
THE UNITED STATES AIR FORCE



AGENCY DRAFT

**OPEN BURN/OPEN DETONATION RANGE
DYE TRACE STUDY RESULTS**

FOR

ANDERSEN AIR FORCE BASE, GUAM

October 2006

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REPORT DOCUMENTATION PAGE			<i>Form Approved</i> <i>OMB No 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE <i>October 2006</i>	3. REPORT TYPE AND DATES COVERED <i>Draft</i>		
4. TITLE AND SUBTITLE <i>Open Burn/Open Detonation Range Dye Trace Study Results Andersen AFB, Guam</i>		5. FUNDING NUMBERS <i>AJJY041601AB FA8903-04-D-8685 Task Order 0003</i>		
6. AUTHOR(S) <i>Jennifer Miller, Alex Johnson, and Toraj Ghofrani, P.E.</i>				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSES(ES) <i>EA Engineering, Science, and Technology, Inc. P.O. Box 4355, Andersen AFB Yigo, Guam 96929-4355</i>		8. PERFORMING ORGANIZATION REPORT NUMBER <i>NA</i>		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESSES(ES) <i>Air Force Center for Environmental Excellence HQ AFCEE/ERD 3300 Sidney Brooks Brooks City-Base, TX 78235-5344</i>		10. SPONSORING/MONITORING AGENCY REPORT NUMBER <i>NA</i>		
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT <i>Approved for Public Release; Distribution is Unlimited</i>		12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words) <i>This report summarizes the results from the Dye Trace Study performed at the Open Burn/Open Detonation (OB/OD) Range located at Andersen Air Force Base (AFB), Guam. The goal of the dye trace study was to identify one groundwater sampling location downgradient from each of the OB and OD Units. The groundwater monitoring results will be used to evaluate any adverse impacts of the OB/OD Range on the quality of the downgradient groundwater at Andersen AFB.</i>				
14. SUBJECT TERMS - Andersen AFB - Dye Trace Study (DTS)		- Open Burn /Open Detonation (OB/OD)		15. NUMBER OF PAGES
				16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT <i>Unclassified</i>	18. SECURITY CLASSIFICATION OF THIS PAGE <i>Unclassified</i>	19. SECURITY CLASSIFICATION OF ABSTRACT <i>Unclassified</i>	20. LIMITATION OF ABSTRACT	

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LIST OF ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
Crawford	Crawford and Associates, Inc.
DTS	Dye Trace Study
EA	EA Engineering, Science, and Technology, Inc.
EOD	Explosive Ordnance Disposal
°F	degrees Fahrenheit
g/L	grams per liter
Guam EPA	Guam Environmental Protection Agency
IRP	Installation Restoration Program
mph	miles per hour
msl	mean sea level
NGL	Northern Guam Lens
nm	nanometer
OB	Open Burn
OD	Open Detonation
ppb	parts per billion
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
SAP	Sampling and Analysis Plan
WP	Work Plan
UV	ultraviolet

1. INTRODUCTION

This document summarizes the methods and results of the dye trace study (DTS) conducted in June 2006 at the Open Burn (OB)/Open Detonation (OD) Range located at Andersen Air Force Base (AFB), Guam. All field activities were performed in accordance with the February 2006 approved Final Work Plan (WP) and Sampling and Analysis Plan (SAP) for the above-referenced site (EA Engineering, Science, and Technology, Inc. [EA], 2006) and in conformance with the Resource Conservation and Recovery Act (RCRA) Part B Permit for Andersen AFB.

In March 1993, Andersen AFB submitted a RCRA Part B Permit Application to the Guam Environmental Protection Agency (Guam EPA). On 02 August 1996, the RCRA Part B Permit Application was modified by subsequent amendment, and on 10 December 2004, the Guam EPA approved RCRA Part B Permit GUS002 for the Andersen AFB Hazardous Waste Management Facility. The effective dates of operation for RCRA Part B Permit GUS002 are from 16 November 2004 to 16 November 2007 (Guam EPA, 2004).

The operations at the OB/OD Range are covered under the RCRA Part B Permit GUS002. Under the provisions of RCRA Part B Permit GUS002, Guam EPA requested a schedule for improving or upgrading the OB Unit, should Andersen AFB choose to resume burning operations. However, the Air Force has decided to discontinue burning of explosives at the OB Unit, and the OB Unit has been non-operational for many years. Andersen AFB is in the process of dismantling the OB Unit and will remove it from the permit in fiscal year 2007.

Conversely, the OD Unit is still actively used to detonate waste ammunitions and waste explosives. RCRA Part B Permit GUS002 requires: *"site monitoring for groundwater beneath the unit and a mitigation plan to protect biological receptors during OB/OD operations"* (Guam EPA, 2004). This DTS was conducted in response to the above-referenced requirements, particularly with regard to the anticipated longer-term operations of the OD Unit.

1.1 Project Goals and Objectives

The purpose of the DTS was to identify the best location for groundwater monitoring at the OB/OD Range.

The specific objectives of the DTS were to:

- Evaluate pathways of connectivity between the OB/OD Range and the Pacific Ocean to establish two representative groundwater sampling points, one downgradient from the OB Unit and one downgradient from the OD Unit.
- Determine appropriate locations where seeps can be sampled during low tides, in lieu of installing permanent groundwater monitoring wells.

The specific objectives of the groundwater monitoring program are to:

- Perform two rounds of groundwater sampling at each of the two selected groundwater monitoring points.
- Evaluate the quality of the groundwater data with respect to the target analyte list referenced in the RCRA Part B Permit and the pertinent regulatory levels.

1.2 Andersen AFB Environmental Setting

Guam is the largest and southernmost island in the Mariana Islands in the western Pacific Ocean. Relative to Guam, Hawaii is located 3,700 miles to the east-northeast and Japan is located 1,560 miles to the north. Guam is approximately 30 miles long, varies in width from 4 to 12 miles, and has a total land area covering approximately 209 square miles (Figure 1-1).

