NOTICE

All drawings located at the end of the document.

RF/RMRS-99-312

Sampling and Analysis Plan for Groundwater Monitoring at the 903 Pad/Ryan's Pit VOC Plume

Final

July 1999
Revision 0

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RF/RMRS-99-312

Revision 0 (Final)

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This Sampling and Analysis Plan has been reviewed and approved by:

S H Singer, RMRS Groundwater Program Manager — 7/8/99 Date

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ACRONYMS

ALF	Action Level Framework
APO	Analytical Project Office
AR	Administrative Records
ASD	Analytical Services Division
CDPHE	Colorado Department of Public Health and the Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DNAPL	Dense Non-Aqueous Phase Liquid
DOE	U S Department of Energy
DQO	Data Quality Objective
EDD	Electronic Disc Deliverable
EMD	Environmental Management Department
EMSL	Environmental Monitoring Support Laboratory
EPA	U S Environmental Protection Agency
ER	Environmental Restoration
FID	Flame Ionization Detector
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FO	Field Operations
GC/MS	Gas Chromatography/Mass Spectrometry
GPS	Global Positioning System
H_2SO_4	Sulfuric acid
HCl	Hydrochloric acid
HNO_3	Nitric acid
HRR	Historical Release Report
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
IMP	Integrated Monitoring Plan
K-H	Kaiser-Hill
LHSU	Lower Hydrostratigraphic Unit
OU	Operable Unit
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCE	Tetrachloroethene
PCM	Perchloromethane (carbon tetrachloride)
PID	Photoionization detector
PPE	Personal protective equipment
QA/QC	Quality Assurance/Quality Control
QAPD	Quality Assurance Program Description
RCRA	Resource Conservation and Recovery Act
SWD	Soil and Water Database
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RMRS	Rocky Mountain Remediation Services, L L C
RPD	Relative Percent Difference

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ACRONYMS (Cont')

SAP	Sampling and Analysis Plan
SID	South Interceptor Ditch
SOPs	Standard Operating Procedures
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
UHSU	Upper Hydrostratigraphic Unit
VOC	Volatile Organic Compound

LIST OF APPLICABLE STANDARD OPERATING PROCEDURES (SOPs)

Identification Number	Procedure Title
RF/RMRS-98-200	*Evaluation of Data for Usability in Final Reports*
2-S47-ER-ADM-05 15	*Use of Field Logbooks and Forms*
5-21000-OPS-FO 15	*General Equipment Decontamination* or successor (RMRS/OPS-PRO 127)
4-S02-ENV-OPS-FO 04	*Decontamination of Equipment at Decontamination Facilities* or successor (RMRS/OPS-PRO 070)
4-H66- ER-OPS-FO 05	*Handling Purge and Development Water* or successor (RMRS/OPS-PRO 128)
5-21000-OPS-FO 06	*Handling of Personal Protective Equipment*
RMRS/OPS-PRO 112	*Handling of Field Decontamination Water and Field Wash Water*
1-PRO-079-WGI-001	*Waste Characterization, Generation, and Packaging*
RMRS/OPS-PRO 069	*Containing, Preserving, Handling and Shipping of Soil and Water Samples*
5-21000-OPS-FO 15	*Photoionization Detectors and Flame Ionization Detectors*
5-21000-OPS-FO 16	*Field Radiological Measurements*
RMRS/OPS-PRO 101	*Logging Alluvial and Bedrock Material*
RMRS/OPS-PRO 114	*Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques*
RMRS/OPS-PRO 117	*Plugging and Abandonment of Boreholes*
5-21000-OPS-GT 06	*Monitoring Wells and Piezometer Installation* or successor (RMRS/OPS-PRO 118)
RMRS/OPS-PRO 102	*Borehole Clearing*
5-21000-OPS-GT 17	*Land Surveying* or successor (RMRS/OPS-PRO 123)
4-S64-ER-OPS-GT 39	*Push Subsurface Soil Sampling* or successor (RMRS/OPS-PRO 124)

LIST OF APPLICABLE STANDARD OPERATING PROCEDURES (SOPs) - Continued

RMRS/OPS-PRO 105	*Water Level Measurements in Wells and Piezometers*
RMRS/OPS-PRO 106	*Well Development*
RMRS/OPS-PRO 108	*Measurement of Groundwater Field Parameters*
RMRS/OPS-PRO 113	*Groundwater Sampling*
RMRS/OPS-PRO 081	*Surface Water Sampling*
RMRS/OPS-PRO 093	*Discharge Measurement*
RMRS/OPS-PRO 094	*Field Measurements of Surface Water Field Parameters*
RM-06 02	*Records Identification, Generation and Transmittal*
RM-06 04	*Administrative Record Document Identification and Transmittal*
4-K56-ENV-OPS-FO 08	*Monitoring and Containerizing Drilling Fluids and Cuttings* or successor (RMRS/OPS-PRO 115)
PADC-96-00003	*WSRIC for OU Operations, Version 6 0, Section 1*

1.0 INTRODUCTION

1.1 Purpose

This Sampling and Analysis Plan (SAP) provides for monitoring well installation, groundwater sampling, and surface water sampling activities at the 903 Pad/Ryan's Pit Plume project area at the Rocky Flats Environmental Technology Site (RFETS) as proposed under *Technical Memorandum, Monitoring of the 903 Pad/Ryan's Pit Plume* (RMRS, 1998a) Volatile organic contaminant groundwater plumes have migrated away from source areas at the 903 Pad and Ryan's Pit toward surface water streams The SAP supports plume monitoring and characterization activities being conducted to evaluate monitored natural attenuation as an effective means of ensuring the protection of surface water quality

The objective of this SAP is to define specific data needs, sampling and analysis requirements, data handling procedures, and associated Quality Assurance/Quality Control (QA/QC) requirements for field activities planned under this project All work will be performed in accordance with the RMRS Quality Assurance Program Description (QAPD) (RMRS, 1997a) Field activities planned under this work plan are limited to well installation, well development, and initial groundwater and surface water sampling activities Additional groundwater sampling for longer-term monitoring will be accomplished by the Groundwater Monitoring Program as specified in the Integrated Monitoring Plan (IMP)

This SAP incorporates information and data interpretations from previous investigations conducted at the project area as a basis for designing and implementing the proposed field activity

Implementation of this project will be performed in accordance with applicable Federal, State, and local regulations, as well as DOE Orders, Rocky Flats Environmental Technology Site (RFETS) policies and procedures, and RMRS Operating Procedures

1.2 Background

1 2 1 Site Description

The 903 Pad (IHSS 112), Ryan's Pit (IHSS 109), and associated groundwater plumes are located in the Buffer Zone Operable Unit (OU) near the southeast corner of the RFETS Industrial Area (IA) Figure 1-1 illustrates the location of the 903 Pad and Ryan's Pit in relationship to surrounding RFETS IA features and surface topography The 903 Pad area was used to store drums that contained radioactively contaminated oils and VOCs from the summer of 1958 to January 1967 Approximately three-quarters of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids Of the drums containing plutonium, the liquid phase was primarily lathe coolant and carbon tetrachloride in varying proportions Also stored in the drums were hydraulic oils, vacuum pump oil, trichloroethene, tetrachloroethene, silicone oils, and acetone still bottoms (DOE, 1992)

Leaking drums were noted in 1964 during routine handling operations The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site Approximately 420 drums leaked to some degree Of these, an estimated 50 drums had leaked their entire contents The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium From 1968 through 1969, some of the radiologically contaminated material was removed, the surrounding area was regraded, and much of the area was covered with clean road base and an asphalt cap (DOE, 1992) Dense, non-aqueous phase liquids (DNAPLs) are suspected to exist underneath the 903 Pad, as high concentrations of VOCs are present in the groundwater (greater than 1% of the chemical's aqueous solubility) However, DNAPLs have not been detected in borings drilled at the Pad to date (45 percent complete) under the 903 Pad Site Characterization Project (RMRS, 1998b)

Ryan's Pit is located approximately 150 feet south of the 903 Pad During the time of operation, it measured approximately 20 feet long, 10 feet wide, and 5 feet deep Ryan's Pit was used as a waste disposal site starting in 1969 and was later used for nonradioactive liquid chemical disposal starting in

1971 Use of the pit ceased in 1971 VOCs disposed of at this location included tetrachloroethene, trichloroethene, and carbon tetrachloride In addition to VOC disposal, paint thinner and small quantities of construction-related chemicals may also have been placed in Ryan's Pit According to historical data, only liquids were put in the pit Their containers were either reused or disposed of in other areas (DOE, 1992) In 1995, source removal activities were completed at Ryan's Pit, including the removal of 180 cubic yards of contaminated soils (RMRS, 1997b)

Historical releases of chlorinated hydrocarbon solvents or solvent-bearing oils to groundwater from these source areas have created two overlapping, aerially extensive plumes of VOC-contaminated groundwater known collectively as the 903 Pad/Ryan's Pit Plume The 903 Pad/Ryan's Pit Plume is defined as the lobe of VOC contaminated groundwater that extends southward from these two source areas toward the South Interceptor Ditch (SID) and Woman Creek The major type of VOC plume contaminants found in groundwater, including carbon tetrachloride, tetrachloroethene, and trichloroethene, correspond to the type of wastes materials reported to have been leaked or disposed of at the source areas Figure 1-2 is a composite plume map that represents the most recent interpretation of groundwater VOC contaminant distribution from the 903 Pad and Ryan's Pit (updated from RMRS, 1998c, Plate 20)

1 2 2 <u>Previous Investigations</u>

Subsurface investigations of the 903 Pad/Ryan's Pit plume were initiated as early as 1986 and have continued intermittantly to the present day The most comprehensive assessment of hydrogeological conditions performed in this region of the Site is contained in the *Phase II OU 2 RCRA Facility Investigation/Remedial Investigation (RFI/RI)* (DOE, 1995) Relevant information on the general geology and hydrogeology of the area is also provided in EG&G (1995a, 1995b)

More recently, RMRS collected site-specific hydrogeologic data in the proposed investigation area during a pre-remedial investigation intended to delineate the extent of groundwater contamination (IT, 1998a) During this investigation, twenty-six direct push borings were advanced and completed as wells in the area shown in Figure 1-1 Soil samples were collected and analyzed from each of the borings Six of the wells yielded sufficient groundwater to collect samples for the analysis of VOCs

These data were then analyzed to estimate the impacts of contaminated groundwater on surface water quality The major conclusions of this analysis were as follows

- The extent of the groundwater plume in close proximity to Woman Creek is limited,
- Concentrations within the plume are relatively low, approaching Tier I groundwater levels in only one of five sample locations, and
- The ability of saturated hydrogeologic units (colluvium and weathered claystone) within the area of the groundwater plume to transmit a significant flux of contaminants to Woman Creek is limited

Based on this analysis, the Site, Environmental Protection Agency (EPA), and Colorado Department of Public Health and the Environment (CDPHE) agreed that collection and treatment of contaminated groundwater upgradient of the SID and Woman Creek was unnecessary, but that additional monitoring would be required The results of this investigation are described in greater detail in Section 1 3 3

1.3 Hydrogeologic Setting

The information contained in the following sections were derived from these investigations, recent plume boundary interpretations (RMRS, 1998c), historical groundwater data, and field observations made in December 1998

1 3 1 Geology

RFETS is situated at the margin of a gently eastward sloping topographic and bedrock pediment surface mantled by unconsolidated Pleistocene Rocky Flats Alluvium and underlain mainly by claystones, siltstones, and sandstones of the Cretaceous Arapahoe and Laramie Formations (EG&G, 1995a) East of this margin, colluvium-covered hillslopes dominate the landscape, except along valley bottoms where valley-fill alluvial deposits occupy the major stream courses The 903 Pad and Ryan's Pit source areas are situated on the Rocky Flats Alluvium and colluvium, respectively, although the groundwater VOC plumes associated with these sources involve all three types of surficial geological deposits, and to a lesser extent, weathered bedrock

The Rocky Flats Alluvium is comprised chiefly of poorly sorted, clayey gravels and sands with abundant cobble and boulder-sized material and discontinuous lenses of clay, silt, and sand Hillside colluvial deposits are markedly finer-grained in texture, being comprised of clay, clayey gravels, and lesser amounts of sand and silt These deposits were derived from geologic material exposed on the steep slopes and topographic highs, and were formed by slope wash, downslope creep, and landslide action Valley-fill deposits were fluvially derived from upstream materials, and consist of clay, silt, and sand with lenses of gravel These deposits occur along the drainage bottoms in and adjacent to stream beds, and are most common in the eastern portions of RFETS

The Arapahoe Formation is 0 to 50 feet thick at RFETS and consists mainly of a discontinuous, but mappable, fine- to medium-grained, moderately- to poorly- sorted sandstone unit that forms the uppermost sandstone of significant lateral extent This sandstone unit is referred to as the Arapahoe Formation (or Number 1) sandstone (EG&G, 1995a) and is known to locally subcrop beneath the Rocky Flats Alluvium and colluvium in the 903 Pad, East Trench and other areas of the eastern Industrial Area It has been shown to be an important pathway for the lateral transport of contaminated groundwater to hillslopes in other areas of the Site (i e , South Walnut Creek)

The Laramie Formation conformably underlies the Arapahoe Formation and consists primarily of massive claystone and siltstone with discontinuous clayey sandstone units (EG&G, 1995a) Unlike the Arapahoe Formation sandstone, these sandstone units exhibit lithologic and hydrologic characteristics (i e , high matrix clay content and low permeability) that are not indicative of contaminant pathways These lenticular Laramie Formation sandstones are texturally distinct from the Arapahoe Formation sandstone by virtue of their high silt and clay content (EG&G, 1995a)

1 3 2 Groundwater Occurrence and Distribution

All unconsolidated surficial and consolidated bedrock geologic deposits contain groundwater although groundwater conditions are known to vary widely across the Site as a function of topography, geologic unit, location, and season Shallow groundwater flow is generally confined to the hydrologically-active upper hydrostratigraphic unit (UHSU), which consists of Rocky Flats Alluvium, colluvium, and

