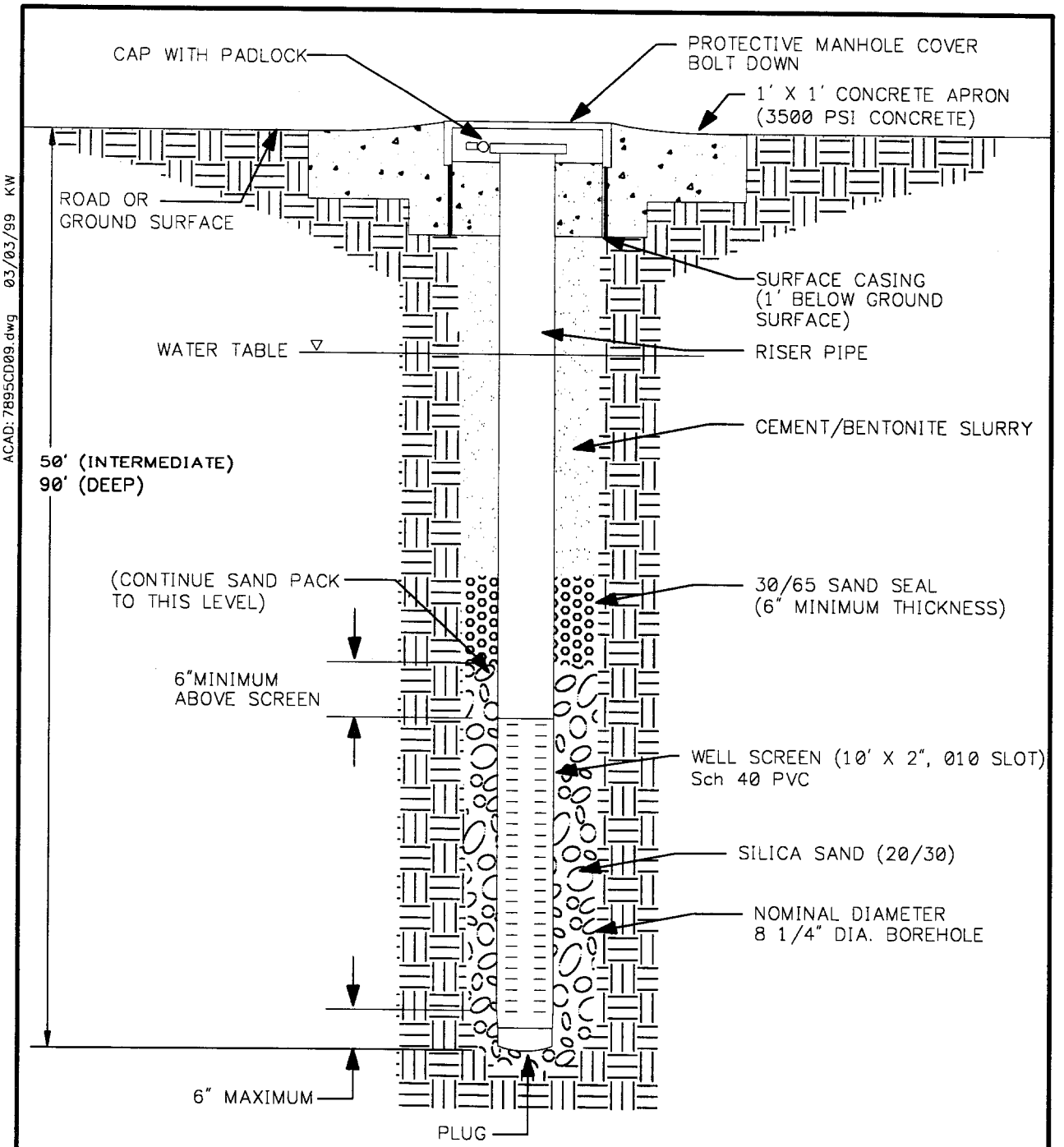

PROPOSED
MONITORING WELL
N.T.S.

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7.3 SAMPLING AND ANALYSIS

7.3.1 Soil Sampling and Analysis

Prior to the startup of the AS/SVE system quarterly during the first year of operation of this system, and twice a year for an additional year, three soil borings will be installed within the contaminant source area in the immediate vicinity of the locations shown on Figure 7-3. The data from the soil borings will be used to verify the cleanup of vadose zone soil due to the SVE system.

Soil borings will be advanced to the water table. Soil samples will be collected from each boring starting at a depth of one foot bgs and from every 2-foot interval thereafter. Samples will be screened with an OVA in accordance with FAC Chapter 62-770.200(8). For each boring, the sample from the interval with the highest OVA reading will be analyzed for KAG as defined in Table 7-1.

After soil samples have been taken, the borings will be backfilled with sand and the top of the borings sealed to grade either with 6-inch thickness bentonite (in HDPE-lined areas) or with asphalt (in paved areas).

7.3.2 Groundwater Sampling and Analysis

Groundwater samples will collected and analyzed to monitor contaminant reduction within the source area contaminant plume and to monitor the contaminant plume migration outside the source area. As discussed below, all samples will be analyzed for KAG as defined in Table 7-1 and some samples will also be analyzed for selected natural attenuation field parameters as defined in Table 7-2. Groundwater sampling locations are shown on Figure 7-1.

Contaminant Reduction Monitoring

The following eight monitoring wells have been selected to monitor groundwater contaminant reduction:

- CEF-46-1S
- CEF-46-2S
- CEF-46-5I
- CEF-46-6D
- CEF-46-7I
- CEF-46-12I
- CEF-46-13I
- CEF-46-21I

TABLE 7-1

KAG ANALYTICALREQUIREMENTS
SOIL AND GROUNDWATER MONITORING
BUILDING 46 REMEDIAL ACTION PLAN
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Parameter	Soil Analytical Method	Groundwater Analytical Method
BTEX and MTBE	EPA SW-846 8021B	EPA SW-846 8021B
Naphthalene and 15 method-listed PAHs	EPA SW-846 8310	EPA SW-846 8310
1,2-DCA and other halogenated VOCs	Not Required	EPA SW-846 8021B
1,2-Dibromomethane	Not Required	EPA 504.1
Total Lead	Not Required	EPA SW-846 6010B or 7421
TRPHs	FDEP FL-PRO	FDEP FL-PRO

TABLE 7-2

GROUNDWATER NATURAL ATTENUATION PARAMETERS
FIELD ANALYTICAL METHODS
BUILDING 46 REMEDIAL ACTION PLAN
NAS CECIL FIELD, JACKSONVILLE, FLORIDA
PAGE 1 OF 2

Parameter	Method[2]/ Reference	Data Use	Sample Volume, Container, & Preservation
Temperature	Direct-reading thermometer	Biological processes are temperature dependent.	100-250 ml in glass or plastic container. Analyze immediately
Dissolved Oxygen	HACH Test Kit Number OX-DT - Digital Titration - Azide modification of Winkler Method (HACH Method 8215)	Concentration of less than 1 mg/L indicates anaerobic conditions.	Follow test kit instructions. Analyze immediately to nearest 0.2 mg/L
pH	Direct-reading meter	Biological processes are pH sensitive.	100-250 ml in glass or plastic container. Analyze immediately
Conductivity	Direct-reading meter	General water quality parameter used to verify that site samples are obtained from the same groundwater system.	100-250 ml in glass or plastic container. Analyze immediately
Alkalinity/Dissolved Inorganic Carbon (DIC)	HACH Test Kit Number AL-DT - Digital Titration - Phenolphthalein and Total Method (HACH Method 8203)	DIC concentrations, in comparison to the total alkalinity, provides an indication of the amount of CO_2 generated during aerobic or anaerobic reduction of a hydrocarbon.	Follow test kit instructions. Analyze immediately to determine carbonate, bicarbonate, and hydroxide ions to the nearest 10 mg/L
Ferrous Iron (Fe^{+2})	HACH Test Kit Number IR-18C - Color Disc 1,10 Phenanthroline Method	Presence of ferrous iron may indicate presence of an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese.	Follow test kit instructions. Analyze immediately to nearest 0.2 mg/L
Hydrogen Sulfide (H_2S)	HACH Test Kit Number HS-C - Color Chart Effervescence of H_2S	Provides evidence of sulfate-based anaerobic degradation. May also indicate natural H_2S production.	Follow test kit instructions. Do not aerate or agitate. Analyze immediately. Analyze to nearest 0.1 mg/L
Oxidation/Reduction Potential (ORP)	Direct-Reading Meter	ORP provides information on RE/DOX conditions and to interpret the nature and state of chemical compounds and biological conditions. ORP typically ranges from +200mV in normal aerobic, oxidizing conditions to -400mV in strongly anaerobic, reductive conditions.	10-250 ml in glass container filling from the bottom. Do not aerate or agitate. Analyze immediately.

TABLE 7-2

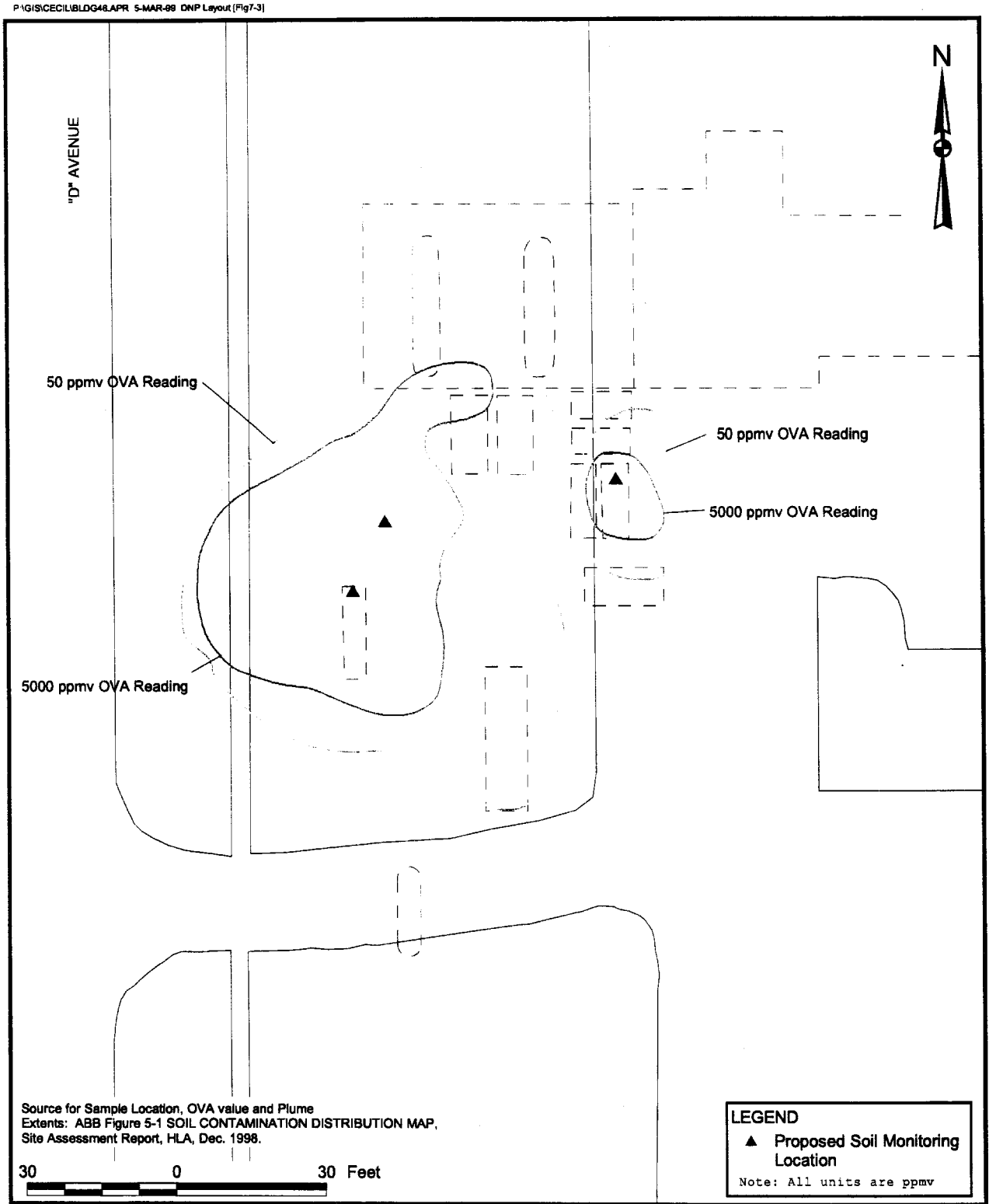
GROUNDWATER NATURAL ATTENUATION PARAMETERS
FIELD ANALYTICAL METHODS
BUILDING 46 REMEDIAL ACTION PLAN
NAS CECIL FIELD, JACKSONVILLE, FLORIDA
PAGE 2 OF 2

Parameter	Method[2]/ Reference	Data Use	Sample Volume, Container, & Preservation
Carbon Dioxide (CO_2)	HACH Test Kit Number CA-DT - Digital Titration - Sodium Hydroxide & Phenolphthalein Method (HACH Method 8205)	May be compared with background values as an indication of aerobic and anaerobic process. Is produced during aerobic respiration as well as anaerobic processes. Is utilized during methanogenesis.	Follow test kit instructions. Do not aerate or agitate. Analyze immediately. Analyze to nearest 0.1 mg/L

NOTES:

1 Table adapted from overview of the Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (Wiedemeier, 1996).
2 Method refers to U.S. EPA test methods. Standard Methods are based on Standard Methods for the Examination of Water and Wastewater (Clesceri, et al, 1992)

P:\GIS\CECIL\BLDG46.APR 5-MAR-99 DNP Layout [Fig7-3]



DRAWN BY: CHAD P. GLICK — DATE: 3/4/99		PROPOSED SOIL MONITORING LOCATION REMEDIAL ACTION PLAN, BUILDING 46 NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER: 7895
CHECKED BY: [illegible] — DATE: 3/14			APPROVED BY: [illegible] — DATE: 05/17/99
CAST/SCHEDULE-AREA			APPROVED BY: — — DATE: —
SCALE: AS NOTED			DRAWING NO.: FIGURE 7-3 — REV: 0

Prior to the remedial action, one round of groundwater samples will be collected from these eight wells and analyzed for KAG and natural attenuation parameters to establish baseline site conditions.

These eight wells will be sampled quarterly during the first-year operation of the AS/SVE system and semi-annually for the remaining 11 years of operation. Samples from five of the wells (CEF-46-1S, CEF-46-2S, CEF-46-5I, CEF-46-6D, and CEF-46-7I) will be analyzed for KAG to evaluate the effectiveness of the AS/SVE system for the remediation of the source area groundwater. Samples from the other three wells (CEF-46-12I, CEF-46-13I, and CEF-46-21I) will be analyzed for KAG and selected natural attenuation field parameters to evaluate the effectiveness of natural attenuation for the remediation of the downgradient groundwater.

After operation of the AS/SVE system has concluded, all eight wells will be sampled on a semi-annual basis for an additional period of four years to assess natural attenuation. Each round of samples will be analyzed for KAG and selected natural attenuation field parameters to evaluate the effectiveness of natural attenuation for the remediation of the residual groundwater contamination.

Contaminant Plume Expansion Monitoring

A total of six monitoring wells have been selected to monitor potential groundwater contaminant plume expansion, including:

- CEF-46-9I
- CEF-46-14D
- CEF-46-15I
- CEF-46-24D
- CEF-46-25I
- CEF-46-26I

Prior to the remedial action, one round of groundwater samples will be collected from these six wells and analyzed for KAG to establish baseline site conditions.

During the remedial action, samples will be collected from these six wells and analyzed for KAG to verify that the groundwater contaminant plume is not expanding. During the first year of operation of the AS/SVE system, sampling frequency will be quarterly. During the remaining 15 years of the remedial action, sampling frequency will be semi-annual.

7.4 MONITORING REPORT

Following installation of the new monitoring wells and the baseline sampling event, an initial monitoring report will be prepared. This report will describe field activities and present analytical results.

Following, each sampling event, the initial monitoring report will be updated to include a description of the latest sampling activities and analytical results. As the remedial action progresses, the monitoring report will also include an analysis of trends in contamination levels over time and an assessment of the effectiveness of the AS/SVE system and natural attenuation process.

At the conclusion of the active remedial action, the monitoring report will also provide conclusions and recommendations for future actions, as may be required.

7.5 CONTINGENCY MEASURES

Based on the conclusions and recommendations presented in the monitoring report, a decision will be made regarding the acceptability of the remedial duration, and a modification to remedial approach may be considered. The modification could consist of the use of an oxygen releasing compound such as that described in Section 4.2.2 within the source are and the outer plume to chemically enhance the natural attenuation of BTEX and MTBE.

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APPENDIX A

SAR ANALYTICAL DATA

Table 5-1
Summary of Soil Analytical Results
August 1998

Site Assessment Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Compound	Soil Boring Identification and Sampling Depth			Chapter 62-770, FAC, FDEP Soil Cleanup Target Levels[1]
	SB-18 (4 ft bls, OVA = 1,300 ppm)	SB-34 (3 ft bls, OVA = >5,000 ppm)	SB-36 (5 ft bls, OVA = 2,500 ppm)	
Polynuclear Aromatic Hydrocarbons (mg/kg)				
Anthracene	ND	0.022	ND	19,000/2,000
Naphthalene	ND	**1.3**	ND	1,000/1
Phenanthrene	ND	0.071	ND	1,900/120
Fluoranthene	0.034	ND	ND	2,800/550
Fluorene	0.005	ND	ND	2,100/87
Benzo(a)anthracene	0.019	0.010	0.005	1.4/2.9
Chrysene	0.029	0.008	0.007	140/80
Dibenz(a,h)anthracene	**0.240**	ND	ND	0.1/14
Benzo(b)fluoranthene	0.120	0.007	0.033	1.4/9.8
Benzo(k)fluoranthene	0.032	0.008	0.014	15/25
Benzo(a)pyrene	**0.140**	0.010	0.013	0.1/7.8
Benzo(g,h,i)perylene	0.190	ND	0.031	2,300/13,000
1-Methylnaphthalene	ND	1.1	ND	NA
2-Methylnaphthalene	ND	2.4	ND	NA
Indeno(1,2,3-cd)pyrene	0.180	ND	0.010	1.5/28
Pyrene	0.380	0.022	ND	2,200/570
Volatile Organic Compounds (mg/kg)				
Benzene	ND	**0.420**	ND	1.1/0.007
Toluene	0.016	**94**	ND	300/0.4
Ethylbenzene	ND	**52**	ND	240/0.4
Total xylenes	ND	**280**	ND	290/0.3
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/kg)				
TRPH	150	**840**	200	350/340

[1] Direct Exposure, Table I/Leachability, Table V.

Notes: Bold indicates that values exceed Chapter 62-770, FAC, direct exposure and/or leachability soil cleanup target levels.

ft bls = feet below land surface.
OVA = organic vapor analyzer.
ppm = parts per million.
> = greater than.
mg/kg = milligrams per kilogram.
FAC = Florida Administrative Code.
FDEP = Florida Department of Environmental Protection.
ND = not detected.
NA = not applicable.

Table 5-2
Summary of Groundwater Analytical Results
June 1998

Site Assessment Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Parameter	Monitoring Well CEF-46-									Groundwater Cleanup Target Levels[1]
	1S	2S	3S	3SD	4S	5I	6D	7I	8I	
Volatile Organic Compounds (µg/ℓ)										
Benzene	13,000	1,300	ND	ND	ND	260	5.7	9,000	ND	1
Ethylbenzene	3,200	180	ND	ND	220	24	18	2,000	ND	30
Toluene	44,000	650	ND	ND	24	79	84	12,000	ND	40
Xylenes	18,000	610	ND	ND	650	150	110	11,000		20
Semivolatile Organic Compounds (µg/ℓ)										
Acenaphthene	26	7.5	ND	ND	ND	ND	ND	ND	ND	20
Acenaphthylene	39	2.4	ND	ND	ND	ND	ND	ND	ND	210
1-Methylnaphthalene	210	2.5	ND	ND	6.8	3.2	ND	100	ND	NA
2-Methylnaphthalene	86	3.4	ND	ND	2.7	ND	ND	ND	ND	NA
Polynuclear Aromatic Hydrocarbons (µg/ℓ)										
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	2,100
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Benzo(d)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	210
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Naphthalene	660	34	ND	ND	18	5	ND	250	ND	20
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	210
Lead[2] (µg/ℓ)										
Lead	25/7.9	ND	ND	ND	ND	17/ND	ND	ND	ND	15
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/ℓ)										
TRPH	60	5.9	0.86	0.65	31	1.4	1.6	3	ND	5

78,200 2,740

See notes at end of table.

Table 5-2 (Continued)
Summary of Groundwater Analytical Results
June 1998

Site Assessment Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Parameter	Monitoring Well CEF-46-									Groundwater Cleanup Target Levels[1]
	9I	10I	11I	12I	13I	14D	15I	16I	17D	
Volatile Organic Compounds (µg/ℓ)										
Benzene	ND	ND	ND	1.3	99	ND	ND	ND	ND	1
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	30
Toluene	ND	ND	ND	ND	ND	ND	ND	1.8	ND	40
Xylenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	20
Semivolatile Organic Compounds (µg/ℓ)										
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	20
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	210
1-Methylnaphthalene	ND	ND	ND	1.4	ND	ND	ND	ND	ND	NA
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
Polynuclear Aromatic Hydrocarbons (µg/ℓ)										
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	2,100
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Benzo(d)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	210
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	20
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	210
Lead[2] (µg/ℓ)										
Lead	ND	ND	ND	ND	ND	ND	ND	5.3	ND	15
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/ℓ)										
TRPH	ND	ND	ND	1.1	1.3	ND	ND	ND	ND	5

See notes at end of table.

Table 5-2 (Continued)
Summary of Groundwater Analytical Results
June 1998

Site Assessment Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL1
Naval Air Station Cecil Field
Jacksonville, Florida

Parameter	Monitoring Well CEF-46-								Groundwater Cleanup Target Levels[1]
	18I	18ID	19I June 1998	19I October 1998	20I	21I	22I	23D	
Volatile Organic Compounds (µg/ℓ)									
Benzene	**2**	**1.9**	**21**	5	ND	**10**	ND	ND	1
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	2	30
Toluene	ND	ND	1.2	ND	ND	20	ND	11	40
Xylenes	**27**	**25**	ND	ND	ND	3.7	ND	4.2	20
Semivolatile Organic Compounds (µg/ℓ)									
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	20
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	210
1-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	NA
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	NA
Polynuclear Aromatic Hydrocarbons (µg/ℓ)									
Anthracene	ND	ND	ND	ND	ND	ND	ND	0.2	2,100
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	0.39	0.2
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	**0.24**	0.2
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	0.1	0.5
Benzo(d)pyrene	ND	ND	ND	ND	ND	ND	ND	**0.32**	0.2
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	0.51	210
Chrysene	ND	ND	ND	ND	ND	ND	ND	0.38	5
Naphthalene	ND	ND	ND	–	ND	ND	ND	ND	20
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	0.14	0.2
Pyrene	ND	ND	ND	ND	ND	ND	ND	1.2	210
Lead[2] (µg/ℓ)									
Lead	ND	ND	ND	–	ND	ND	ND	ND	15
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/ℓ)									
TRPH	ND	ND	0.66	–	ND	0.55	ND	ND	5

See notes at end of table.

Table 5-2 (Continued)
Summary of Groundwater Analytical Results
June 1998

Site Assessment Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL1
Naval Air Station Cecil Field
Jacksonville, Florida

[1] Based on Chapter 62-770, Florida Administrative Code.
[2] Lead concentrations in unfiltered and filtered samples (Unfiltered/Filtered) are reported for groundwater samples which were collected with turbidity readings greater than 10 nephelometric turbidity units.

Notes: Bold-faced values exceed applicable regulatory criteria.

S = monitoring well screened in the shallow surficial aquifer from 5 to 15 feet below land surface (bls).
I = monitoring well screened from 25 to 30 feet bls or 40 to 45 feet bls.
D = monitoring well screened in the deep surficial aquifer from 80 to 85 feet bls.
3SD = duplicate sample of monitoring well CEF-46-3S.
18ID = duplicate sample of monitoring well CEF-46-18I.

µg/ℓ = micrograms per liter.
ND = not detected.
mg/ℓ = milligrams per liter.
-- = not sampled.

1.0 INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES), under contract to the Southern Division, Naval Facilities Engineering Command, has completed the confirmatory sampling for Tanks 46R, 46D, 46SUL, and 46UL at Naval Air Station Cecil Field in Jacksonville, Florida. This report summarizes the related field operations, results, conclusions, and recommendations of the confirmatory sampling.

Building 46, the former base gas station, was located on D Avenue across from the Bachelor Officers Quarters. It was in operation between 1946 and 1987, was demolished, and is currently a parking area between Buildings 903 and 904 (Figure 1). Tanks 46R, 46D, 46SUL, 46UL, and four unidentified underground storage tanks (USTs) were reportedly located at the gas station (ABB-ES, 1994).

Tanks 46R and 46UL were 10,000-gallon USTs used to store regular and unleaded gasoline. Tanks 46D and 46SUL were 6,000-gallon USTs, which stored diesel and super unleaded gasoline. The Tank Inventory List indicates that these tanks were removed in 1988; however, no closure information is available for these tanks. Facility drawings indicate the four unidentified USTs had 2,000-gallon capacities. The contents of these four unidentified USTs are unknown.

A Contamination Assessment Plan for the assessment of soil and groundwater at Tanks 46R, 46D, 46SUL, 46UL, and the four unidentified USTs was prepared by ABB-ES in November 1996 (ABB-ES, 1996).

2.0 FIELD INVESTIGATION

The confirmatory sampling for the Facility 46 site was initiated in June 1997 and included

- the advancement of 39 soil borings to the water table,
- the installation of four shallow groundwater monitoring wells, and
- collection and analysis of four groundwater samples.

Soil samples were collected from each boring at depth intervals of 1 foot below land surface (bls) and every 2 feet thereafter to the water table. These samples were screened for hydrocarbon vapors with an organic vapor analyzer (OVA).

Four monitoring wells, CEF-46-1S, CEF-46-2S, CEF-46-3S, and CEF-46-4S, were installed near the former USTs and fill ports to depths of 14 to 15 feet bls. Groundwater samples were collected from these monitoring wells and analyzed for the gasoline analytical group parameters.

A general site plan indicating the location of the soil borings and the monitoring wells is presented on Figure 2. The monitoring well installation details are included in Appendix A.

3.0 SCREENING AND ANALYTICAL RESULTS

Excessively contaminated soil (greater than 50 parts per million [ppm] on an OVA) was detected in 20 of the 39 soil borings advanced. Nine soil borings had OVA

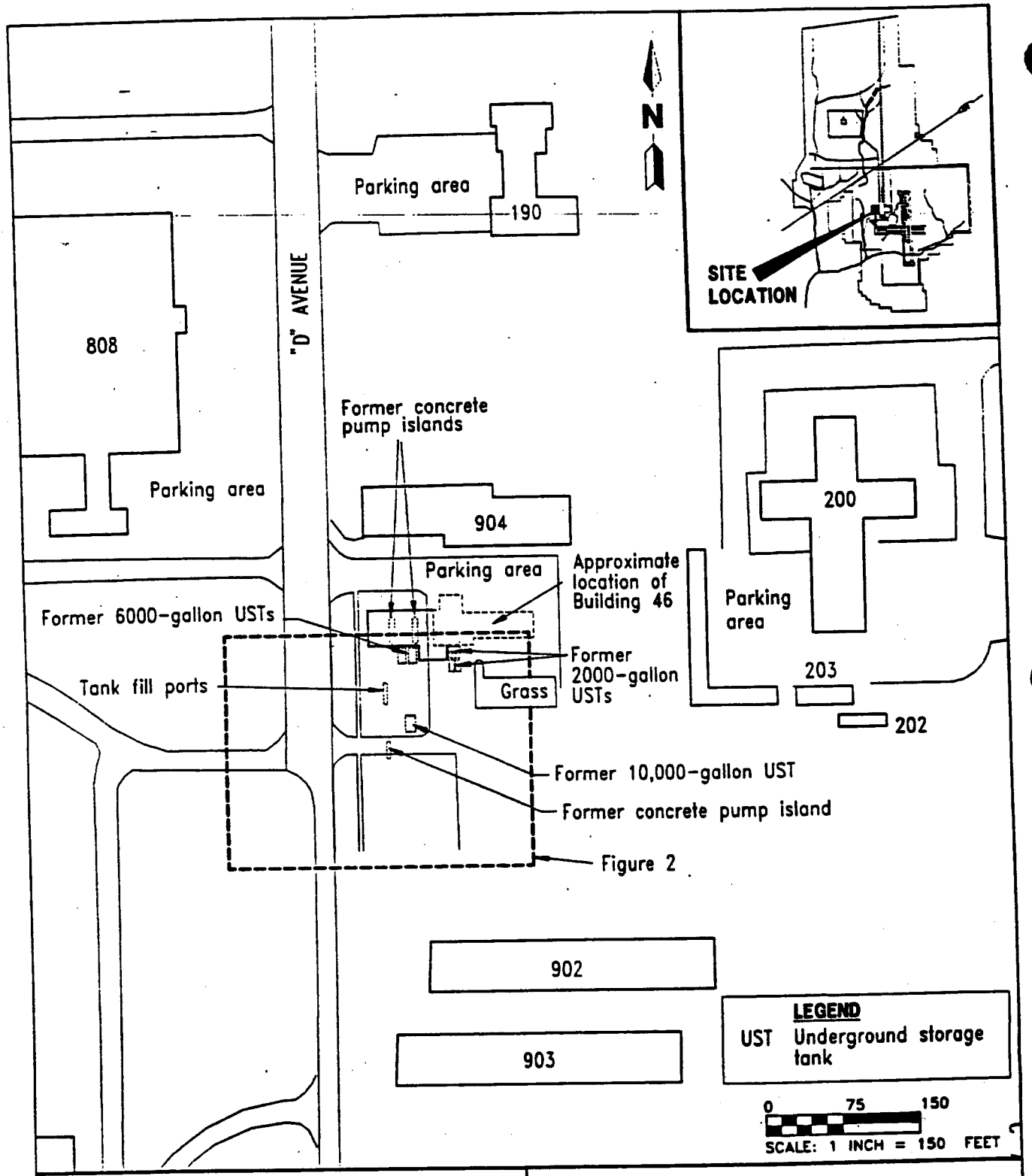

FIGURE 1
TANKS 46R, 46D, 46SUL, AND 46UL
FORMER GAS STATION

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CONFIRMATORY SAMPLING REPORT
BUILDING 46, TANKS 46R, 46D, 46SUL, AND 46UL

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

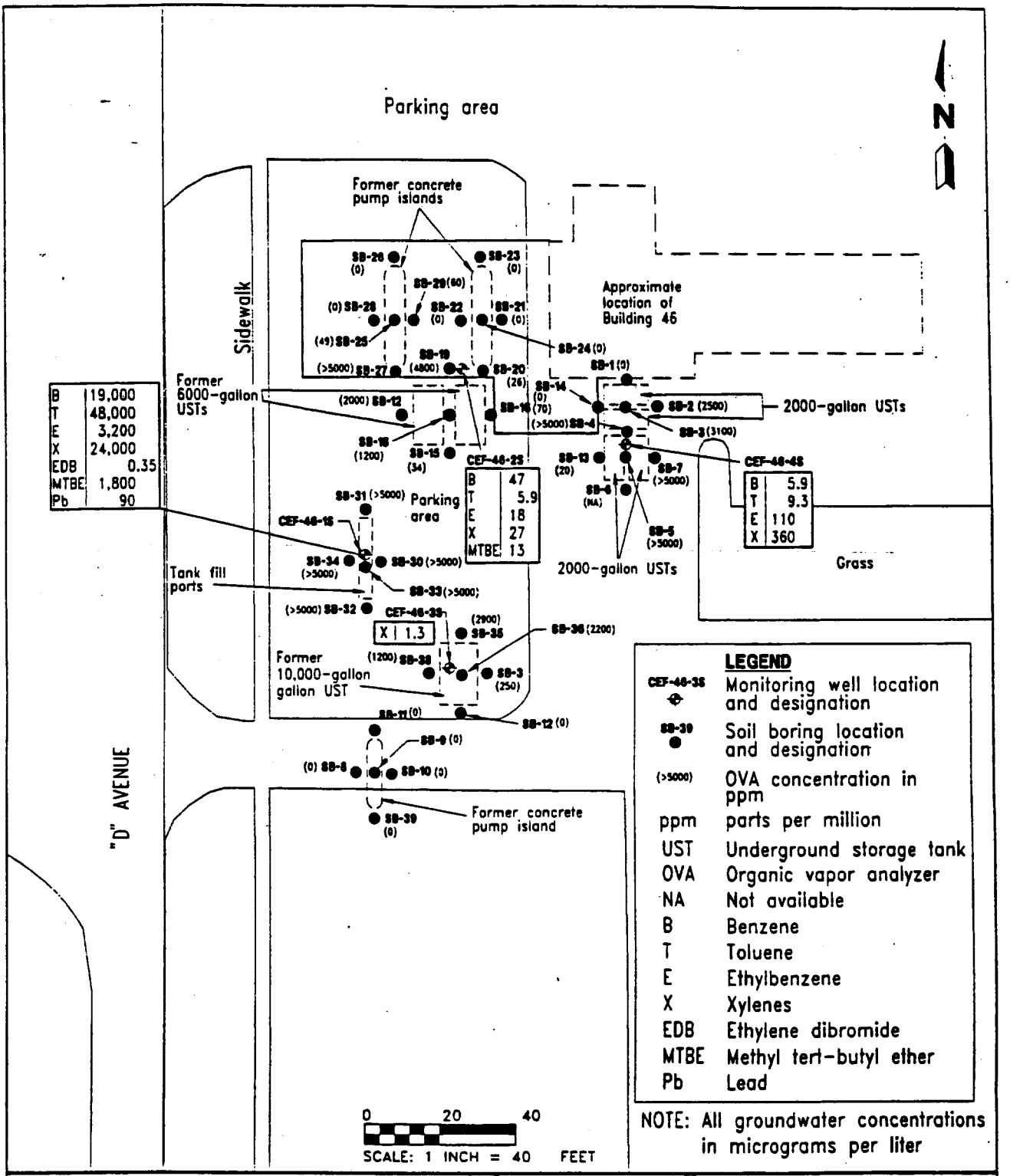

FIGURE 2
TANKS 46R, 46D, 46SUL, AND 46UL SOIL BORING AND MONITORING WELL LOCATIONS

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CONFIRMATORY SAMPLING REPORT BUILDING 46, TANKS 46R, 46D, 46SUL, AND 46UL

NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA

readings in excess of 5,000 ppm. The soil OVA data are summarized in Table 1 and shown on Figure 2.

Volatile organic aromatics were detected in the groundwater samples collected. Benzene, ethylbenzene, toluene, total xylenes, ethylene dibromide, and methyl tert-butyl ether were detected at concentrations exceeding the standards specified in Chapter 62-770. A summary of the groundwater analytical detections is presented in Table 2 and on Figure 2. The complete analytical data set is presented in Appendix B.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Data obtained during the contamination assessment at the Facility 46 site did not provide an adequate assessment of the horizontal and vertical extent of excessively contaminated soil and groundwater. Therefore, it is recommended that a site assessment be conducted to assess the extent of excessively contaminated soil and groundwater contamination at the Tank 46 site.

Table 1
Soil Screening Results

Confirmatory Sampling Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Boring Number	OVA Concentration (ppm)			
	Depth (feet bls)	Unfiltered	Filtered	Actual
SB-1	1 (refusal)	0	–	0
SB-2	1	0	–	2,700
	3	150	0	150
	5	2,500	170	2,330
	7 (wet)	3,200	0	3,200
SB-3	1	110	0	110
	3	180	0	180
	5	3,100	0	3,100
	7	1,200	0	1,200
SB-4	1	0	–	0
	3	1,200	0	1,200
	5	>5,000	0	>5,000
	7 (wet)	>5,000	0	>5,000
SB-5	1	0	–	0
	3	3,200	0	3,200
	5	>5,000	0	>5,000
	7 (wet)	>5,000	0	>5,000
SB-6	1 (refusal)	0	–	0
SB-7	1	0	–	0
	3	>5,000	0	>5,000
	5	2,000	0	2,000
	7 (wet)	1,700	0	1,700
SB-8	1	0	–	0
	3	0	–	0
	5 (wet)	0	–	0
SB-9	1	0	–	0
	3	0	–	0
	5 (wet)	0	–	0
SB-10	1	0	–	0
	3	0	–	0
	5 (wet)	0	–	0
SB-11	1	0	–	0
	3	0	–	0
	5 (wet)	0	–	0

See notes at end of table.

Table 1 (Continued)
Soil Screening Results

Confirmatory Sampling Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Boring Number	Depth (feet bls)	OVA Concentration (ppm)		
		Unfiltered	Filtered	Actual
SB-12	1	0	–	0
	3	0	–	0
	5 (wet)	0	–	0
SB-13	1	0	–	0
	3	20	0	20
	5	0	–	0
	7	5	0	5
SB-14	1	0	–	0
	3	0	–	0
	5	0	–	0
	7 (wet)	0	–	0
SB-15	1	0	–	0
	3	34	0	34
	5	0	–	0
	7 (wet)	50	0	50
SB-16	1	0	–	0
	3	0	–	0
	5	70	0	70
	6 (wet)	270	0	270
SB-17	1	0	–	0
	3	21	0	21
	5	2,000	0	2,000
	6.5 (wet; refusal)	1,700	0	1,700
SB-18	1 (refusal)	0	–	0
SB-18A	2.5 (refusal)	NS	–	NS
SB-18B	1	NS	–	NS
	3	0	–	0
	5	1,200	0	1,200
	6.5 (wet)	1,300	0	1,300
SB-19	1	0	–	0
	3	2,700	0	2,700
	5	4,800	0	4,800
	7 (wet)	3,100	0	3,100

See notes at end of table.