1.2.1 Physiography and Topography

Physiographically, the island of Guam may be divided into northern and southern regions, which are separated by the Adelup Fault (Figure 1-1). The northern region is a limestone plateau consisting of rolling hills and cliffines ranging from 200 to 600 feet above mean sea level (msl). The southern region is a volcanic upland of mountains and valleys, with Mount Lam Lam being the highest point on the island at 1,335 feet above msl (Tracey et al., 1964).

Andersen AFB consists of multiple parcels of land located on the northern half of Guam (Figure 1-1). The Base property includes the Main Base and Northwest Field, is approximately 8 miles wide by 2 to 4 miles long, and covers approximately 24.5 square miles. The OB/OD Range is located at the easternmost corner of Tarague Beach, adjacent to Tagua Point (Figure 1-2).

1.2.2 Climate

Guam is located at 13° 27' north latitude (approximately 900 miles north of the equator), creating a year-round warm and humid climate. The mean annual temperature is 81 degrees Fahrenheit (°F). Daily temperatures range from the lower 70s to the upper 80s °F. Relative humidity ranges from 65 to 80 percent in the afternoon and 85 to 100 percent in the evening. Guam has two distinct seasons, a wet and a dry season. The dry season is typically from December through June, and the wet season occurs from July through November. Approximately 65 percent of the annual precipitation falls during these five rainy months and the annual rainfall on northern Guam averages between 80 and 100 inches (Ward et al., 1965).

The dominant winds are the trade winds, blowing from the east or northeast with velocities between 4 and 12 miles per hour (mph) throughout the year. These winds are strongest during the dry season, averaging 15 to 25 mph, and calm periods are rare. During the wet season, the trade winds are still dominant, but not constant. The winds can blow from any direction with wind speeds generally less than 15 mph, interspersed with frequent calms. Storms may occur at any time during the year, although tropical storms and typhoons are more frequent during the

rainy season. Large rainfall events associated with typhoons are common, with as much as 25 inches in a 24-hour period (Ward et al., 1965).

1.2.3 Geology

The Mariana Islands are a complex geological island-seamount system forming the Mariana Archipelago. Guam, Rota, Tinian, and Saipan are part of an older frontal arc (middle Eocene-age) created 43 million years before present. All islands in the Mariana Archipelago are situated on the Philippine Plate near a feature known as the “andesite line” that separates the Pacific Basin from the Philippine Plate.

Andersen AFB is situated on an undulating limestone plateau with surficial karst features. The geology of the Main Base consists of outcrops of the Mariana and Barrigada Limestones, which are underlain at depth by the volcanic rocks of the Alutom Formation (Tracey et al., 1964). The Pliocene- and Pleistocene-aged (1 to 5 million years) Mariana Limestone consists of the reefal, detrital, molluscan, and fore-reef facies. The reefal facies is situated along the cliffline faces and consists predominantly of corals in position of growth in a matrix of encrusting calcareous algae. The reefal facies is white, massive, generally compact, and porous to cavernous (Tracey et al., 1964). The detrital facies is lagoonal in origin, varies from friable to well cemented, ranges in grain size from coarse to fine, and is generally porous (Tracey et al., 1964). The molluscan facies consists of fine-grained (mud), white to tan limestone of lagoonal origin containing abundant casts and molds of mollusks (Tracey et al., 1964). The fore-reef facies consists of a well-bedded, friable to indurated foraminiferal limestone deposited as fore-reef sand and debris.

The Miocene-aged (5 to 24 million years) Barrigada Limestone lies beneath the Mariana Limestone. The Barrigada Limestone is generally a deep-water deposit of medium- to coarse-grained texture and ranges from compact and well lithified to extremely friable. The formation contains abundant foraminifera *Operculina*, *Gypsina*, and *Cycloclypeus* (Tracey et al., 1964). It is a principal water-bearing unit, and contains abundant solution openings, voids, and fissures.

The Eocene/Oligocene-aged Alutom Formation unconformably underlies the Barrigada Limestone and consists of well-bedded, fine- to coarse-grained volcanic and volcanoclastic rocks.

1.2.4 Surface Water and Groundwater

Throughout most of northern Guam, fresh groundwater floats on seawater in an approximate buoyant equilibrium, described by the Ghyben-Herzberg model. Practical application of this model, when combined with the effect of dynamics of flow of the freshwater, results in a lens-shaped body of freshwater with parabolic surfaces at both the freshwater-air interface and the freshwater-seawater interface (Ward et al., 1965).

The Ghyben-Herzberg model describes the buoyancy relationship between fresh and saline waters in permeable rock, under static, unconfined conditions. Because the specific gravity of

pure water is 1.000 (unitless) and that of seawater is approximately 1.025, each foot of freshwater above msl displaces the seawater surface approximately 40 feet below msl, or at a ratio of 1:40 under static conditions. Consequently, as a general rule, the depth a static freshwater lens extends below msl would be approximately 40 times the height of the freshwater table above msl (Mink, 1976).

The Ghyben-Herzberg model assumes the existence of a sharp boundary or interface between freshwater and seawater. However, the boundary is usually diffuse in nature because of hydrodynamic dispersion induced by movements of the interface from tidal changes, seasonal differences in recharge rates, and withdrawals of freshwater by mechanical means (Mink, 1976). The diffuse zone of brackish water between the seawater and freshwater is called the transition zone. The thickness of this zone varies, and is dependent on the dynamics of flow in the freshwater portion of the lens.

The groundwater aquifer on northern Guam is commonly referred to as the Northern Guam Lens (NGL). The NGL can occur under two conditions: as basal and parabasal groundwater. The basal groundwater lens is the portion of the freshwater lens described by the Ghyben-Herzberg model. The lower boundary of the freshwater lens directly overlies the transition zone or seawater. Moving farther inland, to areas where the base of the freshwater lens directly intercepts the rising Alutom volcanics, the Ghyben-Herzberg model ceases to be the controlling factor in the definition of the base of the freshwater lens. The volcanic surface becomes the lower boundary condition and the water that rests directly on relatively impermeable volcanic rocks is referred to as parabasal groundwater. Regionally, the groundwater flow direction in the NGL is from the limestone/volcanic contacts toward the sea.