M

weathered bedrock materials Consequently, most RFETS groundwater plumes, including the 903 Pad/Ryan's Pit Plume, are limited to the UHSU Groundwater in the underlying lower hydrostratigraphic unit (LHSU) occurs in low permeability unweathered bedrock materials that are hydrologically poorly connected with the UHSU and is essentially uncontaminated

Field activities planned for the 903 Pad/Ryan's Pit VOC Plume investigation will occur entirely within hillslope colluvial deposits and underlying weathered bedrock materials of the UHSU Previous hydrogeological investigations of hillslope areas at RFETS, including former Operable Units 1 and 5 to the west (DOE, 1994, RMRS, 1996) and the recent 903 Pad/Ryan's Pit Plume pre-remedial field investigation (IT, 1998a), have indicated that groundwater occurrence and movement within the colluvium and underlying weathered bedrock is highly complex and difficult to predict Groundwater flow is controlled by variations in surficial and bedrock topography, structural and lithologic heterogeneity within the colluvium and bedrock, and location of recharge and discharge areas These factors combine to produce water table fluctuations of up to 9 feet in nearby wells (i e , 00491) (EG&G, 1995b, Appendix C), with a seasonally high depth to water of 4 to 8 feet below ground level, depending on location At the proposed investigation area, the average depth to groundwater is estimated to range from 7 to 15 feet resulting in a colluvial saturated thickness of approximately 0 to 5 feet (IT Corp , 1998a) Figure 1-3 illustrates the location of existing and abandoned monitoring wells found in the 903 Pad/Ryan's Pit VOC Plume investigation area

Groundwater occurrence in UHSU deposits on the 903 Pad/Ryan's Pit hillslope is controlled by a local hydrogeologic setting that results in limited availability of water for plume migration The south-facing hillslopes of major drainages generally receive smaller amounts of recharge than do north-facing slopes because of slope aspect effects (i e , higher evapotranspiration demands) and a regional Rocky Flats Alluvial groundwater flow direction to the northeast that favors discharge to north-facing hillslopes In the 903 Pad/Ryan's Pit Plume area, the main sources of colluvial UHSU groundwater include subsurface discharge from the Rocky Flats Alluvium and isolated bedrock sandstone units, and infiltration of incident precipitation, especially during the Spring months High on the hillslope, groundwater is discharged from the Rocky Flats Alluvium and a subcropping sandstone (Arapahoe Formation sandstone) to the colluvium at a seep complex found near the pediment rim extending from the southern edge of the 903 Pad to the former 903 hillside soil study area Midslope sources of groundwater are mainly limited to precipitation and subcropping Laramie sandstones and siltstones, such as found at well 1487, which generally tend to be poor producers of water Given the complexity of the hillside flow regime, it is expected that colluvial groundwater may also interact dynamically with the underlying weathered bedrock, with flow entering and exiting the bedrock in accordance with the pathway-of-least-resistance principle

Groundwater on the 903 Pad/Ryan's Pit hillside flows downslope from north to south in a direction that approximates the surface topography On a local scale, flow is expected to follow preferential pathways that may deviate significantly from expected pathways inferred from surface topography alone Figure 1-4 illustrates the configuration of the bedrock surface based on the results of the pre-remedial field investigation (IT, 1998a) Spatial variations in the bedrock topographic configuration combined with zones of enhanced permeability created by landslide slip planes and lithologic heterogeneity are presumed to account for much of the irregularity indicated by the field data These conditions, combined with the low to moderate permeabilities of colluvium and weathered bedrock, suggest that low groundwater flow rates are prevalent in the saturated areas of the 903 Pad/Ryan's Pit hillslope For the saturated area extending from wells 01298 to 01798, IT (1998a) estimated a groundwater flow rate of approximately 8 cubic feet per day (60 gallons per day), most of which occurs primarily along colluvial pathways This flow rate results in a correspondingly low contaminant flux based on contaminant concentrations detected during the pre-remedial investigation The calculated total VOC contaminant flux for the distal end of the 903 Pad/Ryan's Pit Plume is estimated at 0 13 grams per day (IT, 1998a)

The nearest receiving streams for the 903 Pad/Ryan's Pit VOC Plume are the South Interceptor Ditch (SID), located 150 feet upslope of Woman Creek, and Woman Creek Examination of historical aerial photographs and enhanced multispectral scanner images (EG&G, 1989), and subsequent field observations made in December 1998 indicate several potential discharge areas for shallow groundwater associated with the 903 Pad/Ryan's Pit VOC Plume No VOC or flow data are available for any of the seeps however, recent field observations of seep characteristics indicate that surface flow, if present, would be intermittant and probably minimal Previous studies of hillslope seepage areas at RFETS (RMRS, 1998c) have indicated that seeps may represent concentrations of groundwater flow that are associated with primary contaminant plume pathways Hydraulic connection with the SID is inferred for segments containing wetland vegetation found near the base of rock grade control structures Comparison of ditch bed elevations from as-built drawings of the SID to the projected bedrock surface elevations presented in Figure 1-4 indicate that colluvial groundwater, if present, should be close to bed level near the base of these structures The localized nature of this vegetation suggests that any emergent groundwater will primarily evapotranspire rather than discharge laterally as ditch flow As shown on Figure 1-3, groundwater discharge also occurs at a few scattered hillside seepage areas located upslope and downslope of the SID near the known southern extent of the 903 Pad/Ryan's Pit VOC Plume Stream gain/loss investigations conducted along the segment of Woman Creek potentially impacted by the plume indicate that losing conditions are prevalent downstream of Pond C-1 to the first stream bend south of wells 23196 and 2987 (see Figure 6-22, Station 18 of EG&G [1995b]), but transition to a year-round gaining reach in the vicinity of well 6586 (Station 19 of EG&G [1995b]) It is evident from this information that groundwater interactions with surface water are both locally important and locatable for monitoring design purposes

1 3 3 Type and Extent of Contamination

Numerous VOCs have been detected in groundwater associated with the 903 Pad and Ryan's Pit source areas The primary contaminants-of-concern are carbon tetrachloride, tetrachloroethene, and trichloroethene, which are detected above Tier I groundwater action level concentrations (500 µg/L) in wells located approximately 400 and 1,000 feet downgradient of Ryan's Pit and the 903 Pad, respectively Further downgradient, concentrations gradually diminish to Tier II groundwater action levels (5 µg/L) as shown in Figure 1-2 Because VOC concentrations at the leading edge of the plume are below Tier II groundwater action levels, this portion of the plume is not addressed under this SAP

VOC contaminants associated with the Ryan's Pit plume are comprised predominantly of TCE (> Tier I) with lesser concentrations of PCE and carbon tetrachloride (< Tier I) In comparison, the 903 Pad plume is comprised mainly of carbon tetrachloride (> Tier I) with lesser concentrations of TCE and PCE (< Tier I) The concentrations of major constituents of the VOC plume in groundwater from pre-1998 wells located near the 903 Pad/Ryan's Pit downgradient plume boundary are provided in Table 1-1

Table 1-1 Downgradient Groundwater Concentrations – 903 Pad/Ryan's Pit Plume

Contaminant	Well 6286	Well 6386	Well 1487	Well 2987	Well 23196	Well 01291	RFCA Tier II Groundwater Action Level
Carbon Tetrachlorıde	8	ND	460	ND	ND	15	5
Cıs-1,2-Dıchloroethene	ND	ND	ND	ND	ND	0 2	70
Methylene Chlorıde	ND	ND	ND	2	ND	0 5	5
Tetrachloroethene	ND	ND	8	ND	ND	2	5
Trıchloroethene	0 8	ND	190	ND	ND	12	5
Note all values are maxımum concentratıons (µg/l) from 1996 samplıng of monıtorıng wells, ND indıcates not detected or below detectıon lımıt (RMRS, 1997c)							

The Arapahoe Formatıon sandstone, whıch underlıes the Rocky Flats Alluvıum west, east, and northeast of the 903 Pad, ıs known to contaın VOC-contamınated groundwater near subcrop zones, but does not appear to be contamınated east of the Pad In thıs regıon, the sandstone ıs overlaın by a contınuous 4 to 20 foot claystone layer that restrıcts contamınated alluvıal groundwater from enterıng the sandstone The sandstone extends southward to the pedıment rım where ıt ıs truncated by the valley wall and covered by colluvıal deposıts Thıs subcrop zone ıs related to the seep complex descrıbed earlıer ın Sectıon 1 3 2 From the avaılable ınformatıon, ıt appears that groundwater dıscharge from the Arapahoe Formatıon sandstone may recharge hıllslope colluvıal deposıts and dılute plume contamınants ın the upper regıons of the plume Thıs ınfluence would be lımıted to the upslope areas of the hıllsıde, as topographıcally lower Laramıe Formatıon sandstones lack the water transmıttıng abılıty of the Arapahoe Formatıon sandstone

As shown ın Fıgures 1-5 and 1-6, trend plots of carbon tetrachlorıde and TCE concentratıons ın selected 903 Pad/Ryan's Pıt Plume monıtorıng wells ındıcate the dynamıc character of the plume Hıstorıcal carbon tetrachlorıde and TCE concentratıons ın well 1487, located near the SID, ındıcate a slıght upward trend that ıs consıstent wıth an advancıng plume hypothesıs (RMRS, 1998a) Dependıng on the sıgnıfıcance gıven to the 4th quarter 1994 and 2nd quarter 1995 data, the concentratıons of these contamınants ıncrease approxımately 25 to 100 percent durıng the perıod 1989 to 1996, wıth multıple detectıons of carbon tetrachlorıde above Tıer I actıon levels durıng the latter half of the monıtorıng perıod Lıkewıse, sımılar apparent trends are also observed for TCE ın wells 1187 and 1287 located downgradıent of Ryan's Pıt, although the carbon tetrachlorıde concentratıon trends are generally downward ın these wells These apparent trends underscore the ımportance of monıtorıng as a means for protectıng surface water qualıty

Sharp to moderate fluctuations in quarterly carbon tetrachloride and TCE concentrations of up to several hundred µg/L are apparently related to seasonal changes in water level, as concentrations generally rise dramatically following the Spring water level peak Variations in sampling technique (i e , bailing) and analytical data quality may also contribute to apparent fluctuations in the concentration data

In March and April of 1998, a series of direct push (Geoprobe®) borings were installed between existing wells and the SID, which is the nearest surface water location (see Figure 1-3) The boreholes were placed in a line parallel to the SID to delineate the leading edge of the plume The boreholes were completed as temporary wells with a ¾ inch casing and screen intervals of about five feet Groundwater levels were generally checked within one day of well installation Sampling and analysis of the groundwater was performed in accordance with the *Sampling and Analysis Plan (SAP), Characterization of the 903 Pad/Ryan's Pit and East Trenches Plume* (IT Corp , 1998b), and the appropriate RFETS Standard Operating Procedures referenced in the SAP

The upper strata of unconsolidated sediments in these borings consisted of colluvium of various lithologies, principally silty clays and clayey silts, sometimes containing sand Lenses of coarser, subangular to subrounded sands and gravels were occasionally encountered Bedrock consisted of a grayish-brown massive claystone identified by a lack of coarse-grained material The claystone varied from moist to very dry, often becoming drier with depth In places the claystone also contained abundant caliche

The depth to bedrock varied from 2 6 feet in well 02198 to 18 8 feet in well 01198 The bedrock surface slopes to the southeast, in broad conformance with the surficial topography Along the line of Geoprobe® borings, localized bedrock lows occur at borings 00598, 01198, 01298, 01498, and 01698, possibly indicating the presence of south-trending preferential flow pathways (Figure 1-4) A sequence of highly weathered claystone overlying sandy silt also suggests the possibility of slumping in shallow hillslope geologic deposits

Groundwater was encountered in only eight of the 26 wells installed in the study area The six westernmost wells of the alignment were dry (Figure 1-7) To the east, groundwater was encountered infrequently with the water table generally occurring within weathered bedrock The water table was observed within the colluvium in only three wells, all of which are distinguished by local bedrock lows (01298, 01498, and 01698) These wells contained approximately three feet or less of saturated colluvium (Figure 1-4)

The analytical results of groundwater sampling presented in Table 1-2 show that nine VOCs were detected in the 1998 wells (RMRS, 1998a) Concentrations of the major plume constituents (carbon tetrachloride, tetrachloroethene, and trichloroethene) are presented in box plots shown in Figure 1-7 VOCs were detected in all six 1998 wells that contained sufficient water for sampling (01298, 01398, 01498, 01698, 01798, and 01998), although only five wells contained characteristic plume contaminants VOC concentrations in these six wells exceeded Tier II groundwater action levels for methylene chloride in three wells, TCE in four wells, PCE in one well, and carbon tetrachloride in three wells Tier I groundwater action level concentrations were attained in well 01298 for TCE (500 µg/L) and almost attained for carbon tetrachloride (460 µg/L), however, the "E" data qualifier associated with these results indicate that the data should be treated as tentative values In addition to the plume constituents mentioned above, low to trace concentrations of ancillary VOCs, including 1,1-dichloroethene, chloroform, cis-1,2-dichloroethene, xylene, and naphthalene, were detected in various wells

The limited lateral distribution of colluvial groundwater found in the 1998 wells and erratic concentrations of plume contaminants in wells containing water are consistent with the interpretation that preferential pathways are largely responsible for contaminant migration on the 903 Pad hillside Wells with the greatest colluvial saturated thicknesses (01298 and 01698) exhibit the highest VOC concentrations, thus suggesting that colluvial, rather than bedrock, pathways are the primary routes for plume migration toward surface water Contaminant loading calculations prepared by IT (1998a) for each of the wells with VOC detections confirm this assertion The unpredictable nature of these pathways is exemplified by the virtual absence of contaminants in wells 01398 and 01498 located in the swale directly downslope from contaminated well 1487, but found at similar contaminant concentrations in well 01298, located to the southwest Consideration of hillslope bedrock topography and the TCE/carbon tetrachloride composition of the groundwater also suggest that the Ryan's Pit and