Table 1 (Continued)
Soil Screening Results

Confirmatory Sampling Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Boring Number	OVA Concentration (ppm)			
	Depth (feet bls)	Unfiltered	Filtered	Actual
SB-20	1	0	–	0
	3	22	0	22
	5	36	0	36
	6 (wet)	22	0	22
SB-21	1	0	–	0
	3	0	–	0
	5	0	–	0
	6 (wet)	0	–	0
SB-22	1	0	–	0
	3	0	–	0
	5 (wet)	0	–	0
SB-23	1	0	–	0
	3	0	–	0
	5 (wet)	4	–	0
SB-24	1	0	–	0
	3	0	–	0
	5	0	–	0
	6 (wet)	0	–	0
SB-25	1	0	–	0
	3	45	0	45
	5	25	0	25
	5.5 (wet)	5	0	5
SB-26	1	0	–	0
	3	0	–	0
	5	0	–	0
	5.5 (wet)	6	–	6
SB-27	1	240	0	240
	3	3,300	0	3,300
	5	>5,000	0	>5,000
	5.5 (wet)	2,300	0	2,300
SB-28	1	0	–	0
	3	0	–	0
	5 (wet)	0	–	0

See notes at end of table.

Table 1 (Continued)
Soil Screening Results

Confirmatory Sampling Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Boring Number	Depth (feet bls)	OVA Concentration (ppm) Unfiltered	Filtered	Actual
SB-29	1	0	–	0
	3	60	0	60
	5 (wet)	50	0	50
SB-30	1	>5,000	0	>5,000
	3	>5,000	0	>5,000
	5 (wet)	>5,000	0	>5,000
SB-31	1	>5,000	0	>5,000
	3	>5,000	0	>5,000
	5	>5,000	0	>5,000
	7 (wet)	>5,000	0	>5,000
SB-32	1	>5,000	0	>5,000
	3	>5,000	0	>5,000
	5 (wet)	>5,000	0	>5,000
SB-33	1	>5,000	0	>5,000
	3	>5,000	0	>5,000
	5	>5,000	0	>5,000
	6 (wet)	>5,000	0	>5,000
SB-34	1	0	–	0
	3	>5,000	0	>5,000
	5 (moist)	>5,000	0	>5,000
	6 (wet)	>5,000	0	>5,000
SB-35	1	0	–	0
	3	1,900	0	1,900
	5	2,900	0	2,900
	7 (wet)	3,100	0	3,100
SB-36	1	0	–	0
	3	0	–	0
	5	2,200	0	2,200
	7 (wet)	2,200	0	2,200
SB-37	1	0	–	0
	3	9	–	9
	5 (moist)	250	0	250
	6.5 (wet)	170	0	170

See notes at end of table.

Table 1 (Continued)
Soil Screening Results

Confirmatory Sampling Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Boring Number	OVA Concentration (ppm)			
	Depth (feet bls)	Unfiltered	Filtered	Actual
SB-38	1	0	–	0
	3	0	–	0
	5	1,200	0	1,200
	7 (wet)	1,300	0	1,300
SB-39	1	0	–	0
	3	0	–	0
	5	0	–	0

Notes: All soil samples were collected from May 20, 1997, to May 29, 1997.
Soil samples were filtered with carbon to determine the methane concentration.

OVA = organic vapor analyzer.
ppm = parts per million.
bls = below land surface.
– = filtered readings were not collected.
refusal = subsurface obstruction encountered.
wet = soil sample was completely saturated when analyzed.
> = greater than.
NS = no sample collected at this location.
moist = soil sample was moist when analyzed.

Table 2
Summary of Groundwater Analytical Detections

Confirmatory Sampling Report
Building 46, Tanks 46R, 46D, 46SUL, and 46UL
Naval Air Station Cecil Field
Jacksonville, Florida

Compound	CEF-46-				Groundwater Cleanup Target Levels[1]
	1S	2S	3S	4S	
Volatile Organic Aromatics (USEPA Method 601/602) (µg/ℓ)					
Benzene	19,000	47	ND	5.9	1
Toluene	48,000	5.9	ND	9.3	40
Ethylbenzene	3,200	18	ND	110	30
Xylenes	24,000	27	1.3	360	20
Ethylene dibromide	0.35	ND	ND	ND	0.02
Methyl tert-butyl ether	1,800	13	ND	ND	35
Lead (USEPA Method 239.2) (µg/ℓ)					
Lead	10	ND	ND	ND	15

[1] Chapter 62-770, Florida Administrative Code.

Notes: Groundwater samples were collected on August 8, 1997.

USEPA = U.S. Environmental Protection Agency.
µg/ℓ = micrograms per liter.
ND = compound not detected.

APPENDIX B

FDEP CLEANUP TARGET CONCENTRATIONS

UNIVERSITY OF FLORIDA

Center for Environmental & Human Toxicology

Post Workshop Update January 21, 1999

Soil Cleanup Target Level Development Web Site:

The following items are the modified Workshop versions of the Chapter 62-777, F.A.C. Contaminant Cleanup Target Levels Rule. They were developed using the methods and procedures specified in the Technical Background Document with input toxicological and chemical/physical data selected from the new hierarchy specified in the Methodology Group Report to the FDEP Contaminanted Soils Forum. Final versions of these documents are subject to input from the public and review by the Methodology Focus Group of the Contaminated Soils Forum.

Specific comments should be submitted in writting to Roger Register at FDEP by February 1, 1999. Any technical comments or questions can be made directly to the University of Florida staff.

Chapter 62-777 F.A.C. Documents available on this site:

Deviations from the December 7, 1998 Draft versions of the Tables are specified in the following handouts made available at the Rule Workshop. The January 21, 1999 updated Tables, presented here, are based on these changes as well as input from the Rule Workshop.

Workshop Handouts (updated January 21, 1999): NEW

- Changes in Table 1 (Groundwater Cleanup Target Levels) from December 7, 1998 to January 21, 1999
- Changes in Table 2 (SCTL - Direct Exposure) from December 7, 1998 to January 21, 1999
- Changes in Table 2 (SCTL - Leachability) from December 7, 1998 to January 21, 1999
- Changes in Table 5 (Natural Attenuation) from December 7, 1998 to January 21, 1999
- Changes in Table 2 (SCTL) from Chapter 62-785 F.A.C. to Chapter 62-777 F.A.C.

- Comparison of Health-Based and Csat Limited SCTL Values

Rule Tables (Updated January 21, 1999) : UPDATE!!

- Rule Table 1 - Groundwater Cleanup Target Levels
- Rule Table 2 - Soil Cleanup Target Levels
- Rule Table 3 - Soil Properties and Test Methods
- Rule Table 4 - Site-Specific and Geochemical Parameters for Technical Evaluation of for Natural Attenuation
- Rule Table 5 - Natural Attenuation Default Source Concentrations
- Rule Table 6 - Default Parameters for Figures 4, 5, and 7

Technical Background Document Tables: UPDATE!!

- Technical Report Table 1 - Groundwater Cleanup Target Levels
- Technical Report Table 2 - Soil Cleanup Target Levels
- Technical Report Table 3 - Default Exposure Parameters
- Technical Report Table 4 - Chemical / Physical Parameters
- Technical Report Table 5a - Toxicity Data for Carcinogens
- Technical Report Table 5b - Toxicity Data for Non-carcinogens
- Technical Report Table 6 - Target Organs
- Technical Report Table 7 - Synonyms NEW

These Figures correspond to both the Rule and Technical Background Document:

- Rule Figure 1- Equation for Deriving Site-Specific Cleanup Target Levels for Carcinogens in Groundwater
- Rule Figure 2 - Equation for Deriving Site-Specific Cleanup Target Levels for Systemic Toxicants in Groundwater
- Rule Figure 3a - Equation Used to Calculate Health-Based Freshwater or Marine Surface Water Criteria
- Rule Figure 3b - Methodology Used to Calculate Freshwater and Marine Surface Water Criteria Based on Chronic Toxicity
- Rule Figure 4 - Model Equations for Developing Acceptable Risk-Based Concentrations in Soil (Carcinogens)
- Rule Figure 5 - Model Equations for Developing Acceptable Risk-Based Concentrations in Soil (Non-carcinogens)
- Rule Figure 6 - Derivation of the Particulate Emission Factor UPDATE!!
- Rule Figure 7 - Equation Used for the Determination of the Volatilization Factor

- Rule Figure 8 - Equation Used for the Determination of Csat
- Rule Figure 9 - Equation for the Determination of Soil Cleanup Target Levels Based on Leachability

These files are being provided in Abobe's PDF format. If you do not have the reader installed on your system please click on the yellow "Get Acrobat" icon.

Should you have any questions or comments on these Tables please give us a call.

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Post Workshop Update January 21, 1999

Soil Cleanup Target Level Development Web Site:

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- Rule Table 6 - Default Parameters for Figures 4, 5, and 7

Technical Background Document Tables: UPDATE!!

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Table 1 - Technical Background Document

Groundwater Cleanup Target Levels

Contaminant	CAS #	Groundwater Criteria (ug/L)	Freshwater Surface Water Criteria (ug/L)	Marine Surface Water Criteria (ug/L)	Groundwater of Low Yield/Poor Quality Criteria (ug/L)	Target Organ or Effect
Benomyl	17804-35-2	35 *Minimum Criteria* *Systemic Toxicant*	0.3 *Toxicity Criteria*	0.3 *Toxicity Criteria*	350	-Developmental
Bensulide	741-58-2	46.2 *Minimum Criteria* *Systemic Toxicant*	*NA*	*NA*	462	-None Specified
Bentazon	25057-89-0	210 *Minimum Criteria* *Systemic Toxicant*	*NA*	*NA*	2100	-Blood
Benzaldehyde	100-52-7	700 *Minimum Criteria* *Systemic Toxicant*	53.5 *Toxicity Criteria*	53.5 *Toxicity Criteria*	7000	-Gastrointestinal -Kidney
Benzene	71-43-2	1 *Primary Standard* *Carcinogen*	71.28 *62-302* *annual average*	71.28 *62-302* *annual average*	10	-Carcinogen
Benzenethiol	108-98-5	20 *Minimum Criteria* *PQL*	*NA*	*NA*	200	-Liver
Benzidine	92-87-5	400 *Minimum Criteria* *PQL*	*NA*	*NA*	4000	-Carcinogen
Benzo(a)anthracene	56-55-3	0.2 *Minimum Criteria* *PQL*	0.031 *62-302* *annual average*	0.031 *62-302* *annual average*	2	-Carcinogen
Benzo(a)pyrene	50-32-8	0.2 *Primary Standard* *Carcinogen*	0.031 *62-302* *annual average*	0.031 *62-302* *annual average*	2	-Carcinogen
Benzo(b)fluoranthene	205-99-2	0.2 *Minimum Criteria* *PQL*	0.031 *62-302* *annual average*	0.031 *62-302* *annual average*	2	-Carcinogen
Benzo(g,h,i)perylene	191-24-2	210 *Minimum Criteria* *Systemic Toxicant*	0.031 *62-302* *annual average*	0.031 *62-302* *annual average*	2100	-Neurological
Benzo(k)fluoranthene	207-08-9	0.5 *Minimum Criteria* *Carcinogen*	0.031 *62-302* *annual average*	0.031 *62-302* *annual average*	5	-Carcinogen
Benzoic acid	65-85-0	28000 *Minimum Criteria* *Systemic Toxicant*	9000 *Toxicity Criteria*	9000 *Toxicity Criteria*	280000	-None Specified
Benzotrichloride	98-08-7	0.06 *Minimum Criteria* *PQL*	0.0029 *Human Health*	0.0029 *Human Health*	0.6	-Carcinogen
Benzyl alcohol	100-51-6	2100 *Minimum Criteria* *Systemic Toxicant*	500 *Toxicity Criteria*	500 *Toxicity Criteria*	21000	-Gastrointestinal
Benzyl chloride	100-44-7	0.5 *Minimum Criteria* *PQL*	2.95 *Human Health*	2.95 *Human Health*	5	-Carcinogen

Table 1 - Technical Background Document

Groundwater Cleanup Target Levels

Contaminant	CAS #	Groundwater Criteria (ug/L)	Freshwater Surface Water Criteria (ug/L)	Marine Surface Water Criteria (ug/L)	Groundwater of Low Yield/Poor Quality Criteria (ug/L)	Target Organ or Effect
Ethyl acetate	141-78-6	6300 *Minimum Criteria Systemic Toxicant*	6250 *Toxicity Criteria*	6250 *Toxicity Criteria*	63000	-Body Weight -Mortality
Ethyl acrylate	140-88-5	5000 *Minimum Criteria PQL*	125 *Toxicity Criteria*	125 *Toxicity Criteria*	50000	-Carcinogen
Ethyl chloride [or Chloroethane]	75-00-3	12 *Minimum Criteria Carcinogen*	*NA*	*NA*	120	-Carcinogen -Developmental
Ethyl dipropylthiocarbamate, S- [or EPTC]	759-94-4	175 *Minimum Criteria Systemic Toxicant*	235 *Toxicity Criteria*	235 *Toxicity Criteria*	1750	-Cardiovascular
Ethyl ether	60-29-7	750 *Minimum Criteria Organoleptic*	128000 *Toxicity Criteria*	128000 *Toxicity Criteria*	7500	-Body Weight
Ethyl methacrylate	97-63-2	630 *Minimum Criteria Systemic Toxicant*	*NA*	*NA*	6300	-Kidney
Ethyl p-nitrophenyl phenylphosphorothioate [or EPN]	2104-64-5	0.2 *Minimum Criteria PQL*	0.015 *Toxicity Criteria*	0.015 *Toxicity Criteria*	2	-Neurological
Ethylbenzene	100-41-4	30 *Secondary Standard Systemic Toxicant*	605 *Toxicity Criteria*	605 *Toxicity Criteria*	300	-Developmental -Kidney -Liver
Ethylene diamine	107-15-3	10000 *Minimum Criteria PQL*	800 *Toxicity Criteria*	800 *Toxicity Criteria*	100000	-Blood -Cardiovascular
Ethylene glycol	107-21-1	14000 *Minimum Criteria Systemic Toxicant*	16300 *Toxicity Criteria*	16300 *Toxicity Criteria*	140000	-Kidney
Ethylene oxide	75-21-8	10 *Minimum Criteria PQL*	4200 *Toxicity Criteria*	4200 *Toxicity Criteria*	100	-Carcinogen
Ethylene thiourea [or ETU]	96-45-7	5 *Minimum Criteria PQL*	1320 *Toxicity Criteria*	1320 *Toxicity Criteria*	50	-Carcinogen
Ethylphthalyl ethylglycolate [or EPEG]	84-72-0	21000 *Minimum Criteria Systemic Toxicant*	*NA*	*NA*	210000	-Kidney -Mortality
Famphur	52-85-7	3.5 *Minimum Criteria Systemic Toxicant*	*NA*	*NA*	35	-Blood
Fenamiphos	22224-92-6	1.8 *Minimum Criteria Systemic Toxicant*	0.225 *Toxicity Criteria*	0.225 *Toxicity Criteria*	18	-Neurological
Fensulfothion	115-90-2	1.8 *Minimum Criteria Systemic Toxicant*	0.5 *Toxicity Criteria*	0.5 *Toxicity Criteria*	18	-Neurological

Table 1 - Technical Background Document

Groundwater Cleanup Target Levels

Contaminant	CAS #	Groundwater Criteria (ug/L)	Freshwater Surface Water Criteria (ug/L)	Marine Surface Water Criteria (ug/L)	Groundwater of Low Yield/Poor Quality Criteria (ug/L)	Target Organ or Effect
Mirex	2385-85-5	1.4 *Minimum Criteria* *Systemic Toxicant*	0.001 *62-302*	0.001 *62-302*	14	-Liver -Thyroid
Molinate	2212-67-1	14 *Minimum Criteria* *Systemic Toxicant*	17 *Toxicity Criteria*	17 *Toxicity Criteria*	140	-Reproductive
Molybdenum	7439-98-7	35 *Minimum Criteria* *Systemic Toxicant*	*NA*	*NA*	350	-Gout
Naled	300-76-5	14 *Minimum Criteria* *Systemic Toxicant*	0.018 *Toxicity Criteria*	0.018 *Toxicity Criteria*	140	-Neurological
Naphthalene	91-20-3	20 *Minimum Criteria* *Organoleptic*	26 *Toxicity Criteria*	26 *Toxicity Criteria*	200	-Body Weight -Nasal
Naphthylamine, 2-	91-59-8	10 *Minimum Criteria* *PQL*	*NA*	*NA*	100	-Carcinogen
Napropamide	15299-99-7	700 *Minimum Criteria* *Systemic Toxicant*	210 *Toxicity Criteria*	210 *Toxicity Criteria*	7000	-Body Weight
Nickel	7440-02-0	100 *Primary Standard* *Systemic Toxicant*	*a*	8.3 *62-302*	1000	-Body Weight
Nitrate	14797-55-8	10000 *Primary Standard* *Systemic Toxicant*	*62-302* *b*	*62-302* *b*	100000	-Blood
Nitrate+Nitrite	NOCAS#	10000 *Primary Standard* *Systemic Toxicant*	*62-302* *b*	*62-302* *b*	100000	-Blood
Nitrite	14797-65-0	1000 *Primary Standard* *Systemic Toxicant*	*62-302* *b*	*62-302* *b*	10000	-Blood
Nitroaniline, m-	99-09-2	50 *Minimum Criteria* *PQL*	*NA*	*NA*	500	-None Specified
Nitroaniline, o-	88-74-4	50 *Minimum Criteria* *PQL*	*NA*	*NA*	500	-Blood
Nitroaniline, p-	100-01-6	21 *Minimum Criteria* *Systemic Toxicant*	1200 *Toxicity Criteria*	1200 *Toxicity Criteria*	210	-None Specified
Nitrobenzene	98-95-3	4 *Minimum Criteria* *PQL*	90 *Toxicity Criteria*	90 *Toxicity Criteria*	40	-Adrenals -Blood -Kidney -Liver
Nitrophenol, 4-	100-02-7	56 *Minimum Criteria* *Systemic Toxicant*	55 *Toxicity Criteria*	55 *Toxicity Criteria*	560	-None Specified

Table 1 - Technical Background Document

Groundwater Cleanup Target Levels

Contaminant	CAS #	Groundwater Criteria (ug/L)	Freshwater Surface Water Criteria (ug/L)	Marine Surface Water Criteria (ug/L)	Groundwater of Low Yield/Poor Quality Criteria (ug/L)	Target Organ or Effect
Merphos	150-50-5	0.2 *Minimum Criteria Systemic Toxicant*	*NA*	*NA*	2	-Body Weight -Neurological
Metalaxyl	57837-19-1	420 *Minimum Criteria Systemic Toxicant*	36.5 *Toxicity Criteria*	36.5 *Toxicity Criteria*	4200	-Blood -Liver -Neurological
Methacrylonitrile	126-98-7	5 *Minimum Criteria PQL*	*NA*	*NA*	50	-Liver
Methamidophos	10265-92-6	5 *Minimum Criteria PQL*	0.000011 *Toxicity Criteria*	0.000011 *Toxicity Criteria*	50	-Neurological
Methanol	67-56-1	5000 *Minimum Criteria PQL*	45037 *Toxicity Criteria*	45037 *Toxicity Criteria*	50000	-Liver -Neurological
Methidathion	950-37-8	0.7 *Minimum Criteria Systemic Toxicant*	0.03 *Toxicity Criteria*	0.03 *Toxicity Criteria*	7	-Liver
Methomyl	16752-77-5	175 *Minimum Criteria Systemic Toxicant*	0.95 *Toxicity Criteria*	0.95 *Toxicity Criteria*	1750	-Kidney -Spleen
Methoxy-5-nitroaniline, 2-	99-59-2	50 *Minimum Criteria PQL*	*NA*	*NA*	500	-Carcinogen
Methoxychlor	72-43-5	40 *Primary Standard Systemic Toxicant*	0.03 *62-302*	0.03 *62-302*	400	-Developmental -Reproductive
Methoxyethanol, 2-	109-86-4	100000 *Minimum Criteria PQL*	*NA*	*NA*	1000000	-Reproductive
Methyl acetate	79-20-9	5000 *Minimum Criteria PQL*	*NA*	*NA*	50000	-Liver
Methyl acrylate	96-33-3	210 *Minimum Criteria Systemic Toxicant*	*NA*	*NA*	2100	-None Specified
Methyl isobutyl ketone [or MIBK]	108-10-1	560 *Minimum Criteria Systemic Toxicant*	23000 *Toxicity Criteria*	23000 *Toxicity Criteria*	5600	-Kidney -Liver
Methyl methacrylate	80-62-6	25 *Minimum Criteria Organoleptic*	6500 *Toxicity Criteria*	6500 *Toxicity Criteria*	250	-Nasal
Methyl parathion [or Parathion, methyl]	298-00-0	1.8 *Minimum Criteria Systemic Toxicant*	0.01 *Toxicity Criteria*	0.01 *Toxicity Criteria*	18	-Blood -Neurological
Methyl tert-butyl ether [or MTBE]	1634-04-4	50 *Minimum Criteria Organoleptic*	33600 *Toxicity Criteria*	33600 *Toxicity Criteria*	500	-Eye -Kidney -Liver

Table 1 - Technical Background Document

Groundwater Cleanup Target Levels

Contaminant	CAS #	Groundwater Criteria (ug/L)	Freshwater Surface Water Criteria (ug/L)	Marine Surface Water Criteria (ug/L)	Groundwater of Low Yield/Poor Quality Criteria (ug/L)	Target Organ or Effect
Tebuthiuron	34014-18-1	490 *Minimum Criteria* *Systemic Toxicant*	307 *Toxicity Criteria*	307 *Toxicity Criteria*	4900	-Body Weight
Temephos	3383-96-8	140 *Minimum Criteria* *Systemic Toxicant*	0.002 *Toxicity Criteria*	0.002 *Toxicity Criteria*	1400	-None Specified
Terbacil	5902-51-2	91 *Minimum Criteria* *Systemic Toxicant*	2450 *Toxicity Criteria*	2450 *Toxicity Criteria*	910	-Liver -Thyroid
Terbufos	13071-79-9	0.2 *Minimum Criteria* *Systemic Toxicant*	0.01 *Toxicity Criteria*	0.01 *Toxicity Criteria*	2	-Neurological
Terbutryn	886-50-0	330 *Minimum Criteria* *PQL*	3.1 *Toxicity Criteria*	3.1 *Toxicity Criteria*	3300	-Blood
Tetrachlorobenzene, 1,2,4,5-	95-94-3	2.1 *Minimum Criteria* *Systemic Toxicant*	2.3 *Human Health*	2.3 *Human Health*	21	-Kidney
Tetrachloroethane, 1,1,1,2-	630-20-6	1.3 *Minimum Criteria* *Carcinogen*	*NA*	*NA*	13	-Carcinogen -Kidney -Liver
Tetrachloroethane, 1,1,2,2-	79-34-5	0.2 *Minimum Criteria* *Carcinogen*	10.8 *62-302* *annual average*	10.8 *62-302* *annual average*	2	-Carcinogen
Tetrachloroethene [or PCE]	127-18-4	3 *Primary Standard* *Carcinogen*	8.85 *62-302* *annual average*	8.85 *62-302* *annual average*	30	-Body Weight -Carcinogen -Liver
Tetrachlorophenol, 2,3,4,6-	58-90-2	210 *Minimum Criteria* *Systemic Toxicant*	4.5 *Toxicity Criteria*	4.5 *Toxicity Criteria*	2100	-Liver
Tetraethyl dithiopyrophosphate	3689-24-5	3.5 *Minimum Criteria* *PQL*	0.0115 *Toxicity Criteria*	0.0115 *Toxicity Criteria*	35	-Bone Marrow -Neurological
Thallium	7440-28-0	2 *Primary Standard* *Systemic Toxicant*	6.3 *62-302*	6.3 *62-302*	20	-Blood -Hair Loss -Liver
Thiocyanomethylthio-benzothiazole, 2-	21564-17-0	210 *Minimum Criteria* *Systemic Toxicant*	0.435 *Toxicity Criteria*	0.435 *Toxicity Criteria*	2100	-Gastrointestinal
Thiram	137-26-8	35 *Minimum Criteria* *Systemic Toxicant*	0.168 *Toxicity Criteria*	0.168 *Toxicity Criteria*	350	-Neurological
Tin	7440-31-5	4200 *Minimum Criteria* *Systemic Toxicant*	*NA*	*NA*	42000	-Kidney -Liver
Toluene	108-88-3	40 *Secondary Standard* *Systemic Toxicant*	475 *Toxicity Criteria*	475 *Toxicity Criteria*	400	-Kidney -Liver -Neurological

Table 1 - Technical Background Document

Groundwater Cleanup Target Levels

Contaminant	CAS #	Groundwater Criteria (ug/L)	Freshwater Surface Water Criteria (ug/L)	Marine Surface Water Criteria (ug/L)	Groundwater of Low Yield/Poor Quality Criteria (ug/L)	Target Organ or Effect
Vinyl chloride	75-01-4	1 *Primary Standard Carcinogen*	*NA*	*NA*	10	-Carcinogen
Xylenes, total	1330-20-7	20 *Secondary Standard Systemic Toxicant*	370 *Toxicity Criteria*	370 *Toxicity Criteria*	200	-Body Weight -Mortality -Neurological
Zinc	7440-66-6	5000 *Secondary Standard Systemic Toxicant*	*62-302 a*	86 *62-302*	50000	-Blood
Zinc chloride	7646-85-7	2100 *Minimum Criteria Systemic Toxicant*	1.5 *Toxicity Criteria*	1.5 *Toxicity Criteria*	21000	-Blood
Zinc phosphide	1314-84-7	2.1 *Minimum Criteria Systemic Toxicant*	*NA*	*NA*	21	-Body Weight
Zineb	12122-67-7	350 *Minimum Criteria Systemic Toxicant*	13.5 *Toxicity Criteria*	13.5 *Toxicity Criteria*	3500	-Thyroid

* = As provided in Chapters 62-550 and 62-520, F.A.C.
** = As provided in Chapter 62-302, F.A.C.
*** = Equal to 10 times the value provided in Chapters 62-550 and 62-520, F.A.C.

a = Hardness-dependent per Chapter 62-302, F.A.C.

b = Not greater than 10% above background.

c = Shall not be increased more than 50% above background or to 1275, whichever is greater (per Chapter 62-302, F.A.C.).

= Based on similarity to chloride considerations as provided in Chapter 62-302, F.A.C.
= Based on similarity to oil and grease standard as provided in Chapter 62-302, F.A.C.

PQL = Practical Quantitation Limit.
MRL = Minimum Risk Level from ATSDR Toxicant Profile.
Toxicity Criteria = 1/20 of applicable LC50 data.
NA = Not Available at time of Rule adoption.

Surrogate (a): Surrogate RfD based on other non-carcinogenic PAHs (e.g. pyrene).
Surrogate (b): Surrogate RfD based on oral RfD for HCH-gamma (lindane).
Surrogate (c): Surrogate RfD based on Primary Groundwater Standard for 1,2,4-trichlorobenzene.

62-302 = As provided in Chapter 62-302, F.A.C. If the PQL using the most sensitive and currently available technology is higher than the specified criterion, the PQL shall be used.

Note: Freshwater and Marine Surfacewaters shall pass Toxicity Bioassay Tests; "pass test" shall mean mortality less than fifty percent in a 96-hour acute toxicity test performed, in predominantly fresh waters, on both Cyprinella leedsi (bannerfin shiner) and Ceriodaphnia dubia (water flea), and in predominantly marine waters, on both Menidia beryllina (inland silversides) and Americamysis bahia (possum shrimp).

Table 2 - Technical Background Document

Soil Cleanup Target Levels

Contaminant Name	CAS#	Direct Exposure		Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/ Poor Quality	Target Organ/System or Effect
		Residential	Commercial/ Industrial					
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Aroclor mixture [PCBs]	1336-36-3	0.5	2.1	17	0.5	1	170	-Carcinogen -Immunological
Arsenic (b)	7440-38-2	0.8	3.7	29	***	***	290	-Carcinogen -Cardiovascular -Skin
Atrazine	1912-24-9	4	12	0.06	0.04	0.04	0.6	-Body Weight -Carcinogen
Azobenzene	103-33-3	8.2	24	0.4	0.06	0.06	4	-Carcinogen
Barium (b)	7440-39-3	110**	87000	1600	***	***	16000	-Cardiovascular
Bayleton	43121-43-3	2000	29000	4.8	11	11	48	-Blood -Body Weight
Benomyl	17804-35-2	3600	64000	3.1	0.03	0.03	31	-Developmental
Bentazon	25057-89-0	1500	18000	1.2	NA	NA	12	-Blood
Benzaldehyde	100-52-7	2200	18000	4.8	0.4	0.4	48	-Gastrointestinal -Kidney
Benzene	71-43-2	1.1	1.6	0.007	0.5	0.5	0.07	-Carcinogen
Benzenethiol	108-98-5	0.1	1	0.3	NA	NA	3	-Liver
Benzo(a)anthracene	56-55-3	1.4	5	3.2	0.7	0.7	32	-Carcinogen
Benzo(a)pyrene	50-32-8	0.1	0.5	8	1.2	1.2	80	-Carcinogen
Benzo(b)fluoranthene	205-99-2	1.4	4.8	10	1.6	1.6	100	-Carcinogen
Benzo(g,h,i)perylene	191-24-2	2300	41000	32000	4.8	4.8	320000	-Neurological
Benzo(k)fluoranthene	207-08-9	15	52	25	1.6	1.6	250	-Carcinogen
Benzoic acid	65-85-0	150000	*	110	36	36	1100	-None Specified
Benzotrichloride	98-08-7	0.04	0.07	0.003	0.0002	0.0002	0.03	-Carcinogen
Benzyl alcohol	100-51-6	23000	610000	9.5	2.3	2.3	95	-Gastrointestinal
Benzyl chloride	100-44-7	0.8	1.2	0.006	0.03	0.03	0.06	-Carcinogen

Table 2 - Technical Background Document

Soil Cleanup Target Levels

Contaminant Name	CAS#	Direct Exposure		Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/ Poor Quality	Target Organ/System or Effect
		Residential	Commercial/ Industrial					
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Ethoprop	13194-48-4	5.5	69	0.005	0.002	0.002	0.05	-Neurological
Ethoxyethanol, 2-	110-80-5	8100	65000	120	NA	NA	1200	-Body Weight -Reproductive
Ethyl acetate	141-78-6	5500	39000	26	26	26	260	-Body Weight -Mortality
Ethyl acrylate	140-88-5	1.6	2.2	25	0.6	0.6	250	-Carcinogen
Ethyl chloride [or Chloroethane]	75-00-3	2.9	4	0.06	NA	NA	0.6	-Carcinogen -Developmental
Ethyl dipropylthiocarbamate, S- [or EPTC]	759-94-4	1100	13000	11	15	15	110	-Cardiovascular
Ethyl ether	60-29-7	150	1000	5	850	850	50	-Body Weight
Ethyl methacrylate	97-63-2	380	2600	3.5	NA	NA	35	-Kidney
Ethyl p-nitrophenyl phenylphosphorothioate [or EPN]	2104-64-5	0.7	15	0.04	0.003	0.003	0.4	-Neurological
Ethylbenzene	100-41-4	1100	8400	0.6	12	12	6	-Developmental -Kidney -Liver
Ethylene diamine	107-15-3	610	5500	40	3.2	3.2	400	-Blood -Cardiovascular
Ethylene glycol	107-21-1	24000	180000	56	65	65	560	-Kidney
Ethylene oxide	75-21-8	0.3	0.4	0.05	20	20	0.5	-Carcinogen
Fenamiphos	22224-92-6	15	210	0.02	0.003	0.003	0.2	-Neurological
Fensulfothion	115-90-2	14	180	0.01	0.004	0.004	0.1	-Neurological
Fluometuron	2164-17-2	750	9700	0.9	1.8	1.8	9	-None Specified
Fluoranthene	206-44-0	2900	48000	1200	1.3	1.3	12000	-Blood -Kidney -Liver
Fluorene	86-73-7	2200	28000	160	17	17	1600	-Blood
Fluoride	7782-41-4	500**	120000	***	***	***	***	-Teeth
Fonofos	944-22-9	120	1800	0.4	0.003	0.003	4	-Liver -Neurological

Table 2 - Technical Background Document

Soil Cleanup Target Levels

Contaminant Name	CAS#	Direct Exposure		Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/ Poor Quality	Target Organ/System or Effect
		Residential	Commercial/ Industrial					
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Methyl isobutyl ketone [or MIBK]	108-10-1	220	1500	2.6	110	110	26	-Kidney -Liver
Methyl methacrylate	80-62-6	1400	9400	0.1	32	32	1	-Nasal
Methyl parathion [or Parathion, methyl]	298-00-0	18	310	0.06	0.0003	0.0003	0.6	-Blood -Neurological
Methyl tert-butyl ether [or MTBE]	1634-04-4	3200	22000	0.2	150	150	2	-Eye -Kidney -Liver
Methyl-4-chlorophenoxy acetic acid, 2-	94-74-6	30	440	0.02	0.4	0.4	0.2	-Kidney -Liver
Methylaniline, 2-	95-53-4	1.8	3.3	0.3	0.2	0.2	3	-Carcinogen
Methylene bis(2-chloroaniline), 4,4-	101-14-4	6.4	17	0.2	NA	NA	2	-Carcinogen -Liver -Bladder
Methylene bromide	74-95-3	58	400	0.3	NA	NA	3	-Blood
Methylene chloride	75-09-2	16	23	0.02	7.3	7.3	0.2	-Carcinogen -Liver
Methylnaphthalene, 1-	90-12-0	68	470	2.2	10	10	22	-Body Weight -Nasal
Methylnaphthalene, 2-	91-57-6	83	560	6.1	9.1	9.1	61	-Body Weight -Nasal
Methylphenol, 2- [or o-Cresol]	95-48-7	2400	28000	0.3	1.9	1.9	3	-Body Weight -Neurological
Methylphenol, 3- [or m-Cresol]	108-39-4	2500	29000	0.3	3.3	3.3	3	-Body Weight -Neurological
Methylphenol, 4- [or p-Cresol]	106-44-5	250	3000	0.03	0.5	0.5	0.3	-Maternal Death -Neurological -Respiratory
Metolachlor	51218-45-2	9100	120000	1.2	0.01	0.01	12	-Body Weight
Metribuzin	21087-64-9	32	210	2.2	0.8	0.8	22	-Body Weight -Kidney -Liver -Mortality
Mevinphos	7786-34-7	16	240	0.01	0.0003	0.0003	0.1	-Neurological
Molinate	2212-67-1	100	1200	0.1	0.1	0.1	1	-Reproductive
Molybdenum	7439-98-7	390	9700	***	NA	NA	***	-Gout
Naled	300-76-5	130	2100	0.1	0.0002	0.0002	1	-Neurological

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Soil Cleanup Target Levels

Contaminant Name	CAS#	Direct Exposure		Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/ Poor Quality	Target Organ/System or Effect
		Residential	Commercial/ Industrial					
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Naphthalene	91-20-3	40	270	1.7	2.2	2.2	17	-Body Weight -Nasal
Nickel (b)	7440-02-0	110**	28000	130	***	***	1300	-Body Weight
Nitrate	14797-55-8	120000	*	***	***	***	***	-Blood
Nitrite	14797-65-0	7800	180000	***	***	***	***	-Blood
Nitroaniline, o-	88-74-4	5.7	66	0.3	NA	NA	3	-Blood
Nitroaniline, p-	100-01-6	5.2	56	0.1	5.9	5.9	1	-None Specified
Nitrobenzene	98-95-3	14	120	0.03	0.6	0.6	0.3	-Adrenals -Blood -Kidney -Liver
Nitrophenol, 4-	100-02-7	390	4400	0.3	0.3	0.3	3	-None Specified
Nitroso-di-ethylamine, N-	55-18-5	0.003	0.005	0.02	0.0007	0.0007	0.2	-Carcinogen
Nitroso-di-n-butylamine, N-	924-16-3	0.05	0.07	0.05	0.002	0.002	0.5	-Carcinogen
Nitroso-di-n-propylamine, N-	621-64-7	0.09	0.2	0.04	0.008	0.008	0.4	-Carcinogen
Nitroso-dimethylamine, N-	62-75-9	0.009	0.02	0.008	0.002	0.002	0.08	-Carcinogen
Nitroso-diphenylamine, N-	86-30-6	170	440	0.4	2.5	2.5	4	-Carcinogen
Nitroso-N-methylethylamine, N-	10595-95-6	0.01	0.02	0.03	0.005	0.005	0.3	-Carcinogen
Nitrotoluene, m-	99-08-1	210	1800	2.4	3.6	3.6	24	-Spleen
Nitrotoluene, o-	88-72-2	280	2500	3.3	7.3	7.3	33	-Spleen
Nitrotoluene, p-	99-99-0	640	9700	3.3	7.3	7.3	33	-Spleen
Octamethylpyrophosphoramide	152-16-9	83	860	4	NA	NA	40	-Neurological
Oxamyl	23135-22-0	1100	12000	0.9	0.04	0.04	9	-Body Weight
Paraquat	1910-42-5	310	4000	160	230	230	1600	-Respiratory

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Soil Cleanup Target Levels

Contaminant Name	CAS#	Direct Exposure		Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/ Poor Quality	Target Organ/System or Effect
		Residential	Commercial/ Industrial					
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Thiram	137-26-8	330	4900	1.1	0.005	0.005	11	-Neurological
Tin	7440-31-5	44000	660000	***	NA	NA	***	-Kidney -Liver
Toluene	108-88-3	380	2600	0.5	5.6	5.6	5	-Kidney -Liver -Neurological
Toluidine, p-	106-49-0	1.4	2.2	0.7	NA	NA	7	-Carcinogen
Toxaphene	8001-35-2	1	3.7	31	0.02	0.02	310	-Carcinogen -Developmental
Triallate	2303-17-5	740	9500	8.4	6	6	84	-Liver -Spleen
Tributyltin oxide	56-35-9	22	400	36	0.2	0.2	360	-Immunological
Trichloro-1,2,2-trifluoroethane, 1,1,2- [or CFC 113]	76-13-1	13000	88000	27000	NA	NA	270000	-Body Weight -Neurological
Trichloroacetic acid	76-03-9	480	4600	1.2	400	400	12	-None Specified
Trichlorobenzene, 1,2,3-	87-61-6	560	7400	4.6	5.6	5.6	46	-Adrenals -Body Weight
Trichlorobenzene, 1,2,4-	120-82-1	560	7500	5.3	1.7	1.7	53	-Adrenals -Body Weight
Trichlorobenzene, 1,3,5-	108-70-3	190	1800	16	NA	NA	160	-None Specified
Trichloroethane, 1,1,1- [or Methyl chloroform]	71-55-6	400	3300	1.9	2.6	2.6	19	-None Specified
Trichloroethane, 1,1,2-	79-00-5	1.3	1.8	0.03	0.2	0.2	0.3	-Carcinogen -Liver
Trichloroethene [or TCE]	79-01-6	6	8.5	0.03	0.9	0.9	0.3	-Carcinogen
Trichlorofluoromethane	75-69-4	200	1300	33	NA	NA	330	-Cardiovascular -Kidney -Mortality -Respiratory
Trichlorophenol, 2,4,5-	95-95-4	6000	82000	0.3	1.5	1.5	3	-Kidney -Liver
Trichlorophenol, 2,4,6-	88-06-2	72	180	0.06	0.1	0.1	0.6	-Carcinogen
Trichlorophenoxy acetic acid, 2,4,5-	93-76-5	590	8300	0.4	0.8	0.8	4	-Kidney
Trichlorophenoxy propionic acid [or Silvex]	93-72-1	590	12000	5.4	NA	NA	54	-Liver