The OB/OD Range is located approximately 150 to 200 feet from the shoreline of the Pacific Ocean. The NGL is under basal conditions at the OB/OD Range, and the freshwater lens is expected to be very thin to non-existent due to the mixing action caused by tides. More likely, due to the proximity of the ocean, the NGL probably consists of a relatively thin zone of brackish water floating atop seawater. Information provided in a previous DTS conducted in the Landfill Complex (ICF Technology, 1994) indicated that groundwater in the vicinity of the OB/OD Range travels through the aquifer at average velocities ranging from 20 to 36 feet per day. The groundwater gradient flows toward the Pacific Ocean (Figure 1-2) are evident in seeps that are observed along the shoreline during low tides.

1.2.5 Sensitive Receptors and Land Use

The OB/OD Range is located in an area of Andersen AFB that has restricted access and precludes the building or inhabitation of any permanent structures. Human receptors are limited to Explosive Ordnance Disposal (EOD) personnel and wildlife personnel that occasionally access/use the site. As such, human exposures to the OB/OD Range are limited.

1.2.6 Essential Habitats

The OB/OD Range is located within an area designated as part of the Guam National Wildlife Overlay (United States Fish and Wildlife Service, 1995). In particular, the native forest situated above the cliffline is essential habitat for several threatened and endangered floral and faunal species (Figure 1-3).

As a result of security required for range operations, the OB/OD Range is located in some of the healthiest native limestone and coastal habitats remaining on Northern Guam (Andersen AFB, 2003). Restricted access to the site and vicinity affords the Mariana fruit bat, Mariana crow, and threatened green sea turtle greater protection when they frequent the area. OB/OD operations generally impact only the locations of detonation or firing and the immediate vicinity. The expansive safety distances, which include jungle/forest habitat and coastline, are off limits to Base personnel. The Mariana crow and Mariana fruit bat appear to have acclimated to the OB/OD activities and utilize the undisturbed habitat that the security requirements for operating this facility have established. Field monitoring and observations have not identified any adverse impacts to the Mariana crow or Mariana fruit bats to date.

The green sea turtle is a federally endangered species that may nest on beaches on Andersen AFB or forage in the offshore waters. The green sea turtle was federally listed as threatened in July 1978 in Guam (43 CFR 32800), but critical habitat for this species does not exist on Guam (Andersen AFB, 2003). However, green sea turtles may forage in offshore waters and nest on other beaches within the Tarague Embayment during the nesting season, which is generally from April through August.

1.2.7 Cultural Resources

The OB/OD Range is located within an area designated as part of Tarague Historic District, which has been evaluated for inclusion in the National Register of Historic Places (Earth Tech, 2003). The Tarague Historic District is a group of archaeological sites (of various time periods) located within the Tarague Embayment. The OB/OD Range is situated in the eastern portion of the Tarague Embayment. OB/OD Range operations have occurred since 1961. Activities in the OB/OD Range were reported to have possible adverse effects on an archaeological deposit that was formally characterized during a 1996 Tarague study.

For traditional Chamorro sites (Pre-Contact and early Post-Contact), this is one of the most important areas at Andersen AFB (Earth Tech, 2003). Of particular note are the extensive coastal dune areas and caves that contain remains of Chamorro settlements dating back as many as 3,000 years. The coastal dunes and caves are also known to have been used as traditional burial areas and may contain unmarked and unrecorded burials.

Previous archaeological and historic building surveys resulted in the identification of 18 significant (or potentially significant) cultural resource properties on Andersen AFB (Earth Tech, 2003), including the Tarague Historic District. Because of the overlap between the late Latte Period and the early period of Spanish contact, the last phase of the Latte Period village sites in

the Tarague Historic District and at the Pati Point Site may have been occupied during the early Spanish times. However, at present there is no archaeological evidence to verify this occupation. The most direct archaeological evidence documenting the early Spanish period was the abandonment of the nearby villages, which occurred in the late 1600s, and the absence of any subsequent settlement in the area for more than 100 years. The 19th century resettlement in the area left evidence in the form of trails (probably re-used traditional trails) on the plateau and leading into the Tarague embayment and adjacent coastal areas. These include trails in the Tarague Historic District.