Table 1-2 Plume Characterization Sampling - Volatile Organic Compounds in Groundwater

Analyte (µg/l)	RFCA Tier II Groundwater Action Level)	Well Number						
		01298	01398	01498	01698*	01698*	01798	01998
Methylene Chloride	5	24	10	31				
1,1-Dichloroethene	7	3 J						
Chloroform	100	96	7		73	73	32	
Carbon Tetrachloride	5	460 E			150	140	13	
Trichloroethene	5	500 E	9		42	40	12	
Tetrachloroethene	5	0 023			8	7	2 J	
Xylene (total)	100						1 J	
cis-1,2-Dichloroethene	70	9			5	5	1 J	
Naphthalene	1,460		6		3 J		4 J	

* = Duplicate Samples
E = concentration exceeds the instrument calibration range and was diluted
J = result is estimated value below reporting limit
Blank Spaces = Not detected at detection limit of 5 ug/L
Note Table includes only compounds detected in one or more of the samples

903 Pad plumes may converge and comingle in the vicinity of well 01298 The importance of weathered bedrock in transporting contaminants is considered to be minimal given the fact that claystone was the predominant bedrock material encountered in the borings

1 3 4 Conceptual Model

Based on the existing data and hydrogeologic setting, a conceptual model of plume migration has been developed for the investigation area Contaminants present in the groundwater exist as a result of historical releases from drum storage operations at the 903 Pad and liquid waste disposal at Ryan's Pit Drums containing volatile organic compounds and pit liquids leaked to the groundwater where the compounds became solubilized and were slowly transported laterally away from source areas along prevailing groundwater flow paths The potential presence of DNAPL compounds at source areas imply that the 903 Pad/Ryan's Pit plume contaminants may be continuously released for many years to come, although DNAPLs have not been found to date at the 903 Pad In the case of Ryan's Pit, previous source removal actions could eventually offset this effect

VOC-contaminated groundwater originating at the 903 Pad area initially flows to the east and subsequently spreads to the northeast and southeast Some groundwater flow from the pad area may also flow directly south and southeast in the direction of Ryan's Pit Alluvial groundwater flow discharges to hillside colluvial material below the pediment rim in the vicinity of a large seep complex This flow is mixed and diluted with uncontaminated groundwater flow from the Arapahoe Formation sandstone, which subcrops beneath the colluvium in the vicinity of the seep From this point, the plume follows preferential flow pathways in the colluvium toward the SID and Woman Creek Similarly, plume contaminants originating from Ryan's Pit travel via preferential groundwater pathways in the colluvium to the southeast These plumes may partially converge upgradient of the SID and undergo natural attenuation before discharging to the SID or Woman Creek alluvial systems Several small hillside seeps located upslope and downslope of the SID above Woman Creek in the investigation area may indicate preferential flowpath locations related to plume migration routes

2.0 SAMPLING RATIONALE

Historical information detailed in Section 1 2 was used to develop a systematic sampling strategy for this investigation The sampling rationale also accounts for the presence of preferential groundwater flowpaths evaluated in Section 1 3 2 Long-term monitoring well locations will be selected along groundwater flow paths delineated by Geoprobe® investigations Groundwater sampling will mainly be restricted to new long-term monitoring wells, however, opportunity samples will be collected from Geoprobe® boreholes and seeps to further define the extent of plume contamination, if practicable Surface water grab samples will collected from stations located in both the SID and Woman Creek to assess any current impacts of plume contamination on surface water quality

The following conditions were considered in the development of the sampling strategy

- The operating history of 903 Pad Area and Ryan's Pit indicate that volatile organic compounds have been released to the groundwater environment and have migrated toward surface water streams,
- The physical and chemical properties of the contaminants and available groundwater data indicate that natural attenuation processes have reduced plume contaminant concentrations downgradient of source areas, but have not been effective at completely mitigating plume

advancement,

- Hillslope groundwater contaminant occurrence is sporadic, difficult to predict, and limited to preferential flow pathways found primarily in colluvial materials associated with bedrock lows,
- Contaminant concentrations at wells are influenced by plume dynamics and seasonal factors, such as water table fluctuations, and,
- Preferential groundwater flow pathways may cause significant local effects on groundwater flow direction and discharge, including seep occurrence, that can affect monitoring system design and project success

3.0 DATA QUALITY OBJECTIVES (DQOs)

The data quality objective process consists of seven steps and is designed to be iterative, the outputs of one step may influence prior steps and cause them to be refined Each of the seven steps are described below for the investigative area shown in Figure 4-1 Data requirements to support this project were developed and are implemented in the project using criteria established in *Guidance for the Data Quality Objective Process*, QA/G-4 (EPA, 1994)

3.1 State the Problem

Previous investigations of the Site have identified VOC contaminated groundwater plumes associated with solvent releases from the 903 Pad Area and Ryan's Pit These plumes have migrated away from source areas toward surface water streams This investigation will better delineate colluvial groundwater flow pathways associated with plume contamination for the purpose of positioning monitoring wells to be used for natural attenuation monitoring, as proposed in the *903 Pad/Ryan's Pit Plume Monitoring Technical Memorandum* (RMRS, 1998a) Monitoring of these wells will be initiated to assess the adequacy of natural attenuation processes for limiting risk to surface water quality from plume contaminants This approach will be supplemented by an initial round of surface water sampling designed to assess the assumption that there is no current impact of plume VOC contaminants on surface water quality

3.2 Identify the Decision

Decisions required to be made using field data collected from boreholes and groundwater wells, and the results of sample collected for laboratory analysis include

- Do favorable groundwater conditions (i e , saturated colluvial materials) exist upgradient of the SID and downgradient of existing wells 01298 through 01798 for the installation of long-term monitoring wells used to monitor natural attenuation in the plume?
- Do contaminant trends in newly installed wells indicate that natural attenuation is an effective mechanism for protecting surface water quality?
- Is surface water quality currently being impacted by the 903 Pad/Ryan's Pit Plume?

3.3 Identify Inputs to the Decision

Inputs to the decision include field observations and measurements of groundwater occurrence and distribution, VOC analytical results for groundwater samples collected from selected Geoprobe® exploratory borings and seeps for positioning new monitoring wells, and surface water VOC samples from the SID and Woman Creek to assess impacts to surface water quality The parameters of interest include

- Depth to bedrock below ground level (for calculating saturated thickness)
- Depth to water below ground level (for calculating saturated thickness)
- Saturated thickness
- Initial water level recovery rate
- Groundwater VOC concentrations, if available for siting wells
- Surface water VOC concentrations
- Surface water discharge, including seep flow rates

Volatile organic chemical results of groundwater samples collected from newly-installed monitoring wells for trend analysis and comparison to RFCA Action Levels (DOE, 1997) are inputs necessary for making decisions related to plume fate and risk to surface water quality The parameters of interest, sample quantities, and analytical methodology are provided in Table 4-2

Further inputs to the decision include seep samples and water level measurements from new and existing monitoring wells, which will be used to delineate groundwater flow directions for interpretation of groundwater analytical data Surface water samples for VOC analyses will be collected in the SID and Woman Creek to assess potential impacts to surface water quality Streamflow measurements at each surface water sampling location will provide additional data for interpreting surface water VOC analytical results Land surveying of new well casing locations (± 1 foot) and elevations (± 1 foot) will be conducted to provide control for potentiometric contouring

3.4 Define the Boundaries

The investigative boundaries and rationale are detailed in Section 4 0 of this SAP

3.5 Develop a Decision Rule

The decision rule for installing long-term monitoring wells is based on the presence and amount of free groundwater found in initial exploratory Geoprobe® borings located at potential drilling sites This approach is being taken to more accurately delineate preferential plume pathways and improve well and monitoring program success The area of proposed well locations is based on previous hydrogeologic investigations, current-day field observations, interpretation of groundwater flow directions, and seep locations Dry borings will identify potential drilling sites that are unsuitable for well installations Borings with the greatest saturated thickness and ability to supply water are considered to be the most favorable candidate sites for well installation Groundwater samples and analytical results from the exploratory borings will be used, if collected and available, to verify drilling locations

The decision rule for surface water sampling involves an initial evaluation of results from the well drilling and groundwater sampling phase of the investigation Surface water sampling locations will be chosen where plume flowpaths are projected to intersect the SID and Woman Creek These locations will be sampled twice per year (Spring and Fall) to quantify potential fluxes to surface water The number of sampling locations will be determined during the data evaluation phase following well drilling and sampling

The decision rule on further investigation or remediation will be based on 1) an analysis of sampling results using contaminant trend and surface water loading calculations, and 2) seep and surface water sample results Table 3-1 contains the Action Level Framework (ALF) surface water action levels for contaminants-of-concern that will be used for assessing compliance with RFCA

Table 3-1 ALF Surface Water Action Levels for the 903 Pad/Ryan's Pit Plume Contaminants-of-Concern

Compound	ALF Action Levels for Surface Water (µg/L)
Carbon Tetrachloride	5
Cis-1,2-Dichloroethene	70
Methylene Chloride	5
Tetrachloroethene	5
Trichloroethene	5

Additional characterization, if required, will be based upon an evaluation of data collected under this SAP and performed through the groundwater evaluation process specified in the IMP Groundwater monitoring will be performed in accordance with this SAP and the IMP (DOE, 1997)

3.6 Specify Limits on Decision Errors

Confidence in contaminant monitoring for the 903 Pad/Ryan's Pit Plume and subsequent project decisions is dependent on monitoring well location success, sampling frequency, and quality control Well placement is a key aspect of the monitoring program because, given the complexity of the hydrogeologic setting, improper placement could jeopardize the ability of the program to generate samples and provide useable data The timing and frequency of sampling is relevant to program success because contaminant concentrations in nearby wells have been shown to fluctuate with seasonal changes in water level Quality control of field measurements and laboratory analytical data collected during the investigation is important because decision errors may result if not based on reliable information

Monitoring well placement errors (i e , dry well conditions) will be minimized through the implementation of an exploratory boring program designed to locate preferential flow pathways related to plume movement Exploratory Geoprobe® borehole placement is based on a professional judgement approach based on previous investigation results, the interpretation of current site conditions described in Section 1 0, and real-time exploratory boring results One well, 90099, will be located next to well 01298 based on existing groundwater monitoring results The remaining three monitoring wells will be located and installed using hydrogeologic information obtained from the exploratory Geoprobe® boring program

Initially, sampling bias caused by seasonal variations in water level and contaminant concentration will be minimized by implementation of a quarterly well sampling schedule for the first year This approach will ensure that seasonal components of plume transport and flow are accounted for in subsequent trend and loading analyses, which are sensitive to concentration and, in the latter case, to saturated thickness Sampling after the first year will be performed at least annually, but may be performed more frequently if required under the IMP

Quality control samples for the project will include a 1 in 20 frequency for duplicate samples and equipment rinsates for VOC analysis Relative percent difference (RPD) goals for groundwater VOCs will be 30% or less A completion goal of 90% of the data analyzed and verified will be of acceptable quality for decision making Twenty-five percent of the total analytical data will undergo validation by a third party The remaining 75 percent of the data will be verified

Unless otherwise specified in this SAP, all field work will be performed in accordance with approved RMRS standard operating procedures These procedures specify methods and equipment for ensuring the accuracy and integrity of well installations, field parameter measurements, sampling, and other related field data collection activities A listing of applicable procedures is provided at the beginning of this document

3.7 Optimize the Design for Obtaining Data

Monitoring well network design will be optimized through a combination of hydrogeologic interpretation of existing data and exploratory Geoprobe® borings With this approach, potential plume pathway routes identified from the pre-remedial investigation data and projected southward using hydrogeologic interpretations are investigated for possible installation of long-term monitoring wells Determination of the presence of colluvial groundwater at potential drilling sites will be optimized through a "step-out" style boring approach Geoprobe borings oriented perpendicular to the assumed groundwater flow direction will be advanced to bedrock in search of colluvial groundwater The initial borehole will be located along the centerline of the assumed pathway route From that point, borehole spacings will be determined by the field geologist based on field results from the preceding boreholes Borings with the greatest colluvial saturated thicknesses (i e , 1 foot or greater) will indicate the most favorable well drilling sites while dry borings will indicate the least favorable sites Groundwater samples from one or more borings may be collected and analyzed to verify the presence of plume contaminants This method will be implemented for the three proposed well sites located downgradient of new well 90099 to be installed next to well 01298

Surface water sampling design will be optimized by utilizing the results of initial well drilling and groundwater sampling to locate the likely discharge points for plume pathways in the SID and Woman Creek Samples will be collected twice per year (Spring and Fall) to evaluate current impacts to surface water quality

An initial quarterly well sampling frequency will serve to optimize the seasonal aspects of water level and VOC concentration variations, while minimizing costs and other resources Lower resolution sampling (semi-annual and annual) during the first year would potentially compromise the validity of subsequent interpretations because seasonal effects would not be factored into the analyses Higher resolution sampling (i e , monthly or bimonthly) would result in better definition of seasonal variations, but would add little value to the program given the slow rate of plume movement Subsequent sampling timing (calendar quarter selection) and frequency will be specified in the IMP based on the sampling results of the first year For plume monitoring purposes, only VOC samples will be collected under this SAP, as the purpose of the monitoring program involves an evaluation of primary contaminant concentrations and trends for protecting surface water quality

4.0 SAMPLING ACTIVITIES AND METHODOLOGY

4.1 Sampling Station Locations and Numbering

4 1 1 Monitoring Wells

Four (4) monitoring well locations have been chosen to monitor groundwater quality associated with the 903 Pad/Ryan's Pit Plume One well (90099) will be positioned next to well 01298 to monitor upgradient groundwater quality, and two wells (90199 and 90299) will be positioned to the south along primary plume pathways to monitor groundwater quality at the north edge of the SID The fourth well (90399) will be paired with well 90199 to monitor VOC contamination in weathered bedrock Figure 4-1 illustrates the approximate location of these wells in relationship to the probable plume pathway located from hydrogeologic considerations The total number and arrangement of wells reflects the spatial limitations imposed by the terrain, distance to the SID, and geometry of the plume pathway Well names (location codes) were assigned based on a five digit numbering system adopted by the Site in 1992, with the year drilled indicated by the last two digits The rationale for each monitoring well location is summarized in Table 4-1 A block of borehole numbers will also be assigned to the exploratory Geoprobe® borings using a similar borehole naming convention