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Soil Cleanup Target Levels

Contaminant Name	CAS#	Direct Exposure		Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/ Poor Quality	Target Organ/System or Effect
		Residential	Commercial/ Industrial					
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Trichloropropane, 1,2,3-	96-18-4	0.01	0.02	0.001	0.002	0.002	0.01	-Body Weight -Carcinogen -Kidney -Liver -Mortality
Trifluralin	1582-09-8	94	220	3.5	0.6	0.6	35	-Blood -Carcinogen -Liver
Trimethyl phosphate	512-56-1	15	30	0.2	NA	NA	2	-Carcinogen
Trimethylbenzene, 1,2,3-	526-73-8	13	89	0.3	NA	NA	3	-None Specified
Trimethylbenzene, 1,2,4-	95-63-6	13	88	0.3	7.2	7.2	3	-None Specified
Trimethylbenzene, 1,3,5-	108-67-8	11	74	0.3	6.7	6.7	3	-None Specified
Trinitrobenzene, 1,3,5-	99-35-4	1300	14000	1	0.09	0.09	10	-Blood -Spleen
Trinitrotoluene, 2,4,6-	118-96-7	24	55	0.06	0.3	0.3	0.6	-Carcinogen -Liver
TRPH	NOCAS#	340	2500	340	340	340	3400	-Multiple Endpoints Mixed Contaminants
Uranium, natural	7440-61-1	120	470	***	NA	NA	***	-None Specified
Vanadium (b)	7440-62-2	15**	7400	980	NA	NA	9800	-None Specified
Vernam	1929-77-7	29	260	0.1	0.2	0.2	1	-Body Weight
Vinyl acetate	108-05-4	230	1600	0.4	3	3	4	-Body Weight -Kidney -Nasal
Vinyl chloride	75-01-4	0.03	0.04	0.007	NA	NA	0.07	-Carcinogen
Xylenes, total	1330-20-7	5900	40000	0.2	3.9	3.9	2	-Body Weight -Mortality -Neurological
Zinc (b)	7440-66-6	23000	560000	6000	***	***	60000	-Blood
Zinc phosphide	1314-84-7	23	550	***	NA	NA	***	-Body Weight
Zineb	12122-67-7	3400	53000	19	0.7	0.7	190	-Thyroid

Table 1 - Technical Background Document

Groundwater Cleanup Target Levels

Contaminant	CAS #	Groundwater Criteria (ug/L)	Freshwater Surface Water Criteria (ug/L)	Marine Surface Water Criteria (ug/L)	Groundwater of Low Yield/Poor Quality Criteria (ug/L)	Target Organ or Effect
Trichlorophenol, 2,4,6-	88-06-2	3.2 *Minimum Criteria* *Carcinogen*	6.5 *62-302* *annual average*	6.5 *62-302* *annual average*	32	-Carcinogen
Trichlorophenoxy acetic acid, 2,4,5-	93-76-5	70 *Minimum Criteria* *Systemic Toxicant*	145 *Toxicity Criteria*	145 *Toxicity Criteria*	700	-Kidney
Trichlorophenoxy propionic acid [or Silvex]	93-72-1	50 *Primary Standard* *Systemic Toxicant*	*NA*	*NA*	500	-Liver
Trichloropropane, 1,2,3-	96-18-4	0.2 *Minimum Criteria* *PQL*	0.26 *Human Health*	0.26 *Human Health*	2	-Body Weight -Carcinogen -Kidney -Liver -Mortality
Trifluralin	1582-09-8	4.5 *Minimum Criteria* *Carcinogen*	0.78 *Human Health*	0.78 *Human Health*	45	-Blood -Carcinogen -Liver
Trimethyl phosphate	512-56-1	50 *Minimum Criteria* *PQL*	*NA*	*NA*	500	-Carcinogen
Trimethylbenzene, 1,2,3-	526-73-8	10 *Minimum Criteria* *Organoleptic*	*NA*	*NA*	100	-None Specified
Trimethylbenzene, 1,2,4-	95-63-6	10 *Minimum Criteria* *Organoleptic*	217.5 *Toxicity Criteria*	217.5 *Toxicity Criteria*	100	-None Specified
Trimethylbenzene, 1,3,5-	108-67-8	10 *Minimum Criteria* *Organoleptic*	215 *Toxicity Criteria*	215 *Toxicity Criteria*	100	-None Specified
Trinitrobenzene, 1,3,5-	99-35-4	210 *Minimum Criteria* *Systemic Toxicant*	19 *Toxicity Criteria*	19 *Toxicity Criteria*	2100	-Blood -Spleen
Trinitrotoluene, 2,4,6-	118-96-7	10 *Minimum Criteria* *PQL*	49 *Toxicity Criteria*	49 *Toxicity Criteria*	100	-Carcinogen -Liver
TRPH	NOCAS#	5000 *Minimum Criteria* *##*	5000 *62-302* *##*	5000 *62-302* *##*	50000	-Multiple Endpoints Mixed Contaminants
Uranium, natural	7440-61-1	21 *Minimum Criteria* *Systemic Toxicant*	*NA*	*NA*	210	-None Specified
Vanadium	7440-62-2	49 *Minimum Criteria* *Systemic Toxicant*	*NA*	*NA*	490	-None Specified
Vernam	1929-77-7	7 *Minimum Criteria* *Systemic Toxicant*	11.5 *Toxicity Criteria*	11.5 *Toxicity Criteria*	70	-Body Weight
Vinyl acetate	108-05-4	88 *Minimum Criteria* *Organoleptic*	700 *Toxicity Criteria*	700 *Toxicity Criteria*	880	-Body Weight -Kidney -Nasal

Table V
Natural Attenuation Default Concentrations

Contaminant	CAS#	Groundwater Criteria (ug/L)	Natural Attenuation Default Source (ug/L)
Barium	7440-39-3	*	**
Bayleton	43121-43-3	210	2100
Benomyl	17804-35-2	35	350
Bensulide	741-58-2	46.2	462
Bentazon	25057-89-0	210	2100
Benzaldehyde	100-52-7	700	7000
Benzene	71-43-2	*	***
Benzenethiol	108-98-5	20	200
Benzidine	92-87-5	400	40000
Benzo(a)anthracene	56-55-3	0.2	20
Benzo(a)pyrene	50-32-8	*	***
Benzo(b)fluoranthene	205-99-2	0.2	20
Benzo(g,h,i)perylene	191-24-2	210	2100
Benzo(k)fluoranthene	207-08-9	0.5	50
Benzoic acid	65-85-0	28000	280000
Benzotrichloride	98-08-7	0.06	6
Benzyl alcohol	100-51-6	2100	21000
Benzyl chloride	100-44-7	0.5	50
Beryllium	7440-41-7	*	**
Beta radiation		*	**
Bidrin [or Dicrotophos]	141-66-2	0.7	7
Bioallethrin	28057-48-9	35	350
Biphenyl, 1,1- [or Diphenyl]	92-52-4	0.5	5
Bis(2-chloroethyl)ether	111-44-4	4	400
Bis(2-chloroisopropyl)ether	108-60-1	10	1000
Bis(2-ethylhexyl)adipate	103-23-1	*	***
Bis(2-ethylhexyl)phthalate [or DEHP]	117-81-7	*	***
Bisphenol A	80-05-7	350	3500
Boron	7440-42-8	630	6300
Bromacil	314-40-9	91	910

Table V
Natural Attenuation Default Concentrations

Contaminant	CAS#	Groundwater Criteria (ug/L)	Natural Attenuation Default Source (ug/L)
Ethyl chloride [or Chloroethane]	75-00-3	12	1200
Ethyl dipropylthiocarbamate, S- [or EPTC]	759-94-4	175	1750
Ethyl ether	60-29-7	750	7500
Ethyl methacrylate	97-63-2	630	6300
Ethyl p-nitrophenyl phenylphosphorothioate [or EPN]	2104-64-5	0.2	2
Ethylbenzene	100-41-4	*	**
Ethylene diamine	107-15-3	10000	100000
Ethylene glycol	107-21-1	14000	140000
Ethylene oxide	75-21-8	10	1000
Ethylene thiourea [or ETU]	96-45-7	5	500
Ethylphthalyl ethylglycolate [or EPEG]	84-72-0	21000	210000
Famphur	52-85-7	3.5	35
Fenamiphos	22224-92-6	1.8	18
Fensulfothion	115-90-2	1.8	18
Fluometuron	2164-17-2	91	910
Fluoranthene	206-44-0	280	2800
Fluorene	86-73-7	280	2800
Fluoride	7782-41-4	*	**
Fluoridone	59756-60-4	560	5600
Fonofos	944-22-9	14	140
Formaldehyde	50-00-0	600	60000
Formic acid	64-18-6	14000	140000
Furfural	98-01-1	250	2500
Glyphosate [or Roundup]	1071-83-6	*	**
Gross alpha radiation	14127-62-9	*	**
Guthion [or Azinphos, methyl]	86-50-0	10.5	105
Heptachlor	76-44-8	*	***
Heptachlor epoxide	1024-57-3	*	***
Hexachloro-1,3-butadiene	87-68-3	0.5	50
Hexachlorobenzene	118-74-1	*	***

Table V
Natural Attenuation Default Concentrations

Contaminant	CAS#	Groundwater Criteria (ug/L)	Natural Attenuation Default Source (ug/L)
Mercury	7439-97-6	*	**
Mercury, methyl	22967-92-6	0.07	0.7
Merphos	150-50-5	0.2	2
Metalaxyl	57837-19-1	420	4200
Methacrylonitrile	126-98-7	5	50
Methamidophos	10265-92-6	5	50
Methanol	67-56-1	5000	50000
Methidathion	950-37-8	0.7	7
Methomyl	16752-77-5	175	1750
Methoxy-5-nitroaniline, 2-	99-59-2	50	5000
Methoxychlor	72-43-5	*	**
Methoxyethanol, 2-	109-86-4	100000	1000000
Methyl acetate	79-20-9	5000	50000
Methyl acrylate	96-33-3	210	2100
Methyl isobutyl ketone [or MIBK]	108-10-1	560	5600
Methyl methacrylate	80-62-6	25	250
Methyl parathion [or Parathion, methyl]	298-00-0	1.8	18
Methyl tert-butyl ether [or MTBE]	1634-04-4	50	500
Methyl(1,4-chlorophenoxy)propionic acid	7085-19-0	7	70
Methyl-4-chlorophenoxy acetic acid, 2-	94-74-6	3.5	35
Methyl-5-nitroaniline, 2-	99-55-8	10	1000
Methylaniline, 2-	95-53-4	50	5000
Methylene bis(2-chloroaniline), 4,4-	101-14-4	50	5000
Methylene bromide	74-95-3	70	700
Methylene chloride	75-09-2	*	***
Methylnaphthalene, 1-	90-12-0	20	200
Methylnaphthalene, 2-	91-57-6	20	200
Methylphenol, 2- [or o-Cresol]	95-48-7	35	350
Methylphenol, 3- [or m-Cresol]	108-39-4	35	350
Methylphenol, 4- [or p-Cresol]	106-44-5	4	40

Table V
Natural Attenuation Default Concentrations

Contaminant	CAS#	Groundwater Criteria (ug/L)	Natural Attenuation Default Source (ug/L)
Tetrachloroethane, 1,1,1,2-	630-20-6	1.3	130
Tetrachloroethane, 1,1,2,2-	79-34-5	0.2	20
Tetrachloroethene [or PCE]	127-18-4	*	***
Tetrachlorophenol, 2,3,4,6-	58-90-2	210	2100
Tetraethyl dithiopyrophosphate	3689-24-5	3.5	35
Thallium	7440-28-0	*	**
Thiocyanomethylthio-benzothiazole, 2-	21564-17-0	210	2100
Thiram	137-26-8	35	350
Tin	7440-31-5	4200	42000
Toluene	108-88-3	*	**
Toluene-2,4-diamine	95-80-7	100	10000
Toluidine, p-	106-49-0	150	15000
Total dissolved solids [or TDS]	C-010	*	**
Toxaphene	8001-35-2	*	***
Triallate	2303-17-5	91	910
Tributyltin oxide	56-35-9	10	100
Trichloro-1,2,2-trifluoroethane, 1,1,2- [or CFC 113]	76-13-1	500000	5000000
Trichloroacetic acid	76-03-9	300	3000
Trichlorobenzene, 1,2,3-	87-61-6	70	700
Trichlorobenzene, 1,2,4-	120-82-1	*	**
Trichlorobenzene, 1,3,5-	108-70-3	40	400
Trichloroethane, 1,1,1- [or Methyl chloroform]	71-55-6	*	**
Trichloroethane, 1,1,2-	79-00-5	*	***
Trichloroethene [or TCE]	79-01-6	*	***
Trichlorofluoromethane	75-69-4	2100	21000
Trichlorophenol, 2,4,5-	95-95-4	4	40
Trichlorophenol, 2,4,6-	88-06-2	3.2	320
Trichlorophenoxy acetic acid, 2,4,5-	93-76-5	70	700
Trichlorophenoxy propionic acid [or Silvex]	93-72-1	*	**
Trichloropropane, 1,2,3-	96-18-4	0.2	20

Table V
Natural Attenuation Default Concentrations

Contaminant	CAS#	Groundwater Criteria (ug/L)	Natural Attenuation Default Source (ug/L)
Trifluralin	1582-09-8	4.5	450
Trimethyl phosphate	512-56-1	50	5000
Trimethylbenzene, 1,2,3-	526-73-8	10	100
Trimethylbenzene, 1,2,4-	95-63-6	10	100
Trimethylbenzene, 1,3,5-	108-67-8	10	100
Trinitrobenzene, 1,3,5-	99-35-4	210	2100
Trinitrotoluene, 2,4,6-	118-96-7	10	1000
TRPH	NOCAS#	5000	50000
Uranium, natural	7440-61-1	21	210
Vanadium	7440-62-2	49	490
Vernam	1929-77-7	7	70
Vinyl acetate	108-05-4	88	880
Vinyl chloride	75-01-4	*	***
Xylenes, total	1330-20-7	*	**
Zinc	7440-66-6	*	**
Zinc chloride	7646-85-7	2100	21000
Zinc phosphide	1314-84-7	2.1	21
Zineb	12122-67-7	350	3500

* = As provided in Chapters 62-550 and 62-520, F.A.C.

** = Groundwater criteria in Chapter 62-550 and 62-520, F.A.C., multiplied by 10X.

*** = Groundwater criteria in Chapter 62-550 and 62-520, F.A.C., multiplied by 100X.

Note: Natural Attenuation Default Source Concentrations are developed by multiplying the Groundwater Criteria by 10 for non-carcinogens and by 100 for carcinogens, except in the case of carcinogenic elements where the Groundwater Criteria are multiplied by 10. For those contaminants that have both primary and secondary groundwater standards, the Groundwater Criteria and Natural Attenuation Default Source Concentrations are based on the lower of the two standards.

APPENDIX C

COST ESTIMATES

A.1: Technology 1: Soil Excavation, Offsite Treatment & Disposal
A.2: Technology 2: Soil Vapor Extraction
A.3: Technology 3a: Groundwater Natural Attenuation with Source Remediation
A.4: Technology 3b: Groundwater Natural Attenuation without Source Remediation
A.5: Technology 4: Groundwater Chemically-Enhanced Natural Attenuation
A.6: Technology 5: Source Area Air Sparging/Vapor Extraction
A.7: Technology 6: Groundwater Pump & Treat

APPENDIX C.1

COST ESTIMATE
TECHNOLOGY 1
SOIL EXCAVATION, OFFSITE TREATMENT & DISPOSAL

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 1: SOIL EXCAVATION, OFFSITE TREATMENT, AND DISPOSAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 MOBILIZATION/DEMOBILIZATION												
1.1 Equipment Mobilization/Demobilization	1	ls			$300.00	$1,000.00	$0	$0	$300	$1,000	$1,300	
1.2 Site Utilities	1	mo	$1,000.00				$1,000	$0	$0	$0	$1,000	
2 DECONTAMINATION												
2.1 Decontamination Trailer	1	mo	$1,500.00				$1,500	$0	$0	$0	$1,500	
2.2 Temporary Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
2.3 Spent Water Storage Tank	1	mo		$500.00	$264.00		$0	$500	$264	$0	$764	2000 Gallon
2.4 Waste Profile Decon Water	1	ea	$914.00				$914	$0	$0	$0	$914	
3 SITE PREPARATION												
3.1 Pavement Removal, 4" to 6" thick	42	sy			$2.32	$2.43	$0	$0	$97	$102	$200	
3.2 Pavement Disposal	10	cy	$50.00				$500	$0	$0	$0	$500	
4 EXCAVATION/BACKFILL												
4.1 Excavate/Load Contaminated Soil	1425	cy			$0.71	$1.19	$0	$0	$1,012	$1,696	$2,708	
4.2 Technician with OVA for duration of Excavation	5	days			$168.00	$184.30	$0	$0	$840	$922	$1,762	
4.3 Collect/Analyze Confirmatory Samples	40	ea	$565.00	$10.00	$24.78		$22,600	$400	$991	$0	$23,991	VOCs, SVOCs, TRPH, KAG
4.4 Import Clean Fill Material	1325	cy		$6.00			$0	$7,950	$0	$0	$7,950	
4.5 Place/Grade/Compact Fill Material	2	days			$454.40	$935.00	$0	$0	$909	$1,870	$2,779	
5 OFF-SITE TRANSPORTATION/DISPOSAL												
5.1 Temporary Truck Scale	0.5	mo				$2,862.00	$0	$0	$0	$1,431	$1,431	
5.2 Dispose of Soil	1820	ton	$75.00				$136,500	$0	$0	$0	$136,500	1.3 tons/cubic yard
5.3 Waste Profile	1	ls	$1,000.00				$1,000	$0	$0	$0	$1,000	
6 SITE RESTORATION												
6.1 Import Vegetative Cover Material	100	cy		$15.00			$0	$1,500	$0	$0	$1,500	
6.2 Place/Grade Vegetative Cover (6")	1	days			$227.20	$435.00	$0	$0	$227	$435	$662	
6.2 Vegetate Disturbed Area	5	msf		$35.53	$61.50		$0	$178	$308	$0	$485	seed and mulch by hand
6.3 Replace Asphalt Parking Lot	600	sf		$0.62	$0.11	$0.14	$0	$372	$66	$84	$522	
6.4 Replace Concrete Sidewalk	60	lf		$5.55	$6.55	$2.00	$0	$333	$393	$120	$846	
7 OFFICE SUPPORT/FIELD SUPPORT												
7.1 Field Oversight Personnel (2 people)	160	hours			$25.00		$0	$0	$4,000	$0	$4,000	
7.2 Office Oversight Personnel (2 people - 1/2 time)	80	hours			$35.00		$0	$0	$2,800	$0	$2,800	
8 PROJECT DOCUMENTATION												
8.1 Pre- and Post-Construction Submittals	200	hours			$35.00		$0	$0	$7,000	$0	$7,000	
Subtotal Direct Costs less Subcontract								$11,733	$19,657	$7,814	$39,204	
Overhead on Labor Cost @ 30%									$5,897		$5,897	
G & A on Labor Cost @ 10%									$1,966		$1,966	
G & A on Material Cost @ 10%								$1,173			$1,173	
Total Direct Cost								$12,906	$27,520	$7,814	$48,240	
Indirects on Total Direct Labor Cost @ 75%									$20,640		$20,640	
Profit on Total Direct Cost @ 10%											$4,824	
Subtotal											$73,704	
Health & Safety Monitoring @ 3%											$2,211	
Total Field Cost											**$75,915**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 1: SOIL EXCAVATION, OFFSITE TREATMENT, AND DISPOSAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
Subtotal Subcontractor Cost							$164,014				$164,014	
G & A on Subcontract Cost @ 10%							$16,401				$16,401	
Profit on Subcontractor Cost @ 5%											$8,201	
Subcontractor Cost											**$188,616**	
Contingency on Total Field and Subcontractor Costs @ 10%											**$26,453**	
Engineering on Total Field Cost @ 2%											**$1,518**	
TOTAL COST											**$292,502**	

APPENDIX C.2

COST ESTIMATE
TECHNOLOGY 2
SOIL VAPOR EXTRACTION

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 2: SOIL VAPOR EXTRACTION (SVE)

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 MOBILIZATION/DEMOBILIZATION												
1.1 Construction Survey (pre and post-construction)	2	ea	$410.00				$820	$0	$0	$0	$820	
1.2 Equipment Mobilization/Demobilization	1	ls	$2,000.00		$300.00	$1,000.00	$2,000	$0	$300	$1,000	$3,300	Drill rig, backhoe, boom truck
1.3 Site Utilities	2	mo	$1,000.00				$2,000	$0	$0	$0	$2,000	
2 DECONTAMINATION												
2.1 Temporary Decontamination Pad for Drill Rig	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
2.2 Spent Water Storage Tank	2	mo		$500.00	$264.00		$0	$1,000	$528	$0	$1,528	2000 gallon
2.3 Waste Profile Decon Water	1	ls	$914.00				$914	$0	$0	$0	$914	
3 WELL INSTALLATION												
3.1 Install Vapor Extraction Wells	42	ft	$22.75				$956	$0	$0	$0	$956	
3.2 Well Development	6	hr	$35.00				$210	$0	$0	$0	$210	
3.3 Collect/Containerize IDW	6	ea	$50.00				$300	$0	$0	$0	$300	
3.4 Transport/Dispose IDW Off Site	6	drums	$150.00				$900	$0	$0	$0	$900	
4 VAPOR EXTRACTION SYSTEM INSTALLATION												
4.1 Concrete Foundation (6")	500	sf		$2.74	$3.50	$0.67	$0	$1,370	$1,750	$335	$3,455	
4.2 Treatment system building	500	sf		$4.36	$0.93	$0.56	$0	$2,180	$465	$280	$2,925	20 x 25
4.3 Skid-Mounted Extraction Pump (2 hp) w/ Moist. Sep.	1	ls		$4,743.00	$290.00		$0	$4,743	$290	$0	$5,033	
4.4 Electric Drop	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000	
4.5 Vapor Extraction Piping (wells to treatment unit)	600	lf		$2.65	$2.07	$1.08	$0	$1,590	$1,242	$648	$3,480	
4.6 Vault Boxes and Misc Piping/Valves at Well Heads	6	ea		$600.00	$370.00		$0	$3,600	$2,220	$0	$5,820	
4.7 Off-gas Treatment System (GAC)	2	ea		$3,100.00			$0	$6,200	$0	$0	$6,200	1000 pound GAC each
4.8 Plumb/Electrify System	1	ls		$3,000.00	$2,580.00		$0	$3,000	$2,580	$0	$5,580	1 plumber, 1 electrician
4.9 System Start-up and Testing	1	ls		$1,000.00	$750.00		$0	$1,000	$750	$0	$1,750	
5 SITE RESTORATION												
5.1 Restore Asphalt Parking Area	200	lf		$2.28	$4.41	$0.62	$0	$456	$882	$124	$1,462	
5.2 Vegetate Disturbed Areas	1	ls		$250.00	$250.00		$0	$250	$250	$0	$500	
6 OFFICE SUPPORT/FIELD SUPPORT												
6.1 Field Oversight Personnel (2 people)	640	hours			$25.00		$0	$0	$16,000	$0	$16,000	
6.2 Office Oversight Personnel (2 people - 1/2 time)	320	hours			$35.00		$0	$0	$11,200	$0	$11,200	
7 PROJECT DOCUMENTATION												
7.1 Pre- and Post-Construction Submittals	300	hours			$35.00		$0	$0	$10,500	$0	$10,500	
Subtotal Direct Costs less Subcontract								$25,889	$49,407	$2,542	$77,838	
Overhead on Labor Cost @ 30%									$14,822		$14,822	
G & A on Labor Cost @ 10%									$4,941		$4,941	
G & A on Material Cost @ 10%								$2,589			$2,589	
Total Direct Cost								$28,478	$69,170	$2,542	$100,190	
Indirects on Total Direct Labor Cost @ 75%									$51,877		$51,877	
Profit on Total Direct Cost @ 10%											$10,019	
Subtotal											$162,086	
Health & Safety Monitoring @ 3%											$4,863	
Total Field Cost											**$166,949**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 2: SOIL VAPOR EXTRACTION (SVE)

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
Subtotal Subcontractor Cost							$10,100				$10,100	
G & A on Subcontract Cost @ 10%							$1,010				$1,010	
Profit on Subcontractor Cost @ 5%											$505	
Subcontractor Cost											**$11,614**	
Contingency on Total Field and Subcontractor Costs @ 10%											**$17,856**	
Engineering on Total Field Cost @ 4%											**$6,678**	
TOTAL COST											**$203,097**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 2: SOIL VAPOR EXTRACTION (SVE)
Operation, Maintenance, and Monitoring Costs for One Year Operation

	Item	Unit	Unit Cost	Year 1 Qty	Year 2 Qty	Year 1 Cost	Year 2 Cost	Notes
1	Energy - Electric	kWh	$0.06	13,070	13,070	$784	$784	2 hp
2	Maintenance	ls	$1,493.15	1	1	$1,493	$1,493	5% of Installation Cost
3	Carbon Unit Changeout/Regeneration of Spent Carbon	pound	$3.00	4000	3000	$12,000	$9,000	7 times during life of system
4	Labor, Mobilization/Demobilization, Per Diem, Supplies	mo	$925.00	8	10	$7,400	$9,250	1 visit per month - 1 day
5	Labor, Mobilization/Demobilization, Per Diem, Supplies	mo	$2,175.00	4	2	$8,700	$4,350	1 visit per quarter - 2 laborers, 3 days
6	Analysis of Off-gas samples	ea	$250.00	12	12	$3,000	$3,000	1 per month, VOCs
7	Analysis of Soil samples	ea	$565.00	12	6	$6,780	$3,390	3 per quarter, VOCs, SVOCs, TRPH, KOG
8	Quarterly Reports	ea	$3,000.00	4	4	$12,000	$12,000	
	Total Cost for One Year Operation					$52,157	$43,267	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 2: SOIL VAPOR EXTRACTION (SVE)
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$203,097		$203,097	1.000	$203,097
1		$52,157	$52,157	0.935	$48,767
2		$43,267	$43,267	0.873	$37,772
				TOTAL PRESENT WORTH	**$289,637**

APPENDIX C.3

COST ESTIMATE
TECHNOLOGY 3a
GROUNDWATER NATURAL ATTENUATION WITH SOURCE REMEDIATION

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 3A: GROUNDWATER NATURAL ATTENUATION WITH SOURCE REMEDIATION

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 MOBILIZATION/DEMOBILIZATION												
1.1 Mobilize/Demobilize Drill Rig	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000	
1.2 Site Utilities	1	mo	$1,000.00				$1,000	$0	$0	$0	$1,000	
2 DECONTAMINATION												
2.1 Temporary Decontamination Pad for Drill Rig	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
2.2 Spent Water Storage Tank	1	mo		$500.00	$264.00		$0	$500	$264	$0	$764	2000 gallon
2.3 Waste Profile Decon Water	1	ls	$914.00				$914	$0	$0	$0	$914	
3 WELL INSTALLATION												
3.1 Install Monitoring Wells (Mud Rotary) - 2" PVC	190	lf	$23.75				$4,513	$0	$0	$0	$4,513	
3.2 Well Development	15	hour	$35.00				$525	$0	$0	$0	$525	
3.3 Collect/Containerize IDW	3	ea	$50.00				$150	$0	$0	$0	$150	
3.4 Transport/Dispose IDW Off Site	6	drums	$150.00				$900	$0	$0	$0	$900	
3.5 Stick-up Pads w/ Posts	3	ea	$500.00				$1,500	$0	$0	$0	$1,500	
3.6 Survey Well Locations	1	ls	$410.00				$410	$0	$0	$0	$410	
4 GROUNDWATER SAMPLING AND ANALYSIS												
4.1 Collect Samples	3	days		$150.00	$336.00	$100.00	$0	$450	$1,008	$300	$1,758	5 wells per day, 2 laborers
4.2 Sample Analysis - standard turn around time	14	ea	$665.00				$9,310	$0	$0	$0	$9,310	KAG
5 OFFICE SUPPORT/FIELD SUPPORT												
5.1 Field Oversight Personnel (2 people)	160	hours			$25.00		$0	$0	$4,000	$0	$4,000	
5.2 Office Oversight Personnel (2 people - 1/2 time)	80	hours			$35.00		$0	$0	$2,800	$0	$2,800	
6 PROJECT DOCUMENTATION												
6.1 Pre- and Post-Construction Submittals	320	hours			$35.00		$0	$0	$11,200	$0	$11,200	
Subtotal Direct Costs less Subcontract								$1,450	$19,722	$455	$21,627	
Overhead on Labor Cost @ 30%									$5,917		$5,917	
G & A on Labor Cost @ 10%									$1,972		$1,972	
G & A on Material Cost @ 10%								$145			$145	
Total Direct Cost								$1,595	$27,611	$455	$29,661	
Indirects on Total Direct Labor Cost @ 75%									$20,708		$20,708	
Profit on Total Direct Cost @ 10%											$2,966	
Subtotal											$53,335	
Health & Safety Monitoring @ 3%											$1,600	
Total Field Cost											**$54,935**	
Subtotal Subcontractor Cost							$21,222				$21,222	
G & A on Subcontract Cost @ 10%							$2,122				$2,122	
Profit on Subcontractor Cost @ 5%											$1,061	
Subcontractor Cost											**$24,405**	
Contingency on Total Field and Subcontractor Costs @ 10%											**$7,934**	
Engineering on Total Field Cost @ 4%											**$2,197**	
TOTAL COST											**$89,471**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 3A: GROUNDWATER NATURAL ATTENUATION WITH SOURCE REMEDIATION
Operation and Maintenance Costs

	Item	Unit	Unit Cost	Year 1 Qty	Year 2 Qty	Year 3 Qty	Year 4 Qty	Year 5 Qty	Year 6 Qty	Year 7 Qty	Year 8 Qty	Year 9 Qty	Year 10 Qty	Year 11 Qty	Year 12 Qty	Year 13 Qty	Year 14 Qty	Year 15 Qty	Notes
1	Sampling - Personnel	Trip	$3,000	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
2	Analysis/Water - KAG analysis	sample	$665.00	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
3	Analysis/Water - Natural attenuation analysis	trip	$7,000.00	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	
4	Report	each	$3,000.00	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
5	Site Review	each	$5,000.00					1					1					1	

		Year 1 Cost	Year 2 Cost	Year 3 Cost	Year 4 Cost	Year 5 Cost	Year 6 Cost	Year 7 Cost	Year 8 Cost	Year 9 Cost	Year 10 Cost	Year 11 Cost	Year 12 Cost	Year 13 Cost	Year 14 Cost	Year 15 Cost
1	Sampling - Personnel	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
2	Analysis/Water - KAG analysis	$2,660	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330
3	Analysis/Water - Natural attenuation analysis	$14,000	$14,000	$14,000	$14,000	$14,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
4	Report	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
5	Site Review	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000
	Total	$40,660	$27,330	$27,330	$27,330	$32,330	$20,330	$20,330	$20,330	$20,330	$25,330	$20,330	$20,330	$20,330	$20,330	$25,330

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 3A: GROUNDWATER NATURAL ATTENUATION WITH SOURCE REMEDIATION
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$89,471		$89,471	1.000	$89,471
1		$40,660	$40,660	0.935	$38,017
2		$27,330	$27,330	0.873	$23,859
3		$27,330	$27,330	0.816	$22,301
4		$27,330	$27,330	0.763	$20,853
5		$32,330	$32,330	0.713	$23,051
6		$20,330	$20,330	0.666	$13,540
7		$20,330	$20,330	0.623	$12,666
8		$20,330	$20,330	0.582	$11,832
9		$20,330	$20,330	0.544	$11,060
10		$25,330	$25,330	0.508	$12,868
11		$20,330	$20,330	0.475	$9,657
12		$20,330	$20,330	0.444	$9,027
13		$20,330	$20,330	0.415	$8,437
14		$20,330	$20,330	0.388	$7,888
15		$25,330	$25,330	0.362	$9,169
				TOTAL PRESENT WORTH	**$323,695**

APPENDIX C.4

COST ESTIMATE
TECHNOLOGY 3b
GROUNDWATER NATURAL ATTENUATION WITHOUT SOURCE REMEDIATION

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 3B: GROUNDWATER NATURAL ATTENUATION WITHOUT SOURCE REMEDIATION

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 MOBILIZATION/DEMOBILIZATION												
1.1 Mobilize/Demobilize Drill Rig	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000	
1.2 Site Utilities	1	mo	$1,000.00				$1,000	$0	$0	$0	$1,000	
2 DECONTAMINATION												
2.1 Temporary Decontamination Pad for Drill Rig	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
2.2 Spent Water Storage Tank	1	mo		$500.00	$264.00		$0	$500	$264	$0	$764	2000 gallon
2.3 Waste Profile Decon Water	1	ls	$914.00				$914	$0	$0	$0	$914	
3 WELL INSTALLATION												
3.1 Install Monitoring Wells (Mud Rotary) - 2" PVC	190	lf	$23.75				$4,513	$0	$0	$0	$4,513	
3.2 Well Development	15	hour	$35.00				$525	$0	$0	$0	$525	
3.3 Collect/Containerize IDW	3	ea	$50.00				$150	$0	$0	$0	$150	
3.4 Transport/Dispose IDW Off Site	6	drums	$150.00				$900	$0	$0	$0	$900	
3.5 Stick-up Pads w/ Posts	3	ea	$500.00				$1,500	$0	$0	$0	$1,500	
3.6 Survey Well Locations	1	ls	$410.00				$410	$0	$0	$0	$410	
4 GROUNDWATER SAMPLING AND ANALYSIS												
4.1 Collect Samples	3	days		$150.00	$336.00	$100.00	$0	$450	$1,008	$300	$1,758	5 wells per day, 2 laborers
4.2 Sample Analysis - standard turn around time	14	ea	$665.00				$9,310	$0	$0	$0	$9,310	KAG
5 OFFICE SUPPORT/FIELD SUPPORT												
5.1 Field Oversight Personnel (2 people)	160	hours			$25.00		$0	$0	$4,000	$0	$4,000	
5.2 Office Oversight Personnel (2 people - 1/2 time)	80	hours			$35.00		$0	$0	$2,800	$0	$2,800	
6 PROJECT DOCUMENTATION												
6.1 Pre- and Post-Construction Submittals	320	hours			$35.00		$0	$0	$11,200	$0	$11,200	
Subtotal Direct Costs less Subcontract								$1,450	$19,722	$455	$21,627	
Overhead on Labor Cost @ 30%									$5,917		$5,917	
G & A on Labor Cost @ 10%									$1,972		$1,972	
G & A on Material Cost @ 10%								$145			$145	
Total Direct Cost								$1,595	$27,611	$455	$29,661	
Indirects on Total Direct Labor Cost @ 75%									$20,708		$20,708	
Profit on Total Direct Cost @ 10%											$2,966	
Subtotal											$53,335	
Health & Safety Monitoring @ 3%											$1,600	
Total Field Cost											**$54,935**	
Subtotal Subcontractor Cost							$21,222				$21,222	
G & A on Subcontract Cost @ 10%							$2,122				$2,122	
Profit on Subcontractor Cost @ 5%											$1,061	
Subcontractor Cost											**$24,405**	
Contingency on Total Field and Subcontractor Costs @ 10%											**$7,934**	
Engineering on Total Field Cost @ 4%											**$2,197**	
TOTAL COST											**$89,471**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 3B: GROUNDWATER NATURAL ATTENUATION WITHOUT SOURCE REMEDIATION
Operation and Maintenance Costs

	Item	Unit	Unit Cost	Year 1 Qty	Year 2 Qty	Year 3 Qty	Year 4 Qty	Year 5 Qty	Year 6 Qty	Year 7 Qty	Year 8 Qty	Year 9 Qty	Year 10 Qty	Year 11 Qty	Year 12 Qty	Year 13 Qty	Year 14 Qty	Year 15 Qty	Notes
1	Sampling - Personnel	Trip	$3,000	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
2	Analysis/Water - KAG analysis	sample	$665.00	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
3	Analysis/Water - Natural attenuation analysis	trip	$7,000.00	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	
4	Report	each	$3,000.00	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
5	Site Review	each	$5,000.00					1					1					1	

		Year 1 Cost	Year 2 Cost	Year 3 Cost	Year 4 Cost	Year 5 Cost	Year 6 Cost	Year 7 Cost	Year 8 Cost	Year 9 Cost	Year 10 Cost	Year 11 Cost	Year 12 Cost	Year 13 Cost	Year 14 Cost	Year 15 Cost
1	Sampling - Personnel	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
2	Analysis/Water - KAG analysis	$2,660	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330
3	Analysis/Water - Natural attenuation analysis	$14,000	$14,000	$14,000	$14,000	$14,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
4	Report	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
5	Site Review	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000
	Total	$40,660	$27,330	$27,330	$27,330	$32,330	$20,330	$20,330	$20,330	$20,330	$25,330	$20,330	$20,330	$20,330	$20,330	$25,330