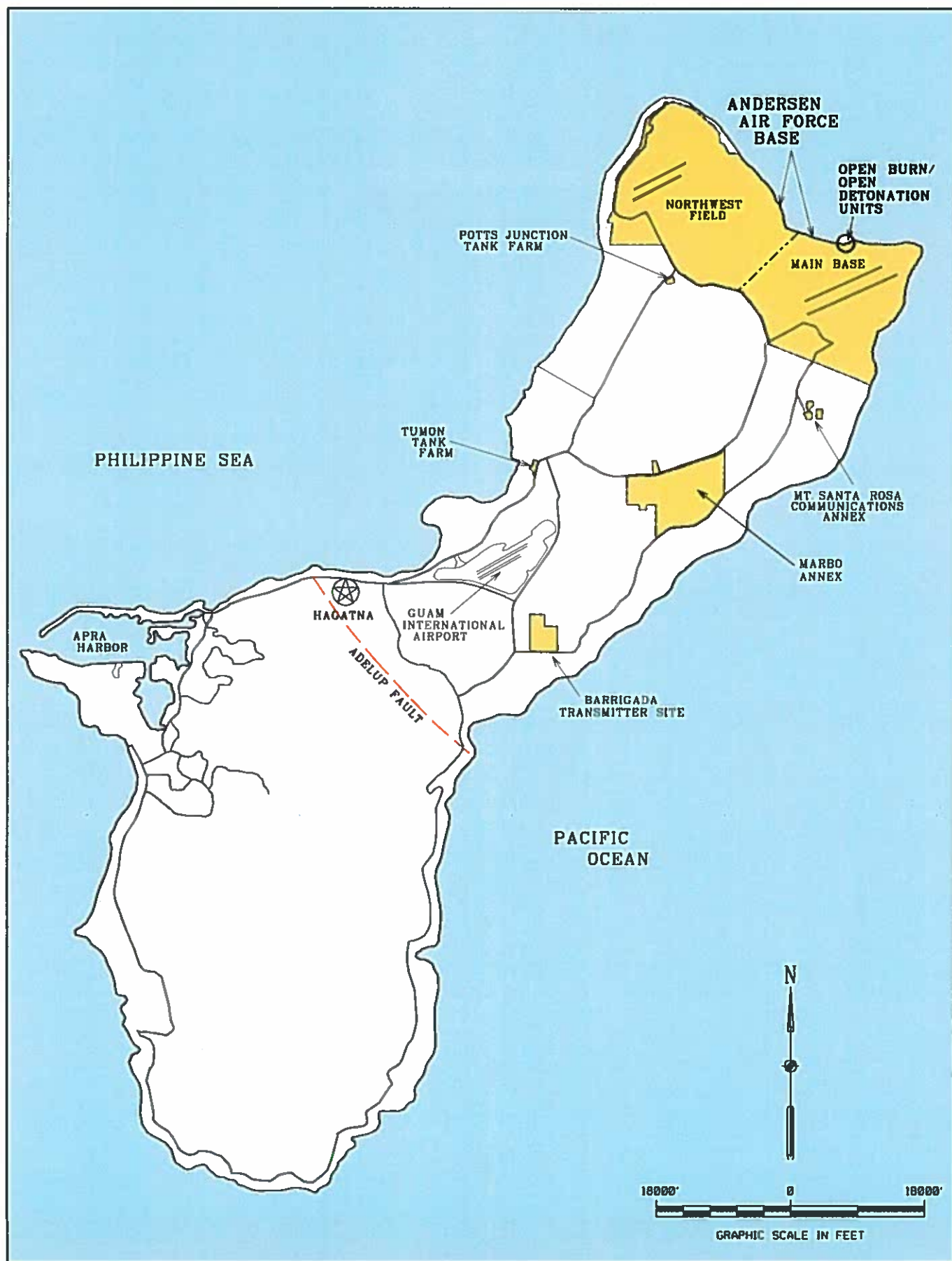


Figure 1-1. Location Map of Andersen Air Force Base on Guam.

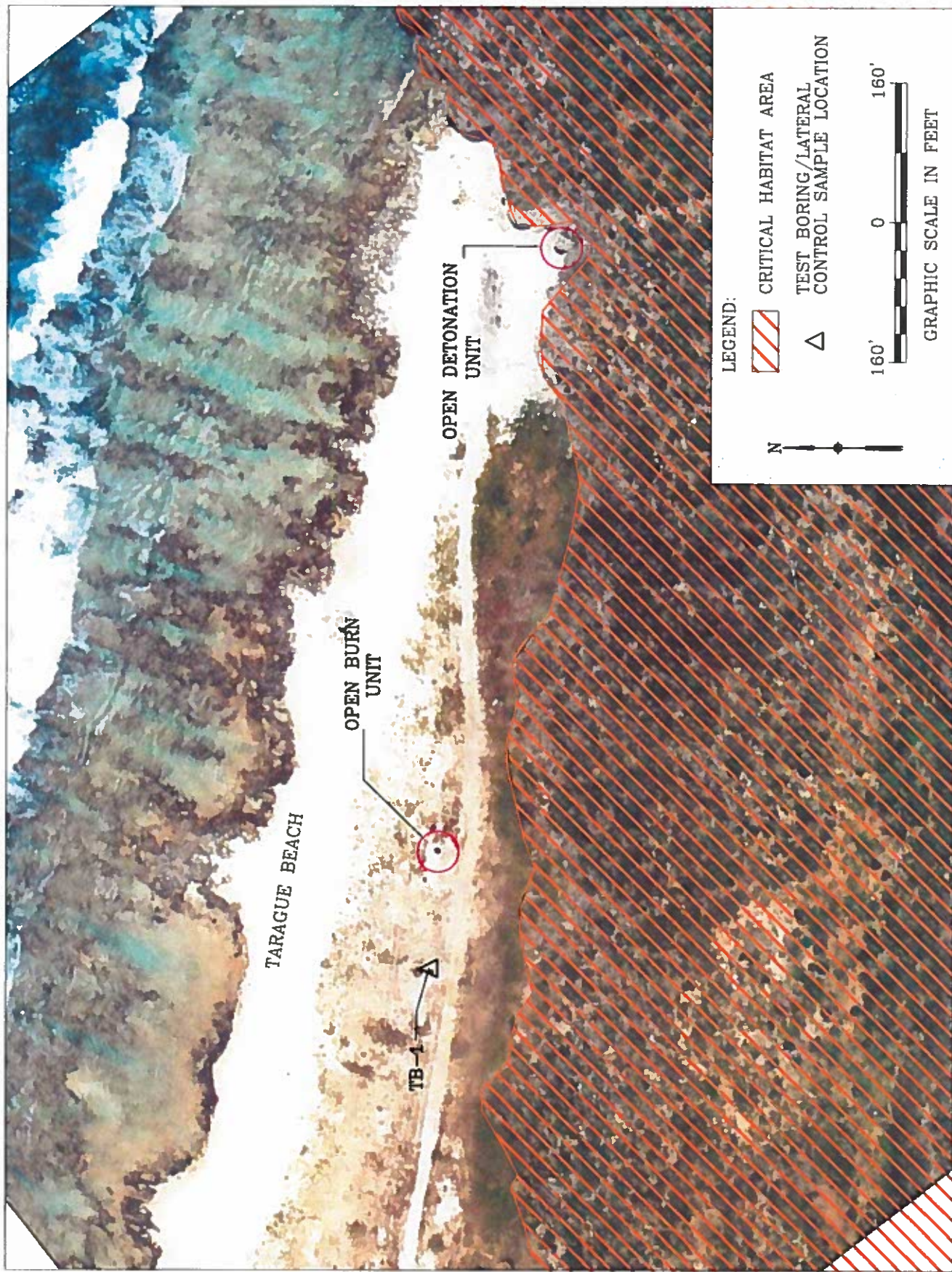


Figure 1-3. Critical Habitat Near Open Burn/Open Detonation Units at Tarague Beach, Andersen AFB, Guam.