4 1 2 Surface Water Stations

Surface water sampling sites for the SID and Woman Creek will be located in the area shown in Figure 4-2 The exact location and number of sampling sites will be determined following an evaluation of data collected during the well drilling and groundwater sampling phase of the investigation It is expected that this approach will better delineate potential groundwater flowpaths and discharge areas associated with plume migration, which, in turn, will be used to identify stream reaches that are likely to receive the greatest contaminant fluxes Four surface water (stream) sampling locations are assumed for planning purposes, although it is recognized that additional locations may be necessary to adequately evaluate contaminant fluxes into the stream At each selected station, minor deviations in foot section of 16 to 20-inch inner diameter (ID) steel surface casing and concrete pad, and 2-inch ID, schedule 40 or 80 polyvinyl chloride (PVC) riser and factory cut (0 010-inch slot width) well screen Protective casing consisting of 6-inch ID or larger steel riser with locking cap and lock will be set in sackrete to a depth of about 2 to 3 feet

4 2 2 Pre-Drilling Activities

Before advancing boreholes, all locations will be cleared in accordance with PRO 102, *Borehole Clearing*, and marked in accordance with GT 39, *Push Subsurface Soil Sampling* A prework radiological survey will be conducted in accordance with FO 16, *Field Radiological Measurements* All Health and Safety protocols will be followed in accordance with the *903 Pad/Ryan's Pit Plume Health and Safety Plan* addendum, as appropriate

4 2 3 Borehole Drilling and Logging

4 2 3 1 Geoprobe® Borings

Exploratory boreholes will be drilled at proposed well sites using push-type techniques (Geoprobe®) to assist in locating plume pathways Detailed drilling and sampling procedures using this methodology are provided in GT 39 If probe refusal is encountered before reaching bedrock, the borehole will be abandoned using procedure PRO 117, *Plugging and Abandonment of Boreholes*, and an offset boring will be attempted within 3 feet of the original boring

Soil cores will be recovered continuously in 2 to 4-foot increments using a 1-inch diameter by 48-inch long stainless steel- or lexon-lined California core barrel Following recovery, cores will be monitored with a Flame Ionization Detector (FID) or a Photoionization Detector (PID) in accordance with Site Procedure 5-1000-OPS-FO 15, *Photoionization Detectors and Flame Ionization Detectors,* for health and safety purposes The core samples will then be boxed and logged in accordance with PRO 101, *Logging Alluvial and Bedrock Material,* except that logging will be conducted more qualitatively than specified in PRO 101 (i e , sieving, microscope examination, and plasticity testing will not be conducted) All core boxes will be labeled and transferred to an ER core storage conex for archiving

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Table 4-1 Monitoring Well Location Rationale

Well Number	Location	Rationale
90099	At well 01298	Monitor colluvial groundwater quality
90199	At the north edge of the SID below well 01298	Monitor groundwater quality downgradient of well 01298 to assess natural attenuation along plume pathways
90299	At the north edge of the SID below well 01698	Monitor groundwater quality downgradient of well 01698 to assess natural attenuation along plume pathways
90399	At the north edge of the SID below well 01298	Monitor groundwater quality downgradient of well 01298 to assess natural attenuation along plume pathways in weathered bedrock

location, either upstream or downstream of the eventual map sites, may be made by sampling personnel for purposes of improving access to the stream and locating favorable channel sections for flow measurement and sample collection

4.2 Well Design and Installation

4 2 1 Well Design

The type of monitoring wells selected for monitoring 903 Pad/Ryan's Pit Plume contaminants are conventional 2-inch inside diameter wells that are suitable for long-term monitoring of shallow water-bearing zones These wells will be designed with screened intervals that fully penetrate saturated colluvial materials A screen length of 5 feet is tentatively selected for all wells based on evidence from existing wells which indicate the presence of thinly saturated conditions To ensure that these wells have a multi-purpose monitoring function, potentially contaminated surface soils associated with the 903 Pad radionuclide release will be cased-off from deeper zones using surface conductor casing isolation techniques Final depth determinations will be made in the field based on actual drilling and initial depth to water results

All wells will be installed using dual ("aseptic") casing construction methods described in GT 06, *Monitoring Well and Piezometer Installation* Typical well construction materials will consist of a two foot section of 16 to 20-inch inner diameter (ID) steel surface casing and concrete pad, and 2-inch ID, schedule 40 or 80 polyvinyl chloride (PVC) riser and factory cut (0 010-inch slot width) well screen Protective casing consisting of 6-inch ID or larger steel riser with locking cap and lock will be set in sackrete to a depth of about 2 to 3 feet

4 2 2 Pre-Drilling Activities

Before advancing boreholes, all locations will be cleared in accordance with PRO 102, *Borehole Clearing*, and marked in accordance with GT 39, *Push Subsurface Soil Sampling* A prework radiological survey will be conducted in accordance with FO 16, *Field Radiological Measurements* All Health and Safety protocols will be followed in accordance with the *903 Pad/Ryan's Pit Plume Health and Safety Plan* addendum, as appropriate

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Soil cores will be recovered continuously in 2 to 4-foot increments using a 1-inch diameter by 48-inch long stainless steel- or lexon-lined California core barrel Following recovery, cores will be monitored with a Flame Ionization Detector (FID) or a Photoionization Detector (PID) in accordance with Site Procedure 5-1000-OPS-FO 15, *Photoionization Detectors and Flame Ionization Detectors*, for health and safety purposes The core samples will then be boxed and logged in accordance with PRO 101, *Logging Alluvial and Bedrock Material*, except that logging will be conducted more qualitatively than specified in PRO 101 (i e sieving microscope examination, and plasticity testing will not be conducted) All core boxes will be labeled and transferred to an ER core storage conex for archiving

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following project completion

After the boring reaches bedrock, an initial saturated thickness of colluvium will be estimated from water level measurements made within the boring through the drive pipe or temporary retrievable casing These measurements will be repeated after a 24 hour or longer period to allow for water level recovery effects If a sufficient amount of water collects in the boring to permit groundwater sampling, an opportunistic sample for VOC analysis may be collected at the discretion of the Project Manager for the purpose of verifying the presence of plume contamination Following drive pipe or casing removal, the borehole will be abandoned in accordance with procedure PRO 117, *Plugging and Abandonment of Boreholes*, unless reserved for monitoring well installation

4 2 3 2 Monitoring Wells

Boreholes for monitoring well installation will be advanced to bedrock through a two foot depth of pre-set surface conductor casing using hollow stem auger techniques Well locations will be chosen at an existing Geoprobe® borehole location selected on the basis of favorable hydrogeologic characteristics, including depth to bedrock, saturated colluvial thickness, and relative water level recovery rates In general, soil core samples will not be collected for logging purposes unless the Geoprobe® bedrock contact is questionable and requires further verification All drilling activities will comply with procedure PRO 114, *Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques*

4 2 4 Well Installation

Groundwater monitoring wells will be installed in accordance with FO 06, *Monitoring Wells and Piezometer Installation* Monitoring wells will be land surveyed in accordance with GT 17, *Land Surveying*, or RFETS global positioning system manuals (Ashtech, 1993)

4.3 Well Development

Monitoring wells will be developed prior to sampling using the procedures specified in PRO 106, *Well*

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Development All water produced during well development will be handled as uncharacterized development water in accordance with FO 05, *Handling Purge and Development Water*

4.4 Sample Designation

The site standard sample numbering system will be implemented in this project Location codes have been assigned to individual wells as shown in Figure 4-1 and listed in Table 4-1 using the ER well numbering convention adopted in 1992 For each groundwater sample or surface water sample, dual sample numbers will be assigned 1) a standard RIN sample number (i e , 98AXXXX 00X 00X) will be assigned to the project by the Analytical Services Division (ASD), and 2) an RMRS sample number (i e GW0XXXXTE or SW0XXXXTE) for internal sample tracking The block of sample numbers will be of sufficient size to include the entire number of possible samples (including QA samples) and location codes For the final report, the ASD and RMRS sample numbers will be cross-referenced with location codes

4.5 Sample Collection

4 5 1 <u>Groundwater Samples</u>

Prior to sample collection, the water level will be measured according to PRO 105, *Water Level Measurements in Wells and Piezometers*, to determine purge water requirements

Groundwater samples will be collected using the methods specified in PRO 108, *Measurement of Groundwater Field Parameters*, and PRO 113, *Groundwater Sampling* After an initial sampling round is completed for all new wells, sampling of wells will be conducted on a quarterly basis in support of natural attenuation monitoring, as specified by the IMP (to be modified for 903 Pad/Ryan's Pit Plume monitoring wells)

4 5 2 Surface Water Samples

4 5 2 1 Flow-Measurement Procedures

Stream-flow measurements will be made at each sampling station using either the volumetric method for small flows specified in PRO 093, *Discharge Measurement*, or portable cutthroat flumes for larger flows as described below and in accordance with PRO 093, *Discharge Measurement*, and Skogerboe et al (1973)

Cutthroat flumes manufactered for RFETS use employ a large plastic apron at the upstream end of the flume which, when used with sand bags, reduce leakage to acceptable values (usually less than 10 percent of the total measured discharge) during stream-flow measurements Throat widths ranging from 1 to 12 inches are available for measuring the normal range of flow conditions in the SID and Woman Creek Flume selection will be based on historical seasonal discharge data (Woman Creek) and visual estimates of flow made at the time of sampling

Accurate stream-flow measurement is dependent on a number of factors, including flume selection, installation, and alignment, channel geometry and bed conditions, and flow depth and approach conditions According to Skogerboe et al (1973), the flume should be placed in a straight section of channel preferably with relatively uniform flow conditions in a non-ponded area Place the flume in the center of the channel and align parallel to the axis of the channel and flow Seat the flume, spread the apron upstream, and seal the stream bed with sand bags until minimal or no leakage is observed past the flume Using a leveling device, level the flume in the x-y direction and wait at least 15 minutes for flow to stabilize before taking a staff reading The staff reading should be taken to the nearest 0 01 foot in the inlet converging section of the flume at a distance of

$$L_a = 2L/9 \qquad \text{(Skogerboe et al , 1973)}$$

where L_a is the centerline distance from the throat to the inlet staff measurement location, and
L is the flume length

The staff reading is then entered into the appropriate rating equation found in Skogerboe et al (1973)

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to provide tbe flow rate

4 5 2 2 Surface Water Sample Collection

Prior to sample collection, surface water field parameters will be measured using the methods specified in PRO 094, *Field Measurements of Surface Water Field Parameters* Grab samples for VOC analysis of surface water will be collected by container immersion, if a sufficient water depth exists for submergence, or a transfer device (i e , dipper), for low flow conditions, in accordance with the requirements of PRO 081, *Surface Water Sampling* All samples will be collected immediately upstream of the discharge measurement point to avoid collecting sediment suspended by channel disturbances associated with flow measurement

4.6 Sample Handling and Analysis

Samples will be handled according to PRO 069, *Containing, Preserving, Handling, and Shipping of Soil and Water Samples,* and 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging* If necessary, a Health and Safety Specialist (HSS) or Radiological Control Technician (RCT) will scan each sample with a Field Instrument for the Detection of Low Energy Radiation (FIDLER) Equipment will also be monitored for radiological contamination during and after sampling activities if required

Table 4-2 indicates the analytical requirements for each sample Samples will be submitted to an offsite, EPA-approved laboratory for analysis under a 30-day result turnaround time, unless shorter turnaround times for special opportunity samples (i e , Geoprobe® borings) are specified by the Project Manager to aid in siting well locations

4.7 Equipment Decontamination and Waste Handling

Reusable drilling and sampling equipment will be decontaminated with Liquinox solution, and rinsed with deionized or distilled water, in accordance with procedure FO 03, *Field Decontamination Procedures* Decontamination waters generated during the project will be managed according to procedure PRO 112, *Handling of Field Decontamination Water and Field Wash Water* Geoprobe® and drilling equipment will be decontaminated following project completion using procedure FO 04, *Decontamination of Heavy Equipment at Decontamination Facilities* Personal protective equipment will be disposed of according to FO 06, *Handling of Personal Protective Equipment* All excess drill cuttings will be handled in accordance with PRO 115, *Monitoring and Containerizing Drilling Fluids and Cuttings*

Table 4-2 Analytical Requirements for Groundwater, Surface Water, and Seep Samples

Analysis	Sample Type	Matrix	No. of Samples/ Event[a]	No. of Events	EPA Method	Container	Preservation	Holding Time
Target Compound List (TCL) Volatiles	Ground-water	Water	6	4	EPA 524 2	3 (three) 40 ml amber glass vials with teflon-lids	Unfiltered, cool, 4° C	14 days
Target Compound List (TCL) Volatiles	Surface Water/ Seep	Water	7[c d]	2	EPA 524 2	3 (three) 40 ml amber glass vials with teflon-lids	Unfiltered, cool, 4° C	14 days
Rad Screen	GW/SW/ Seep	Water	10[c]	4	N/A[b]	1 (one) 125 ml poly bottle	Unfiltered	180 days

[a] Includes two QC samples except for rad screens

[b] No EPA-approved method is currently in place for radionuclide analyses However, guidance is provided in procedures defined in Environmental Monitoring Support Laboratory (EMSL)-LV 0539-17, *Radiological and Chemical Analytical Procedures for Analysis of Environmental Samples*, March 1979

[c] Initial characterization sampling only

[d] Four surface water and three seep samples

5.0 DATA MANAGEMENT

A project field logbook will be created and maintained by the project manager or designee in accordance with Site Procedure 2-S47-ER-ADM-05 15, *Use of Field Logbooks and Forms* The logbook will include time and date of all field activities, sketch maps of sample locations, and any additional relevant information not specifically required by the SAP The originator will legibly sign and date each logbook page Appropriate field data forms will also be utilized when required by the operating procedures that govern the field activity A peer reviewer will examine each completed original hard copy of data Any modifications will be indicated in ink, and initialed and dated by the reviewer Logbooks will be controlled through RMRS Document Control Borehole geologic logs will be entered into the Equis Geo database for electronic storage and future applications