	Item	Unit	Unit Cost	Year 16 Qty	Year 17 Qty	Year 18 Qty	Year 19 Qty	Year 20 Qty	Year 21 Qty	Year 22 Qty	Year 23 Qty	Year 24 Qty	Year 25 Qty	Year 26 Qty	Year 27 Qty	Year 28 Qty	Year 29 Qty	Year 30 Qty
1	Sampling - Personnel	Trip	$3,000	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	Analysis/Water - KAG analysis	sample	$665.00	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	Analysis/Water - Natural attenuation analysis	trip	$7,000.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	Report	each	$3,000.00	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	Site Review	each	$5,000.00					1					1					1

		Year 16 Cost	Year 17 Cost	Year 18 Cost	Year 19 Cost	Year 20 Cost	Year 21 Cost	Year 22 Cost	Year 23 Cost	Year 24 Cost	Year 25 Cost	Year 26 Cost	Year 27 Cost	Year 28 Cost	Year 29 Cost	Year 30 Cost
1	Sampling - Personnel	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
2	Analysis/Water - KAG analysis	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330	$1,330
3	Analysis/Water - Natural attenuation analysis	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
4	Report	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
5	Site Review	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000
	Total	$20,330	$20,330	$20,330	$20,330	$25,330	$20,330	$20,330	$20,330	$20,330	$25,330	$20,330	$20,330	$20,330	$20,330	$25,330

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 3B: GROUNDWATER NATURAL ATTENUATION WITHOUT SOURCE REMEDIATION
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$89,471		$89,471	1.000	$89,471
f		$40,660	$40,660	0.935	$38,017
2		$27,330	$27,330	0.873	$23,859
3		$27,330	$27,330	0.816	$22,301
4		$27,330	$27,330	0.763	$20,853
5		$32,330	$32,330	0.713	$23,051
6		$20,330	$20,330	0.666	$13,540
7		$20,330	$20,330	0.623	$12,666
8		$20,330	$20,330	0.582	$11,832
9		$20,330	$20,330	0.544	$11,060
10		$25,330	$25,330	0.508	$12,868
11		$20,330	$20,330	0.475	$9,657
12		$20,330	$20,330	0.444	$9,027
13		$20,330	$20,330	0.415	$8,437
14		$20,330	$20,330	0.388	$7,888
15		$25,330	$25,330	0.362	$9,169
16		$20,330	$20,330	0.339	$6,892
17		$20,330	$20,330	0.317	$6,445
18		$20,330	$20,330	0.296	$6,018
19		$20,330	$20,330	0.277	$5,631
20		$25,330	$25,330	0.258	$6,535
21		$20,330	$20,330	0.242	$4,920
22		$20,330	$20,330	0.226	$4,595
23		$20,330	$20,330	0.211	$4,290
24		$20,330	$20,330	0.197	$4,005
25		$25,330	$25,330	0.184	$4,661
26		$20,330	$20,330	0.172	$3,497
27		$20,330	$20,330	0.161	$3,273
28		$20,330	$20,330	0.154	$3,131
29		$20,330	$20,330	0.141	$2,867
30		$25,330	$25,330	0.131	$3,318
				TOTAL PRESENT WORTH	**$393,771**

APPENDIX C.5

COST ESTIMATE
TECHNOLOGY 4
GROUNDWATER CHEMICALLY-ENHANCED NATURAL ATTENUATION

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 4: GROUNDWATER CHEMICALLY-ENHANCED NATURAL ATTENUATION

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 MOBILIZATION/DEMOBILIZATION												
1.1 Mobilize/Demobilize Drill Rig	1	ls	$4,000.00				$4,000	$0	$0	$0	$4,000	Mud Rotary Rig and DP Rig
1.2 Site Utilities	2	mo	$1,000.00				$2,000	$0	$0	$0	$2,000	
2 DECONTAMINATION												
2.1 Temporary Decontamination Pad for Drill Rig	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
2.2 Spent Water Storage Tank	2	mo		$500.00	$264.00		$0	$1,000	$528	$0	$1,528	2000 gallon
2.3 Waste Profile Decon Water	1	ls	$914.00				$914	$0	$0	$0	$914	
3 WELL INSTALLATION												
3.1 Install Monitoring Wells (Mud Rotary) - 2" PVC	190	lf	$23.75				$4,513	$0	$0	$0	$4,513	
3.2 Well Development	15	hour	$35.00				$525	$0	$0	$0	$525	
3.3 Collect/Containerize IDW	3	ea	$50.00				$150	$0	$0	$0	$150	
3.4 Transport/Dispose IDW Off Site	6	drums	$150.00				$900	$0	$0	$0	$900	
3.5 Stick-up Pads w/ Posts	3	ea	$500.00				$1,500	$0	$0	$0	$1,500	
3.6 Survey Well Locations	1	ls	$410.00				$410	$0	$0	$0	$410	
4 GROUNDWATER SAMPLING AND ANALYSIS												
4.1 Collect Samples	3	days		$150.00	$336.00	$100.00	$0	$450	$1,008	$300	$1,758	5 wells per day, 2 laborers
4.2 Sample Analysis - standard turn around time	14	ea	$665.00				$9,310	$0	$0	$0	$9,310	VOCs, SVOCs, TRPH, KOG
5 GROUNDWATER SEEDING												
5.1 Direct Push Drilling	14000	lf	$6.00				$84,000	$0	$0	$0	$84,000	
5.2 Seed	2000	pounds	$1.34				$2,680	$0	$0	$0	$2,680	
6 OFFICE SUPPORT/FIELD SUPPORT												
6.1 Field Oversight Personnel (2 people)	640	hours			$25.00		$0	$0	$16,000	$0	$16,000	
6.2 Office Oversight Personnel (2 people - 1/2 time)	320	hours			$35.00		$0	$0	$11,200	$0	$11,200	
7 PROJECT DOCUMENTATION												
7.1 Pre- and Post-Construction Submittals	320	hours			$35.00		$0	$0	$11,200	$0	$11,200	
Subtotal Direct Costs less Subcontract								$1,950	$40,386	$455	$42,791	
Overhead on Labor Cost @ 30%									$12,116		$12,116	
G & A on Labor Cost @ 10%									$4,039		$4,039	
G & A on Material Cost @ 10%								$195			$195	
Total Direct Cost								$2,145	$56,540	$455	$59,140	
Indirects on Total Direct Labor Cost @ 75%									$42,405		$42,405	
Profit on Total Direct Cost @ 10%											$5,914	
Subtotal											$107,460	
Health & Safety Monitoring @ 3%											$3,224	
Total Field Cost											**$110,684**	
Subtotal Subcontractor Cost							$110,902				$110,902	
G & A on Subcontract Cost @ 10%							$11,090				$11,090	
Profit on Subcontractor Cost @ 5%											$5,545	
Subcontractor Cost											**$127,537**	
Contingency on Total Field and Subcontractor Costs @ 10%											**$23,822**	
Engineering on Total Field Cost @ 4%											**$4,427**	
TOTAL COST											**$266,470**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 4: GROUNDWATER CHEMICALLY-ENHANCED NATURAL ATTENUATION
Operation and Maintenance Costs

	Item	Unit	Unit Cost	Year 1 Qty	Year 2 Qty	Year 3 Qty	Year 4 Qty	Year 5 Qty	Year 6 Qty	Year 7 Qty	Year 8 Qty	Year 9 Qty	Year 10 Qty	Year 11 Qty	Year 12 Qty	Year 13 Qty	Year 14 Qty	Year 15 Qty	Notes
1	Maintenance Seeding	pound	$1.34	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	10 pounds/well, 14 wells per quarter
2	Maintenance Labor	day	$450.00	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	2 laborers, 2 days per site visit
3	Maintenance Mobilization/Demobilization/ Per Diem	trip	$2,000.00	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
4	Sampling Labor, Mobilization/ Demobilization, Per Diem, Supplies	trip	$3,000	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
5	Analysis/Water - KAG analysis	sample	$665.00	56	28	28	28	28	28	28	28	28	28	28	28	28	28	28	14 wells per trip
6	Analysis/Water - Natural attenuation analysis	trip	$7,000.00	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	
7	Report	each	$3,000.00	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
8	Site Review	each	$5,000.00					1					1					1	

		Year 1 Cost	Year 2 Cost	Year 3 Cost	Year 4 Cost	Year 5 Cost	Year 6 Cost	Year 7 Cost	Year 8 Cost	Year 9 Cost	Year 10 Cost	Year 11 Cost	Year 12 Cost	Year 13 Cost	Year 14 Cost	Year 15 Cost
1	Maintenance Seeding	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
2	Maintenance Labor	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600
3	Maintenance Mobilization/Demobilization/ Per Diem	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000
4	Sampling Labor, Mobilization/ Demobilization, Per Diem, Supplies	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
5	Analysis/Water - KAG analysis	$37,240	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620
6	Analysis/Water - Natural attenuation analysis	$14,000	$14,000	$14,000	$14,000	$14,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
7	Report	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
8	Site Review	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000
	Total	$86,915	$56,295	$56,295	$56,295	$61,295	$49,295	$49,295	$49,295	$49,295	$54,295	$49,295	$49,295	$49,295	$49,295	$54,295

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 4: GROUNDWATER CHEMICALLY-ENHANCED NATURAL ATTENUATION
Present Worth Analysis

Year	Capital Cost	eratioin and Maintenan Sampling Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$266,470		$266,470	1.000	$266,470
1		$86,915	$86,915	0.935	$81,266
2		$56,295	$56,295	0.873	$49,146
3		$56,295	$56,295	0.816	$45,937
4		$56,295	$56,295	0.763	$42,953
5		$61,295	$61,295	0.713	$43,703
6		$49,295	$49,295	0.666	$32,830
7		$49,295	$49,295	0.623	$30,711
8		$49,295	$49,295	0.582	$28,690
9		$49,295	$49,295	0.544	$26,817
10		$54,295	$54,295	0.508	$27,582
11		$49,295	$49,295	0.475	$23,415
12		$49,295	$49,295	0.444	$21,887
13		$49,295	$49,295	0.415	$20,457
14		$49,295	$49,295	0.388	$19,126
15		$54,295	$54,295	0.362	$19,655
				TOTAL PRESENT WORTH	**$780,644**

APPENDIX C.6

COST ESTIMATE
TECHNOLOGY 5
SOURCE AREA AIR SPARGING/VAPOR EXTRACTION

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 5: SOURCE AREA AIR SPARGING/VAPOR EXTRACTION (AS/VE)

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 MOBILIZATION/DEMOBILIZATION												
1.1 Construction Survey (pre and post-construction)	2	ea	$410.00				$820	$0	$0	$0	$820	1/2 acre
1.2 Equipment Mobilization/Demobilization	1	ls	$2,000.00		$300.00	$1,000.00	$2,000	$0	$300	$1,000	$3,300	Drill Rig, Backhoe, Boom Truck
1.3 Site Utilities	2	mo	$1,000.00				$2,000	$0	$0	$0	$2,000	
2 DECONTAMINATION												
2.1 Temporary Decontamination Pad for Drill Rig	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
2.2 Spent Water Storage Tank	2	mo		$500.00	$264.00		$0	$1,000	$528	$0	$1,528	2000 Gallon
2.3 Waste Profile Decon Water	1	ea	$914.00				$914	$0	$0	$0	$914	
3 PILOT SCALE TREATABILITY STUDY												
3.1 Design, Install, and Test Pilot Scale AS/VE System	1	ls	$5,000.00		$10,000.00	$10,000.00	$5,000	$0	$10,000	$10,000	$25,000	
4 MONITORING WELL INSTALLATION												
4.1 Install Monitoring Wells (Mud Rotary) - 2" PVC	190	lf	$23.75				$4,513	$0	$0	$0	$4,513	
4.2 Well Development	15	hour	$35.00				$525	$0	$0	$0	$525	
4.3 Collect/Containerize IDW	3	ea	$50.00				$150	$0	$0	$0	$150	
4.4 Transport/Dispose IDW Off Site	6	drums	$150.00				$900	$0	$0	$0	$900	
4.5 Stick-up Pads w/ Posts	3	ea	$500.00				$1,500	$0	$0	$0	$1,500	
4.6 Collect Groundwater Samples	5	days		$150.00	$336.00	$100.00	$0	$750	$1,680	$500	$2,930	5 wells per day, 2 laborers
4.7 Analyze Groundwater Samples	24	ea	$665.00				$15,960	$0	$0	$0	$15,960	VOCs, SVOCs, TRPHs, KAG
5 TREATMENT SYSTEM WELL INSTALLATION												
5.1 Install Sparge Wells (Mud Rotary) - 2" PVC	570	lf	$23.75				$13,538	$0	$0	$0	$13,538	
5.2 Install Extraction Wells (HSA) - 2" PVC	112	lf	$22.75				$2,548	$0	$0	$0	$2,548	
5.3 Well Development	45	hour	$35.00				$1,575	$0	$0	$0	$1,575	
5.4 Collect/Containerize IDW	3	ea	$50.00				$150	$0	$0	$0	$150	
5.5 Transport/Dispose IDW Off Site	15	drums	$150.00				$2,250	$0	$0	$0	$2,250	
6 TREATMENT SYSTEM INSTALLATION AND START-UP												
6.1 Air sparging compressor (100 cfm, 30 hp)	1	ls	$400.00	$11,595.00			$400	$11,595	$0	$0	$11,995	
6.2 Vapor Extraction pump w/ moisture separator (200 cfm, 5 h	1	ls	$200.00	$8,000.00			$200	$8,000	$0	$0	$8,200	
6.3 Granular activated carbon treatment units	2	ea		$4,685.00			$0	$9,370	$0	$0	$9,370	2000 pounds each
6.4 Concrete Foundation (6")	500	sf		$2.74	$3.50	$0.67	$0	$1,370	$1,750	$335	$3,455	
6.5 Treatment system building	500	sf		$4.36	$0.93	$0.56	$0	$2,180	$465	$280	$2,925	20 x 25
6.6 Vault boxes and misc. piping/valves at well heads	27	ea		$600.00	$370.00		$0	$16,200	$9,990	$0	$26,190	
6.7 Injection/Extraction Pipe Installation	1500	lf		$2.65	$2.07	$1.08	$0	$3,975	$3,105	$1,620	$8,700	
6.8 System Electric	1	ls	$6,800.00				$6,800	$0	$0	$0	$6,800	
6.9 Plumb System	1	ls		$2,500.00	$2,608.00		$0	$2,500	$2,608	$0	$5,108	2 plumbers + materials, 1 week
6.10 System Start-up and Testing	1	ls		$500.00	$2,608.00		$0	$500	$2,608	$0	$3,108	
7 SITE RESTORATION												
7.1 Restore Asphalt Parking Area	750	lf		$2.28	$4.41	$0.62	$0	$1,710	$3,308	$465	$5,483	
7.2 Vegetate Disturbed Areas	1	ls		$250.00	$250.00		$0	$250	$250	$0	$500	
8 GROUNDWATER SAMPLING AND ANALYSIS												
8.1 Collect Samples	3	days		$150.00	$336.00	$100.00	$0	$450	$1,008	$300	$1,758	5 wells per day, 2 laborers
8.2 Sample Analysis - standard turn around time	14	ea	$665.00				$9,310	$0	$0	$0	$9,310	KAG
9 OFFICE SUPPORT/FIELD SUPPORT												
9.1 Field Oversight Personnel (2 people)	640	hours			$25.00		$0	$0	$16,000	$0	$16,000	
9.2 Office Oversight Personnel (2 people - 1/2 time)	320	hours			$35.00		$0	$0	$11,200	$0	$11,200	
10 PROJECT DOCUMENTATION												
10.1 Pre- and Post-Construction Submittals	300	hours			$35.00		$0	$0	$10,500	$0	$10,500	
Subtotal Direct Costs less Subcontract								$60,350	$75,750	$14,655	$150,755	
Overhead on Labor Cost @ 30%									$22,725		$22,725	
G & A on Labor Cost @ 10%									$7,575		$7,575	
G & A on Material Cost @ 10%								$6,035			$6,035	
Total Direct Cost								$66,385	$106,049	$14,655	$187,089	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 5: SOURCE AREA AIR SPARGING/VAPOR EXTRACTION (AS/VE)

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
Indirects on Total Direct Labor Cost @ 75%									$79,537		$79,537	
Profit on Total Direct Cost @ 10%											$18,709	
Subtotal											$285,335	
Health & Safety Monitoring @ 3%											$8,560	
Total Field Cost											**$293,895**	
Subtotal Subcontractor Cost							$71,052				$71,052	
G & A on Subcontract Cost @ 10%							$7,105				$7,105	
Profit on Subcontractor Cost @ 5%											$3,553	
Subcontractor Cost											**$81,710**	
Contingency on Total Field and Subcontractor Costs @ 10%											**$37,561**	
Engineering on Total Field Cost @ 4%											**$11,756**	
TOTAL COST											**$424,921**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 5: SOURCE AREA AIR SPARGING/VAPOR EXTRACTION (AS/VE)
Present Worth Analysis

Year	Capital Cost	Operation & Maint. Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$424,921		$424,921	1.000	$424,921
1		$118,347	$118,347	0.935	$110,654
2		$60,037	$60,037	0.873	$52,412
3		$55,797	$55,797	0.816	$45,530
4		$55,797	$55,797	0.763	$42,573
5		$60,797	$60,797	0.713	$43,348
6		$55,797	$55,797	0.666	$37,160
7		$55,797	$55,797	0.623	$34,761
8		$55,797	$55,797	0.582	$32,474
9		$55,797	$55,797	0.544	$30,353
10		$60,797	$60,797	0.508	$30,885
11		$55,797	$55,797	0.475	$26,503
12		$55,797	$55,797	0.444	$24,774
			TOTAL PRESENT WORTH		**$936,348**

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 5: SOURCE AREA AIR SPARGING/VAPOR EXTRACTION (AS/VE)
Operation, Maintenance, and Monitoring Costs for One Year Operation

	Item	Unit	Unit Cost	Year 1 Qty	Year 2 Qty	Year 3 Qty	Year 4 Qty	Year 5 Qty	Year 6 Qty	Year 7 Qty	Year 8 Qty	Year 9 Qty	Year 10 Qty	Year 11 Qty	Year 12 Qty	Notes
1	Energy - Electric	kWh	$0.06	228,725	228,725	228,725	228,725	228,725	228,725	228,725	228,725	228,725	228,725	228,725	228,725	35 hp
2	Maintenance	ls	$1,003.03	1	1	1	1	1	1	1	1	1	1	1	1	5% of Installation Cost
3	Carbon Unit Changeout/Regeneration of Spent Carbon	pound	$3.00	8,000												4 times during life of system
4	Groundwater and Offgas sampling - Labor, Mobilization/Demobilization, Per Diem, Supplies	mo	$2,850.00	4	2	2	2	2	2	2	2	2	2	2	2	Per visit - 2 laborers, 3 days
5	Offgas Sampling - Labor, Mobilization/Demobilization, Per Diem, Supplies	mo	$975.00	8	10	10	10	10	10	10	10	10	10	10	10	Per visit - 1 laborer, 1 day
6	Soil Sampling - Labor,Per Diem, Supplies	mo	$425.00	4	2											Per visit - 1 day
7	Carbon Unit Changeout - Labor, Per Diem, Supplies	mo	$425.00	4												Per visit - 1 day
8	Analysis of Off-gas samples	ea	$250.00	4	4	4	4	4	4	4	4	4	4	4	4	Analyze for VOCs
9	Analysis of Soil samples	ea	$565.00	12	6											Analyze samples for VOCs, SVOCs, TRPHs, and KAG; 3 per quarter
10	Analysis of Groundwater samples	ea	$665.00	56	28	28	28	28	28	28	28	28	28	28	28	Analyze samples for VOCs, SVOCs, TRPHs, and KAG, 10 per quarter
11	Sampling Event Reports	ea	$3,000.00	4	2	2	2	2	2	2	2	2	2	2	2	Following each sampling event
12	Five Year Evaluation Report	ea	$5,000.00					1					1			

		Year 1 Cost	Year 2 Cost	Year 3 Cost	Year 4 Cost	Year 5 Cost	Year 6 Cost	Year 7 Cost	Year 8 Cost	Year 9 Cost	Year 10 Cost	Year 11 Cost	Year 12 Cost
1	Energy - Electric	$13,724	$13,724	$13,724	$13,724	$13,724	$13,724	$13,724	$13,724	$13,724	$13,724	$13,724	$13,724
2	Maintenance	$1,003	$1,003	$1,003	$1,003	$1,003	$1,003	$1,003	$1,003	$1,003	$1,003	$1,003	$1,003
3	Carbon Unit Changeout/Regeneration of Spent Carbon	$24,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	Groundwater and Offgas sampling - Labor, Mobilization/Demobilization, Per Diem, Supplies	$11,400	$5,700	$5,700	$5,700	$5,700	$5,700	$5,700	$5,700	$5,700	$5,700	$5,700	$5,700
5	Offgas Sampling - Labor, Mobilization/Demobilization, Per Diem, Supplies	$7,800	$9,750	$9,750	$9,750	$9,750	$9,750	$9,750	$9,750	$9,750	$9,750	$9,750	$9,750
6	Soil Sampling - Labor,Per Diem, Supplies	$1,700	$850	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7	Carbon Unit Changeout - Labor, Per Diem, Supplies	$1,700	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
8	Analysis of Off-gas samples	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
9	Analysis of Soil samples	$6,780	$3,390	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10	Analysis of Groundwater samples	$37,240	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620	$18,620
11	Sampling Event Reports	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
12	Five Year Evaluation Report	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000	$0	$0
	Total Annual Cost	$118,347	$60,037	$55,797	$55,797	$60,797	$55,797	$55,797	$55,797	$55,797	$60,797	$55,797	$55,797

APPENDIX C.7

COST ESTIMATE
TECHNOLOGY 6
GROUNDWATER PUMP & TREAT

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 6: GROUNDWATER PUMP AND TREAT

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 MOBILIZATION/DEMOBILIZATION												
1.1 Construction Survey (pre and post-construction)	2	ea	$1,634.00				$3,268	$0	$0	$0	$3,268	
1.2 Equipment Mobilization/Demobilization	1	ls	$2,000.00		$300.00	$1,000.00	$2,000	$0	$300	$1,000	$3,300	Drill rig, backhoe, boom truck
1.3 Site Utilities	2	mo	$1,000.00				$2,000	$0	$0	$0	$2,000	
2 DECONTAMINATION												
2.1 Temporary Decontamination Pad for Drill Rig	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
2.2 Spent Water Storage Tank	2	mo		$500.00	$264.00		$0	$1,000	$528	$0	$1,528	2000 gallon
2.3 Waste Profile Decon Water	1	ls	$914.00				$914	$0	$0	$0	$914	
3 GROUNDWATER PUMPING TEST												
3.1 Perform Groundwater Pumping Test	1	ls	$2,000.00		$5,000.00	$5,000.00	$2,000	$0	$5,000	$5,000	$12,000	
4 WELL INSTALLATION												
4.1 Install Groundwater Extraction Wells - 4" PVC (HSA)	25	ft	$30.00				$750	$0	$0	$0	$750	
4.2 Install Groundwater Extraction Wells - 4" PVC (Mud Rotary)	240	ft	$30.75				$7,380	$0	$0	$0	$7,380	
4.3 Install Groundwater Monitoring Wells - 2" PVC (Mud Rotary)	190	ft	$23.75				$4,513	$0	$0	$0	$4,513	
4.4 Well Development	35	hr	$35.00				$1,225	$0	$0	$0	$1,225	
4.5 Collect/Containerize IDW	8	ea	$50.00				$400	$0	$0	$0	$400	
4.6 Transport/Dispose IDW Off Site	12	drums	$150.00				$1,800	$0	$0	$0	$1,800	
5 GROUNDWATER SAMPLING AND ANALYSIS												
5.1 Collect Samples	3	days		$150.00	$336.00	$100.00	$0	$450	$1,008	$300	$1,758	5 wells per day, 2 laborers
5.2 Sample Analysis - standard turn around time	14	ea	$665.00				$9,310	$0	$0	$0	$9,310	VOCs, SVOCs, TRPH, KOG
6 EXTRACTION AND TREATMENT UNIT												
6.1 Concrete Foundation (6")	500	sf		$2.74	$3.50	$0.67	$0	$1,370	$1,750	$335	$3,455	
6.2 Treatment system building	500	sf		$4.36	$0.93	$0.56	$0	$2,180	$465	$280	$2,925	20 x 25
6.3 Air Stripper (5 hp, 20 gpm)	1	ls	$400.00	$12,000.00			$400	$12,000	$0	$0	$12,400	low-profile, tray-type
6.4 GAC Treatement System (effluent)	2	ea		$4,685.00			$0	$9,370	$0	$0	$9,370	2000 pounds each
6.5 Treated effluent discharge pipe	500	lf		$1.35	$5.13	$1.37	$0	$675	$2,565	$685	$3,925	
6.6 GAC Treatement System (off-gas)	2	ea		$3,100.00			$0	$6,200	$0	$0	$6,200	1000 pound GAC each
6.7 Groundwater Extraction Piping (wells to treatment unit)	1000	lf		$1.48	$7.31	$1.37	$0	$1,480	$7,310	$1,370	$10,160	
6.8 Vault Boxes and Misc Piping/Valves at Well Heads	5	ea		$399.50	$299.63		$0	$1,998	$1,498	$0	$3,496	
6.9 Groundwater Pumps	5	ea		$700.00	$328.80		$0	$3,500	$1,644	$0	$5,144	4 gpm, submersible
6.10 Plumb System	1	ls		$3,500.00	$2,608.00		$0	$3,500	$2,608	$0	$6,108	2 plumbers, 1 week
6.11 Install Electrical	1	ls	$9,543.50				$9,544	$0	$0	$0	$9,544	
6.12 System Start-up and Testing	1	ls		$1,000.00	$750.00		$0	$1,000	$750	$0	$1,750	
7 SITE RESTORATION												
7.1 Restore Asphalt Parking Area	500	lf		$2.28	$4.41	$0.62	$0	$1,140	$2,205	$310	$3,655	
7.2 Vegetate Disturbed Areas	1	ls		$250.00	$250.00		$0	$250	$250	$0	$500	
8 OFFICE SUPPORT/FIELD SUPPORT												
8.1 Field Oversight Personnel (2 people)	640	hours			$25.00		$0	$0	$16,000	$0	$16,000	
8.2 Office Oversight Personnel (2 people - 1/2 time)	320	hours			$35.00		$0	$0	$11,200	$0	$11,200	
9 PROJECT DOCUMENTATION												
9.1 Pre- and Post-Construction Submittals	300	hours			$35.00		$0	$0	$10,500	$0	$10,500	
9.2 Permitting	1	ls	$15,000.00				$15,000	$0	$0	$0	$15,000	
Subtotal Direct Costs less Subcontract								$46,613	$66,031	$9,435	$122,079	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 6: GROUNDWATER PUMP AND TREAT

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
Overhead on Labor Cost @	30%								$19,809		$19,809	
G & A on Labor Cost @	10%								$6,603		$6,603	
G & A on Material Cost @	10%							$4,661			$4,661	
Total Direct Cost								$51,274	$92,444	$9,435	$153,152	
Indirects on Total Direct Labor Cost @	75%								$69,333		$69,333	
Profit on Total Direct Cost @	10%										$15,315	
Subtotal											$237,800	
Health & Safety Monitoring @	3%										$7,134	
Total Field Cost											**$244,934**	
Subtotal Subcontractor Cost							$60,503				$60,503	
G & A on Subcontract Cost @	10%						$6,050				$6,050	
Profit on Subcontractor Cost @	5%										$3,025	
Subcontractor Cost											**$69,578**	
Contingency on Total Field and Subcontractor Costs @	10%										**$31,451**	
Engineering on Total Field Cost @	4%										**$9,797**	
TOTAL COST											**$355,761**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 6: GROUNDWATER PUMP AND TREAT
Operation, Maintenance, and Monitoring Costs for One Year Operation

	Item	Unit	Unit Cost	Year 1 Qty	Year 2 Qty	Year 3 Qty	Year 4 Qty	Year 5 Qty	Year 6 Qty	Year 7 Qty	Year 8 Qty	Year 9 Qty	Year 10 Qty	Year 11 Qty	Year 12 Qty	Year 13 Qty	Year 14 Qty	Year 15 Qty	Notes
1	Energy - Electric	kWh	$0.06	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	169,068	35 hp
2	Maintenance	ls	$2,234.28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3% of Installation Cost
3	Carbon Unit Changeout/ Regeneration of Spent Carbon	pound	$3.00	4,000	4,000														4 times during life of system
4	Carbon Unit Changeout/ Regeneration - Labor, Per Diem, Supplies	mo	$425.00	1	1														Per visit - 1 laborer, 1 day
5	Groundwater sampling - Labor, Per Diem, Supplies	mo	$2,100.00	4	4	2	2	2	2	2	2	2	2	2	2	2	2	2	Per visit - 2 laborers, 3 days
6	Treated Groundwater and Offgas Sampling - Labor, Mobilization/Demobilization, Per Diem, Supplies	mo	$975.00	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	Per visit - 1 laborer, 1 day
7	Analysis of Off-gas samples	ea	$250.00	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	Analyze for VOCs
8	Analysis of Groundwater samples	ea	$665.00	60	60	32	32	32	32	32	32	32	32	32	32	32	32	32	Analyze samples for VOCs, SVOCs, TRPHs, and KAG; 10 per quarter
9	Sampling Event Reports	ea	$3,000.00	4	4	2	2	2	2	2	2	2	2	2	2	2	2	2	Following each sampling event
10	Five Year Evaluation Report	ea	$5,000.00					1					1					1	

		Year 1 Cost	Year 2 Cost	Year 3 Cost	Year 4 Cost	Year 5 Cost	Year 6 Cost	Year 7 Cost	Year 8 Cost	Year 9 Cost	Year 10 Cost	Year 11 Cost	Year 12 Cost	Year 13 Cost	Year 14 Cost	Year 15 Cost
1	Energy - Electric	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144	$10,144
2	Maintenance	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234	$2,234
3	Carbon Unit Changeout/ Regeneration of Spent Carbon	$12,000	$12,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	Carbon Unit Changeout/ Regeneration - Labor, Per Diem, Supplies	$425	$425	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5	Groundwater sampling - Labor, Per Diem, Supplies	$8,400	$8,400	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200
6	Treated Groundwater and Offgas Sampling - Labor, Mobilization/Demobilization, Per Diem, Supplies	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900	$3,900
7	Analysis of Off-gas samples	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
8	Analysis of Groundwater samples	$39,900	$39,900	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280	$21,280
9	Sampling Event Reports	$12,000	$12,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
10	Five Year Evaluation Report	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000	$0	$0	$0	$0	$5,000
	Total Annual Cost	$90,003	$90,003	$48,758	$48,758	$53,758	$48,758	$48,758	$48,758	$48,758	$53,758	$48,758	$48,758	$48,758	$48,758	$53,758

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46
TECHNOLOGY 6: GROUNDWATER PUMP AND TREAT
Present Worth Analysis

Year	Capital Cost	peration & Maintenance Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$355,761		$355,761	1.000	$355,761
1		$90,003	$90,003	0.935	$84,153
2		$90,003	$90,003	0.873	$78,573
3		$48,758	$48,758	0.816	$39,787
4		$48,758	$48,758	0.763	$37,203
5		$53,758	$53,758	0.713	$38,330
6		$48,758	$48,758	0.666	$32,473
7		$48,758	$48,758	0.623	$30,376
8		$48,758	$48,758	0.582	$28,377
9		$48,758	$48,758	0.544	$26,525
10		$53,758	$53,758	0.508	$27,309
11		$48,758	$48,758	0.475	$23,160
12		$48,758	$48,758	0.444	$21,649
13		$48,758	$48,758	0.415	$20,235
14		$48,758	$48,758	0.388	$18,918
15		$53,758	$53,758	0.362	$19,461
				TOTAL PRESENT WORTH	$882,290

APPENDIX D

DESIGN CALCULATIONS

SOURCE AREA SOIL CONTAMINANT MASS CALCULATION

CLIENT SITE NO.: NAS Cecil Field Building 46
TTNUS PROJECT NO 7895 By: Jiffrudeep Kumar
DATE CALCULATED: 3/12/99 Checked By: JLG 03/15/99

Soil TRPH Mass:

Most of the data is from soil screening using an OVA. Only three of these soil samples have been analyzed in a lab for true TRPH values.

SB-18: OVA= 1,300 ppmv, TRPH conc= 150 mg/kg
SB-18: OVA= 2,500 ppmv, TRPH conc= 200 mg/kg

Assume that an OVA reading to TRPH ratio is approx= 9 ppmv/mg/kg to 13 ppmv/mg/kg

The average OVA reading is reported= 3908 ppmv (Appendix F of SAR, HLA, Dec 1998)
Therefore, the average TRPH concentration= 450.9 mg/kg to 312.6 mg/kg

Assume an average TRPH concentration = 500 mg/kg to be conservative because of variability in OVA reading to actual analyzed conc

Contaminated source area soil volume is reported = 1436 cu yd (Appendix F, SAR)

Therefore, estimated total mass of TRPH= volume x conc/1e06 x 1.5 ton/cu yd x 2000/2.2 kg
= 979 kg
2154 lb

WEIGHTED-AVERAGE CONCENTRATION CALCULATIONS

CLIENT SITE NO.:	Naval Air Station Cecil Field, Site 46		
TETRA-TECH, NUS PROJECT NO.:	7895	By:	Pradeep Kumar
DATE CALCULATED:	3/11/99	Checked By:	JIG 03/12/99
SPARGING WELL:	SW-1, SW-2, SW-3/SW-4, SW-5/SW-6, SW-7/SW-8, SW-9		

(Source: FDEP Compliance Manual, "Getting It Right the First Time")

Maximum contaminant concentrations at the sparging wells may be estimated by calculating a weighted average of nearby well contaminant concentrations under static conditions. The weighted average is based on the inverse of the distance from the monitoring well or DPT nearest to the sparging well. In order to be conservative, the detection limit was used when a COC was not detected.

MTBE was not analyzed at all monitoring well locations, and therefore the nearest DPT concentrations were assumed.

Napthalenes were not analyzed at DPT locations, and therefore, the nearest monitoring well concentrations were assumed.

Weighted Average Concentrations are calculated using the following formula (25% factor of safety added):

$$C = \frac{(c1/d1 + c2/d2 + \ldots + cn/dn)}{(1/d1 + 1/d2 + \ldots + 1/dn)} \times 1.25$$

Variables:

C = Weighted Average Concentration

c# = monitoring well or DPT concentrations

d# = distance from sparging well to nearest monitoring well/DPT

All concentrations are in micrograms/liter

Ratio of concentrations/distance to nearest MW or DPT

	Benzene	Toluene	Ethylbenzene	Xylenes	MTBE	Napthalene
SW-01	280	10	180	800	0	0
SW-02	4	1	0	2	119	0
SW-03	4400	9400	880	5000	1600	132
SW-04	27	16	4	26	1600	0
SW-05	1	1	12	36	0	1
SW-06	1	1	12	36	0	1
SW-07	35	18	5	16	49	1
SW-08	35	18	5	16	49	1
SW-09	1800	2400	400	2200	2400	20
Weighted ave:	**8396**	**15133**	**1911**	**10373**	**7419**	**198**

(Input to the ASVE system)

Source area only:

Monitoring well/DPT data:

DPT-10	1400	50	900	4000	2	1
CEF-46-18I	2	1	1	27	2	1
DPT-1	22000	47000	4400	25000	8000	660
CEF-46-5I	260	79	24	150	8000	1
CEF-46-6D	6	84	18	110	8000	1
CEF-46-2S	1300	650	180	610	1800	34

WEIGHTED-AVERAGE CONCENTRATION CALCULATIONS

CEF-46-4S	20	24	220	650	2	10
DPT-3	600	1	1	1	2	18
DPT-2	9500	12000	2400	10000	12000	250
CEF-46-7I	9000	12000	2000	11000	12000	100

Distances of MW/DPT from SW			Corresponding Concentrations
SW-1 to DPT-10	5	ft	Obtained from DPT-10
SW-2 to 5I	67	ft	Obtained from 5I
SW-3 to DPT-1	5	ft	Obtained from DPT-1
SW-4 to 5I	5	ft	Average of concentrations obtained from 5I and 6D
SW-4 to 6D	5	ft	
SW-5 to 4S	18	ft	Obtained from 4S
SW-6 to 4S	18	ft	Obtained from 4S
SW-7to 2S	37	ft	Obtained from 2S
SW-8 to 2S	37	ft	Obtained from 2S
SW-9 to 7I	5	ft	Obtained from 7I

EMISSION RATE

CLIENT SITE NO.:	NAS Cecil Field Building 46		
TTNUS PROJECT NO.:	7895	By:	JPK
DATE CALCULATED:	3/11/99	Checked By:	JLG 03/12/99

Estimate the VOC emission rate from the ASVE system:

Emission from air sparging:

Vs x -dC(t)/dt

where:Vs= plume volume= 7001 m^3

dC(t)/dt= rate of decrease of gw concentration

= $C_{(o)x}(-B)xe^{-Bt}$

Time (day)	Benzene (lb/day)	Toluene (lb/day)	Ethylbenzen (lb/day)	Xylenes (lb/day)	Napthalene (lb/day)	MTBE (lb/day)	Total (lb/day)
0	2.6E-01	4.6E-01	5.9E-02	3.2E-01	4.9E-03	1.8E-01	1.3
30	2.4E-01	4.4E-01	5.5E-02	3.0E-01	4.6E-03	1.7E-01	1.2
180	1.8E-01	3.2E-01	4.1E-02	2.2E-01	3.7E-03	1.4E-01	0.9
365	1.2E-01	2.2E-01	2.8E-02	1.5E-01	2.7E-03	1.0E-01	0.6

Emission from Vapor Extraction

Estimate based on soil-gas concentrations

Because soi-gas concentrations were taken at soil-vapor equiquilibrium conditions, actual concs when vapor extraction system is in operation will be lower.