2. DYE TRACE STUDY METHODOLOGY

This section outlines the methodologies used during the DTS at the OB/OD Range in June 2006.

2.1 Field Survey

A field survey was conducted with Guam EPA employees, Victor Wuerch, Mike O'Mallan, and Omar Damian, on site to assess the Dye Trace Study sampling plan and discuss alternative sampling approaches and approve seep sample locations. The field survey was conducted at low tide by walking the coastline of the study area to visually identify groundwater seep monitoring locations. The area of coastline seaward and to the west of the OD Unit appeared to have numerous groundwater seeps. The coastline east of the OD Unit is inaccessible due to the presence of a headland and very steep cliffs. The monitoring seep locations were chosen for high seep flow and proximity to the OB and OD Units. Seven seep locations were selected for dye monitoring based on observations made during the field survey (Figure 2-1).

2.2 Dye Selection

Two dyes were used during this DTS, Fluorescein and Tinopal CBS-X. Fluorescein is visible (yellow) and photochemically sensitive, while Tinopal CBS-X is only visible under ultraviolet (UV) light. Both Fluorescein and Tinopal CBS-X are non-toxic and can be detected at very low concentrations. Crawford Hydrology Laboratory can detect Fluorescein and Tinopal CBS-X in carbon receptor samples at concentrations as low as 0.005 parts per billion (ppb) and 0.1 ppb, respectively. Dye absorbed onto charcoal receptors is extremely stable at ambient temperatures. The Material Safety Data Sheets for the selected dyes are found in Appendix A

Fluorescein and Tinopal CBS-X can both be positively identified from a single charcoal receptor sample by laboratory analysis of the emission spectra (Crawford and Associates, Inc. [Crawford], 2001). As the emission wavelength for Fluorescein (516 nanometers [nm]) and Tinopal CBS-X (396 nm) (Crawford, 2001) are distinct, the two dyes can be used simultaneously. Also, from a visual observation perspective the dyes are compatible, as one is colorless and the other is yellow.

2.3 Receptor Construction

The receptors consisted of small packets constructed of vinyl-coated fiberglass screen mesh (Photo 2-1). The mesh was filled with 10 grams of activated coconut charcoal. Receptors were prepared in advance in a dye-free environment and individually packaged in sealed polyethylene bags by the Crawford Hydrology Laboratory (Crawford, 2001).

2.4 Receptor Holder Construction

Due to the high energy nature of intertidal environments and photochemical sensitivity of Fluorescein, it was necessary to place the dye receptors into holders. The holders consisted of an envelope of Mirafi® Filterweave® Woven Textile FW 404 (Photo 2-1). Mirafi® Filterweave® Woven Textile FW 404 has a tensile strength of approximately 3,000 pounds per foot, and a

90 percent UV resistance over 500 hours. Mirafi® Filterweave® Woven Textile FW 404 can allow a flow through rate of approximately 70 gallons per minute per square foot (Appendix B).

2.5 Dye Quantity and Mixing

In accordance with the Air Force and regulatory-approved Final WP and SAP (EA, 2006), 10 pounds of Fluorescein was mixed with 300 gallons of water to make an initial Fluorescein concentration of 4 grams per liter (g/L) prior to dye injection (Photo 2-2). Similarly, 20 pounds of Tinopal CBS-X was also mixed with 300 gallons of water (Photo 2-3) to make an initial Tinopal CBS-X concentration of 8 g/L. The initial concentration of Tinopal CBS-X was higher due to the higher detection limit for Tinopal CBS-X. The mixing water was transported from the Installation Restoration Program (IRP) field office to the study area in two separate water tanks and mixed with the respective dyes on site. To reduce the potential for cross-contamination, the dyes were thoroughly mixed by two separate teams wearing Tyvek® suits, boot covers, and gloves (Photos 2-2 and 2-3).

2.6 Dye Injection

Fluorescein dye was injected into the injection pit located at the OD Unit and Tinopal CBS-X was injected into the injection pit located at the OB Unit (Figure 2-1). The pits were approximately 3 feet deep, 4 feet long, and 4 feet wide. The dye injection was timed to coincide with the high tide. The injection pits were first primed with approximately five gallons of potable water. Then 300 gallons of the Fluorescein/water solution was injected into the pit at the OD Unit and 300 gallons of the Tinopal CBS-X/water solution was injected into the pit at the OB Unit using two separate electric pumps (Photos 2-4 and 2-5). The dye injection took 25 minutes at the OD Unit and 20 minutes at the OB Unit. Once all dyes had been injected into the pits, the injection pits were flushed with 25 gallons of potable water.

2.7 Receptor Placement and Retrieval

Receptors were placed at each groundwater seep monitoring location (Photo 2-6). Prior to placement, the detectors were inspected for signs of damage. Disposable latex gloves were worn when handling the receptors to avoid transferring dyes. The receptors were submerged and secured in a location where ample flow could pass through the receptor and where they could be retrieved under high tide conditions. The receptors were shielded by the receptor holder to minimize photochemical decay of dyes in the sunlight. Two dye receptors were used at each groundwater seep monitoring points. This provided a backup in the event that one receptor was lost. Duplicate receptors were used at a frequency of 10 percent to evaluate quality control (QC).