Analytical data record storage for this project will be performed by KH-ASD Sample analytical results will be delivered directly from the laboratory to KH-ASD in an Electronic Disc Deliverable (EDD) format and archived in the Soil and Water Database (SWD) Hard copy records of laboratory results will be obtained from KH-ASD in the event that the analytical data is unavailable in EDD or SWD at the time of report preparation

6.0 PROJECT ORGANIZATION

Figure 6-1 illustrates the project organization structure The RMRS Groundwater Operations manager will be responsibility for supplying equipment and personnel, and maintaining data collection and management methods that are consistent with Site operations Other organizations assisting with the implementation of this project are RMRS Health and Safety, RMRS Closure Projects, RMRS Quality Assurance, RMRS Radiological Engineering, and KH-ASD

Sampling personnel will be responsible for field data collection, documentation, and transfer of samples for analysis Field data collection will include sampling and obtaining screening results Documentation will require field logs and completing appropriate forms for data management and chain-of-custody shipment The sampling crews will coordinate sample shipment for on-site and off-site analyses through the ASD personnel The sampling manager is responsible for verifying that chain-of-custody documents are complete and accurate before the samples are shipped to the analytical laboratories

7.0 HEALTH AND SAFETY PLAN

All field actıvıtıes contaıned withın thıs SAP wıll be performed ın accordance wıth the health and safety requırements set forth ın an addendum to the *Health and Safety Plan for the 1996 Well Abandonment and Replacement Program, RF/ER-96-0016* Thıs addendum wıll be prepared and approved prıor to the ınıtıatıon of field work and wıll specıfically address hazards and preventatıve measures assocıated wıth well and Geoprobe® drıllıng, and surface and groundwater samplıng at the project sıte

8.0 QUALITY ASSURANCE

All components and processes wıthın thıs project wıll comply wıth the RMRS Qualıfy Assurance Program Descrıptıon RMRS-QAPD-001 (RMRS, 1997a), whıch ıs consıstent wıth the K-H Team QA Program The RMRS QA Program ıs consıstent wıth qualıty requırements and guıdelınes mandated by the EPA, CDPHE and DOE In general, the applıcable categorıes of qualıty control are as follows

- Qualıty Program,
- Traınıng,
- Qualıty Improvement,
- Documents/Records,
- Work Processes,
- Desıgn,
- Procurement,
- Inspectıon/Acceptance Testıng,
- Management Assessments, and
- Independent Assessments

The project manager wıll be ın dırect contact wıth QA to ıdentıfy and address ıssues wıth the potentıal to affect project qualıty Fıeld samplıng qualıty control wıll be conducted to ensure that data generated from all samples collected ın the field for laboratory analysıs represent the actual condıtıons ın the field The confidence levels of the data wıll be maıntaıned by the collectıon of QC and duplıcate samples and equıpment rınsate samples

Duplicate samples will be collected on a frequency of one duplicate sample for every twenty real samples Rinsate samples will be generated at a frequency of one rinsate sample for every 20 real samples collected Data validation will be performed on 25% of the laboratory data according to the Rocky Flats ASD, Performance Assurance Group procedures Samples will be randomly selected from adequate surface and subsurface sample sets (RINS) by ASD personnel to fulfill data validation of 25% of the total number of VOC and radioisotopic analyses Table 8-1 provides the QA/QC samples and frequency requirements of QA sample generation

Table 8-1 QA/QC Sample Type, Frequency, and Quantity

Sample Type	Frequency	Comments	Quantity/Event (estimated)
Duplicate	One duplicate for each twenty real samples		1
Rinse Blank	One rinse blank for each twenty real samples	To be performed with reusable sampling equipment following decontamination procedures	1

Analytical data that is collected in support of 903 Pad/Ryan's Pit Plume monitoring will be evaluated using the guidance developed by the RMRS Administrative Procedure RF/RMRS-98-200, *Evaluation of Data for Usability in Final Reports* This procedure establishes the guidelines for evaluating analytical data with respect to precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters

A definition of PARCC parameters and the specific applications to the investigation are as follows

Precision. A quantitative measure of data quality that refers to the reproducibility or degree of agreement among replicate or duplicate measurements of a parameter The closer the numerical values of the measurements are to each other, the lower the relative percent difference and the greater the precision The relative percent difference (RPD) for results of duplicate and replicate samples will be tabulated according to matrix and analytical suites to compare for compliance with established precision DQOs Specifications on repeatability are provided in Table 8-2 Deficiencies will be noted and qualified, if required

Accuracy A quantitative measure of data quality that refers to the degree of difference between measured or calculated values and the true value of a parameter The closer the measurement to the true value, the more accurate the measurement The actual analytical method and detection limits will be compared with the required analytical method and detection limits for VOCs and radionuclides to assess the DQO compliance for accuracy

Representativeness. A qualitative characteristic of data quality defined by the degree to which the data absolutely and exactly represent the characteristics of a population Representativeness is accomplished by obtaining an adequate number of samples from appropriate spatial locations within the medium of interest The actual sample types and quantities will be compared with those stated in the SAP or other related documents and organized by media type and analytical suite Deviation from the required and actual parameters will be justified

Completeness. A quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from a measurement system A completeness goal of 90% has been set for this SAP Real samples and QC samples will be reviewed for the data usability and achievement of internal DQO usability goals If sample data cannot be used, the non-compliance will be justified, as required

Comparability. A qualitative measure defined by the confidence with which one data set can be compared to another Comparability will be attained through consistent use of industry standards (e g , SW-846) and standard operating procedures, both in the field and in laboratories Statistical tests may be used for quantitative comparison between sample sets (populations) Deficiencies will be qualified, as required Quantitative values for PARCC parameters for the project are provide in Table 8-2

Table 8-2 PARCC Parameter Summary

PARCC	Radionuclides	Non-Radionuclides
Precision	N/A	RPD ≤ 30% for VOCs
Accuracy	N/A	Comparison of Laboratory Control Sample Results with Real Sample Results
Representativeness	N/A	Based on SOPs and SAP
Comparability	N/A	Based on SOPs and SAP
Completeness	N/A	90% Useable

Laboratory validation shall be performed on 25% of the characterization data collected in support of

d1

this project Laboratory verification shall be performed on the remaining 75% of the data Data usability shall be performed on laboratory validated data according to procedure RF/RMRS-98-200, *Evaluation of Data for Usability in Final Reports*

Data validation will be performed according to KH-ASD procedures, but will be done after the data is used for its intended purpose Analytical laboratories supporting this task have all passed regular laboratory audits by KH-ASD

9.0 SCHEDULE

Geoprobe® activities are scheduled to begin in late March 1999 followed by well drilling in mid-April All well installation activities are scheduled to be completed by the end of the month (April 30, 1999) Well development, groundwater sampling, and surface water sampling will commence within one week of well completions Land surveying or GPS of well and borehole locations and elevations will be performed following the completion of all intrusive activities

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FIGURES

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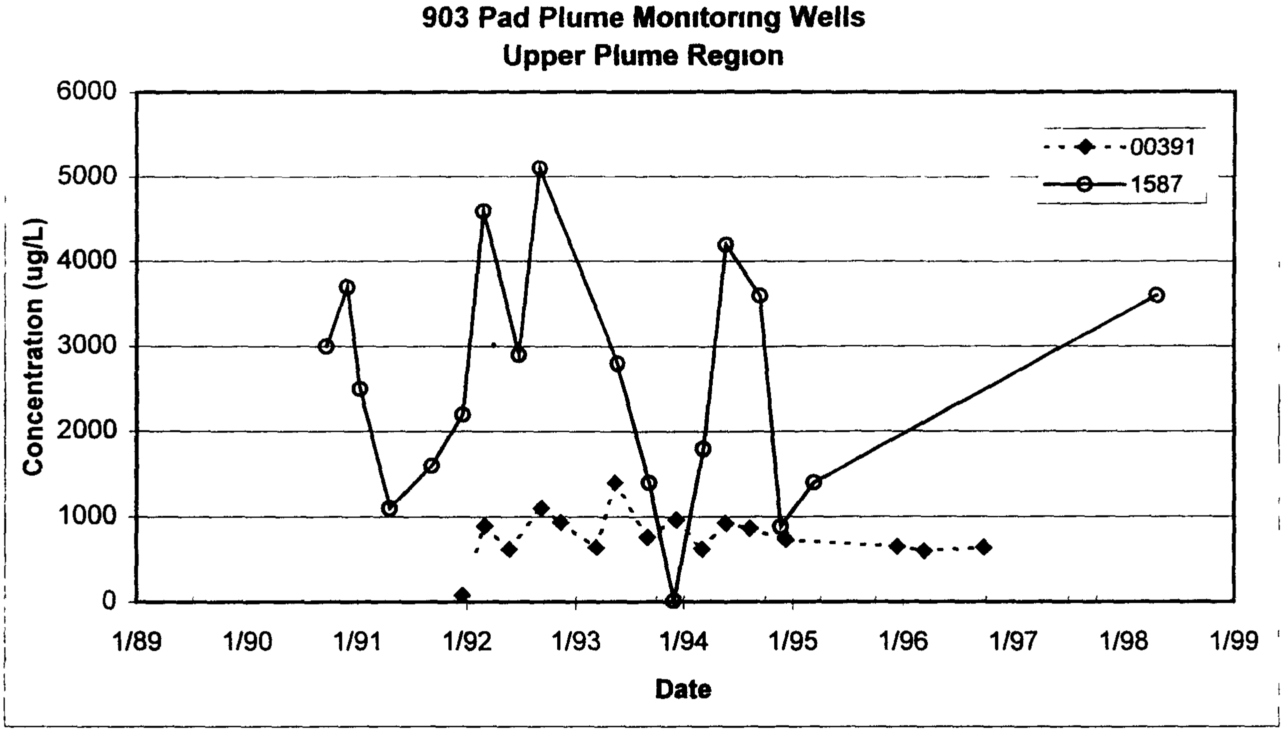
Figure 1-5 Carbon Tetrachloride Trends in Selected 903 Pad/Ryan's Pit Plume Monitoring Wells



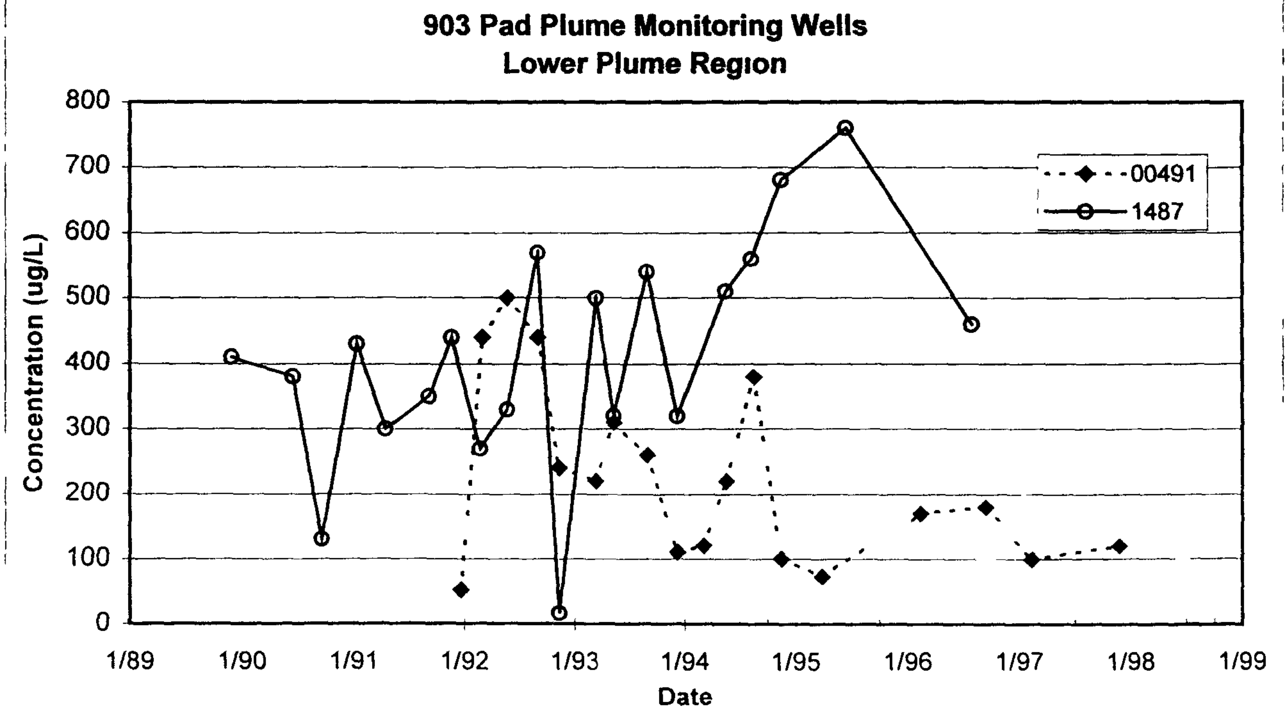


Figure 1-5 (Cont') Carbon Tetrachloride Trends in Selected 903 Pad/Ryan's Pit Plume Monitoring Wells