Estimate a more realistic vapor conc as follows:

1. Assume that equilibrium levels are attained after 24 hours of zero vapor flow rate
2. Assume that vapor concentrations will be inversely proportional and linearly related to vapor flow rate
3. Estimate an extracted vapor conc:
   = Soil-gas concentration x source area vadose zone pore volume/1440 min x 1/vapor extraction rate

Measured average soi-gas concentration (from SAR)=	3908 ppmv
Source area vadose zone soil volume=	1436 cu yd
Pore volume in vadose zone (@ 25% porosity)=	9693 cu ft
Vapor extraction rate in the source area vadose zone=	90 scfm

Therefore, extracted vapor concentration= 3908 ppmvx 9693 cu ft/1440 min /90 scfm

= 292 ppmv

Estimate an average mol wt of vapor in proportion to vapor pressure

VOC	Mol wt	Vap Pressure (mm Hg)
Benzene	78	76
Toluene	92	22
Ethylbenzen	106	7
Xylenes	106	9
MTBE	88	245

87 g/g mol (weighted average vapor mol wt)

Estimated VOC emission rate from vadose zone alone=

EMISSION RATE

expected extracted vapor concx vapor flow rate x air density/air mol wt x vapor mol wt

= 292 ppmvx 10^(-6) x 90 scfm x 0.075 lb/ft^3 /29 g/gmol x87 g/gmol

= **8.5** **lb/day**

Total emission rate expected from ASVE system= emission from air sparging + emission from vapor extraction

= 9.8 lb/day

Note that this is the maximum emission rate expected during initial operation

AIR SPARGING CLEANUP DURATION ESTIMATION

CLIENT SITE NO.:	NAS Cecil Field Building 46		
TTNUS PROJECT NO.:	7895	By:	JPK
DATE CALCULATED:	3/15/99	Checked By:	JIG 03/15/99

(Source: "Air Sparging Model for Predicting Groundwater Cleanup Rate" K.L. Sellers and R.P Schreiber, CDM Inc. 1992)

The following first order decay/rate equation may be used to estimate a conservative time for the contaminants of concern concentrations to be reduced below the remedial action ojectives. This model calculates both the weighted average and maximum clean-up times as dictated by the initial concemtrations.

$$C_{(t)} = C_{(o)} \times e^{-Bt}$$

Variables:

$C_{(t)}$ = Concentration at end of duration or RAO's (ug/L)

$C_{(o)}$max = Initial Maximum Concentration (ug/L)

$C_{(o)}$ave = Initial Weighted Average Concentration (ug/L)

e = base of the natural log (approx. 2.71828)

B = first order differential rate constant (see page 2 of 4)

t = duration (solving for)

Solving for t reduces to:

$$t = \ln(C_{(t)}/C_{(o)}) / -B$$

CONTAMINANT TYPE	C_o Max (ug/l)*	C_o Ave (ug/L)*	C_t (ug/L)*	t Max (years)	t Ave (years)
Benzene	22000	8396	1.00	13.75	12.43
Toluene	44000	15133	40.00	9.63	8.16
Ethylbenzene	2400	1911	30.00	6.03	5.71
Total Xylenes	25000	10373	20.00	9.81	8.60
Naphthalenes	600	198	20.00	5.85	3.94
TRPH	31	7	5.00	3.14	0.65
MTBE	12000	7419	50	9.42	8.60

Assumptions:

* - TRPH units are listed in milligrams per Liter

AIR SPARGING CLEANUP DURATION

"Calculation of Rate Constant B"

CLIENT SITE NO.:	NAS Cecil Field Building 46		
TTNUS PROJECT NO.:	7895	By:	JFK
DATE CALCULATED:	3/15/99	Checked by:	JLG 03/15/99

(Source:"Air Sparging Model for Predicting Groundwater Cleanup Rate" K.L. Sellers and R.P Schreiber,CDM Inc. 1992)

The first order rate coefficient B can be calculated by the following equation.

$$B = f \times d \times D/L \times S/V \times H/\upsilon \times Q/V_s$$

Variables:

f = Fraction of plume sparged (unitless)	f =	1.0	assumed
d = Fraction of 24-hour day unit operates (unitless)	d =	1.0	assumed
D = Contaminant diffusion coefficent (cm^2/s)	D =	see below	
L = Diffusive distance around bubble (m)	L =	4.49E-03	see page 1 of 2
S/V = effective surface area to volume ratio of a bubble (m^{-1})	S/V =	667.7	see page 1 of 2
H = Depth of screen below water table (m)	H =	17.8	see page 2 of 2
u = Bubble terminal Rise velocity (m/s)	υ =	2.51E-01	see page 2 of 2
Q = Total air flow (m^3/s)	Q =	1.53E-02	see page 2 of 2
V_s = Volume of water in plume that contact bubbles (m^3)	V_s =	7001.4	see page 2 of 2

CONTAMINANT TYPE	D	B (sec^{-1})	B (yr^{-1})
Benzene	1.00E-09	2.31E-08	7.27E-01
Toluene	1.00E-09	2.31E-08	7.27E-01
Ethylbenzene	1.00E-09	2.31E-08	7.27E-01
Total Xylenes	1.00E-09	2.31E-08	7.27E-01
Naphthalenes	8.00E-10	1.84E-08	5.82E-01
TRPH	8.00E-10	1.84E-08	5.82E-01
MTBE	8.00E-10	1.84E-08	5.82E-01

AIR SPARGING CLEANUP DURATION

"Calculation of Variables"

Estimation of Contaminant Diffusion Coefficient

Volatiles =	**1.00E-09**	**m^2/s**
Semi-Volatiles =	**8.00E-10**	**m^2/s**

Calculate the diffusive distance around bubble (L)

This model assumes L = r

Where r is equal to the effective radius of the bubble

$$r = 2 \times R \times \{6\sigma/[R^2 \times (P_w - P_a) \times g]\}^{1/3}$$

Given

R =	**2.54E-04**	**m**	(orifice diameter of the sparger or well screen slot)
σ =	**0.0728**	**N/m**	(air water surface tension)
Pw =	**1000**	**kg/m^3**	(density of water)
Pa =	**1.29**	**kg/m^3**	(density of air at 50F)
g =	**9.8**	**m/s^2**	(acceleration due to gravity)
well slot	**0.01**	**in**	
L = r =	**4.49E-03**	**m**	

S/V is the effective surface area to volume ratio of a bubble

S/V = 3/r

r is calculated above, therefore

S/V = 667.7 m^{-1}

υ is the terminal rise velocity of a bubble

$$\upsilon = \{1.04 \times g \times r + (1.07 \times \sigma)/(r \times P_w)\}^{1/2}$$

Where:

g =	**9.8**	**m/s^2**	(acceleration due to gravity)
r =	**4.49E-03**	**m**	(calculated above)
σ =	**0.0728**	**N/m**	(air water surface tension)
P_w =	**1000**	**kg/m^3**	(density of water)

υ = 0.251 m/s

AIR SPARGING CLEANUP DURATION

"Calculation of Variables"

The height H is equal to the average total depth of the sparge well to the water table

TD =	63	ft
DTW =	5	ft
H =	58.3	ft
H =	17.8	m

The air flow rate is determined by the number of sparge wells and a correction for pressure caused by well depth

Q = # wells x flow rate per well x adjustment for pressure

# wells =	9	unitless
low/well =	10.00	SCFM
TD =	63.33	ft (=Average of 3 deep wells @ 90 ft bgs and six intermediate @ 50 ft bgs)
DTW =	5.00	ft
ADJF =	0.36	unitless
Q =	32.52	CFM
Q =	1.53E-02	m^3/s

Volume of plume in sparged area is determined by following calculation

Vs = A x h x η

Where:

A =	16,965	ft^2	(plume sparged area= 6 air sparging locations x 30 ft radius circles)
h =	58.33	ft	(groundwater plume average thickness)
η =	0.25	unitless	(porosity from SAR)
V_s =	247400.421	ft^3	
V_s =	7001.4	m^3	

PRESSURE LOSS CALCULATIONS

CLIENT SITE NO.:	NAS Cecil Field Building 46					
TTNUS PROJECT NO.:	7895	By:				
DATE CALCULATED:	3/12/99	Checked By:				

Pressure loss calculation: Vapor Extraction System

Start with a maximum allowable vacuum of 45 inches w.g. to prevent excessive moisture uptake

Take the longest run of the three vapor extraction header pipes: EW-07 to plant inlet

Calculate pressure loss due to pipe length and fittings

For each section of header pipe estimate a pressure loss due to additional flow rate

Within the plant, include pressure loss due to fittings, the moisture separator and air filter on the vacuum side of the vacuum extraction pump. Include pressure loss due to fittings and GAC units

For all line losses, a friction loss graph is used (see attached copy)

For all fitting losses, the Crane manual (1957) is used (see attached copy)

Well laterals are all 2" I.d. PVC and headers are 4" I.d. PVC

EW-07 to header junction (45 ft)					
Applied vacuum		45	inches w.g.=	1.6	psig
2xElbow (L/D)=	100	0.023	inches w.g.=	0.0	psig
Flow meter				0.2	psig assumed
Ball valve (L/D)=	150	0.035	inches w.g.=	0.0	psig
Pressure gauge=				0	assumed
Branch "T" (L/D)=	60	0.014	inches w.g.=	0.0	psig
Entrance loss (2" to 4 " expander)				0	psig (assumed)
Line loss=	45	0.0630	inches w.g.=	0.0	psig
	(calculated @	0.0014	"w.g./ft		
	for 2"I.d.pipe carrying 10 scfm)				
Junction of EW-07 to junction of EW-08 (30 ft header)					
Line loss=	30	0.06	inches w.g.=	0.0	psig
	(calculated @	0.002	"w.g./ft		
	for 4"I.d.pipe carrying 70 scfm)				
Junction of EW-08 to system entrance (160 ft)					
Line loss=	160	0.544	inches w.g.=	0.0	psig
Elbow (L/D)=	100	0.113	inches w.g.=	0.0	psig
Branch "T"(L/D)=	60	0.068	inches w.g.=	0.0	psig
	(calculated @	0.0034	"w.g./ft		
	for 4"I.d.pipe carrying 90 scfm)				
Inside Treatment Plant					
	(20 ft of 4" I.d., carrying 160 scfm)				

PRESSURE LOSS CALCULATIONS

	Line loss=	20	0.2	inches w.g.=	0.0	psig	
		(calculated @	0.01	"w.g./ft			
		for 4"I.d.pipe carrying 160 scfm)					
	Flow meter				0.2	psig (assumed)	
	Moisture separator ent/exit loss		5	inches w.g.=	0.2	psig	
		(From GAST brochure, 1/95)					
	Gate valves (L/D)	39	0.1	inches w.g.=	0.0	psig	
	(3 total)						
	Air filter				0.5	psig (assumed)	
	Pressure gauge				0	psig (assumed)	
	Butterfly valves				0	psig for fully open	
				TOTAL=	**2.8**	**psig**	
Vacuum Extraction Pump sizing:							
		Flow rate=		160	scfm		
		Vacuum side=		2.8	psig		
		Pressure side=		0.29	psig		
					(GAC canisters @ 4" w.g./canister)		
		Inlet temperature=		60	oF		
		Blower-size required: wRT/550ne[(Pi/Po)^n -1](Metcalf&Eddy,1991)					
		w= air flow in lb/s using density of air= 0.078 lb/ft^3					
		R gas constant=53.5			n=Polytropic gas exponent=0.28 for air		
		T= inlet temp in Rankine			e= efficiency=		
						70%	(assumed)
		Po; Pi= absolute outlet and inlet pressures					
		=	2.3	H.P.			
		Standard motor size would be 3.0 H.P.					
Pressure Loss Calculation: Air Sparging System:							
	Start with the pressure required to force out/evacuate the water column in the deeper air sparging well						
	Calculate fitting and line losses from farthest air sparging well location to the treatment plant						
	Within the treatment plant, include fittings and line losses						
	All piping outside the plant is Schedule 80 PVC						
	All piping inside the plant is Schedule 80 galvanized steel						
	For the purposes of pressure loss, both are assumed identical						
	For all line losses, friciton loss graph is used (see attached copy)						
	For all fitting losses, the Crane manual (1957) is used (see attached copy)						

PRESSURE LOSS CALCULATIONS

Hydrostatic Head SW-03						
Depth to bottom of screen=		90	ft bgs			
Depth to water table=		5	ft bgs			
Pressure required=		85	ft=	37	psig	
Pressure loss through well screen=				3	psig (prof. judgement)	
Pressure loss gradient=		0.001	inches w.g./ft			
Pressure loss through well riser=						
	90	0.09	inches w.g.	0.0	psig	
SW-03 to plant inlet (=		230	ft)			
Branch "T"(L/D)=	60	0.01	inches w.g.=	0.00	psig	
Flow meter				0.2	psig (assumed)	
90 elbowx2 (L/D)	100	0.02	inches w.g.=	0.00	psig	
Piping =		0.23	inches w.g.=	0.01	psig	
Inside plant						
Elbows (L/D)x2	100	0.02	inches w.g.=	0.00	psig	
Flow "T" (L/D)	60	0.01	inches w.g.=	0.00	psig	
Flow meter				0.2	psig (assumed)	
High pressure lines (50 psi before pressure regulators and >100 psi at compressor outlet)						
despite the higher flow rates have minimal pressure loss because of shortness of pipe length.						
Total pressure loss in the air sparging side=				40	psig	

Friction Loss Chart

This chart may be used to compute friction losses in a piping system. For example, determine the friction loss incurred when 70 CFM flows through a 2″ pipe, 50′ long.

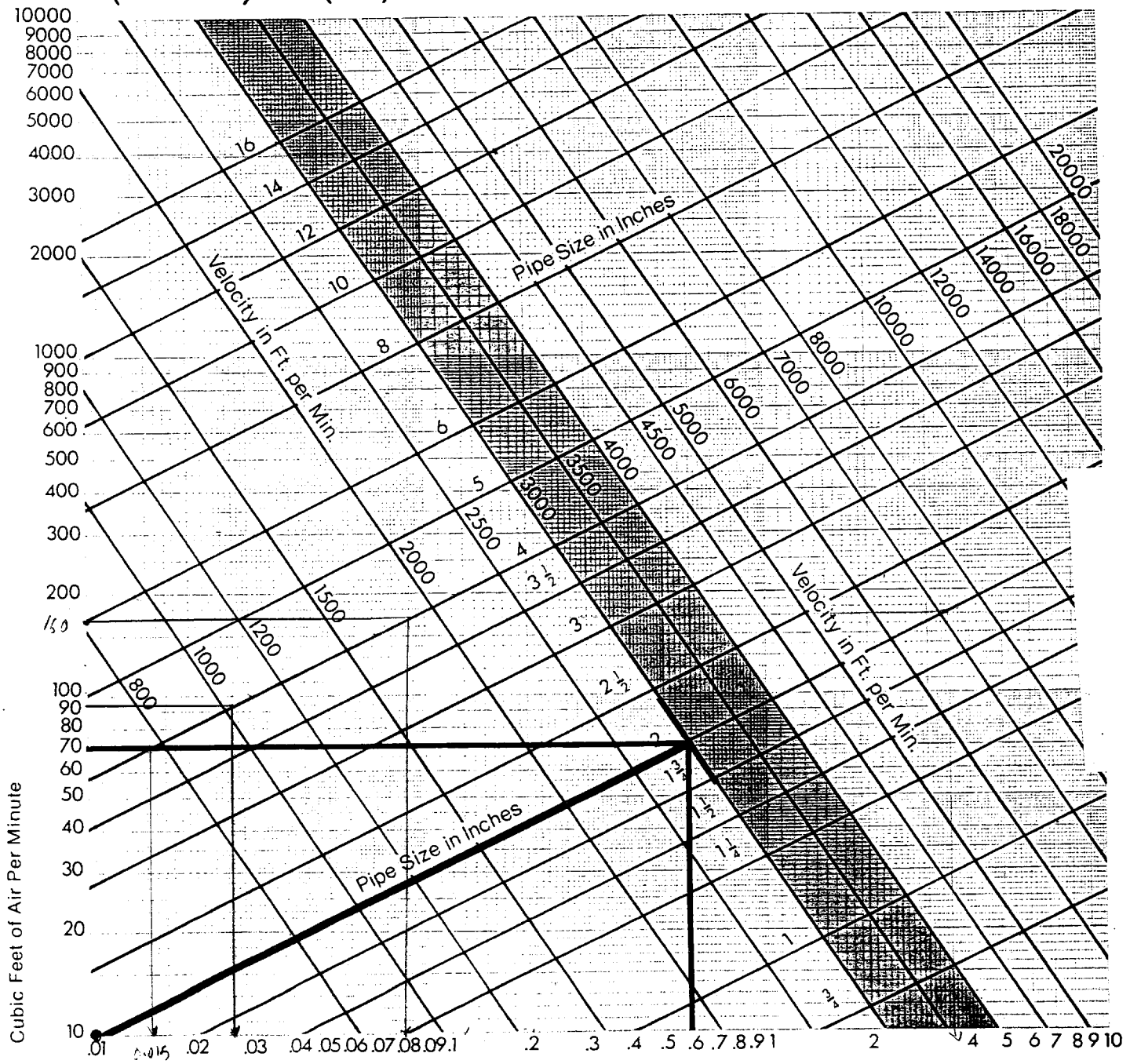
Step 1: Intersect 70 CFM and the sloping line for 2″ pipe as shown.

Step 2: Drop a vertical from this point of intersection and read the loss/100′ of line, in this case, .60Hg/100′.

Step 3: Multiply the loss/100′ of line by the length of run/100′. The loss for 50′, then, is

$$.60\left(\frac{\text{length of run}}{100'}\right) = .60\left(\frac{50'}{100'}\right) = 0.30'' \text{ Hg.}$$

Also: Velocity in the line may be read from the negatively sloping lines on the graph. Here, to get 70 CFM through a 2″ line, the air must travel at a velocity of approximately 3000 FPM.



Friction Loss in Inches of Hg. Per 100 Ft. of Line With Inlet Air at 70° F. and 14.7 P.S.I.A

inches Hg × 13.6 ft TDH water / = psi

Schedule (Thickness) of Steel Pipe Used in Obtaining Resistance Of Valves and Fittings of Various Pressure Classes by Test*

Valve or Fitting ASA Pressure Classification (Steam Rating)		Schedule No. of Pipe (Thickness)
50-Pound and Lower		Schedule 40
00-Pound to 600-Pound		Schedule 80
00-Pound		Schedule 120
00-Pound		Schedule 160
00-Pound	Sizes ½ to 6-inch	xx (Double Extra Strong)
	Sizes 8-inch and larger	Schedule 160

*These schedule numbers have been arbitrarily selected only for the purpose of identifying the various pressure classes of valves and fittings with specific pipe dimensions for the interpretation of flow test data; they should not be construed as a recommendation for installation purposes.

Representative Equivalent Length in Pipe Diameters (L/D) Of Various Valves and Fittings

Description of Product					Equivalent Length In Pipe Diameters (L/D)
Globe Valves	Conventional	With no obstruction in flat, bevel, or plug type seat		Fully open	340
		With wing or pin guided disc		Fully open	450
	Y-Pattern	(No obstruction in flat, bevel, or plug type seat)			
		– With stem 60 degrees from run of pipe line		Fully open	175
		– With stem 45 degrees from run of pipe line		Fully open	145
Angle Valves	Conventional	With no obstruction in flat, bevel, or plug type seat		Fully open	145
		With wing or pin guided disc		Fully open	200
Gate Valves	Conventional Wedge Disc, Double Disc, or Plug Disc			Fully open	13
				Three-quarters open	35
				One-half open	160
				One-quarter open	900
	Pulp Stock			Fully open	17
				Three-quarters open	50
				One-half open	260
				One-quarter open	1200
	Conduit Pipe Line			Fully open	3**
Check Valves	Conventional Swing		0.5†	Fully open	135
	Clearway Swing		0.5†	Fully open	50
	Globe Lift or Stop		2.0†	Fully open	Same as Globe
	Angle Lift or Stop		2.0†	Fully open	Same as Angle
	In-Line Ball		2.5 vertical and 0.25 horizontal†	Fully open	150
Foot Valves with Strainer		With poppet lift-type disc	0.3†	Fully open	420
		With leather-hinged disc	0.4†	Fully open	75
Butterfly Valves (6-inch and larger)				Fully open	20
Cocks	Straight-Through	Rectangular plug port area equal to 100% of pipe area		Fully open	18
	Three-Way	Rectangular plug port area equal to 80% of pipe area (fully open)		Flow straight through	44
				Flow through branch	140
Fittings	90 Degree Standard Elbow				30
	45 Degree Standard Elbow				16
	90 Degree Long Radius Elbow				20
	90 Degree Street Elbow				50
	45 Degree Street Elbow				26
	Square Corner Elbow				57
	Standard Tee	With flow through run			20
		With flow through branch			60
	Close Pattern Return Bend				50
Pipe	Smooth Pipe Bends				See Page A-27
	Miter Bends				See Page A-27
	Sudden Enlargements and Contractions				See Page A-26
	Entrance and Exit Losses				See Page A-26

**Exact equivalent length is equal to the length between flange faces or welding ends.

†Minimum calculated pressure drop (psi) across valve to provide sufficient flow to lift disc fully.

‡For limitations, see page 2-11. For effect of end connections, see page 2-10.

For resistance factor "K", equivalent length in feet of pipe, and equivalent flow coefficient "C", see pages A-31 and A-32.

E

TETRA TECH NUS, INC. **CALCULATION WORKSHEET** PAGE 1 OF 2

CLIENT NAS Cecil Field		JOB NUMBER 7895	
SUBJECT Estimate wastewater generation from compressor - ASVE system			
BASED ON		DRAWING NUMBER	
BY Jagadeesh Kumar	CHECKED BY JLG 03/15/99	APPROVED BY	DATE March 3 '99

Ambient air intake : 100 cfm @ 100°F, 80°F dew point
(Summer, Jacksonville, FL)

Compress to 125 psig (139.7 psia), 115°F (inlet + 15°F) @ aftercooler

Δ Humidity (see attached chart)

$= 0.02 \text{ lb } H_2O/\text{lb dry air} - 0.006 \text{ lb } H_2O/\text{lb dry air}$

$= 0.014 \text{ lb } H_2O/\text{lb dry air}$

Moisture removed $= 0.014 \text{ lb } H_2O/\text{lb dry air} \times 100 \text{ scfm} \times 0.075 \text{ lb/ft}^3 \times 1440 \text{ min/day} \times \frac{1}{8.34 \text{ lb/gal}}$

$= 18 \text{ gal/day}$

[Could vary by ±20% depending on ambient humidity]

Page 2 of 2

MOISTURE CONTENT OF AIR

ANASTAS LAZARIDIS, Day & Zimmerman, Inc.

Many chemical engineering calculations require knowledge of the water carried by—or removed from—a stream of air. Conventionally, this water is identified as the specific humidity, w, which is the relative amount of water vapor per unit mass of dry air and is expressed in terms of vapor pressure as:

$$w = 0.622\, P_w/(P_t - P_w)$$

where P_w is the vapor pressure of water at the indicated temperature and P_t is the total pressure.

Two families of curves (Fig. 1 and 2) were prepared from this equation showing the maximum moisture content of air as a function of pressure and temperature, for 1-3,000 psia. and −100 to +350 F. These facilitate for design calculations.

Example: Air is compressed from atmospheric conditions (71.5 F. dew point at 14.7 psia.) to 71 psia. and 100 F. How much water is condensed? From Fig. 1, the moisture content at 14.7 psia. and 71.5 F. is 1.7×10^{-2} lb. of water per lb. of dry air. From Fig. 2, the moisture content at 71 psia. and 100 F. is 8.5×10^{-3} lb./lb. The difference is 0.85×10^{-2} lb. of water per lb. of dry air, and is the amount of moisture condensed in the process. ■

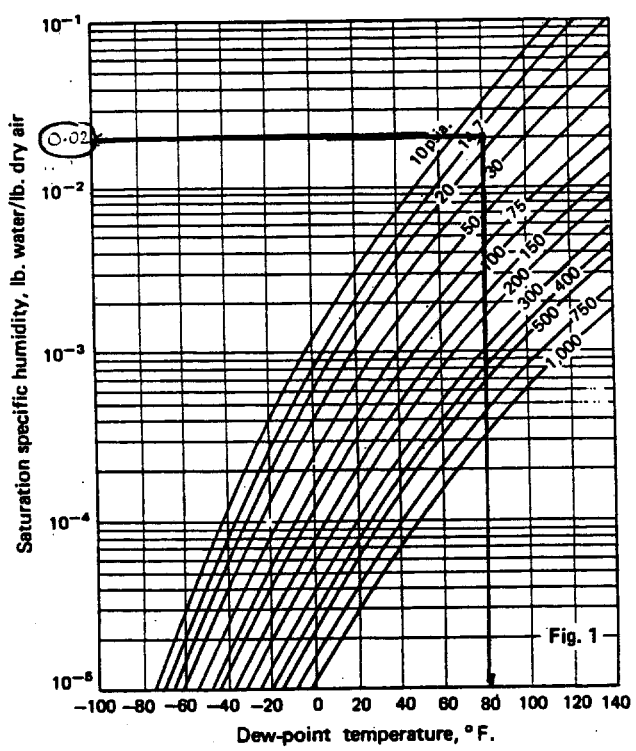


Fig. 1

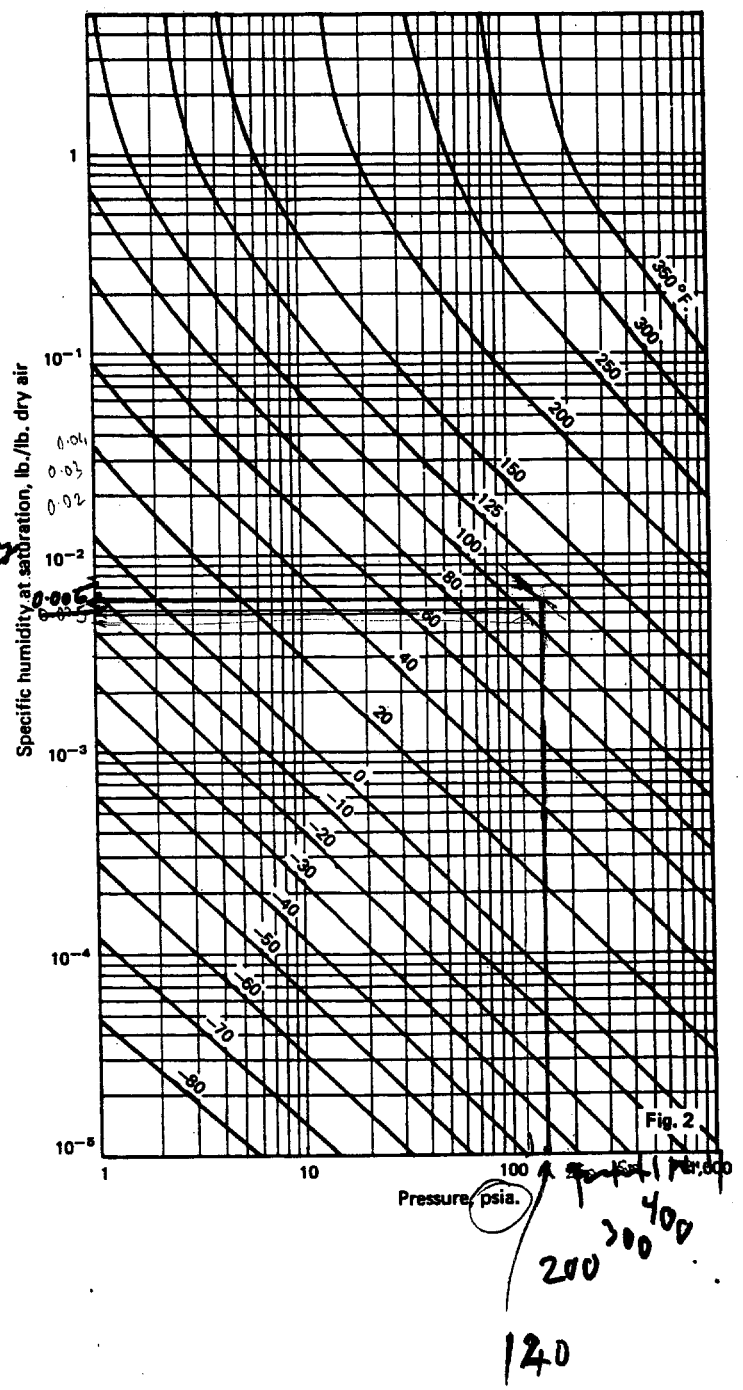
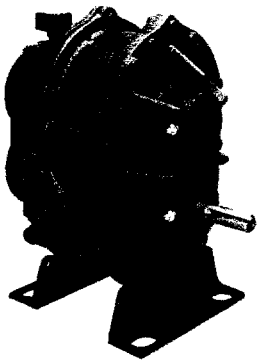
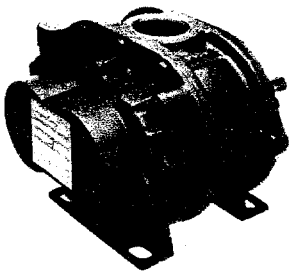


Fig. 2

APPENDIX E

PROCESS EQUIPMENT VENDOR INFORMATION





SPECIFICATIONS

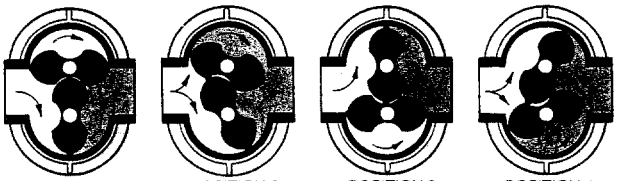
Roots Universal RAI®

Rotary Positive Blowers

FRAME 22 thru 718

B-1

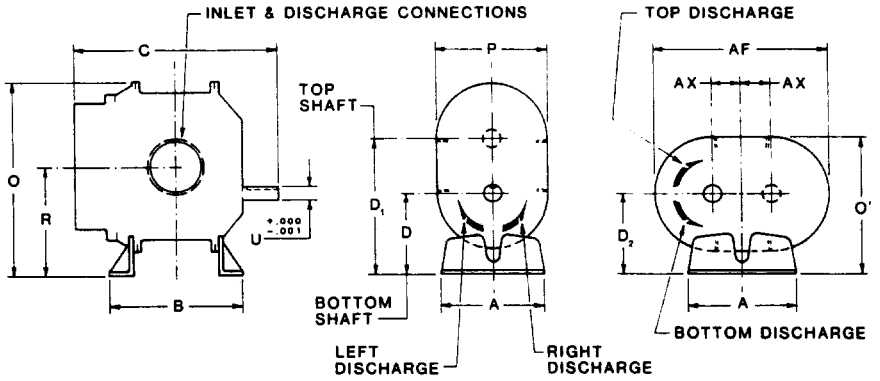
OPERATING PRINCIPLE



Two figure eight lobe impellers mounted on parallel shafts rotate in opposite directions. As each impeller passes the blower inlet, it traps a definite volume of air and carries it around the case to the blower outlet, where the air is discharged. With constant speed operation, the displaced volume is essentially the same regardless of pressure, temperature or barometric pressure.

Timing gears control the relative position of the impellers to each other and maintain small but definite clearances. This allows operation without lubrication being required inside air casing.

OUTLINE DRAWING & DIMENSIONAL TABLE



VERTICAL CONFIGURATION — HORIZONTAL CONFIGURATION

Frame Size	A	B	C	Drive Shaft Location: D Bottom Shaft	D1 Top Shaft	D2 Horiz. Shaft	O	O'	P	R	U	Keyway	Inlet & Disch. Dia.	AF	AX	Approx. Net Wt. (Lbs.)
22	5.13	5.00	9.75	3.75	6.25	3.75	9.63	6.88	6.25	5.00	.625	.188 x .094	1.0 NPT	9.25	1.25	32
24	5.13	7.00	11.75	3.75	6.25	3.75	9.63	6.88	6.25	5.00	.625	.188 x .094	2.0 NPT	9.25	1.25	43
33	7.25	7.63	12.13	5.00	8.50	5.00	12.81	8.88	7.75	6.75	.750	.188 x .094	2.0 NPT	12.13	1.75	74
36	7.25	10.00	14.63	5.00	8.50	5.00	12.81	8.88	7.75	6.75	.750	.188 x .094	2.5 NPT	12.13	1.75	102
42	8.00	7.25	13.00	6.25	10.25	6.25	15.06	10.63	8.75	8.25	.875	.188 x .094	1.5 NPT	13.63	2.00	88
45	8.00	10.00	15.50	6.25	10.25	6.25	15.06	10.63	8.75	8.25	.875	.188 x .094	2.5 NPT	13.63	2.00	109
47	8.00	11.75	17.63	6.25	10.25	6.25	15.06	10.50	8.50	8.25	.875	.188 x .094	3.0 NPT	13.63	2.00	128
53	10.50	8.38	15.38	6.25	11.25	6.75	17.38	11.88	10.25	8.75	1.125	.250 x .125	2.5 NPT	17.25	2.50	143
56	10.50	11.00	18.00	6.25	11.25	6.75	17.38	12.25	11.00	8.75	1.125	.250 x .125	4.0 NPT	17.25	2.50	170
59	10.50	14.00	21.18	6.25	11.25	6.75	17.38	12.25	11.00	8.75	1.125	.250 x .125	4.0 NPT	17.25	2.50	204
65	11.00*	10.00	18.38	8.75	14.75	8.75	21.63	15.13	12.75	11.75	1.375	.312 x .156	3.0 NPT	19.75	3.00	245
68	11.00*	13.00	21.38	8.75	14.75	8.75	21.63	15.13	12.75	11.75	1.375	.312 x .156	5.0 NPT	19.75	3.00	285
615	11.00*	20.00	28.38	8.75	14.75	8.75	21.63	16.25	15.00	11.75	1.375	.312 x .156	6.0 FLG	19.75	3.00	425
76	14.00**	11.75	19.94	11.00	18.00	11.00	26.13	20.69	19.38	14.50	1.562	.375 x .188	4.0 NPT	23.25	3.50	400
711	14.00**	16.75	25.19	11.00	18.00	11.00	26.13	19.50	17.00	14.50	1.562	.375 x .188	6.0 FLG	23.25	3.50	530
718	14.00**	23.75	32.19	11.00	18.00	11.00	26.13	19.50	17.00	14.50	1.562	.375 x .188	8.0 FLG	23.25	3.50	650

* 17.00 in horizontal configuration
** 21.00 in horizontal configuration

All dimensions in inches

BASIC BLOWER DESCRIPTION

Universal RAI blowers ar heavy duty rotary blowers de signed with detachable rugge steel mounting feet, which perm easy in-field adaptability to eithe vertical or horizontal installatio requirements. The Universal RA blowers can even be hung fror overhead supports.

Because of the detachabi mounting feet, these units can b easily adapted to any of fou drive shaft positions — rigt hand, left hand, bottom or to The compact, sturdy design engineered for continuous se vice when operated in acco dance with speed and pressu ratings.

The basic model consists a cast iron casing, hardene alloy steel gears secured to ste shafts with a taper mounting ar locknut, and cast iron involu impellers. Anti-friction bearin are used, with an oversized cyli drical roller bearing at the dri shaft on all except the tw smallest sizes to withstand V-be pull. All other bearings are ove sized ball bearings. The Univers RAI features thrust control, wi splash oil lube on the gear er and grease lube on the drive en After standard tests, the unit sprayed with a protective pai and boxed or placed on skids

Available accessories i clude driver, relief valve, inlet ai discharge silencer, inlet filt check valve, extended base, belt or flexible coupling and dri guards.

EVERY GROWING PLANT NEEDS ROO

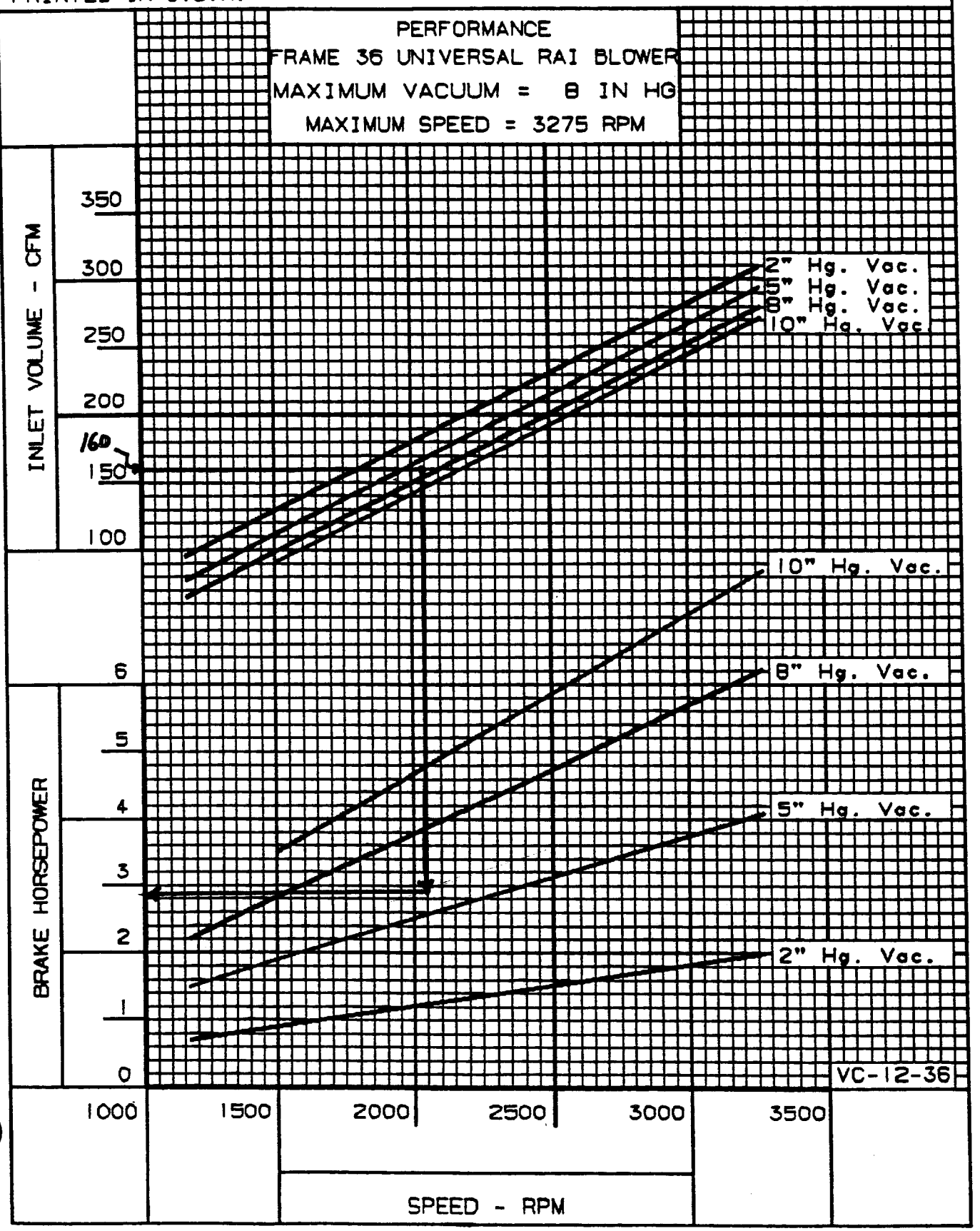
B-1

ROOTS DIVISION

DRESSER INDUSTRIES, INC.
CONNERSVILLE, IN. 47331

PRINTED IN U.S.A.