The charcoal dye receptors were retrieved every 2 hours for the first 24 hours, every 6 hours for the following 72 hours, and every 12 hours for the following ten days. When retrieving the receptors, the groundwater seep was visually examined for the presence of dye or other noteworthy conditions. The receptors were then placed in a labeled, sealable, Ziploc® bag. The receptor bag was labeled with the following data:

- Project name
- Sample identification number

- Name of monitored point
- Date and time of retrieval
- Initials of staff collecting the receptor

Retrieved receptors were placed in a cooler with ice and sent to Crawford Hydrology Laboratory in Bowling Green, Kentucky under chain-of-custody procedures.

2.8 Visual Monitoring of Dyes

Even though the Tinopal CBS-X was not expected to be visible to the unaided eye, all seep locations downgradient from the OB and OD Units were visually inspected during every sample period. A description of the time, location, and relative intensity of the observation was noted in the field logbook.

2.9 Upgradient Well Monitoring

Two charcoal receptors were placed in the upgradient well IRP-52B prior to dye injection and remained in place until the completion of the study (Figure 1-2). Similarly, two charcoal receptors were placed in well TB-1 for a duration of 12 hours at the end of the field effort. TB-1 is located in close proximity to the OB Unit (Figure 2-1).

2.10 Data Evaluation

2.10.1 Background Fluorescence Samples

The dyes used for tracing can often be found in products ranging from food coloring to toilet bowl cleaners and as such there was the potential for fluorescent dyes to be present in source water due to pollution or natural interferences. Fluorescent dyes also have extremely low detection limits. Therefore, fluorescent dyes used for tracing can be observed in source water at low, background concentrations.

To establish the background concentrations for Fluorescein and Tinopal CBS-X, dye receptors were placed at groundwater seep monitoring points prior to dye injection using three different soak times (2, 6, and 12 hours). The results of the background fluorescence investigation were used to evaluate the dye receptor results.

2.10.2 Laboratory Analysis

Dye receptors were analyzed at the Crawford Hydrology Laboratory in Bowling Green, Kentucky. The lab used a solution with a dried aliquot of 0.5 grams of charcoal and an alkali buffer solution. The solution was then analyzed on a Shimadzu Model RF 5301PC scanning spectrofluorophotometer that had been calibrated with the appropriate dye solution at the emission wavelength for the specific dye. The emission spectra from the synchronous scan were then used to determine the concentration of each individual dye present in the sample. Dye analysis procedures and the Quality Assurance (QA)/QC Plan are presented in Appendix C.

2.11 Site Access

Prior to commencing fieldwork, a Work Clearance Request Form (Air Force Form 103, Appendix D) was completed and approved. No additional permit, license, or clearance was required for compliance with United States Air Force, Territory of Guam, and federal requirements. All field activities were coordinated with Andersen AFB. Site access was coordinated daily both with EOD point of contact Msgt. Courter (366-5198) and the Combat Arms Training & Maintenance point of contact Sgt. Kelly (366-3215) prior to conducting any field investigations.

Field activities were also coordinated with the Guam EPA. On 16 June 2006, Mr. Mike O'Mallen of Guam EPA visited the OB and OD Units, approved the seep sample locations, and observed the DTS.

2.12 Dye Quantification

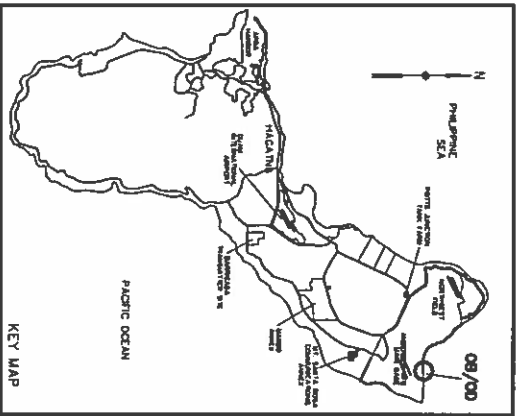
Dye concentrations are expressed in ppb and should not be converted to micrograms per kilogram. The dye concentration for the eluted charcoal samples expressed in ppb is not an accurate quantitative measurement of the amount of dye in the water at the time the sample was collected (Crawford, 2001). The results are semi-quantitative when compared with the actual quantity of dye in the water passing over the receptor (Crawford, 2001).

The quantity of dye absorbed by the charcoal is a function of the dye concentration in the water and the quantity, velocity, temperature, and duration of exposure (Crawford, 2001). Turbidity and the quantity and species of other absorbents competing with the dye for the charcoal receptors can reduce the quantity of dye absorbed onto the charcoal. Also, the quantity of dye eluted from the charcoal is dependent on the amount of charcoal and eluent used, the type of eluent, whether the charcoal is wet or dry before elution, and the length of time the charcoal is eluted before being analyzed (Crawford, 2001). The laboratory procedures can be standardized, but the water exposure variables can not. Therefore, the concentration of dye absorbed by the charcoal may not accurately represent the quantity of dye that flowed past the dye receptor due to the water exposure variables. Analysis of two dye receptors placed in the same general area for the same time period often resulted in differences when expressed in ppb. Although dye concentrations for eluted samples are measured and recorded in ppb, these values will virtually always be much higher than the dye concentrations ever reached in the water (Crawford, 2001). Therefore, the following abbreviations are used to express the dye concentration in more general terms rather than ppb:

- ND = Below Quantitation Limit
- + = Positive
- ++ = Very Positive
- +++ = Extremely Positive
- B = Background
- NS = Dye receptor not recovered

Although dye concentrations obtained from charcoal dye receptors do not accurately reflect the concentration in the source water, detection of dye at a sufficient concentration above background levels does constitute a positive trace.

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- LEGEND:**
- SHORELINE
 - OB-OD DYE INJECTION POINT
 - SP-1 SEEP SAMPLE LOCATIONS
 - MONITORING WELL

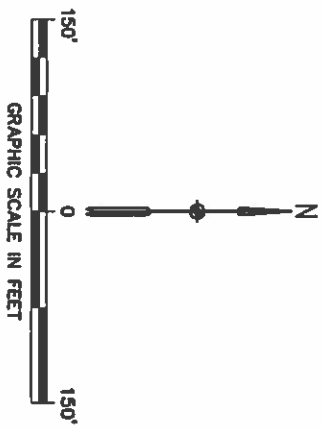


Figure 2-1.
Injection and Seep Sample Locations at
the Open Burn/Open Detonation Range,
Andersen AFB, Guam.