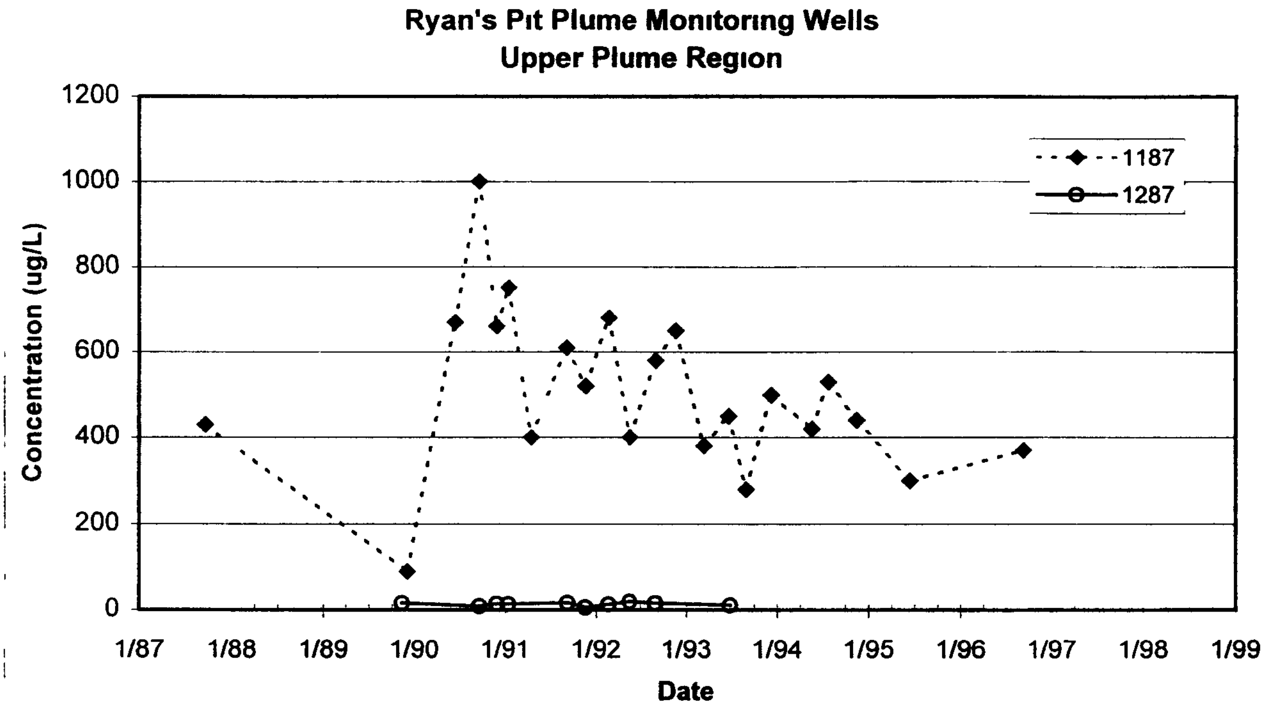
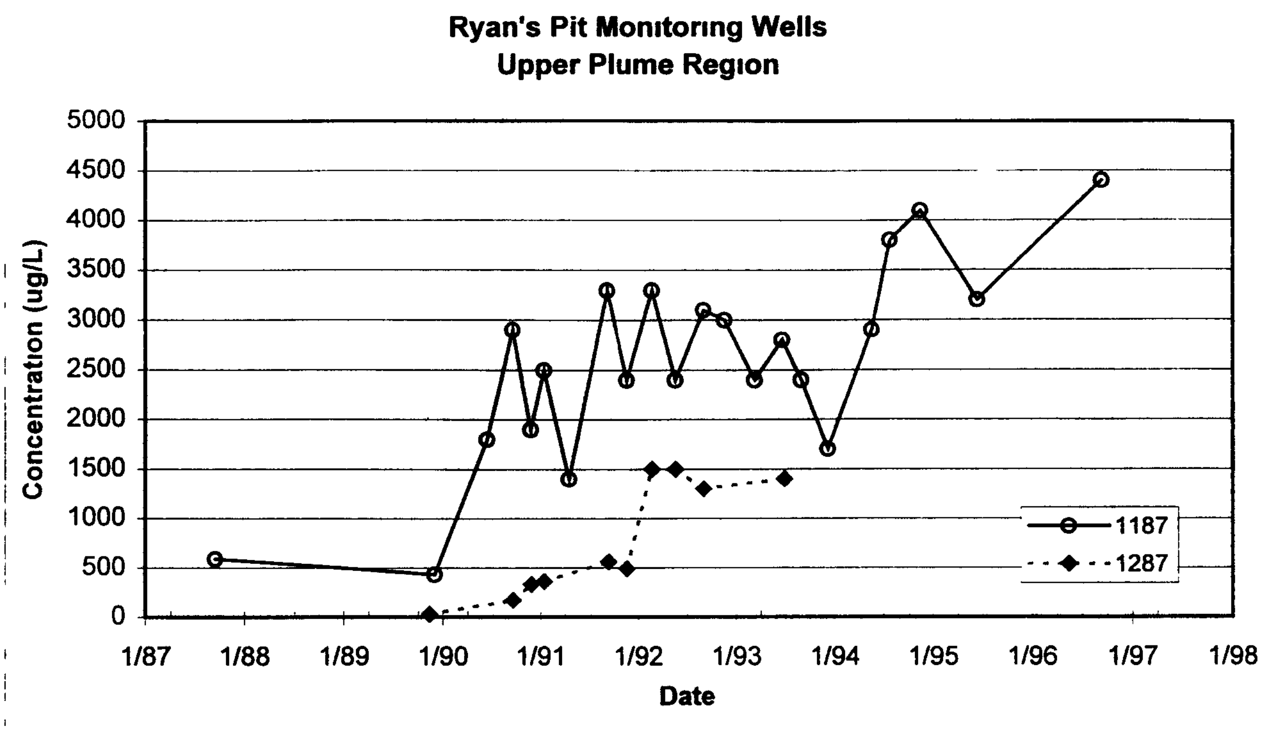


Figure 1-6 Trichloroethene Trends in Selected 903 Pad/Ryan's Pit Plume Monitoring Well



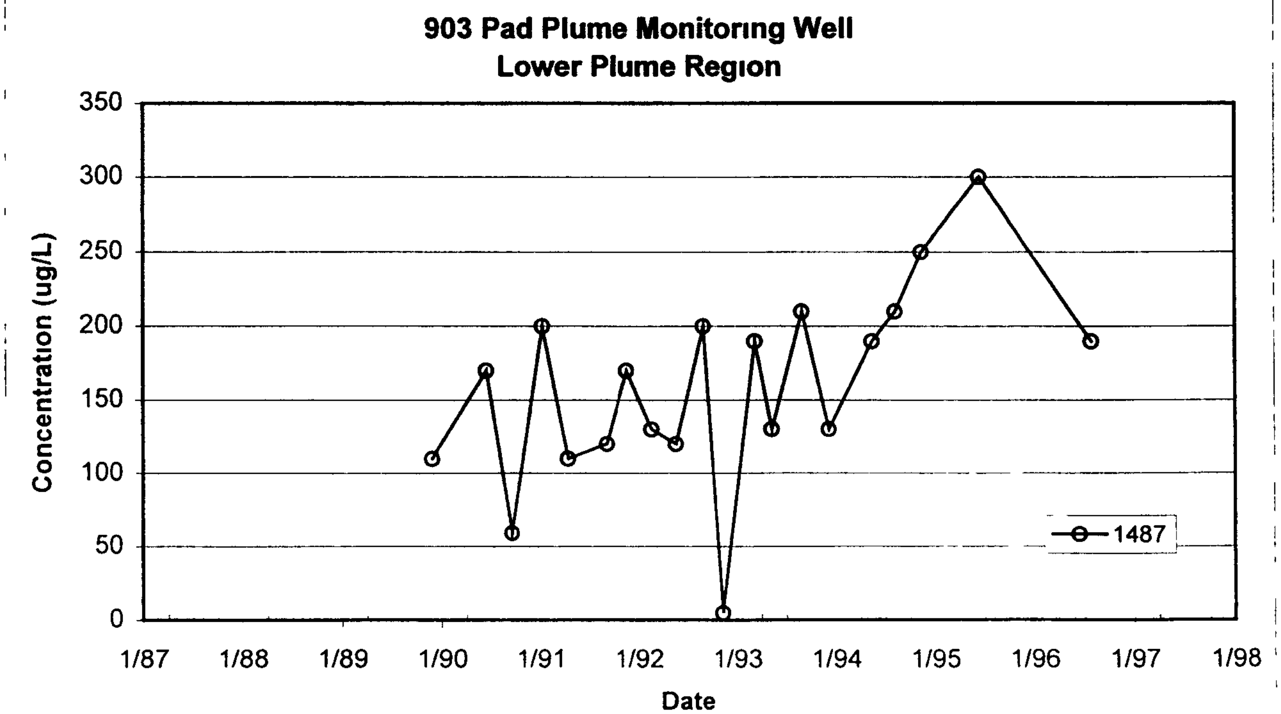
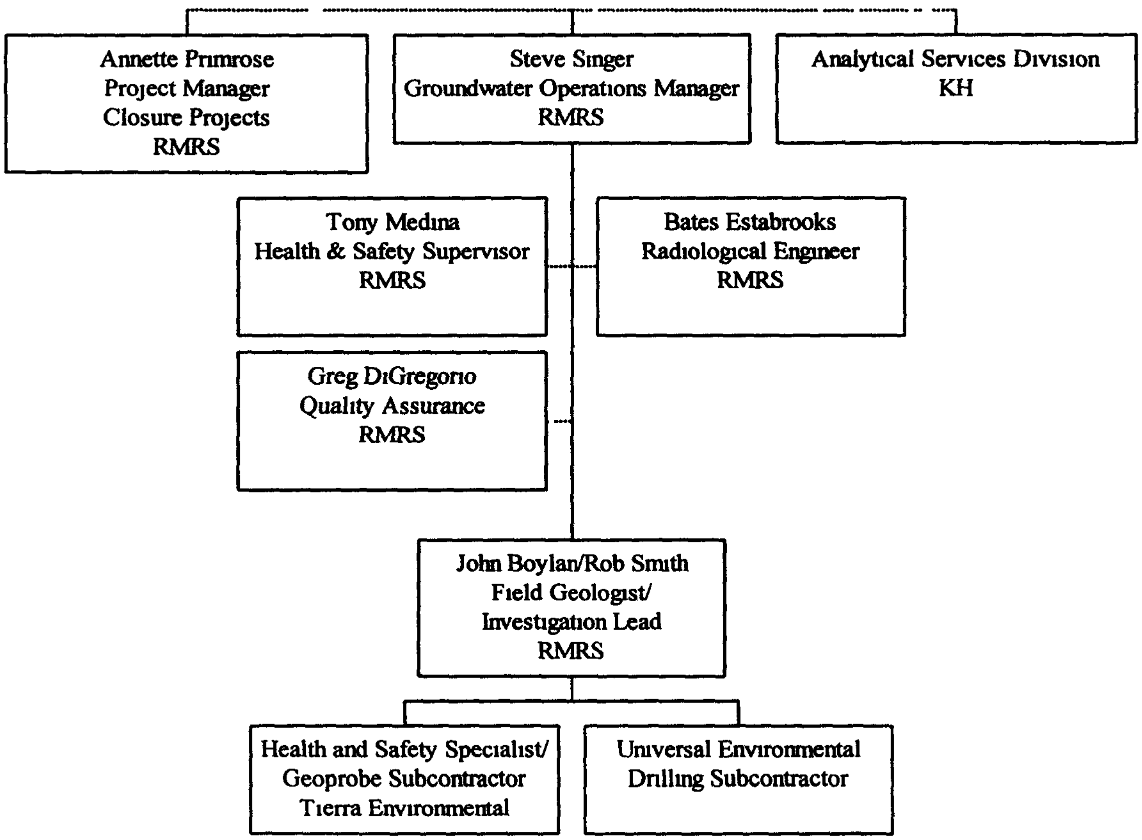


Figure 6-1
903 Pad/Ryan's Pit Plume Monitoring Organization Chart



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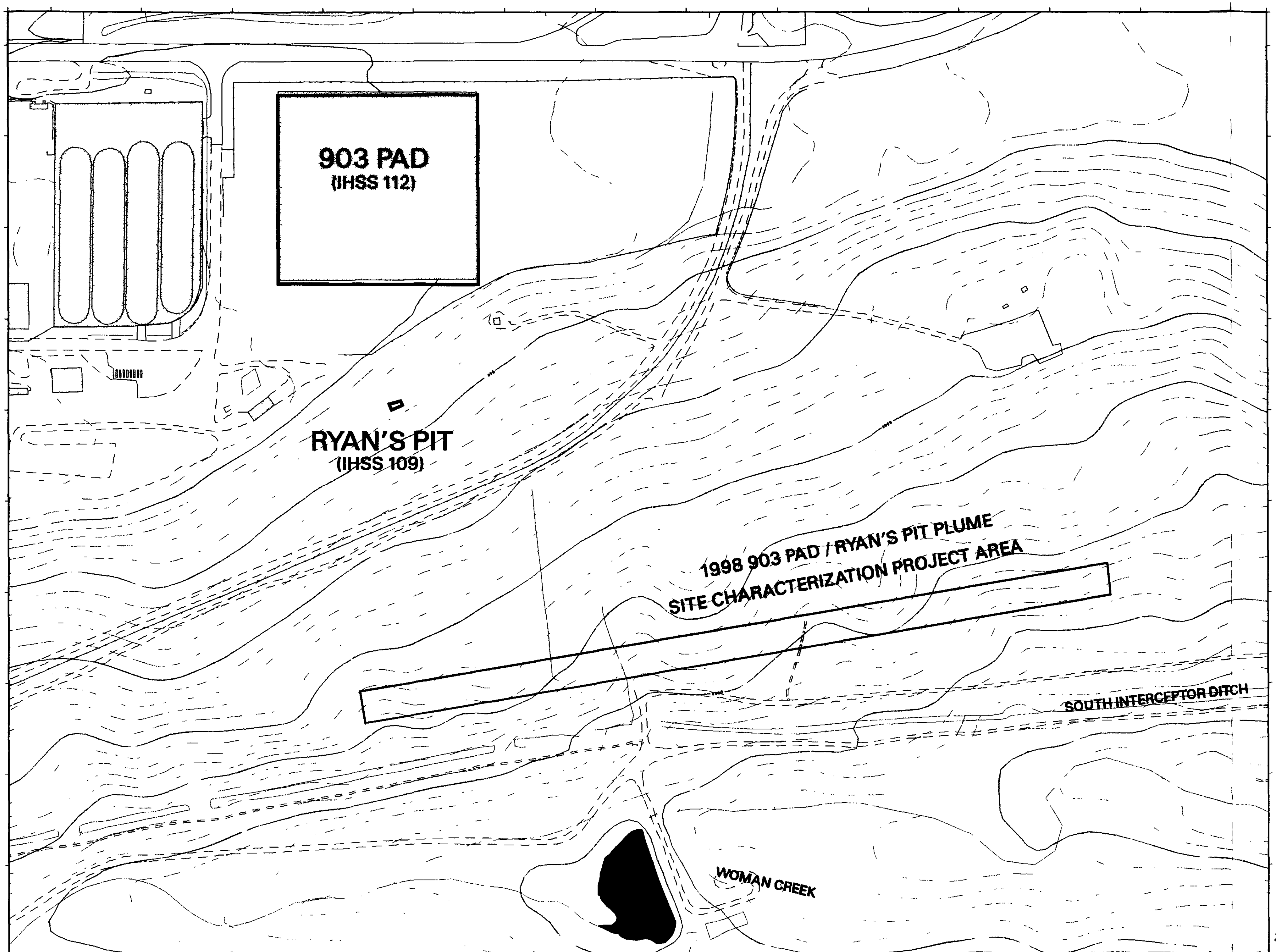