PERFORMANCE BASED ON 68°F
INLET AIR & DISCHARGE
PRESSURE - 30" HG ABS
AUGUST 1986



Gas Phase Carbon Adsorbers

Carbonair's gas phase carbon adsorbers are designed to provide an efficient and economical means to control odor, toxic vapors and corrosive gases. Several types of activated carbons are available for a variety of applications.

DESIGN

GPC 3 & 3H

- UN Standard 55-gallon steel drum.
- Two 2" PVC connections. (GPC 3)
- Two 4" PVC connections. (GPC 3H)
- Baked enamel exterior.
- Epoxy-phenolic interior lining.
- Quick installation.

Carbon Cap.: GPC 3 - 200 lbs.
GPC 3H - 200 lbs.

GPC 3.85

- UN Standard 85-gallon steel drum.
- Two 4" PVC connections.
- Baked enamel exterior.
- Epoxy-phenolic interior lining.
- PVC internals.

Carbon Cap.: GPC 3.85 - 250 lbs.

GPC 5R

- Welded steel round construction.
- Two 4" NPT connections.
- One ½" drain.
- Fork tubes for easy lifting.
- Bolt down lugs.
- Polyamide epoxy/urethane interior & exterior finish.
- FRP grate with stainless steel screen.

Carbon Cap.: GPC 5R - 500 lbs.

GPC 7R

- Welded steel round construction.
- Two 6 ⅝" nozzle connections.
- FRP grate with stainless steel screen.
- Bolt down lugs.
- Polyamide epoxy/urethane interior & exterior finish.
- Fork tubes for easy lifting.

Carbon Cap.: GPC 7R - 1000 lbs.

GPC 13R & GPC 20R

- Welded steel round construction.
- Fork tubes for easy lifting.
- One condensation drain.
- FRP grate with stainless steel screen.
- Polyamide epoxy/urethane interior & exterior finish.
- Two 8 ⅝" nozzle connections.

Carbon Cap.: GPC 13R - 1,500 lbs.
GPC 20R - 2,000 lbs.

GCAS-1

GPC 50R

- Welded steel round construction.
- Fork tubes for easy lifting.
- FRP grate with stainless steel screen.
- Two 12 ¾" nozzle connections.
- Bolt down lugs.
- Polyamide epoxy/urethane interior & exterior finish.
- Two ½" drain/sample couplings.

Carbon Cap.: GPC 50R - 5,000 lbs.

GPC 70 & 120

- Welded steel rectangular construction.
- Skid mounted with lifting lugs.
- Polyamide epoxy/urethane interior & exterior finish.
- FRP grate with stainless steel screen.
- Four 12¾" inlet ports.
- Two quick-disconnect off-gas ports.
- Two sample ports.
- One condensation drain.

Carbon Cap.: GPC 70 - 10,000 lbs.
GPC 120 - 13,600 lbs.

OPTIONS

Blowers Humidity control
Influent/effluent ducting
Discharge stack Controls
Additional sampling couplings and valves

CARBONAIR®
ENVIRONMENTAL SERVICES
2731 Nevada Avenue North
New Hope, MN 55427
612-544-2154 800-526-4999
Fax 612-544-2151

GCAS-1

SPECIFICATIONS

MODELS	GPC 3	GPC 3H	GPC 3.85	GPC 5R	GPC 7R	GPC 13R	GPC 20R	GPC 50R	GPC 70	GPC 120
DIMENSIONS	24½" OD (0.62 m) 36½"H (0.93 m)	24½" OD (0.62 m) 36½"H (0.93 m)	28½" OD (0.72 m) 38½"H (0.98 m)	30" OD (0.76 m) 5'8"H (1.73 m)	3' OD (0.91 m) 7'2"H (2.18 m)	4' OD (1.2 m) 7'2"H (2.18 m)	5' OD (1.5 m) 7'2"H (2.18 m)	8' OD (2.44 m) 7'2"H (2.18 m)	16'8½"L x 5'W x 7'6" H (5.0 m x 1.5 m x 2.3 m)	16'6"L x 8'W x 7'10"H (5.0 m x 2.4 m x 2.4 m)
BED AREA	2.7 sq.ft. (0.29 sq.m)	2.7 sq.ft. (0.29 sq.m)	3.68 sq.ft. (0.39 sq.m)	4.91 sq.ft. (0.53 sq.m)	7.07 sq.ft. (0.76 sq.m)	12.57 sq.ft. (1.35 sq.m)	19.63 sq.ft. (2.11 sq.m)	50.27 sq.ft. (5.41 sq.m)	69.8 sq.ft. (6.49 sq.m)	120 sq.ft. (11.15 sq.m)
FLOW RANGE	20-100 cfm (0.6-3 m^3/min)	20-270 cfm (0.6-8 m^3/min)	36-360 cfm (1-10 m^3/min)	40-380 cfm (1-10 m^3/min)	76-500 cfm (2-15 m^3/min)	120-800 cfm (3-24 m^3/min)	200-1,800 cfm (6-54 m^3/min)	480-4,000 cfm (14-120 m^3/min)	700-7,000 cfm (20-200 m^3/min)	200-12,000 cfm (34-340 m^3/min)
CARBON CAPACITY	200 lbs (68 kg)	200 lbs (68 kg)	250 lbs (114 kg)	500 lbs (228 kg)	1,000 lbs (456 kg)	1,500 lbs (681 kg)	2,000 lbs (908 kg)	5,000 lbs (2,270 kg)	10,000 lbs (4,540 kg)	13,600 lbs (6,174 kg)
FITTINGS	1½" PVC inlet and outlet ports	4" PVC inlet and outlet ports	4" PVC inlet and outlet ports	4½" nozzle (2) ½" half couplings (1) 30" access port	6 ⅝" nozzle (2) ½" half couplings (1) 24" access port	8 ⅝" nozzle (2) ½" half couplings (1) 24" access port	8 ⅝" nozzle (2) ½" half couplings (1) 24" access port	12 ¾" nozzle (2) ½" half couplings (1) 24" access port	(4) 12¾" inlet nozzles (2) 12¾" outlet nozzles 1" condensate drain (2) ¾" half coupling (2) 20" access ports	(4) 12¾" inlet nozzles (2) 12¾" outlet nozzles 1" condensate drain (2) ¾" half coupling (2) 20" access ports
EMPTY WEIGHT	65 lbs (29 kg)	65 lbs (29 kg)	100 lbs (45 kg)	375 lbs (170 kg)	700 lbs (317 kg)	950 lbs (431 kg)	1,200 lbs (544 kg)	2,900 lbs (1,315 kg)	5,500 lbs (2,495 kg)	7,500 lbs (3,402 kg)
OPERATING WEIGHT	275 lbs (125 kg)	275 lbs (125 kg)	350 lbs (159 kg)	900 lbs (408 kg)	1,800 lbs (816 kg)	2,450 lbs (1,111 kg)	3,200 lbs (1,452 kg)	8,000 lbs (3,629 kg)	16,000 lbs (7,258 kg)	22,000 lbs (9,979 kg)
INLET/OUTLET NOZZLES	1½" (3.81 cm)	4" (10.16 cm)	4" (10.16 cm)	4½" (11.43 cm)	6 ⅝" (16.83 cm)	8 ⅝" (21.9 cm)	8 ⅝" (21.9cm)	12 ¾" (32.38 cm)	12 ¾" (32.38 cm)	12 ¾" (32.38 cm)

Product Data Sheet EE200A-97
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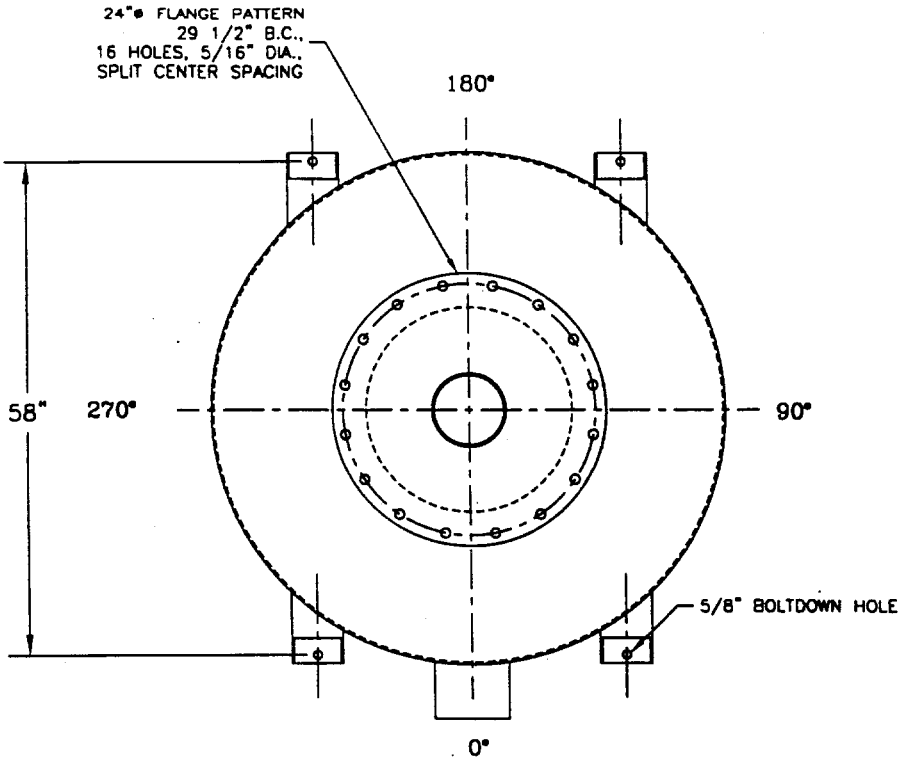
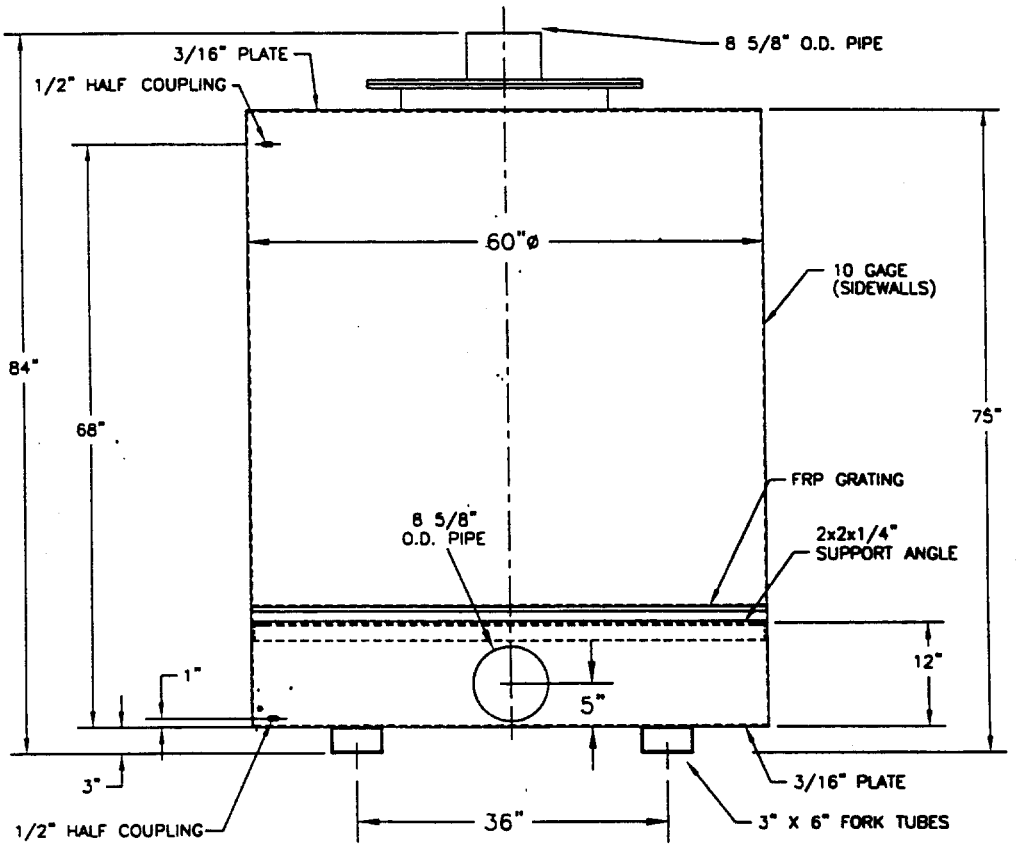
G CAS-1

GPC-20R



PLAN VIEW



ELEVATION

Sales Drawing #156000
07.16.97

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SPECIFICATIONS

B-2/B-3

SERIES	MODEL	HP (HP)	CAPACITY CFM	CAPACITY (M³/MIN)	RATED PRESSURE (PSIG)	RATED PRESSURE (BAR)	NOISE LEVEL (dba)	SPEED (RPM)	OIL CAPACITY (GAL)	OIL CAPACITY (LTR)	WEIGHT* (LBS)	WEIGHT* (KGS)
	OPEN											
500	ERC 504L	5	21	(0.6)	125	(8)	72	1750	0.53	(2)	275	(125)
	ERC 505L	7.5	29	(0.8)	125	(8)	74	1750	0.53	(2)	295	(134)
	ERC 507L	10	39	(1.1)	125	(8)	77	1750	0.92	(4)	374	(170)
	ERC 511L	15	60	(1.7)	125	(8)	78	1750	0.92	(4)	396	(180)
	ERC 515L	20	75	(2.1)	125	(8)	78	1750	0.92	(4)	671	(302)
1000	ERC1018L	25	98	(2.8)	125	(8)	81	1750	2.64	(10)	919	(305)
	ERC1022L	30	122	(3.5)	125	(8)	81	1750	2.64	(10)	925	(416)
	ERC1030L	40	147	(4.2)	125	(8)	81	1750	2.64	(10)	1,067	(480)
EM	EM500	50	215	(6.1)	115	(8)	86	1750	5.0	(19)	1,444	(656)
	EM600	60	265	(7.5)	115	(8)	87	1750	5.0	(19)	1,506	(685)
	EM750	75	335	(9.5)	115	(8)	90	1750	9.75	(38)	2,148	(976)
	EM1000	100	460	(13.0)	115	(8)	90	1750	9.75	(38)	2,437	(1,108)
	ENCLOSED											
500	AC 504L	5	21	(0.6)	125	(8)	61	1750	0.53	(2)	385	(175)
	AC 505L	7.5	29	(0.8)	125	(8)	63	1750	0.53	(2)	407	(185)
	AC 507L	10	39	(1.1)	125	(8)	68	1750	0.92	(4)	528	(240)
	AC 511L	15	60	(1.7)	125	(8)	69	1750	0.92	(4)	550	(250)
	AC 515L	20	74	(2.1)	125	(8)	69	1750	0.92	(4)	961	(432)
1000	AC1018L	25	100	(2.8)	125	(8)	69	1750	2.64	(10)	1,209	(544)
	AC1022L	30	124	(3.5)	125	(8)	69	1750	2.64	(10)	1,215	(547)
2000	AC2030L	40	147	(4.2)	125	(8)	71	1750	2.64	(10)	1,710	(776)
EMS	EMS500	50	215	(6.1)	115	(8)	68	1750	5.0	(19)	2,114	(959)
	EMS600	60	265	(7.5)	115	(8)	70	1750	5.0	(19)	2,176	(987)
	EMS750	75	335	(9.5)	115	(8)	72	1750	9.75	(38)	2,965	(1,345)
	EMS1000	100	460	(13.0)	115	(8)	72	1750	9.75	(38)	3,264	(1,481)
	HIGH PRESSURE OPEN/ENCLOSED											
500	ERC/AC 505H	7.5	25	(0.7)	150	(10)	74/63	1750	0.53	(2)	295/407	(134/185)
	ERC/AC 511H	15	46	(1.3)	150	(10)	78/69	1750	0.92	(4)	396/550	(180/250)
	ERC/AC 515H	20	74	(2.0)	150	(10)	78/69	1750	0.92	(4)	671/961	(302/432)
1000	ERC/AC1022H	30	95	(2.1)	150	(10)	81/69	1750	2.64	(10)	925/1,215	(416/547)
	ERC 1030H	40	95	(3.4)	150	(10)	81	1750	2.64	(10)	1,067	(480)
2000	AC 2030H	40	120	(3.4)	150	(10)	71	1750	2.64	(10)	1,710	(776)
	EM/S 600H	60	208	(5.9)	150	(10)	87/70	1750	5.0	(19)	1,506/2,176	(683/987)
	EM/S 1000H	100	349	(9.9)	150	(10)	90/72	1750	9.75	(38)	2,437/3,264	(1,106/1,481)

DIMENSIONS

ERC/ EM	L" x	W" x	H"	AIR CONNECTION	AC/ EMS	L" x	W" x	H"	AIR CONNECTION
504/505	41	17	26	1/2"	504/505	50	21	29	1/2"
507	46	17	30	3/4"	507	59	23.5	32	3/4"
511/515	51.5	20.5	31.5	3/4"	511/515	59/65	23.5/28	32/38	3/4"
1018/1022	58	22	35	1"	1018/1022	65	28	38	1"
1030	62	24	39	1"	2030	72	36.5	62	2"
500/600	75	30	47	1-1/2"	500/600	72	39.5	68	2"
750/1000	89	32.1	50.6	2"	750/1000	83.5	42.5	76.8	2"

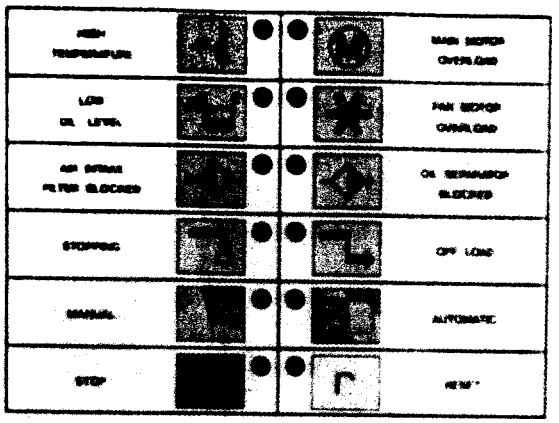
* FOR SHIPPING OF COMPRESSORS ADD ALLOWANCE FOR CRATING

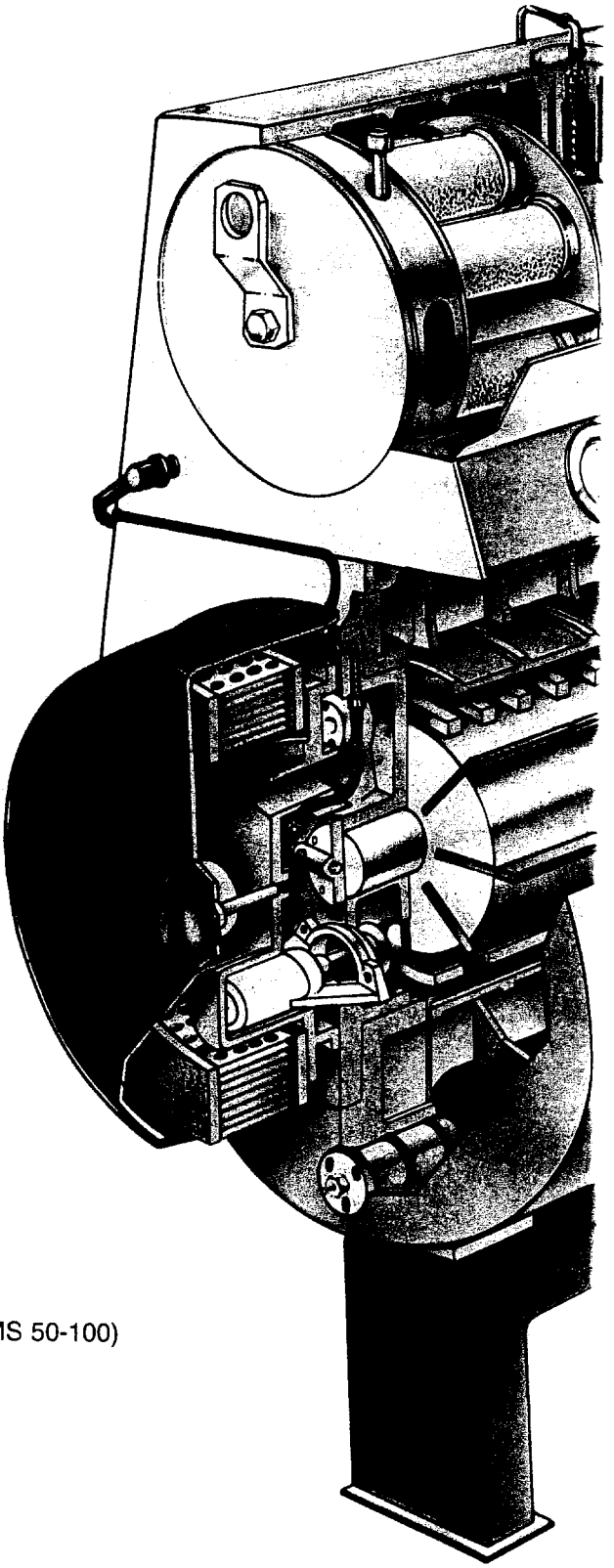
mattei®

029601

B-2/B-3

EM SERIES





Mattei's "Ready to Use" Rotary Air Compressors

For over 30 years, Mattei has established a reputation as world leader in the design and manufacture of rotary vane air compressors. The latest in computer-aided design, engineering and manufacturing (CAD/CAM) techniques assure that Mattei will maintain its leadership position as a rotary vane compressor manufacturer. Mattei's continuing investment in research and development has produced one of the most cost-effective packages available today.

Mattei Compressors are sold as complete air systems—"Ready to Use." Installation takes as little as 30 minutes and is simplicity itself.

The following equipment is standard on all models:

- 1750 RPM Open Drip-Proof Motor (Class F insulation).
- Accurate Temperature Sensors provide maximum thermal overload protection for electric motor.
- Oil/Air-cooled Aftercooler.

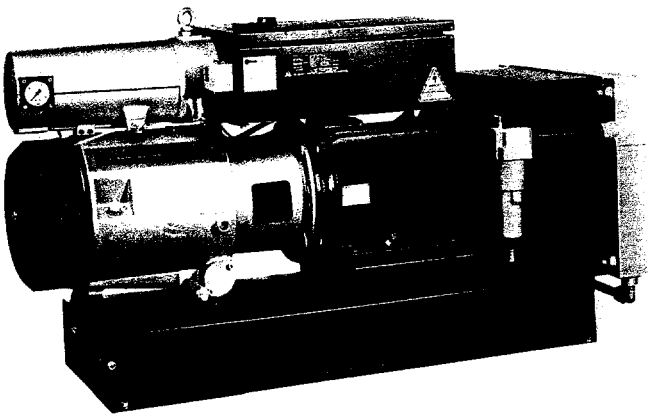
Models are available for 208/230/460/575 Volt operation, and totally enclosed Fan Cooled (TEFC) motors are an available option. All models are rated continuous operation (100% duty cycle).

Control system with across-the-line starters up to 30 HP and Star Delta Starter from 40 to 100 HP. Comprehensive instrumentation includes:

- Start/Stop Button
- Reset Button
- Emergency Stop Button
- Low Oil Level Switch (25 to 100 HP)
- High air temperature shutdown
- Indicator light and shutdown
- Main Motor Overload Indicator Light and Shutdown (EMS 50-100)
- Manual Operation Button
- Automatic Operation Button
- Fan Motor Over Load (AC2030L + 50-100)
- Off Load/Idling Indicator Light
- Stop Indicator Light
- Air Pressure Gauge
- Oil Temperature Gauge (50-100 HP)
- Running Time Meter
- Blocked Inlet Filter Warning Light (option) (50-100)
- Blocked Seperator Warning Light (option) (50-100)

B-2/B-3

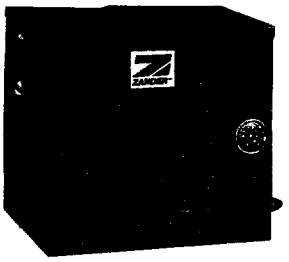
EM 500–1000



ERC 504–ERC 1030

WE'D LIKE TO CLEAR THE AIR.

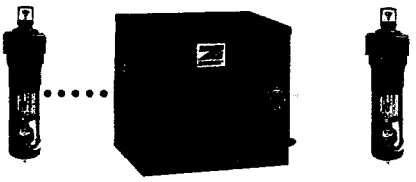
Zander Ecostar Refrigerated Compressed Air Dryer Series for small flow applications are constructed for long life and dependable operation. Highly refined, modern refrigeration units have proven their reliability and economy of operation many times over. The individual components are engineered for optimum performance and assembled in a compact, space-saving unit with excellent accessibilty for general maintenance and routine checks.



STANDARD EQUIPMENT

- Six-foot Power Cord
- Electrical Terminal Block (RD-100A to RD-200A)
- On/Off Switch
- Power On & High Temperature Indicator Lights
- Tube-in-Tube Heat Exchangers (RD-10A to RD-40A)
- Brazed Plate Heat Exchangers (RD-50A to RD-200A)
- Moisture Separator / Automatic Drain
- Refrigerant Suction Pressure Gauge
- Inlet Air Temperature and Outlet Air Pressure Gauge (RD-200A)

AD-1



RDF OPTION:

Includes Series X coalescing final filter with differential pressure gauge and auto drain mounted on filter housing. This filter provides 99.9999% efficiency at 0.01 micron, with oil removal down to 0.01 ppm at 100 psig and 68°F.

RDP OPTION

Includes Series X final filter described above and the Series Z prefilter with differential pressure gauge and automatic drain mounted on filter housing. This filter provides a 99.99% efficiency at 1 micron with oil removal down to 0.5 ppm at 100 psig and 68°F.

MODELS RD-10A THRU RD-200A

SPECIFICATIONS & DIMENSIONS

Model No.	Comp. Hp.	In/Out (NPTF)	Net Weight	Length	Width	Height
RD-10A	1/6	3/8	45	15	12	14
RD-20A	1/5	1/2	50	16	15	14
RD-30A	1/5	3/4	80	18	19	19
RD-40A	1/4	3/4	80	18	19	19
RD-50A	1/4	3/4	90	18	19	19
RD-75A	1/2	3/4	120	18	19	19
RD-100A	1/2	2	185	25	31	31
RD-150A	3/4	2	210	25	31	31
RD-200A	1	2	225	25	31	31

MAXIMUM CAPACITIES

Model No.	Maximum Capacity SCFM 38° F Pressure Dew Point	Maximum Capacity SCFM 50° F Pressure Dew Point
RD-10A	10	15
RD-20A	20	25
RD-30A	30	37
RD-40A	40	50
RD-50A	50	60
RD-75A	75	90
RD-100A	100	120
RD-150A	150	180
RD-200A	200	240

Capacities are based upon 100 psi inlet pressure at 100° F ambient.

ELECTRICAL DATA

- Models RD-10A thru RD-30A 115/60/1
- Models RD-40A thru RD-150A 115/60/1 or 230/60/1
- Model RD-200A 230/60/1

Electrical wiring is completed to junction box on dryer and is accessible from dryer exterior.

OTHER OPTIONS

Traptronic or Ecodrain Electronic Drains, and Ecosep Oil/Water Condensate Separators

Technical specifications available on request.
Specifications and dimensions subject to change without notice.

DISTRIBUTED BY

ZANDER®

ZANDER Filter Systems, Inc.

5201-D Brook Hollow Parkway • Norcross, Georgia 30071
Telephone: 770-446-3614 • Fax: 770-263-0856
Toll Free 1-800-543-0851

- Microfilters for oil-free, clean, compressed air and gases
- Activated-Carbon Adsorbers for odor-free, neutral compressed air
- Sterilizing Filters for aseptic compressed air • Steam Filters • Ventilation Filters • Autoclave Filters
- Vacuum Filters • High-Pressure Filters up to 5,000 psi • Microfilter Mufflers • MIN-DRY Terminal Dryers
- Electronically-Controlled Condensate Drain – Ecodrain Series
- Oil and Water Separation Systems – Ecosep Series, Aquafil
- Heatless Regenerated Adsoption Dryers – KM, KEN and HDK Series
- Adsorption Drying Installations for special gases, such as CO_2 and inert gas
- Refrigeration Dryers • Breathing Air Processing Equipment • Dew Point Meters

MICROFILTERS

AF-2

Compressed air is an important energy source in modern factories because it is flexible and reliable, however it is only fully efficient when it is clean.

The problem

Dust particles are ever present in the atmosphere. They are drawn in and intensified 8 times by the compressor. Additionally, depending on compressor type, oil in fine aerosol form goes into the compressed air network to cause problems. In a wet compressed system, rust particles, scale and other contaminants lead to:

- Production down time
- High repair costs
- Rejected products
- Missed delivery times.

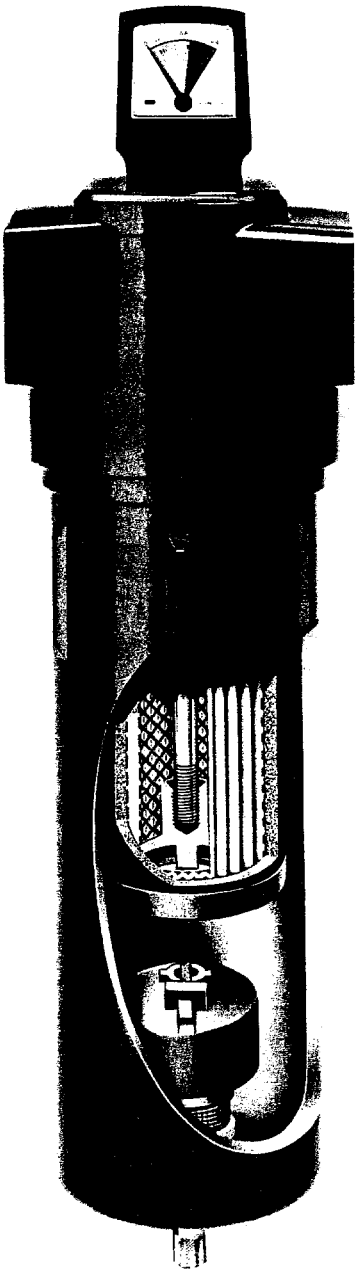
Increased automation on the one hand and higher quality requirements on the other means that these unnecessary problems must be eliminated.

ZANDER has successfully solved these problems over many years using a modular range of purification equipment.

As one of the leading companies in the compressed air and gas purification business, we have now increased the quality even further to produce the new ZANDER Microfilter.

ZANDER Microfilters offer a unique solution to compressed air purification thanks to the modular range of products.

The ZANDER range includes filter housings from 1/4" NPT to 12" flanged connections and will operate at pressures from 0 – 5000 psig so that every requirement is met with a standard range of products. Larger housings and higher pressures are available upon request.



Economical – reliable – flexible

Economical thanks to the newly developed, environmentally friendly filter media.

Reliable thanks to the compact and easy to service construction.

Flexible because 5 filter qualities are available.

The high quality standards of the ZANDER Microfilter can be identified by both a normal reference number and an easy color coding which ensures that the correct element is selected each time.

The concept

The Microfilters are designed to work efficiently either on their own or in several combinations depending on the application.

Microfilter series V

The prefilter range mainly takes out particles from the compressed air.

Thanks to the use of materials specially developed for this duty, the user enjoys a long service life with constant efficiency.

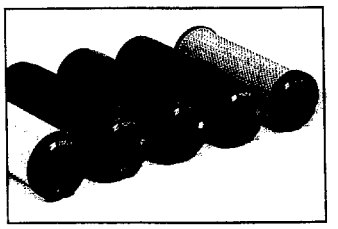
The efficiency is 99.99% of all particles of 3 micron and larger.

There are fine particles smaller than 3 micron, such as dust and especially oil aerosols which must be filtered out by a finer filter.

This is where the newly developed high efficiency depth Microfilter with its various grades are used.

Microfilter series Z (green)

Efficiency 99.99% at 1 micron. Oil retention down to ≙ ≈ 0.5 ppm at 100 psig and 68°F.



Element series V, Z, Y, X, A

Microfilter series Y (white)

Efficiency 99.99% at 0.01 micron. Oil retention down to ≙ ≈ 0.1 ppm at 100 psig and 68°F.

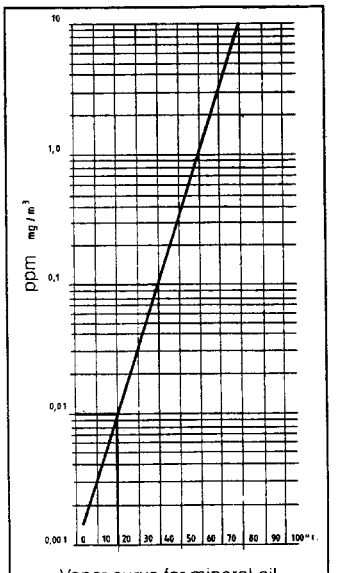
Microfilter series X (red)

Efficiency 99.9999% at 0.01 micron. Oil retention down to ≙ ≈ 0.01 ppm at 100 psig and 68°F.

If an even better quality of compressed air than the series X filter is required to remove the oil vapors, then an adsorption type filter is required.

Microfilter series A

The Microfilter series A incorporates an activated carbon bed which adsorbs oil vapor. It is always preceded by a Microfilter series X to remove oil aerosols.

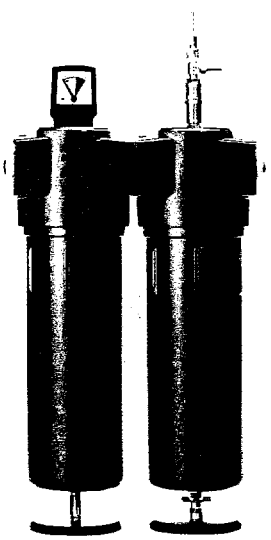


Vapor curve for mineral oil at 100 psi

4 PHASE FILTRATION

ZANDER®

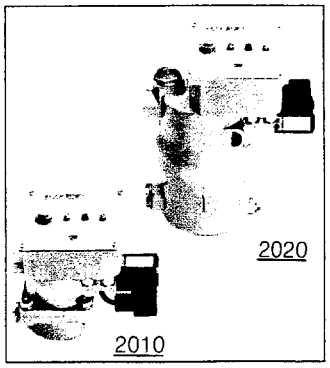
Microfilter series XA



The Microfilter combination XA gives technically oil free and clean air, which is essential for the protection of instruments, spray painting plants, food industry where compressed air comes into contact with product.

ecodrain

All Microfilters except the A range (activated carbon) come complete with automatic drain. For an even more reliable and efficient condensate removal from the filter housings, we offer our ecodrain float controlled drain as an option. Please see the ecodrain technical literature.



ZANDER filter technology

ZANDER has nearly two decades of experience using pleated filters as sterile filters, prefilters and adsorption filters in compressed air and gases. This experience has been incorporated in the latest ZANDER filter manufacturing facility.

ZANDER's application experience coupled with an aggressive research and development program has resulted in the ZANDER technology concept.

The market requires that the filter media have various degrees of efficiency so the four phases of filtration have different separation characteristics.

The pleating of the medium increases its stability under changing loads and reduces the specific surface tension. The results from this, is a higher load factor compared with conventional filters. This increases the flow capability and the dirt holding capacity.

The chart on the right shows the ZANDER advantage over conventional filters, a lower working pressure differential and a longer service life. The pleated filter element allows a higher dirt holding capacity with a comparable efficiency.

Production area for filter elements

The important criteria for the economical choice of a filter are:

- High flow capabilities
- Low differential pressure
- High dirt holding capacity by integrating the prefilter medium with the various final filtration layers.
- Long service life
- High product quality due to the latest manufacturing techniques

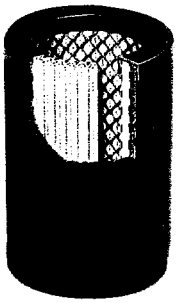
ZANDER Microfilter increases factory efficiency by reducing downtime and rejects. Product quality increases and delivery times decrease.

Environmentally friendly

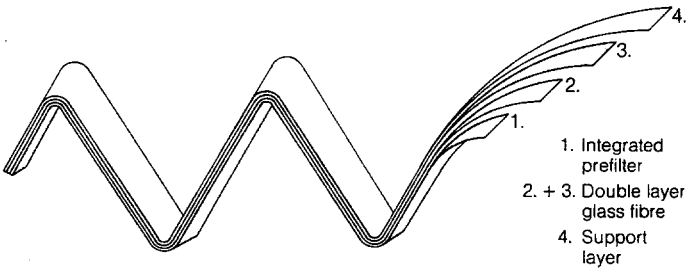
Due to the abilities of the Microfilter range to remove dirt, oil and condensed moisture out of compressed air economically, the compressed air and gases exhausted to atmosphere are now cleaner and less polluting.

As costs are reduced using ZANDER Microfilter it means that it is now easier to install them in a plant thus enhancing the overall factory environment.

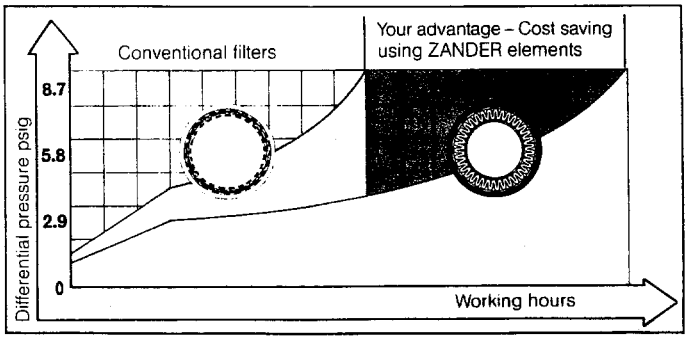
This cut away picture clearly shows the new 4 layer pleated element construction



4 Phase Filtration



1. Integrated prefilter
2. + 3. Double layer glass fibre
4. Support layer

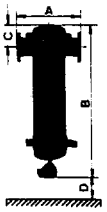


ZANDER®

AF-2

Technical Data
Series V, Z, Y, X

Aluminium housings. Powder coated outer protection. G 3 D to G 19 D with differential pressure gauge type ZD 90



Carbon steel housings. Differential pressure gauge type ZD 95.