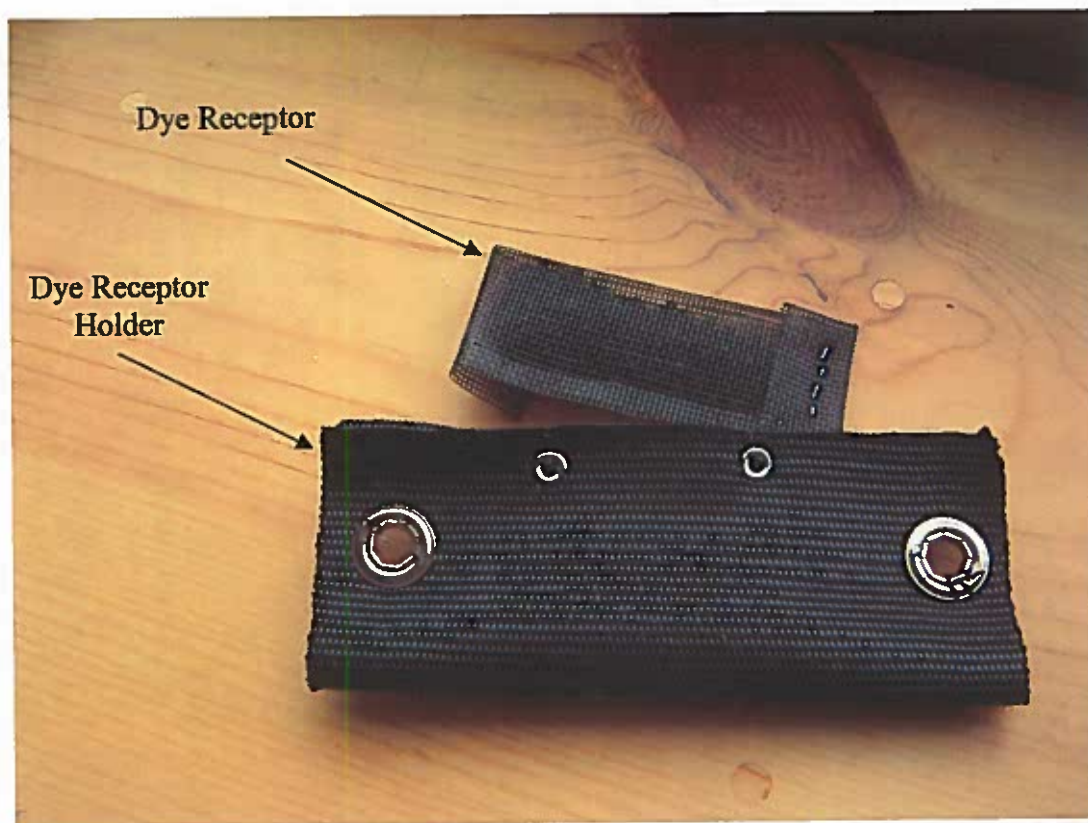


Photo 2-1. Dye receptor and receptor holder.

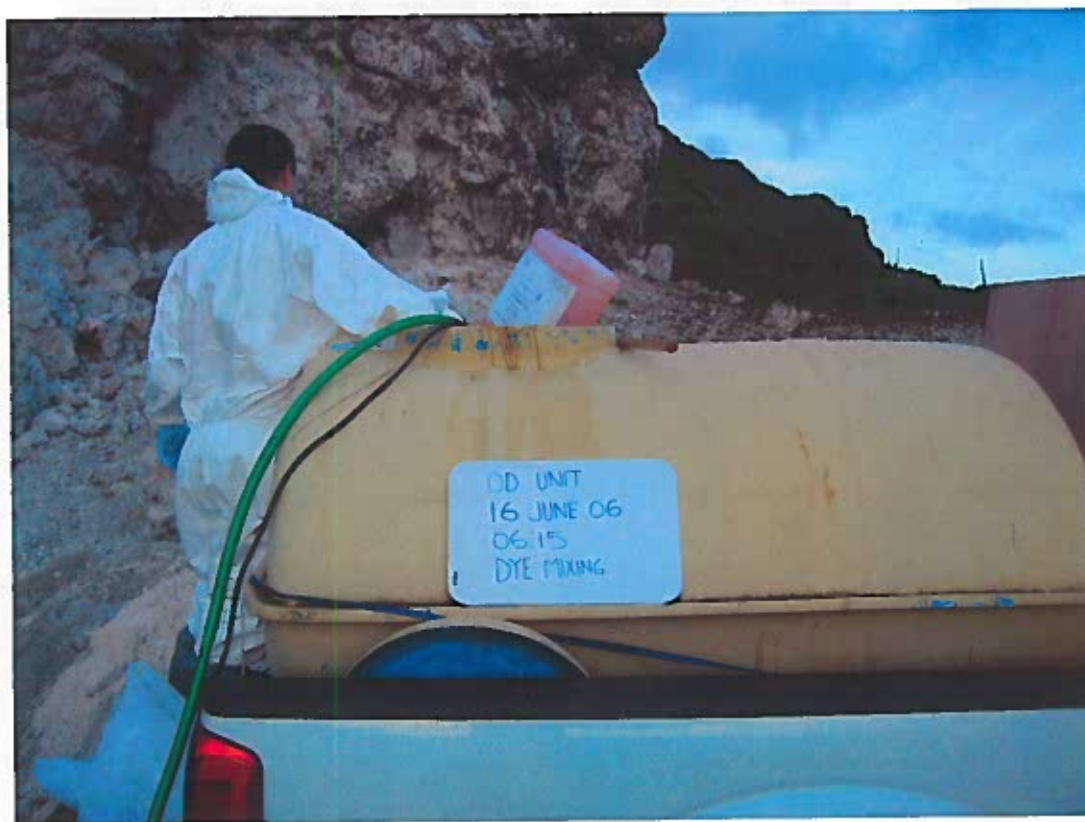


Photo 2-2. Fluorescein mixing at the OD Unit, Andersen AFB, Guam.