Figure 1 1
903 Pad/Ryan s Pit
Area Location Map

EXPLANATION

Standard Map Features

- Buildings nd othe structures
- Lake nd ponds
- Streams, ditches, or othe drainage features
- Fence nd other barriers
- Contour (5-Foot)
- Paved road
- Dirt road

Scale 1 2430
1 i ch represent approximately 203 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Cent al Zon
Datum NAD27

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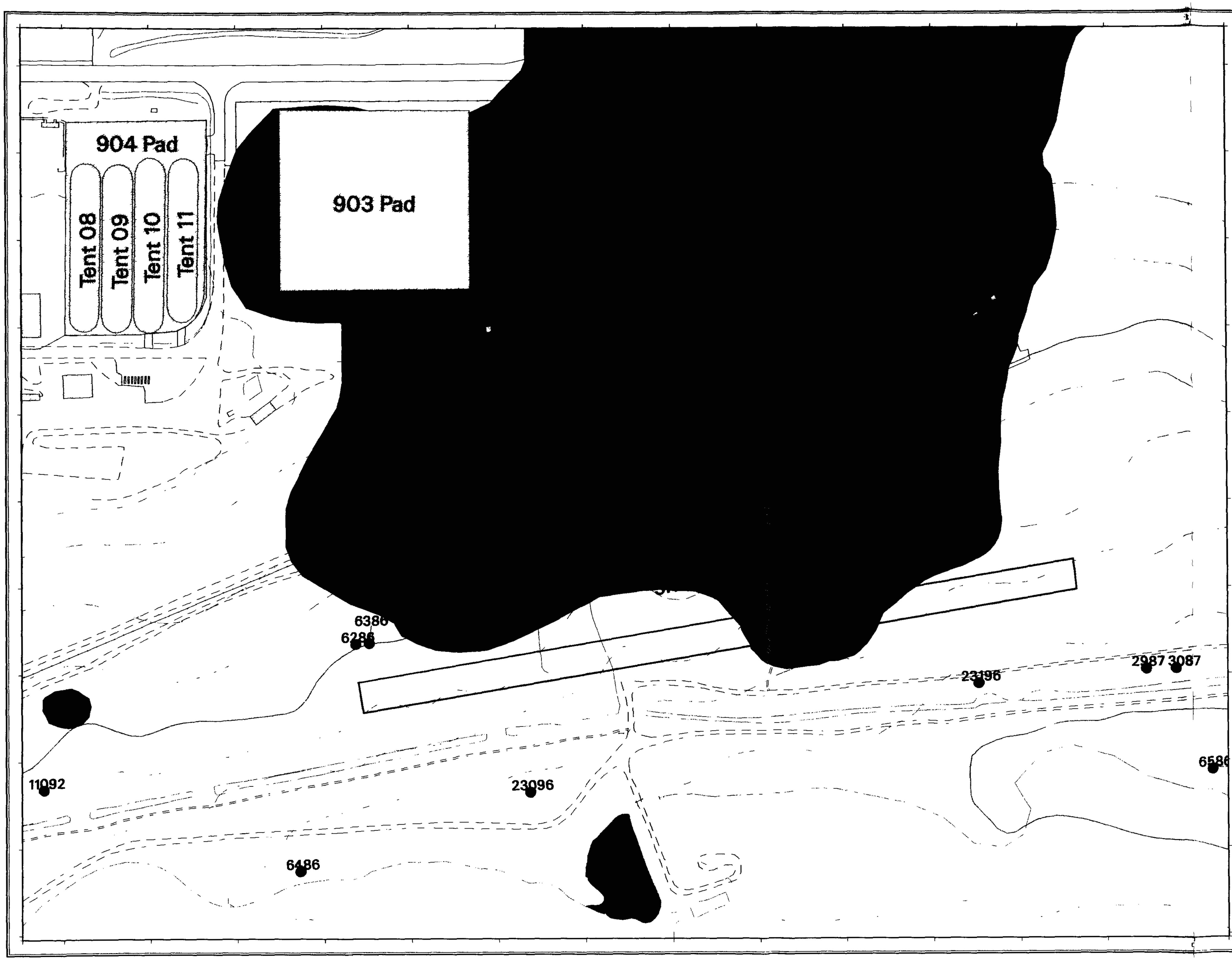

Figure 1 2
VOC Composite Plume Map

EXPLANATION

- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentratio equal to MCL)
- IMP Water Quality Monitoring Well
- Non-IMP Monitoring Well

Standard Map Features

- Building and othe structure
- Solar evaporatio ponds
- Lakes and pond
- Streams, ditches, or othe d ainage feature
- Fence and othe barriers
- Contour (20-Foot)
- Paved roads
- Dirt road

Scal 1 2430
1 inch epresent appr ximately 203 feet

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State Plane Coordi at Projection
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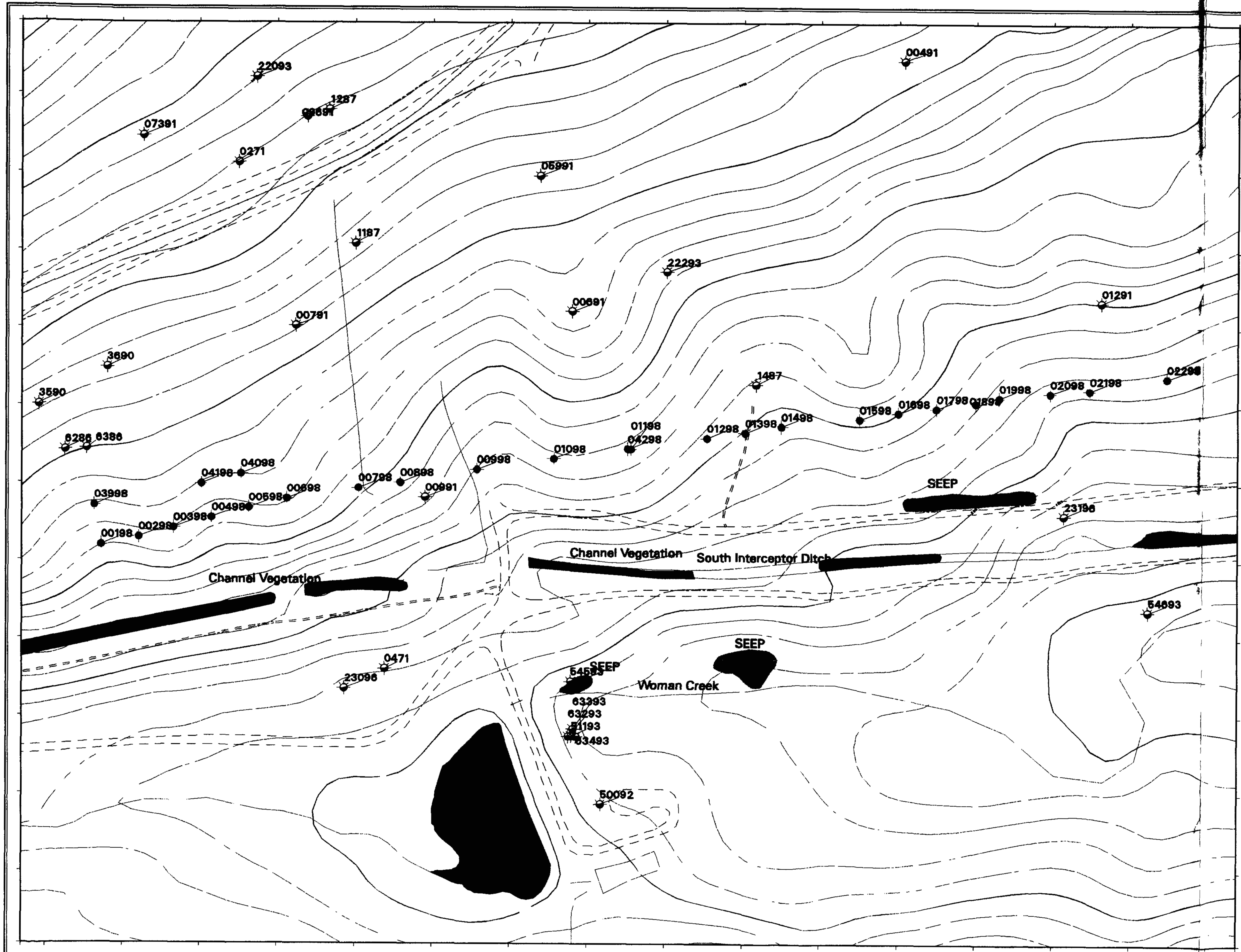

Existing Monitoring Wells and Piezometer Location Map

Figure 1-3

EXPLANATION

- 1998 Well Locations (IT 1998a)
- Existing Well Locations
- Proposed Well locatio
- Seep
- Channel Vegetatio

Standard Map Features

- Lakes d pond
- Streams, ditches, or othe drainage feature
- Fence nd othe barriers
- Contou (5-Foot)
- Dirt roads

Scale – 1 1530
1 inch represent approximately 128 feet

50 0 100 200ft

State Plane Coordi at Projectio
Colorado Cent al Zone
Datum NAD27

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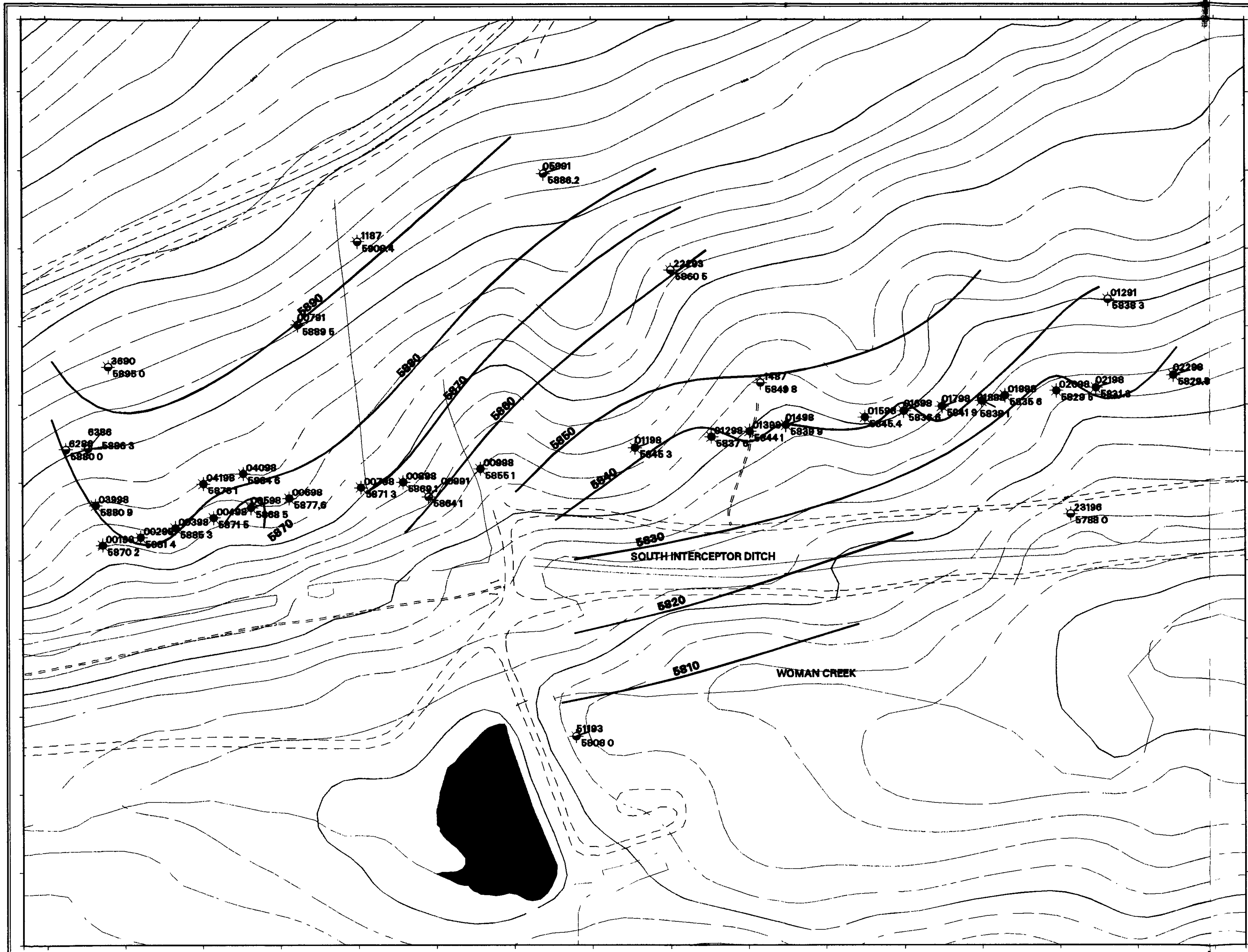