Type	Capacity (scfm) at 100 PSI effective working pressure nominal	maximum	Connection NPT/FL	Dimensions (inches) A	B	C	D	Max. operat. pressure (PSI)	Weight (lbs)	Filter element number/ type
G 2	18	24	¼"	2.36	6.57	0.06	2.36	228	1.76	1/1030
G 3	29	35	¼"	3.43	8.23	0.83	2.95	228	3.30	1/1050
G 5	41	47	⅜"	3.43	8.23	0.83	3.54	228	3.30	1/1070
G 7	59	71	½"	3.43	10.98	0.83	6.30	228	3.74	1/1140
G 9	106	118	¾"	5.12	12.40	1.69	5.31	228	9.46	1/2010
G 11	177	200	1"	5.12	16.34	1.69	9.25	228	11.00	1/2020
G 12	277	318	1½"	5.12	20.28	1.69	13.19	228	12.10	1/2030
G 13	412	471	1½"	5.12	28.15	1.69	20.67	228	15.18	1/2050
G 14	553	618	2"	6.46	32.40	1.89	20.47	228	21.12	1/3050
G 17	853	924	2"	6.46	42.24	1.89	30.31	228	39.38	1/3075
G 18	1,142	1,324	2½"	9.84	41.42	2.91	24.02	228	44.00	1/5060
G 19	1,412	1,648	3"	9.84	47.32	2.91	29.92	228	60.50	1/5075
F 17	853	924	3" FL	14.96	49.61	6.69	20.87	228	118.80	1/3075
F 19	1,412	1,648	3" FL	17.32	51.57	7.87	20.87	228	176.00	1/5075
F 20	1,707	1,848	4" FL	19.68	56.69	9.05	21.65	228	237.60	2/3075
F 30	2,560	2,772	4" FL	19.68	56.69	9.05	21.65	228	242.00	3/3075
F 40	3,413	3,696	6" FL	25.20	62.60	11.02	21.65	228	332.20	4/3075
F 60	5,120	5,544	6" FL	31.10	65.35	11.81	21.65	228	466.40	6/3075
F 80	6,827	7,392	8" FL	31.10	68.70	13.38	21.65	228	510.40	8/3075
F 100	8,533	9,239	8" FL	33.07	70.08	14.17	21.65	228	785.40	10/3075
F 120	10,240	11,087	10" FL	37.00	75.98	16.53	23.62	228	1001.00	12/3075
F 160	13,653	14,783	10" FL	37.00	75.98	16.53	23.62	228	1016.40	16/3075
F 200	17,066	18,479	12" FL	37.00	77.16	17.22	23.62	228	1161.60	20/3075

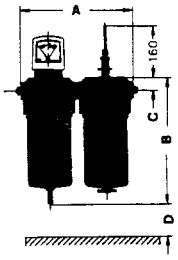
Nominal initial pressure differential in clean condition

Series V = 0.44 psig
Series Z = 0.44 psig
Series Y = 0.73 psig
Series X = 1.31 psig

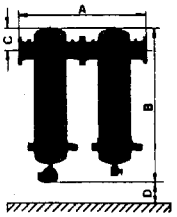
Performance:

Series V = 99.99% at 3 micron
Series Z = Oil retention* down to 0.5 ppm
Series Y = Oil retention* down to 0.1 ppm
Series X = Oil retention* down to 0.01 ppm
*at 68°F and 101.5 psi

Technical Data
Series XA



Aluminium housings. Powder coated outer protection. G 3 XAD OP to G 19 XAD OP with differential pressure gauge ZD 90 on the first stage and oil indicator type 01 (option) on the second activated carbon stage.



Carbon steel housing. Differential pressure gauge type ZD 95 on the first stage and oil indicator type 01 (option) on the second activated carbon stage.

Type	Capacity (scfm) at 100 PSI effective working pressure nominal	maximum	Connection	Dimensions (inches) A	B	C	D	Max. operat. pressure (PSI)	Weight (lbs)	Filter element number / type 1. stage	2. stage
G 2 XA	18	24	¼"	4.72	6.57	0.06	2.36	228	3.52	1/1030 X	1/1030 A
G 3 XA	29	35	¼"	6.86	8.23	0.83	2.95	228	6.60	1/1050 X	1/1050 A
G 5 XA	41	47	⅜"	6.86	8.23	0.83	3.54	228	6.60	1/1070 X	1/1070 A
G 7 XA	59	71	½"	6.86	10.98	0.83	6.30	228	7.48	1/1140 X	1/1140 A
G 9 XA	106	118	¾"	10.24	12.40	1.69	5.31	228	19.58	1/2010 X	1/2010 A
G 11 XA	177	200	1"	10.24	16.34	1.69	9.25	228	23.54	1/2020 X	1/2020 A
G 12 XA	277	318	1½"	10.24	20.28	1.69	13.19	228	25.52	1/2030 X	1/2030 A
G 13 XA	412	471	1½"	10.24	28.15	1.69	20.67	228	31.24	1/2050 X	1/2050 A
G 14 XA	553	618	2"	13.38	32.40	1.89	20.47	228	43.34	1/3050 X	1/3050 A
G 17 XA	853	924	2	13.38	42.24	1.89	30.31	228	56.76	1/3075 X	1/3075 A
G 18 XA	1,142	1,324	2½"	20.28	41.42	2.91	24.02	228	88.00	1/5060 X	1/5060 A
G 19 XA	1,412	1,648	3"	20.28	47.32	2.91	29.92	228	122.76	1/5075 X	1/5075 A
F 17 XA	853	924	3" FL	29.92	49.61	6.69	20.87	228	237.60	1/3075 X	1/3075 A
F 19 XA	1,412	1,648	3" FL	34.65	51.57	7.87	20.87	228	352.00	1/5075 X	1/5075 A
F 20 XA	1,707	1,848	4" FL	39.37	56.70	9.06	21.65	228	473.00	2/3075 X	2/3075 A
F 30 XA	2,560	2,772	4" FL	39.37	56.70	9.06	21.65	228	481.80	3/3075 X	3/3075 A
F 40 XA	3,413	3,696	6" FL	50.39	62.60	11.02	21.65	228	666.60	4/3075 X	4/3075 A
F 60 XA	5,120	5,544	6" FL	62.20	65.35	11.81	21.65	228	935.00	6/3075 X	6/3075 A
F 80 XA	6,827	7,392	8" FL	62.20	68.70	13.39	21.65	228	1,027.40	8/3075 X	8/3075 A
F 100 XA	8,533	9,239	8" FL	66.14	70.08	14.17	21.65	228	1,577.40	10/3075 X	10/3075 A
F 120 XA	10,240	11,087	10" FL	74.02	75.98	16.54	23.62	228	2,013.00	12/3075 X	12/3075 A
F 160 XA	13,653	14,783	10" FL	74.02	75.98	16.54	23.62	228	2,037.20	16/3075 X	16/3075 A
F 200 XA	17,066	18,479	12" FL	74.02	75.98	17.72	23.62	228	2,327.60	20/3075 X	20/3075 A

Nominal initial pressure
Differential in clean condition

Series XA 2.9 psig

Performance

Oil retention down down to ≦ 0.005 ppm at 68°F and 100 psig

Conversion factor f for other operating pressures

Pressure, bar	1	2	3	4	5	[illegible]	7	8	9	10	11	12	13	14	15	16
f=	0,25	0,38	0,5	0,65	0,75	0,88	1	1,13	1,25	1,38	1,5	1,63	1,75	1,88	2	2,13

ZANDER produces:

Microfilters for oil-free and clean compressed air and gases · Activated-carbon adsorbers for odour-free and neutral compressed air · Sterilizing filters for aseptic compressed air · Steam filters · Ventilation filters · Autoclave filters · Vacuum filters · High-pressure filters up to 5000 psi · Microfilter mufflers · MIN-DRY terminal dryers Electronically controlled condensate drain: series ecodrain · Oil/Water separating systems: series ecosep, aquafil, aquatec · Heat regenerated adsorption dryers: series WI, WVN · Heatless regenerated adsorption dryers: series KEN, KEA, HDK · Adsorption drying installations for special gases, such as CO_2, natural gas, inert gas · Refrigeration dryers · Breathing air processing equipment ecolight · ecopac · Dew point meter

We reserve the right to change design and dimensions.

MF US 2/96

ZANDER®

ZANDER Filter Systems, Inc.
5201-D Brook Hollow Parkway
Norcross, Georgia 30071
Tel. (770) 446-3614 · Fax (770) 263-0856
US & Canada Call Toll Free 1-800-543-0851

Regulator
R11

FOR
AIR SPARGING HEADERS
(SH-01 / SH-02)
TYPICAL.

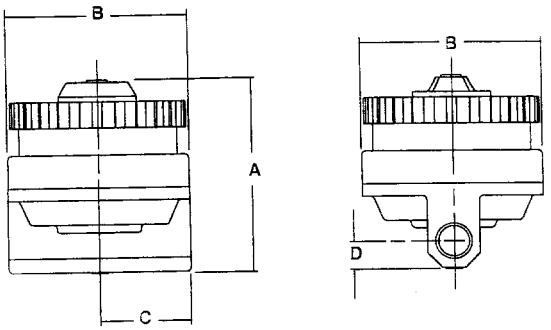
Specifications

Flow Capacity*	1/4	117 scfm (55 dm³/s)
Maximum Operating Temperature		175°F (79°C)
Maximum Supply Pressure		300 psig (21 bar)
Adjusting Range Pressure		0-160 psig (0-11 bar)
Bleed Rate		0.05 scfm (0,024 dm³/s)
Port Size	NPT/BSP	1/4
Weight	lb. (kg)	1.3 (0,5)

*Inlet pressure 100 psig (7 bar). Secondary pressure 90 psig (6 bar).

Materials of Construction

Body	Zinc
Bonnet	Zinc/Brass
Piston	Acetal
Valve Assembly	Brass/Nitrile/Acetal
Springs	Steel
Seals	Nitrile



Dimensions

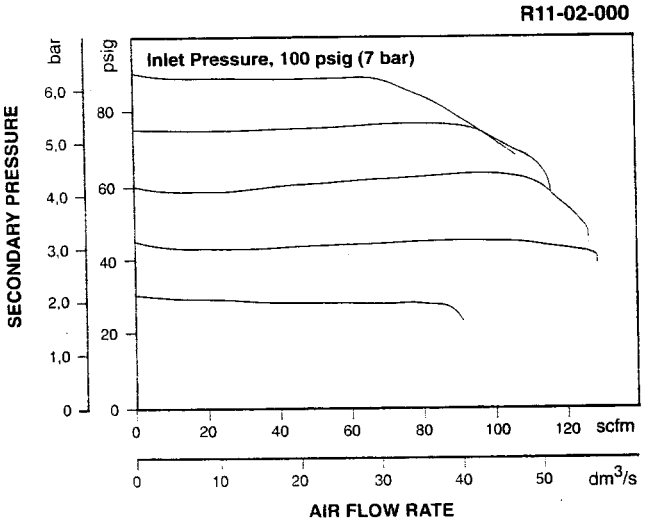
Models	Inches mm	A	B	C	D
Standard Unit		2.8	2.6	1.3	.4
R11-XX-000		71	66	33	10

FOR

AIR SPARGING HEADERS

(SH-01/SH-02)

TYPICAL.

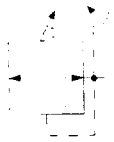


Ordering Information

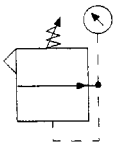
Model Type	Port Size	Standard Pressure 5-160 psig (0,4-11 bar)	Low Pressure 2-40 psig (0,1-3 bar)
Pilot	1/4	R11-02-000	R11-02-L00

Regulator
R07

FOR
AIR SPARGING LATERALS
(AS-01 .... AS-09)
TYPICAL



Relieving



Nonrelieving

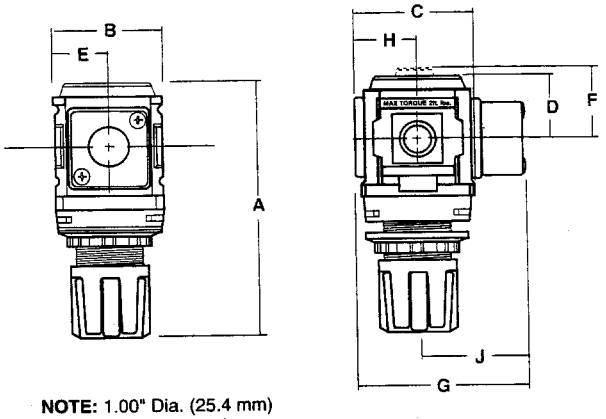
Specifications

Flow Capacity*	1/8 1/4	52.0 scfm (24,5 dm³/s) 78.0 scfm (37,0 dm³/s)
Maximum Operating Temperature		140°F (60°C)
Maximum Supply Pressure		140 psig (10 bar)
Adjusting Range Pressure		7-120 psig (0,5 - 8,3 bar)
Port Size	NPT/BSP	1/8, 1/4
Gauge Port(s)	NPT/BSPT	(1) 1/4
Weight	lb. (kg)	.43 (0,195)

*Inlet pressure 100 psig (7 bar). Secondary pressure 90 psig (6 bar).

Materials of Construction

Body Cover	Acrylonitrile-butadiene-styrene
Body	Polyamide
Bonnet Knob	Polyamide Polyacetal
Diaphragm	Nitrile/Polyacetal
Pressure Gauge And Gauge Plug	Polybutylene terephthlate Acrylonitrile-butadiene-rubber (nitrile)
Bottom Plug	Polyacetal
Valve Assembly	Brass/Nitrile
Springs	Steel
Seals	Nitrile
Panel Nut	Polyacetal



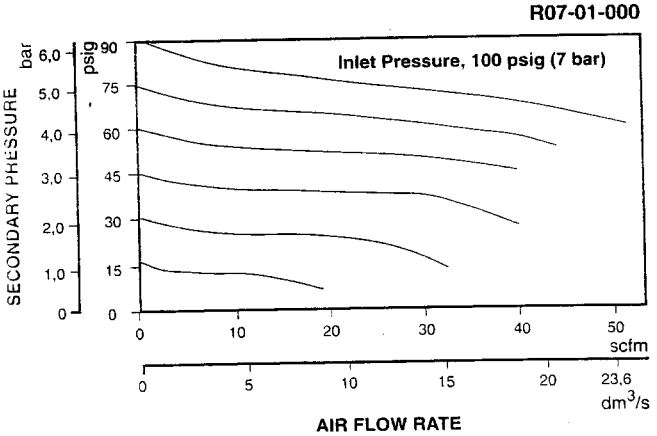
NOTE: 1.00" Dia. (25.4 mm) hole required for panel nut mounting

Dimensions

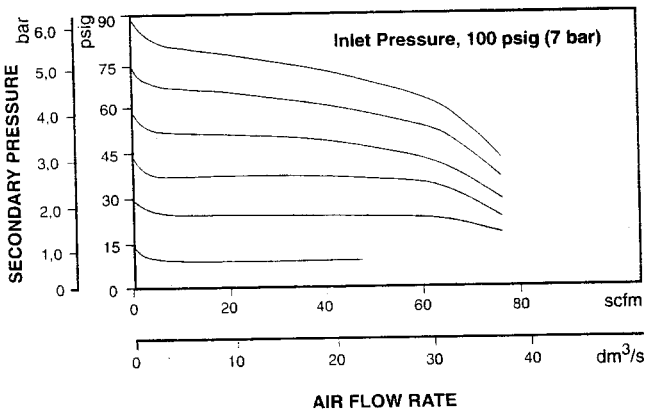
Models	Inches mm	A	B	C	D	E	F	G	H	J
Standard Unit R07-XX-000		3.73 95	1.57 40	1.88 48	.97 25	.78 20	2.29 58	— —	.94 24	— —
With Gauge		3.73 95	1.57 40	1.88 48	.97 25	.78 20	2.29 58	2.47 63	.94 24	1.53 39

For Air Sparging Laterals
(AS-01 .... AS-09)
Typical

R07-01-000



R07-02-000



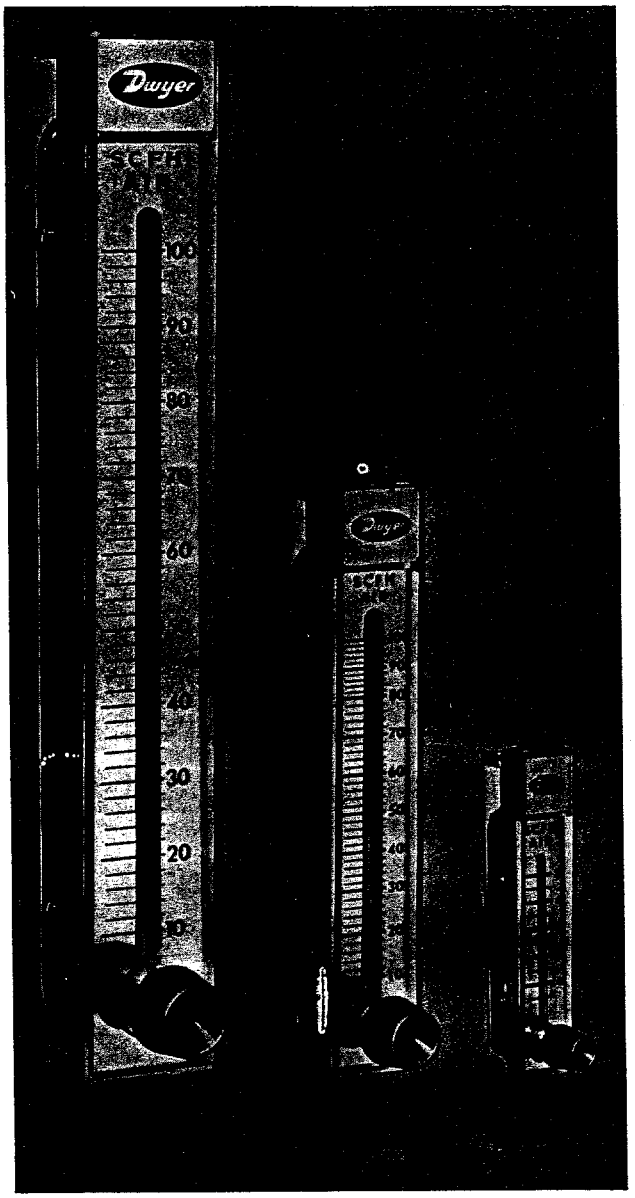
Ordering Information

Model Type	Port Size	Without Gauge 7-120 psig (0,5-8,2 bar)	Without Gauge 3-50 psig (0,2-3,4 bar)	With Gauge 7-120 psig (0,5-8,2 bar)	With Gauge 3-50 psig (0,2-3,4 bar)
Relieving	1/8	R07-01-000	R07-01-L00	R07-01-G00	R07-01-GL0
	1/4	R07-02-000	R04-02-L00	R07-02-G00	P07-02-GL0
Nonrelieving	1/8	R07-01-N00	R07-01-LN0	R07-01-GN0	R07-01-GLN
	1/4	R07-02-N00	R07-02-LN0	R07-02-GN0	R07-04-GLN

Options - To order an option supplied with the unit model, add the appropriate coded suffix letter in position 6, 7, 8 of the model number. For additional information on regulator accessories and repair kits see page R36.

Accessories	Part Number
L-Bracket	GPA-97-013

Series RM Rate-Master® Flowmeters



Molded of tough polycarbonate plastic. Used to indicate or manually control air or gas flow from .1-1800 SCFH... water flows to 10 GPM

The Dwyer Rate-Master line of direct reading precision flowmeters incorporates many unique user features at moderate cost. These low cost flowmeters are ideal for general use.

Easy to read design – The direct reading scales eliminate troublesome conversions. The scales are brushed aluminum, coated with epoxy and the graduations are on both sides of the indicating tube. Special integral flow guides stabilize the float throughout the range to keep it from hunting or wandering in the bore. The float is highly visible against a white background.

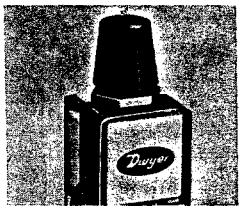
Construction assures accuracy–All Rate-Master flowmeter bodies are injection molded of tough, clear, shatter-proof polycarbonate plastic around a precision tapered pin. Critical internal diameter of the variable orifice tube is held within ± 0.0004". The result is accurate and repeatable readings. The single piece plastic body is mounted to a stainless steel backbone into which pipe thread inserts are welded to absorb piping torque. Precision metering valves of brass or stainless steel (specify BV or SSV on order) are available as an optional extra and permit precise flow adjustments. For vacuum applications, Model RMA units are available with top mounted valves (specify TMV). The small Series RMA models are accurate within ± 4% of full scale reading; Series RMB within ± 3%; large Series RMC within ± 2%.

Installation is simple – The Rate-Master can be neatly through-panel mounted to keep flow tube centers in the same plane as the panel surface or surface mounted on the panel by means of tapped holes in the backbone. When through-panel mounted, the bezel automatically positions the instrument at the correct depth in the panel cutout. Surface mounted units can also be held in place by the piping. All mounting hardware plus installation and operating instructions are included.

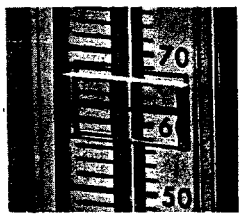
Cleaning is easy–To release the plastic flowmeter body from the stainless steel backbone, just remove four screws. Pipe thread flow connections remain undisturbed. Remove the slide cover and the plug ball stop, clean the flow tube with soap and water and reassemble. It's that simple.

Specials–See page 5 for typical examples of special ranges, scales, mounting arrangements, etc., available on special order, or in OEM quantities.

Easy-to-interchange bodies – Within a given Series, Rate-Master flowmeter bodies can be instantly interchanged. Simply "unplug" the body from backbone and replace it with another. "O" rings provide a tight seal on inlet and outlet. Piping remains undisturbed. Interchangeability is useful where different scale ranges are sometimes required at the same location in the laboratory or plant.



Top Mounted Metering Valves – Same precision construction for vacuum applications. . .



Adjustable pointer flags–Red-lined pointer flags provide quick visual reference to a required flow level. Of clear plastic, they snap into place inside bezel and slide to desired level.

Dwyer Instruments, Inc. P.O. Box 373/Michigan City, Indiana 46361/Phone 219 879-8000/Fax 219 872-9057 • U.K. Phone (01494)-461707 • Australia Phone (02) 9708-4799

FOR V.E. WELL LATERALS (TYPICAL)

SPECIFICATIONS	
Meter Body, Bezel and Tube	Polycarbonate
Wetted Metal Parts	Stainless Steel (except for optional brass valves)
Floats	St. Steel, Blk. Glass, Alum., K Monel, Tung. Carbide
Float Stops	Polycarbonate
Pipe Connections	Model RMA, 1/8"; Model RMB, 1/4"; Model RMC, 1/2" NPT
"O" Rings	Neoprene and Buna N
Fittings	Stainless Steel brazed to Stainless Steel backbone plate
Rivets	Stainless Steel, set into slots
Scale	Brushed Aluminum–Clear Epoxy Coated
Knobs	ABS Plastic
Pressure Rating	RMA 100 P.S.I., RMB 70 P.S.I., RMC 35 P.S.I. max.
Temperature Rating	To 130° F. maximum
Accuracy	Model RMA, 4%; Model RMB, 3%; Model RMC, 2% of full scale

OPTIONS AND ACCESSORIES		CODE
Metering Valve	Brass	BV
	Stainless Steel	SSV
Top Mounted Valve	Stainless Steel–available only on RMA for air (vacuum applications)	TMV
Pointer Flag	Polycarbonate	PF

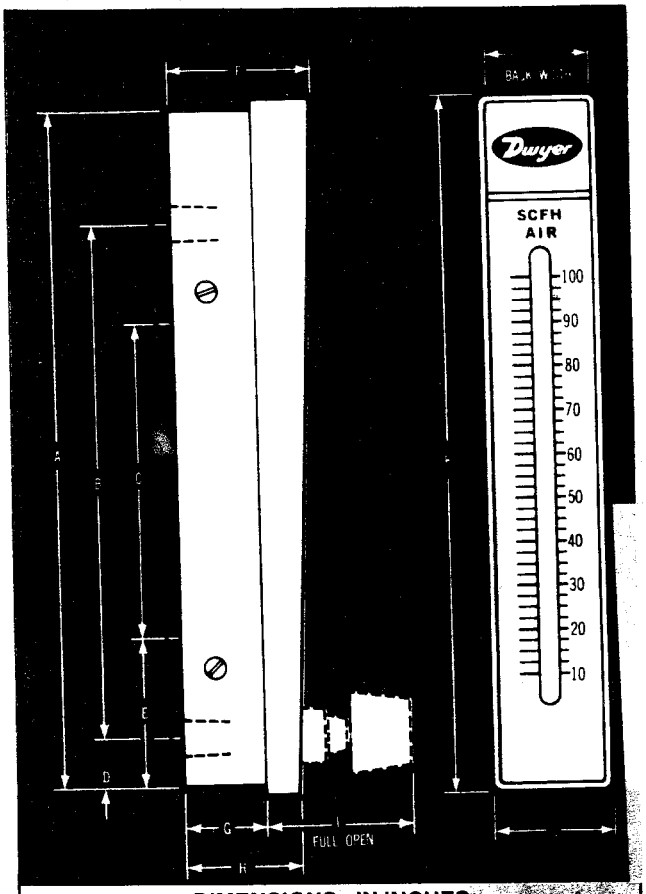
Series RM RATE-MASTER® Models and Ranges

Model RMA–2" Scale		Model RMB–5" Scale		Model RMC–10" Scale	
Range SCFH Air	Ordering No.	Range SCFH Air	Ordering No.	Range SCFH Air	Ordering No.
.05-.5	1	.5-5	49	5-50	101
.1-1	2	1-10	50	10-100	102
.2-2	3	2-20	51	20-200	103
.5-5	4	5-50	52	40-400	104
1-10	5	10-100	53	60-600	105
2-20	6	20-200	54	100-1000	106
5-50	7	40-400	55	120-1200	107
10-100	8	50-500	56	180-1800	108
15-150	9	60-600	57	**SCFM Air**	
20-200	10	**Gal. Water per hour**		1-10	121
CC Air/min.				2-20	122
5-50	151*	1-12	82	3-30	123
10-100	150*	1-20	83	**Gal. Water per hour**	
30-240	11	4-40	84		
50-500	12	10-100	85	2-20	134
100-1000	13			8-90	135
200-2500	14			**Gal. Water per min.**	
LPM Air					
.5-5	26			.1-1	141
1-10	21			.2-2.2	142
2-25	22			.4-4	143
5-50	23			.8-7	144
5-70	24			1.2-10	145
10-100	25				
CC Water/min.					
5-50	32				
10-110	33				
20-300	34				
Gal. Water/hr.					
1-11	42				
2-24	43				
4-34	44				
5-50	45				

*Accuracy ±8%

CAUTION

Dwyer Rate-Master® flowmeters are designed to provide satisfactory long term service when used with air, water, or other compatible media. Refer to factory for information on questionable gases or liquids. Caustic solutions, anti-freeze (ethylene glycol) and aromatic solvents should definitely not be used.



DIMENSIONS–IN INCHES

	Model RMA	Model RMB	Model RMC
A	4 9/16	8 1/2	15 1/8
B	3 1/8 NPT Conn.	6 7/16 1/4 NPT Conn.	12 1/4 1/2 NPT Conn.
C	1 5/8 10-32 Thds.	3 15/16 1/4-20 Thds.	8 3/4 3/8-24 Thds.
D	3/8	5/8	1
E	1 1/16	1 7/8	2 3/4
F	1 3/16	1 3/4	2 1/4
G	3/4	1	1 7/8
H	1	1 7/16	1 31/32
I (OPEN)	1 3/8	1 13/16 (BV or SSV MODELS ONLY)	2 1/2
J	3/4	1 1/4	2
K	4 13/16	8 3/4	15 5/8
L	1	1 1/2	2 1/4

How To Order

1. Select series by letter designation, RMA, RMB or RMC.
2. Add ordering number to specify range. Example: RMB-49.
3. Add suffix BV for brass valve, SSV for stainless steel valve or TMV for top mounted valve (RMA only). Example: RMB-49-SSV.
4. For adjustable pointer flag add -APF (RMA), -BPF (RMB) or -CPF (RMC). Example: RMB-49-SSV-BPF

Prices

RMA	$16.90	RMB	$25.90
RMA-BV	21.40	RMB-BV	31.90
RMA-SSV	22.40	RMB-SSV	33.90
RMA-TMV	30.90	-BPF pointer flag	1.70
Add to prices above for -150 and -151 ranges	8.00	-RK-RMB regulator kit	63.90
-APF pointer flag	1.40	RMC	51.90
-RKA regulator kit	63.90	RMC-BV	63.90
		RMC-SSV	67.90
		-CPF pointer flag	1.90

Simplicity of Design Ensures Reliable Operation

Housing is molded from strong mineral and glass filled nylon.

Pointer stops of molded rubber prevent pointer over-travel without damage.

Full view lens is removable and molded of tough polycarbonate.

Aluminum scale litho-printed black on white, enhances readability.

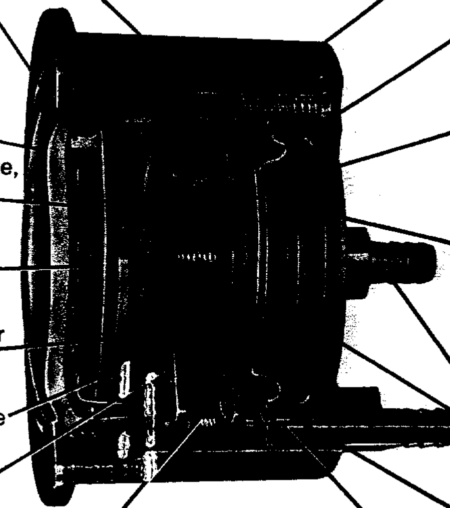
Red tipped aluminum pointer, rigidly mounted to helix is easy to see.

Wishbone assembly provides mounting for helix, helix bearings, and pointer shaft.

Jewel bearings provide virtually friction-free helix motion.

Helix is free to rotate in jewel bearings. It aligns with magnetic field of magnet to transmit pressure indications to pointer.

Zero adjustment screw, located behind the removable lens, eliminates tampering.



Range spring calibration clamp fixes live length of spring for proper gage calibration and is factory set and sealed.

Silicone rubber diaphragm allows accurate response to a broad range of temperatures and at extremely low pressure. Incorporates blow out area for overpressure protection.

Diaphragm support plates of lightweight aluminum on each side of the diaphragm minimize position or attitude sensitivity and help define pressure area.

Flat leaf range spring reacts to pressure on the diaphragm. Live length is adjustable for calibration. Small amplitude of motion minimizes inaccuracies and assures long life.

Low pressure tap connects to rear chamber.

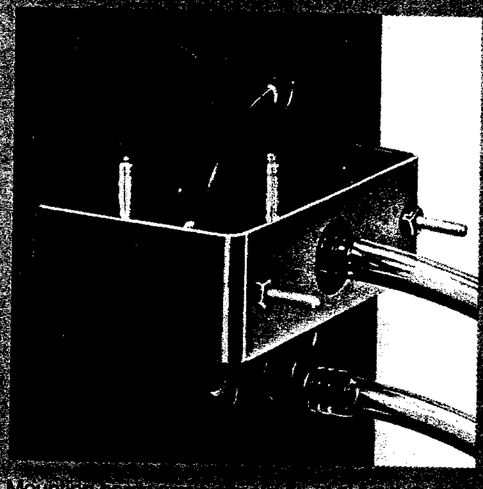
Coil spring link provides a resilient connection between the diaphragm and the range spring.

Ceramic magnet mounted on a molded bracket at the end of the range spring rotates the helix without direct mechanical linkage.

High pressure tap connects with the front chamber through passageway in the plastic case and a sealing ring molded into the edge of the diaphragm.

Patent No. 4,347,744

PANEL MOUNTIN[illegible]



Mounting hardware is supplied with the Minihelic [illegible] gage for panel mounting through a single hol[illegible] 2⅝" in diameter. Panel thickness up to [illegible] can [illegible] accommodated with the hardware supplied. [illegible] necessary, surface mounting of the gage can [illegible] accomplished by means of two 4-40 screws [illegible] the tapped mounting bracket stud holes in the rea[illegible] of the gage. Surface mounting requires clearan[illegible] holes in the panel for the two pressure taps.

MODEL RANGE CHA[illegible]

[illegible]

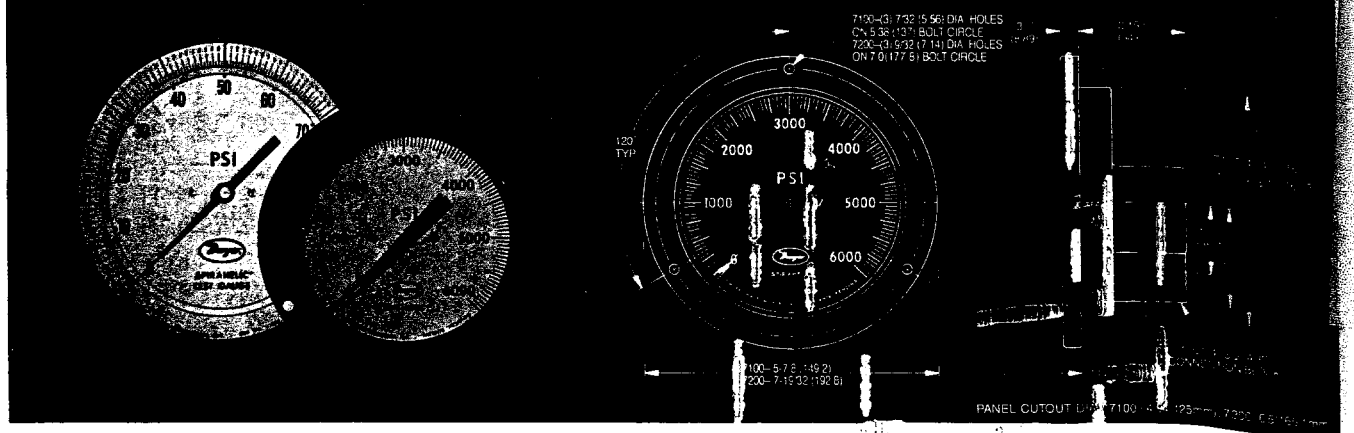
Suggested Specificatio[illegible]

[illegible] diaphragm actuated, round dial type [illegible] black [illegible] pointer zero adjustment, and [illegible] type pressure conne[illegible] [illegible] Minihelic II Catalog [illegible]

SERIES 7000

Spirahelic® Pressure Gages

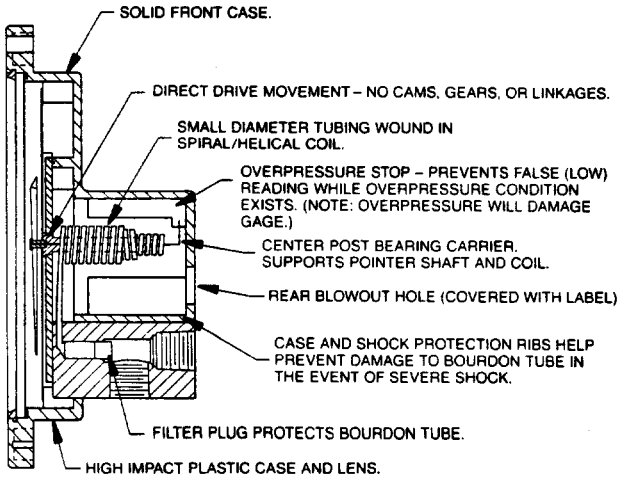
Reliability and Accuracy in a 4½″ or 6″ solid-front gage



Choose 4½″ or 6″ Gages, both with triple coil spiral/helical wound Bourdon tube to provide dependable service. ASME Grade A, 2A or 3A accuracy is built in for life. Spirahelic® Bourdon tube design eliminates gears, springs, linkages and complex movements which can wear and cause inaccuracy or early failure. Direct drive of lightweight, precision balanced pointer reduces friction and mass, improving responsiveness and accuracy. Units resist shock and vibration which would quickly ruin conventional "C" tube gages and avoids the need for expensive and leaky liquid filled gages.

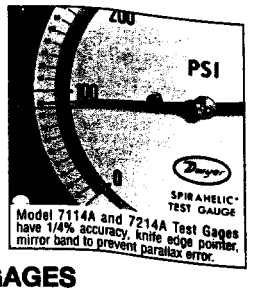
Center post bearing carrier ensures precise bearing alignment for nearly friction free operation. Low volume Bourdon tube reduces fluid volume and stored energy, reducing potential for damage if tube ruptures from overpressure or other causes. Large area filter plug keeps dirt out and restricts flow from damaged Bourdon tube. "Throttling" feature of small diameter tubing combines with solid front and rear blowout features for exceptional safety. Brass or 316 stainless steel connection block has both bottom and back openings. Impact resistant plastic case is sized to conform to ASME B40.1, replacing existing gages without changes in panel cutout or mounting holes.

For applications requiring both an analog gage and remote signal transmission, choose the Series 7116 Spirahelic® Pressure Indicating Transmitter. It adds a versatile 4-20 mA DC; 2, 3 or 4 wire output signal to the ASME Grade 2A accuracy of the 7112 models. Span and zero controls included.