Top of Bedrock Map,
in the 903 PAD/Ryan s Pit Plume Study Area
Figure 1-4

EXPLANATION

- 1998 Well Location (IT 1998a)
- Existing Well Locations
- Top of Bedrock Elevatio Contours (Feet bove mea sea level)

Standard Map Features

- Building nd othe structure
- Sola evaporatio pond
- Lakes d pond
- Streams, ditches, or othe drainage feature
- Fence nd othe barriers
- Contou (5-Foot)
- Paved road
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95. Topography (contours) were derived from digital elevation model (DEM) data by MarkHurd Corp. (MHC) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

Scal 1 1530
1 inch represent approximately 128 feet

50 0 100 200ft

Stat Plane Coordi at Projection
Colorado Cent al Zone
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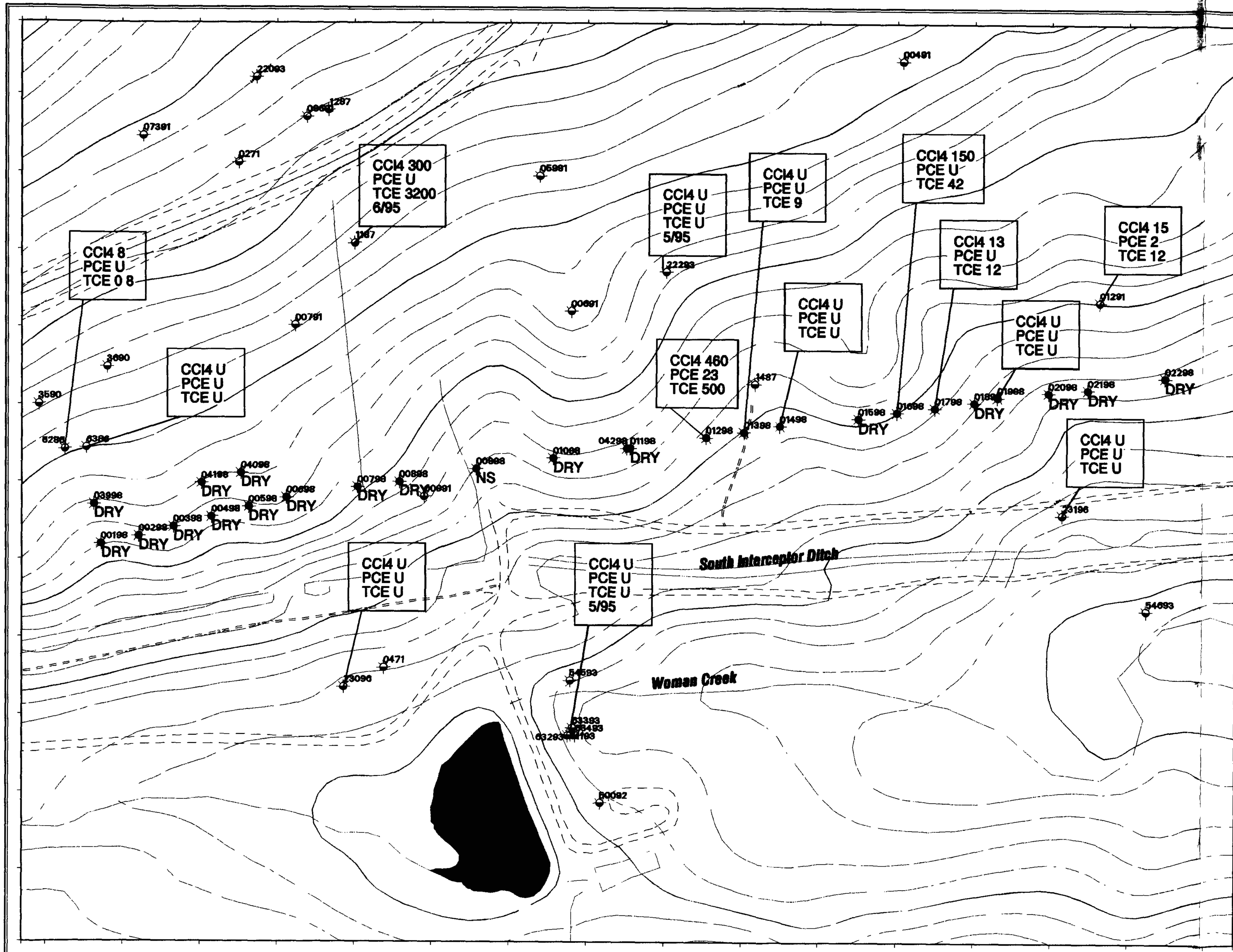

VOCs in Groundwater at the 903 PAD/Ryans s Pit Plume Study Area

Figure 1-7

EXPLANATION

Groundwater Sampling Wells

- 1998 Well Locations (IT 1998a)
- Existing Well Locations

CCl4 460
PCE 23
TCE 500

VOC Concentrations in Groundwater ug/l
-CCl4 = Carbon Tetrachloride
PCE = Tetrachloroethene
TCE = Trichloroethene
-U = Not Detected
-DRY = Not Sampled (No Water)
-NS = Not Sampled (Insufficient Water)

Standard Map Features

- Lake d pond
- Streams, ditches, or othe drainage features
- Fence nd othe barriers
- Contou (5-Foot)
- Dirt roads

Scal 1 1530
1 inch represent approximately 128 feet

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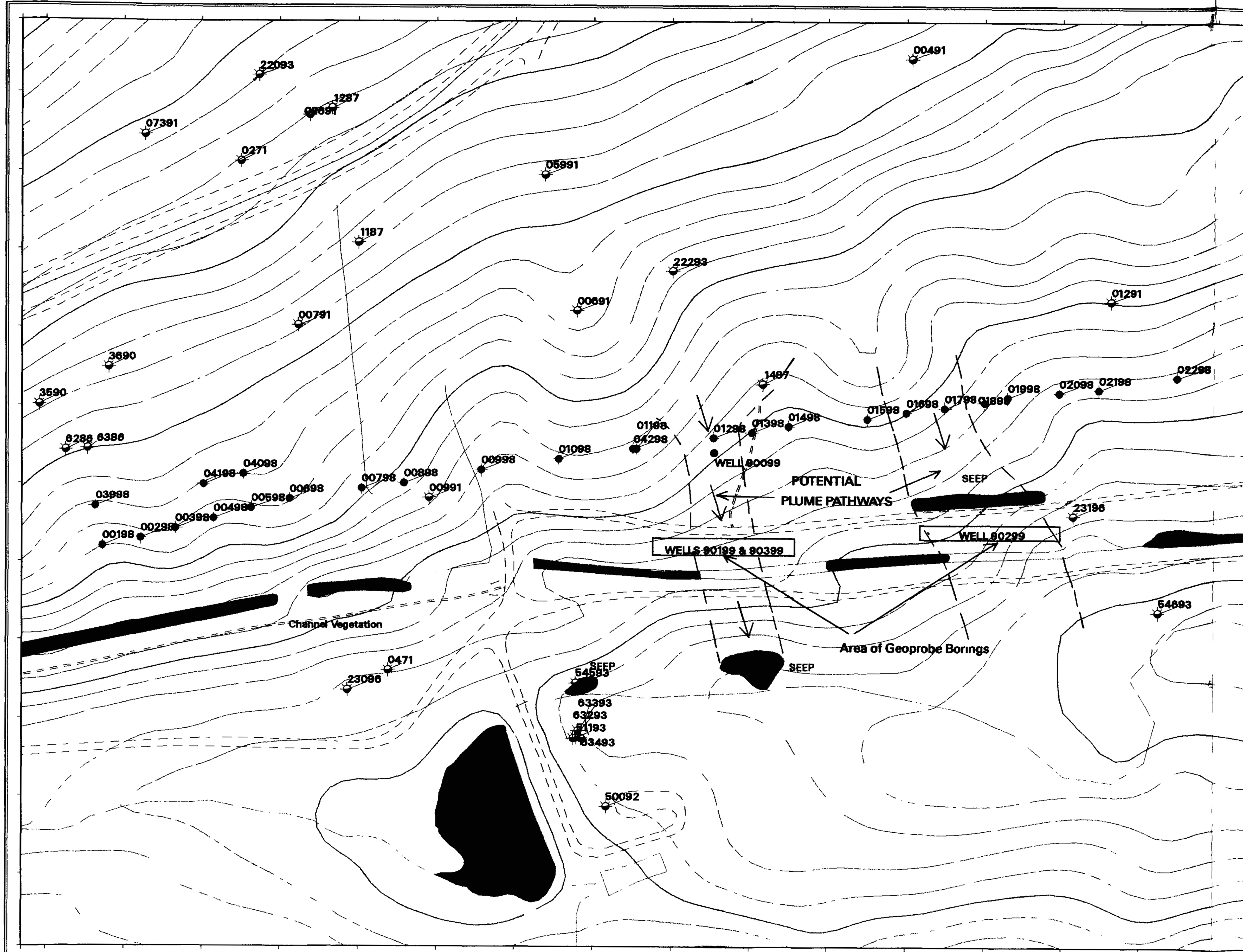

Location of Monitoring Wells, for the 903/Ryan s Pit VOC Plume

Figure 4-1

EXPLANATION

- 1998 Well Locations (IT 1998a)
- Existing Well Locations
- Proposed Well location
- Geoprobe/Well Ivestigation Area
- Seeps
- Cha nel Vegetatio

Standard Map Features

- Lakes d pond
- Streams, ditches, or othe drainage feature
- Fence nd othe barriers
- Contou (5-Foot)
- Dirt road

N

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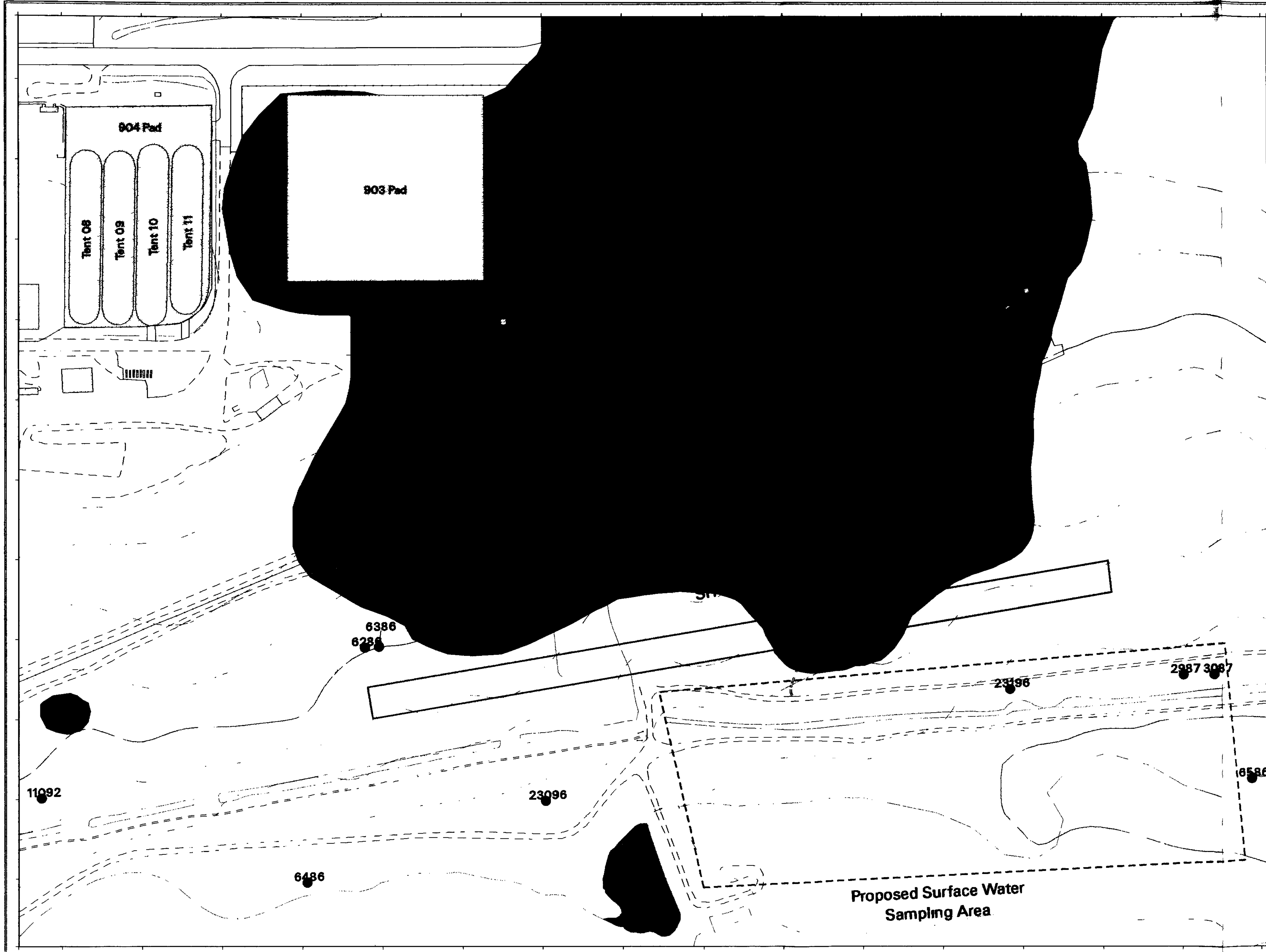

Figure 4-2

Proposed Surface Water Sampling Area
903 Pad / Ryan s Pit Plume

EXPLANATION

- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)
- IMP Water Quality Monitoring Wells
- Non-IMP Monitoring Well

Standard Map Feature

- Buildings nd other structures
- Lakes nd ponds
- Streams, ditches, or other dra nage features
- Fences nd other barriers
- Contour (20-Foot)
- Paved roads
- D rt roads

Scale 1 2470
1 inch represents pproximately 206 feet

0 100 200

State Plane Coordinate Projection
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Datum NAD27

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