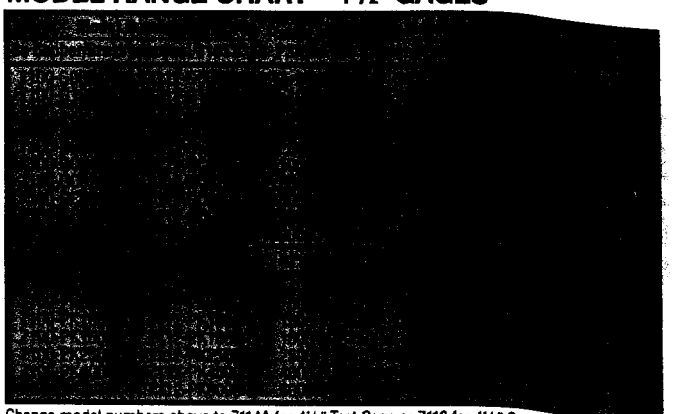
PHYSICAL DATA

Size: 4½″ (7100) or 6″ (7200) – design conforms to ASME B40.1.
Accuracy: Model 7100-ASME Grade A (1% middle half, 2% first and last quarters). Models 7112, 7116-ASME Grade 2A (1/2% of full scale). Model 7114A, 7214A-ASME Grade 3A (1/4% of full scale).
Pressure Connection: 1/4″ NPT female, duplicated back and bottom.
Wetted Parts: Model 7100 – Beryllium copper Bourdon tube, nickel plated brass connection block. Models 7112, 7114A, 7116, 7214A – Inconel® X-750 Bourdon tube, 316 SS connection block.
Housing: Impact resistant, mineral filled black nylon.
Calibration: Vertical mounting standard.
Movement: Direct drive of pointer.
Overpressure: 150% of full scale. Normal operation between 25% and 75% of full scale.
Temperature Limits, 7100: –65 to 160°F (–54 to 71.1°C); **7112, 7114A, 7214A:** –65 to 180°F (–54 to 82.2°C); **7116:** 20 to 120°F (–6.7 to 49°C).
Weight: 7100; 18 oz. (.5 kg), 7200; 26 oz. (.74 kg).
Standard Accessory: (1) ¼″ NPT plug, brass or stainless steel.
Optional Accessory: No. A-341 Brass Adapter. ¼″ NPT×G 1/2 A (per ISO 228/1) parallel thread.



Model 7114A and 7214A Test Gages have 1/4% accuracy, knife edge pointer, mirror band to prevent parallax error.

MODEL RANGE CHART – 4½″ GAGES



Change model numbers above to 7114A for 4½″ Test Gage or 7116 for 4½″ Gage with Transmitter.
† These ranges also available in 6″ size Test Gage. To order, change 7112 to 7214A.

PRICES

7100 (ALL MODELS)	$50.00
7112 (ALL MODELS)	91.00
7116 (ADD to 7112 price)	99.00
A-341 Brass adapter	11.90
7114A-G060 to 7114A-G600	$174.00
7114A-GC010 to 7114A-GC030	209.00
7114A-GC060 to 7114A-GC100	249.00
7214A-G100 to 7214A-G600	205.00
7214A-GC010 to 7214A-GC030	240.00
7214A-GC060	340.00

INCONEL® INCO ALLOYS INTERNATIONAL, INC.

Air Velocity Measurement

Introduction

In air conditioning, heating and ventilating work, it is helpful to understand the techniques used to determine air velocity. In this field, *air velocity* (distance traveled per unit of time) is usually expressed in feet per minute (f.p.m.). By multiplying air velocity by the cross section area of a duct, you can determine the air volume flowing past a point in the duct per unit of time. *Volume flow* is usually measured in cubic feet per minute (c.f.m.).

Velocity or volume measurements can often be used with engineering handbook or design information to reveal proper or improper performance of an airflow system. The same principles used to determine velocity are also valuable in working with pneumatic conveying, flue gas flow and process gas systems. However, in these fields the common units of velocity and volume are sometimes different from those used in air conditioning work.

To move air, fans or blowers are usually used. They work by imparting motion and pressure to the air with either a screw propeller or paddle wheel action. When force or pressure from the fan blades causes the air to move, the moving air acquires a force or pressure component in its direction of motion due to its weight and inertia. Because of this, a flag or streamer will stand out in the air stream. This force is called *velocity pressure*. It is measured in inches of water column (w.c.) or water gage (w.g.). In operating duct systems, a second pressure is always present. It is independent of air velocity or movement. Known as *static pressure*, it acts equally in all directions. In air conditioning work, this pressure is also measured in inches w.c.

In pressure or supply systems, static pressure will be positive on the discharge side of the fan. In exhaust systems, a negative static pressure will exist on the inlet side of the fan. When a fan is installed midway between the inlet and discharge of a duct system, it is normal to have a negative static pressure at the fan inlet and positive static pressure at its discharge.

Total pressure is the combination of static and velocity pressures, and is expressed in the same units. It is an important and useful concept to us because it is easy to determine and, although velocity pressure is not easy to measure directly, it can be determined easily by subtracting static pressure from total pressure. This subtraction need not be done mathematically. It can be done automatically with the instrument hook-up.

Sensing Static Pressure

For most industrial and scientific applications, the only air measurements needed are those of static pressure, total pressure and temperature. With these, air velocity and volume can be quickly calculated.

To sense static pressure, six types of devices are commonly used. These are connected with tubing to a pressure indicating instrument. Fig. 1-A shows a simple thru-wall static pressure tap. This is a sharp, burr-free opening through a duct wall provided with a tubing connection of some sort on the outside. The axis of the tap or opening must be perpendicular to the direction of flow. This type of tap or sensor is used where air flow is relatively slow, smooth and without turbulence. If turbulence exists, impingement, aspiration or unequal distribution of moving air at the opening can reduce the accuracy of readings significantly.

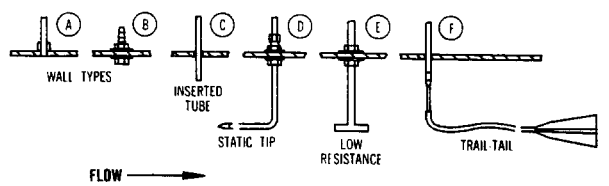


FIG. 1 – TYPES OF STATIC PRESSURE SENSING DEVICES

Fig. 1-B shows the Dwyer No. A-308 Static Pressure Fitting. Designed for simplified installation, it is easy to install, inexpensive, and provides accurate static pressure sensing in smooth air at velocities up to 1500 f.p.m.

Fig. 1-C shows a simple tube through the wall. Limitations of this type are similar to wall type 1-A.

Fig. 1-D shows a static pressure tip which is ideal for applications such as sensing the static pressure drop across industrial air filters and refrigerant coils. Here the probability of air turbulence requires that the pressure sensing openings be located away from the duct walls to minimize impingement and aspiration and thus insure accurate readings. For a permanent installation of this type, the Dwyer No. A-301 or A-302 Static Pressure Tip is used. It senses static pressure through radially-drilled holes near the tip and can be used in air flow velocities up to 12,000 f.p.m.

Fig. 1-E shows a Dwyer No. A-305 low resistance Static Pressure Tip. It is designed for use in dust-laden air and for rapid response applications. It is recommended where a very low actuation pressure is required for a pressure switch or indicating gage—or where response time is critical.

Under field conditions, air turbulence in a duct or plenum often makes it impossible to quickly install and align a rigid static pressure sensor to take accurate readings. Under these circumstances, the Dwyer Trail-Tail® Static Pressure Sensor (Fig. 1-F), can be quickly inserted through a small hole in the duct and will trail into automatic alignment with the air stream. The pressure sensing holes in this device are thus presented at a 90° angle to actual air flow assuring quick, consistent, accurate readings.

Measuring total pressure and velocity pressure

In sensing static pressure we make every effort to eliminate the effect of air movement. To determine velocity pressure, it is necessary to determine these effects fully and accurately. This is usually done with an impact tube which faces directly into the air stream. This type of sensor is frequently called a "total pressure pick-up" since it receives the effects of both static pressure and velocity pressure.

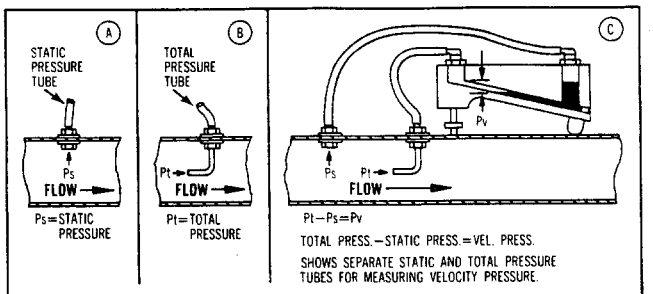


FIG. 2 – TYPES OF PRESSURE MEASUREMENTS

In Figure 2, note that separate static connections (A) and total pressure connections (B) can be connected simultaneously across a manometer (C). Since the static pressure is applied to both sides of the manometer, its effect is cancelled out and the manometer indicates only the velocity pressure.

To translate velocity pressure into actual velocity requires either mathematical calculation, reference to charts or curves, or prior calibration of the manometer to directly show velocity. In practice this type of measurement is usually made with a Pitot tube which incorporates both static and total pressure sensors in a single unit.

Essentially, a Pitot tube consists of an impact tube (which receives total pressure input) fastened concentrically inside a second tube of slightly larger diameter which receives static pressure input from radial sensing holes around the tip. The air space between inner and outer tubes permits transfer of pressure from the sensing holes to the static pressure connection at the opposite end of the Pitot and then, through connecting tubing, to the low or negative pressure side of a manometer. When the total pressure tube is connected to the high pressure side of the manometer, velocity pressure is indicated directly. See Figure 3.

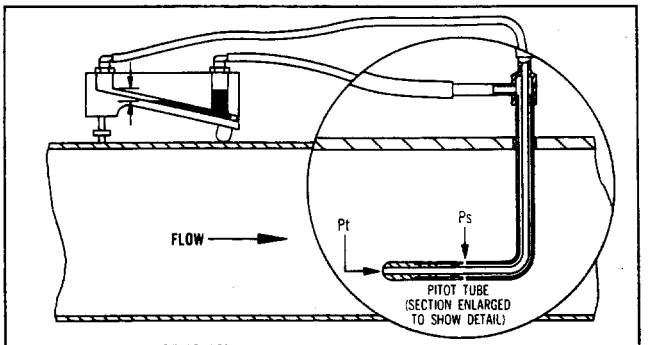


FIG. 3 – PITOT TUBE SENSES TOTAL AND STATIC PRESSURES. MANOMETER MEASURES VELOCITY PRESSURE – (DIFFERENCE BETWEEN TOTAL AND STATIC PRESSURES).

Since the Pitot tube is a primary standard device used to calibrate all other air velocity measuring devices, it is important that great care be taken in its design and fabrication. In modern Pitot tubes, proper nose or tip design – along with sufficient distance between nose, static pressure taps and stem – will minimize turbulence and interference. This allows use without correction or calibration factors. All Dwyer Pitot tubes are built to AMCA and ASHRAE standards and have unity calibration factors to assure accuracy.

To insure accurate velocity pressure readings, the Pitot tube tip must be pointed directly into (parallel with) the air stream. As the Pitot tube tip is parallel with the static pressure outlet tube, the latter can be used as a pointer to align the tip properly. When the Pitot tube is correctly aligned, the pressure indication will be maximum.

Because accurate readings cannot be taken in a turbulent air stream, the Pitot tube should be inserted at least 8½ duct diameters downstream from elbows, bends or other obstructions which cause turbulence. To insure the most precise measurements, straightening vanes should be located 5 duct diameters upstream from the Pitot.

How to take traverse readings

In practical situations, the velocity of the air stream is not uniform across the cross section of a duct. Friction slows the air moving close to the walls, so the velocity is greater in the center of the duct.

To obtain the average total velocity in ducts of 4" diameter or larger, a series of velocity pressure readings must be taken at points of equal area. A formal pattern of sensing points across the duct cross section is recommended. These are known as traverse readings. Figure 4 shows recommended Pitot tube locations for traversing round and rectangular ducts.

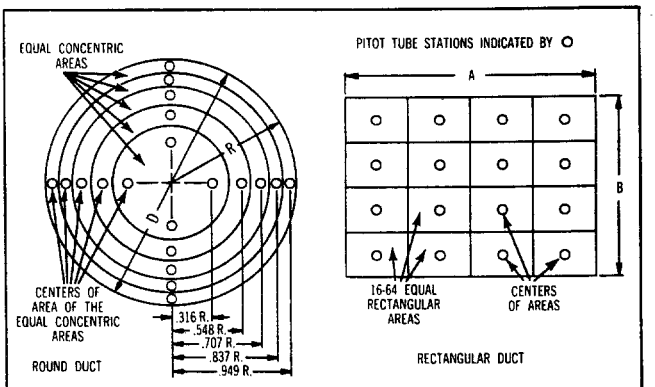


FIG. 4 – TRAVERSE ON ROUND AND SQUARE DUCT AREAS

In round ducts, velocity pressure readings should be taken at centers of equal concentric areas. At least 20 readings should be taken along two diameters. In rectangular ducts, a minimum of 16 and a maximum of 64 readings are taken at centers of equal rectangular areas. Actual velocities for each area are calculated from individual velocity pressure readings. This allows the readings and velocities to be inspected for errors or inconsistencies. The velocities are then averaged.

By taking Pitot tube readings with extreme care, air velocity can be determined within an accuracy of ± 2%. For maximum accuracy, the following precautions should be observed:

1. Duct diameter should be at least 30 times dia. Pitot.
2. Locate the Pitot tube in a duct section providing 8½ or more duct diameters upstream and 1½ or more diameters downstream of Pitot tube free of elbows, size changes or obstructions.
3. Provide an egg-crate type of flow straightener 5 duct diameters upstream of Pitot.
4. Make a complete, accurate traverse.

In small ducts or where traverse operations are otherwise impossible, an accuracy of ± 5% can frequently be achieved by placing Pitot in center of duct. Determine velocity from the reading, then multiply by 0.9 for an approximate average.

Calculating air velocity from velocity pressure

Manometers for use with a Pitot tube are offered in a choice of two scale types. Some are made specifically for air velocity measurement and are calibrated directly in feet per minute. They are correct for standard air conditions: i.e. air density of .075 lbs. per cubic foot which corresponds to dry air at 70°F, barometric pressure of 29.92 inches Hg. To correct the velocity reading for other than standard air conditions, the actual air density must be known. It may be calculated if relative humidity, temperature and barometric pressure are known.

Most manometer scales are calibrated in inches of water. Using readings from such an instrument, the air velocity may be calculated using the basic formula:

$$V = 1096.7\sqrt{\frac{h_v}{d}} \quad \left[= 4004.4\sqrt{h_v} \text{ for .075 lb/ft}^3\text{ dry air @ 70°F, 29.92 in. Hg Baro.}\right]$$

Where: V = Velocity in *feet per minute.*
h_v = Velocity pressure in *inches of water.*
d = Density of air in *pounds per cubic foot.*

To determine dry air density, use the formula:

$$d = 1.325\frac{P_B}{T}$$

Where: d = Air density in *pounds per cubic foot.*
P_B = Barometric (or absolute) static pressure in *inches of mercury.*
T = Absolute temperature (indicated temperature in °F plus 460°).

With dry air at 29.9 inches mercury, air velocity can be read directly from curves on page 5 in this bulletin. For partially or fully saturated air a further correction is required. To save time when converting velocity pressure into air velocity, the Dwyer Air Velocity Calculator may be used. A simple slide rule, it provides for all the factors needed to calculate air velocity quickly and accurately. It is included as an accessory with each Dwyer Pitot tube.

To use the Dwyer Calculator:

1. Set relative humidity on scale provided. On scale opposite known dry bulb temperature, read correction factor.
2. Set temperature under barometric pressure scale. Read density of air over correction factor established in 1 (above).
3. On the other side of calculator, set air density reading just obtained on the scale provided.
4. Under Pitot tube reading (velocity pressure, inches of water) read air velocity, feet per minute.

Determining volume flow

Once the average air velocity is known, the air flow rate in cubic feet per minute is easily computed using the formula:

$$Q = AV$$

Where: Q = Quantity of flow in *cubic feet per minute.*
A = Cross sectional area of duct in *square feet.*
V = Average velocity in *feet per minute.*

Determining air volume by calibrated resistance

Manufacturers of air filters, cooling and condenser coils and similar equipment often publish data from which approximate air flow can be determined. It is characteristic of such equipment to cause a pressure drop which varies proportionately to the square of the flow rate. Figure 5 shows a typical filter and a curve for air flow versus resistance. Since it is plotted on logarithmic paper, it appears as a straight line. On this curve, a clean filter which causes a pressure drop of .50 inches w.c. would indicate a flow of 2,000 c.f.m.

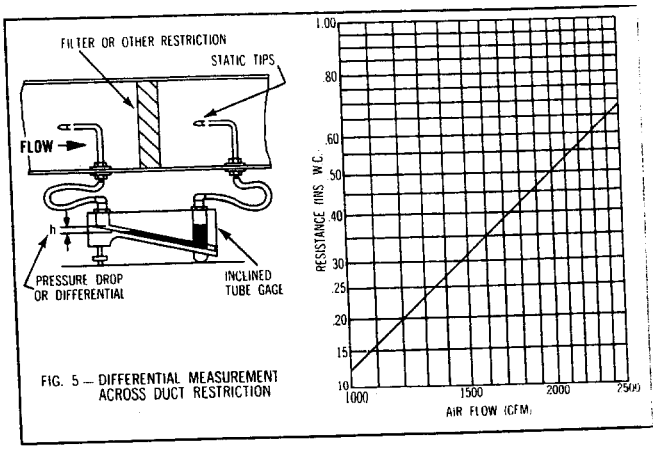


FIG. 5 — DIFFERENTIAL MEASUREMENT ACROSS DUCT RESTRICTION

For example, assuming a manufacturer's specification for a filter, coil, etc:

Given Flow Q (ft³/min.) = at differential "h" (inches w.c.)

To determine flow at other differentials the formula is:

$$Q_n \text{ (other flows)} = Q\sqrt{\frac{h_n}{h}}$$

Where: Q = Quantity of flow in *cubic feet per minute*
h = differential in *inches water column*
h_n = differential (other flow conditions)

Dwyer Air Volume Kits No. 170VT, 171VT and 172VT are designed specifically for this type of field test work.

Other devices for measuring air velocity

A wide variety of devices are commercially available for measuring air velocities. These include hot wire anemometers for low air velocities, rotating and swinging vane anemometers and variable area flowmeters.

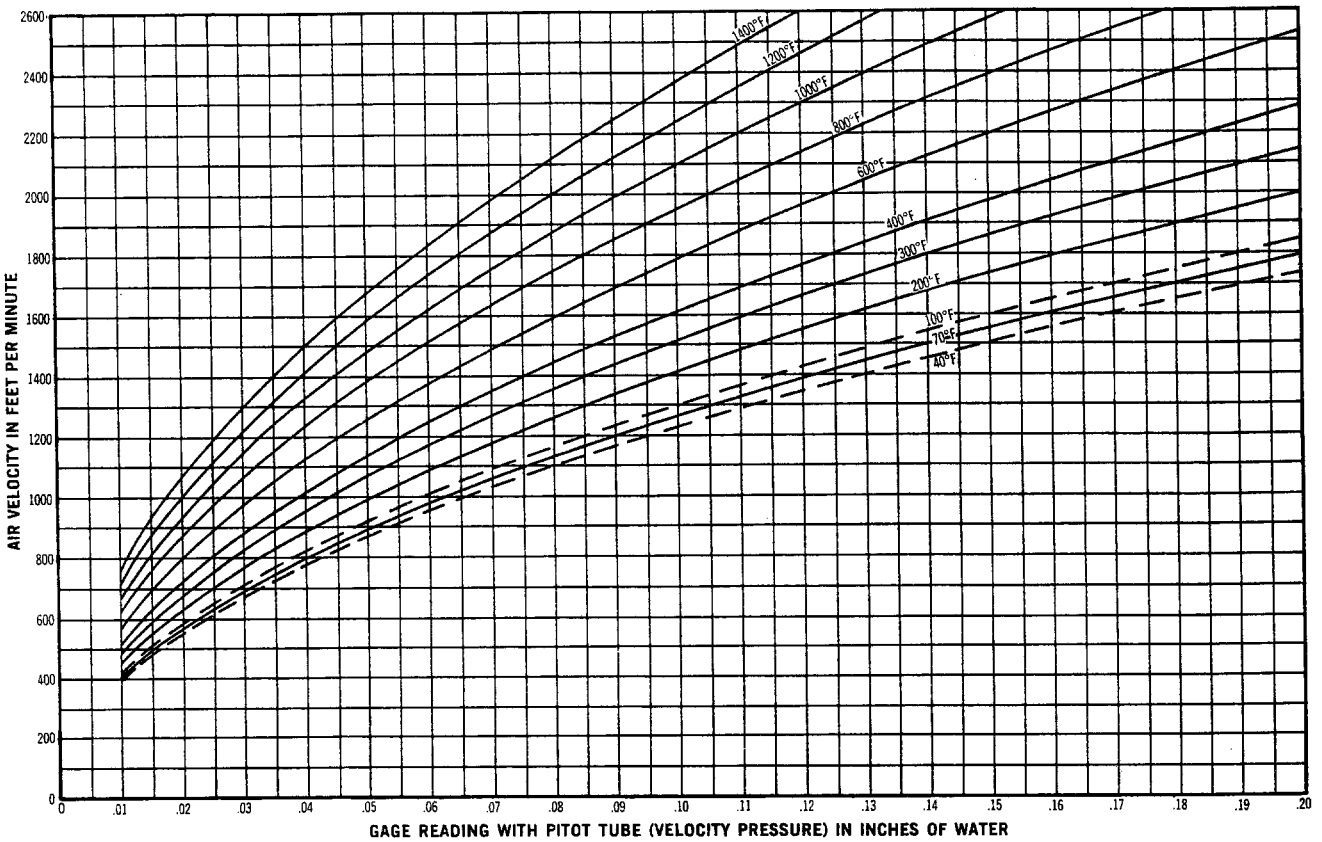
The Dwyer No. 460 Air Meter is one of the most popular and economical variable area flowmeter type anemometers. Quick and easy to use, it is a portable instrument calibrated to provide a direct reading of air velocity.

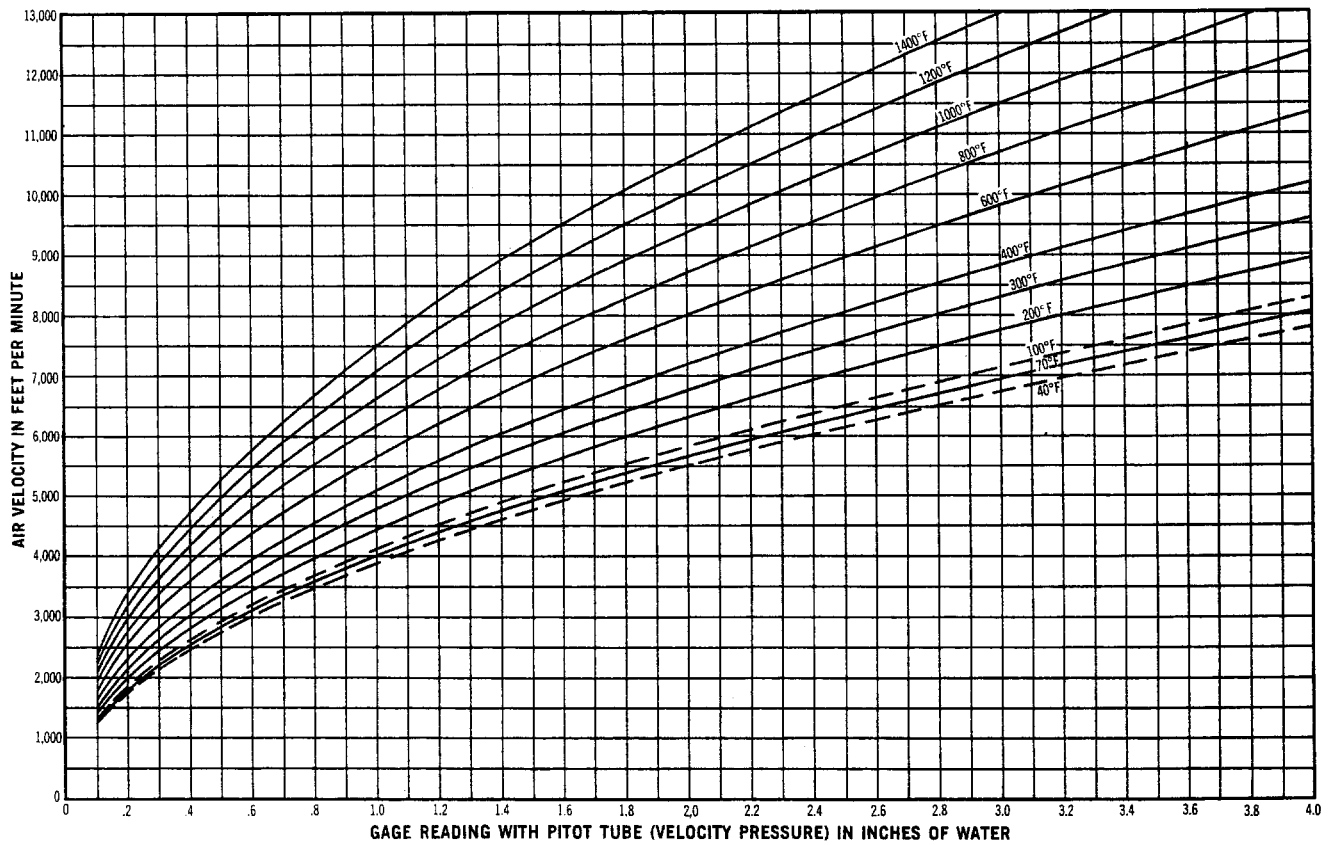
A second scale is provided on the other side of the meter to read static pressure in inches w.c. The 460 Air Meter is widely used to determine air velocity and flow in ducts, and from supply and return grilles and diffusers. Two scale ranges are provided (high and low) with calibrations in both f.p.m. and inches w.c.

To check accuracy

Use only devices of certified accuracy. All anemometers and to a lesser extent portable manometers should be checked regularly against a primary standard such as a hook gage or high quality micromanometer. If in doubt return your Dwyer instrument to the factory for a complete calibration check at no charge.

AIR VELOCITY FLOW CHARTS





Series DS-200 and DS-300 Flow Sensors

For use with the Dwyer Capsuhelic® differential pressure gage to measure high flow rates of air or water in pipes.

Flow & Air Velocity

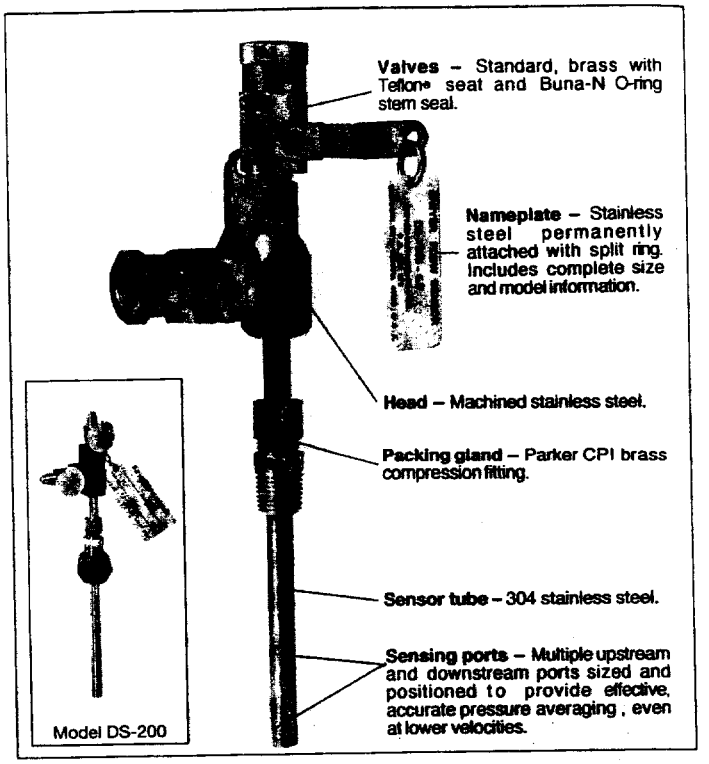
The Dwyer flow sensor is an averaging pitot tube providing accurate and convenient flow rate sensing. When purchased with a Dwyer Capsuhelic® differential pressure gage of appropriate range, the result is a flow indicating system delivered off the shelf at an economical price.

Pitot tubes have been used in flow measurement for years. Conventional pitot tubes sense velocity pressure at only one point in the flowing stream. Therefore, a series of measurements must be taken across the stream to obtain a meaningful average flow rate. The Dwyer flow sensor eliminates the need for "traversing" the flowing stream because of its multiple sensing points and built-in averaging capability.

Dwyer Series DS-300 flow sensors are designed to be inserted in the pipeline through a compression fitting. They are furnished with instrument shut-off valves on both pressure connections. Valves are fitted with ⅛" NPT female connections. Accessories include adapters with ¼" SAE 45° flared ends compatible with hoses supplied with the Model A-471 Portable Capsuhelic kit. Standard valves are rated at 200 psig (13.7 bar) and 200°F (93.3°C). Where valves are not required, they can be omitted at reduced cost. Series DS-300 flow sensors are available for pipe sizes from 1" to 10". If replacing a DS-200 flow sensor or using an A-160 thredolet with a DS-300, an optional ¼"×⅜" bushing, P/N A-161 is required.

DS-200 models are also available in ten insertion lengths from 1" - 10". Operation is similar to DS-300 units. Basic differences are the multi-turn shut-off valves, ⅜" NPT mounting and installed ¼" SAE 45° flared pressure connections.

FLOW SENSORS FOR V.E. HEADERS & A.S. LATERALS (TYP.)



Prices – Select model with suffix which matches pipe size

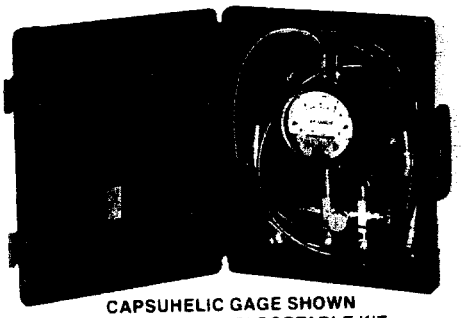
DS-200-1"	$136.75Ⓑ	DS-300-1"	$95.00
DS-200-1¼"	139.25Ⓑ	DS-300-1¼"	95.00
DS-200-1½"	139.25Ⓑ	DS-300-1½"	95.00
DS-200-2"	139.25Ⓑ	DS-300-2"	95.00
DS-200-2½"	149.25Ⓑ	DS-300-2½"	95.00
DS-200-3"	170.50Ⓑ	DS-300-3"	109.00
DS-200-4"	184.00Ⓑ	DS-300-4"	129.00
DS-200-6"	290.25Ⓑ	DS-300-6"	165.00
DS-200-8"	323.50Ⓑ	DS-300-8"	209.00
DS-200-10"	342.25Ⓑ	DS-300-10"	249.00

A-160 Thredolet, ⅜" NPT, forged steel, 3000 psi 6.60
A-161 Brass Bushing, ¼"×⅜" 1.00
Less Valves (DS-300) To order, add suffix –LV ..... deduct 15.00
Ⓑ Items subject to Schedule B discounts

Model A-471 Portable Kit

The Dwyer Series 4000 Capsuhelic® differential pressure gage is ideally suited for use as a read-out device with the DS-300 Flow Sensors. The gage may be used on system pressures of up to 500 PSIG even when the flow sensor differential pressure to be read is less than 0.5" w.c. With accuracy of ±3% of full scale, the Capsuhelic® gage can be used in ambient temperatures from 32°F to 200°F. Zero and range adjustments are made from outside the gage. The standard gage with a die cast aluminum housing can be used with the flow sensor for air or oil applications. For water flow measurements, the optional forged brass housing should be specified.

The Capsuhelic gage may be panel or surface mounted and permanently plumbed to the flow sensor if desired. The optional A-610 pipe mounting bracket allows the gage to be easily attached to any 1¼"-2" horizontal or vertical pipe.



CAPSUHELIC GAGE SHOWN INSTALLED IN A-471 PORTABLE KIT

For portable operation, the A-471 Capsuhelic Portable Gage Kit is available complete with tough polypropylene carrying case, mounting bracket, 3-way manifold valve, two 10' high pressure hoses, and all necessary fittings. See Bulletin A-30 for complete information on the Capsuhelic gage.

Dwyer Instruments, Inc. P.O. Box 373/Michigan City, Indiana 46361/Phone 219 879-8000/Fax 219 872-9057 • U.K. Phone (01494)-461707 • Australia Phone (02) 9708-4799

How To Order

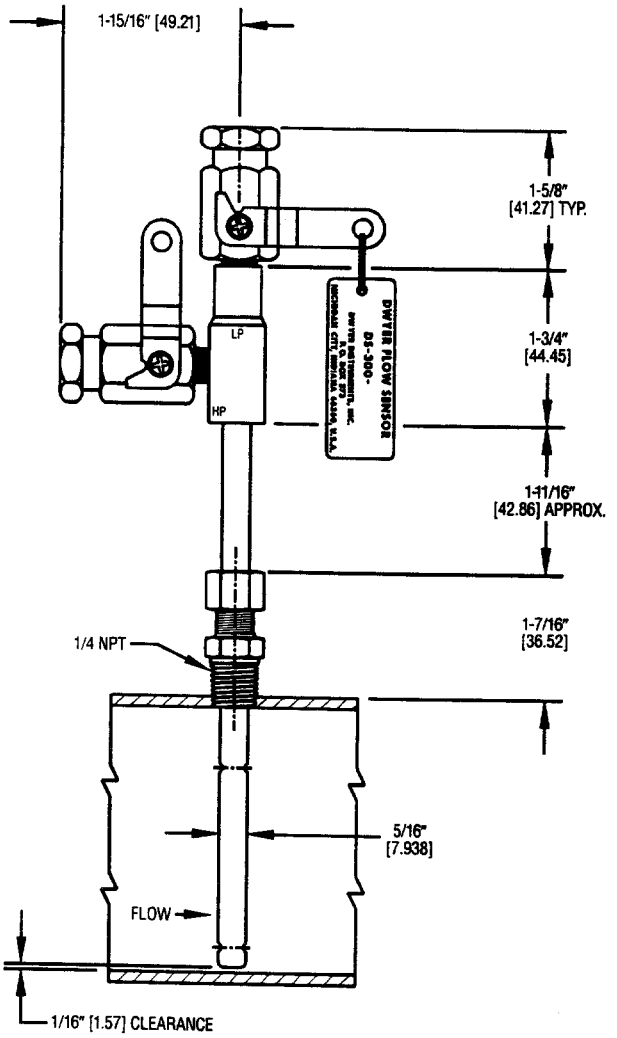
Merely determine the pipe size into which the flow sensor will be mounted and designate the size as a suffix to Model DS-300. For example, a flow sensor to be mounted in a 2" pipe would be a Model No. DS-300-2".

Options and Accessories

Less Valves (DS-300) – To order, add suffix -LV. Example: DS-300-2"-LV
A-160 Thredolet – ⅜" NPT, forged steel, 3000 psi
A-161 Bushing – ¼"×⅜" brass bushing

For non-critical water and air flow monitoring applications, the chart below can be utilized for ordering a stock Capsuhelic differential pressure gage for use with the DS-300 flow sensor. Simply locate the maximum flow rate for the media being measured under the appropriate pipe size and read the Capsuhelic gage range in inches of water column to the left. The DS-300 sensor is supplied with installation and operating instructions, Bulletin F-50. It also includes complete flow conversion charts for the three media conditions shown in the chart below. This information enables the user to create a complete differential pressure to flow rate conversion table for the sensor and differential pressure gage employed. Both the Dwyer Capsuhelic gage and flow sensor feature excellent repeatability so, once the desired flow rate is determined, deviation from that flow in quantitative measure can be easily determined. You may wish to order the adjustable signal flag option for the Capsuhelic gage to provide an easily identified reference point for the proper flow.

Capsuhelic gages with special ranges and/or direct reading scales in appropriate flow units are available on special order for more critical applications. Customer supplied data for the full scale flow (quantity and units) is required along with the differential pressure reading at that full flow figure. Prior to ordering a special Capsuhelic differential pressure gage for flow read-out, we recommend you request Bulletin F-50 to obtain complete data on converting flow rates of various media to the sensor differential pressure output. With this bulletin and after making a few simple calculations, the exact range gage required can easily be determined.



FLOW INDICATORS FOR A.S. LATERAL (TYP.)

FLOW INDICATORS FOR V.E. HEADER (TYP.)

2	WATER (GPM) AIR @ 14.7 PSIA (SCFM) AIR @ 100 PSIG (SCFM)	4.8 19.0 50.0	8.3 33.0 90.5	11.5 42.0 120.0	20.5 65.0 210.0	30 113 325	49 183 510	86 330 920	205 760 2050	350 1340 3600	560 2130 6000
5	WATER (GPM) AIR @ 14.7 PSIA (SCFM) AIR @ 100 PSIG (SCFM)	7.7 30.0 83.0	14.0 51.0 142.0	18.0 66.0 190.0	34.0 118.0 340.0	47 178 610	78 289 820	138 510 1600	320 1200 3300	560 2150 5700	890 3400 10000
10	WATER (GPM) AIR @ 14.7 PSIA (SCFM) AIR @ 100 PSIG (SCFM)	11.0 41.0 120.0	19.0 72.0 205.0	25.5 93.0 275.0	45.5 163.0 470.0	67 250 740	110 410 1100	195 725 2000	450 1690 4600	800 3040 8100	1260 4860 15000
25	WATER (GPM) AIR @ 14.7 PSIA (SCFM) AIR @ 100 PSIG (SCFM)	18.0 63.0 185.0	32.0 112.0 325.0	40.5 155.0 430.0	72.0 255.0 760.0	108 390 1200	173 640 1800	310 1130 3300	720 2630 7200	1250 4860 13000	2000 7700 22000
50	WATER (GPM) AIR @ 14.7 PSIA (SCFM) AIR @ 100 PSIG (SCFM)	25.0 90.0 260.0	44.0 161.0 460.0	57.5 205.0 620.0	100.0 360.0 1050.0	152 560 1700	247 900 2600	435 1600 4600	1000 3700 10000	1800 6400 18500	
100	WATER (GPM) AIR @ 14.7 PSIA (SCFM) AIR @ 100 PSIG (SCFM)	36.5 135.0 370.0	62.0 230.0 660.0	82.0 300.0 870.0	142.0 505.0 1500.0	220 800 2300	350 1290 3600	620 2290 6500	1500 5000 15000		