Photo 2-3. Tinopal CBS-X mixing at the OB Unit, Andersen AFB, Guam.

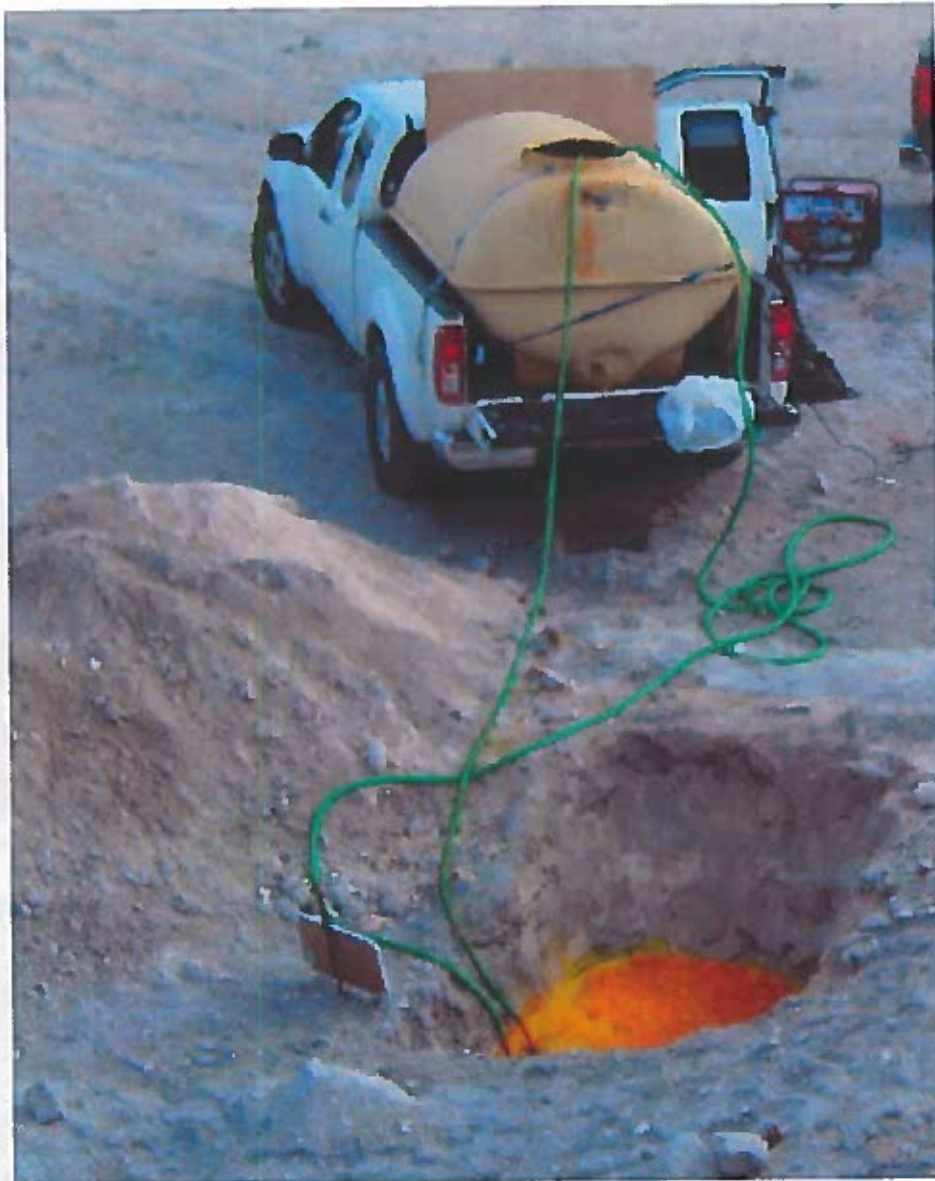


Photo 2-4. Fluorescein Dye injection at the OD Unit, Andersen AFB, Guam.



Photo 2-5. Tinopal CBS-X Dye injection at the OB Unit, Andersen AFB, Guam.



Photo 2-6. Dye receptors in situ at SP-1, Andersen AFB, Guam.

3. DYE TRACE STUDY RESULTS

This section outlines the results of the DTS conducted at the OB/OD Range. Results for the background samples and seep samples are presented, as well as recommendations for proposed sampling points.

3.1 Background Sample Results

As presented in Table 3-1, background sample results indicate that Fluorescein was not detected in the hour 2:00 or 6:00 background samples (collected on 10 June 2006), but was detected at concentrations of 0.006 and 0.007 ppb in the hour 12:00 background samples (Table 3-1).

Optical brighteners similar to Tinopal CBS-X were detected at low concentrations in all background samples (Table 3-1). Tinopal CBS-X was detected in the background samples at concentrations ranging from 0.6 to 0.3 ppb (Table 3-1).

The background sample results for Fluorescein and Tinopal CBS-X were used by the Crawford Hydrology Laboratory to establish the values that constituted a positive detection of the dyes.

3.2 Upgradient Well Sample Results

Fluorescein and Tinopal CBS-X were detected at background concentrations in charcoal receptors collected from wells IRP-52B and TB-1 (Table 3-1). Fluorescein was detected at a concentration of 0.005 ppb in samples collected from IRP-52B and at a concentration of 0.023 ppb in the sample collected from well TB-1 (Table 3-1).

3.3 Seep Sample Results

Fluorescein dye was first detected in seep samples collected from SP-1 and SP-2 at concentrations above background (3.4 and 0.25 ppb, respectively) on 16 June 2006 at 11:55 (Table 3-1). This is considered the "break-through" time for Fluorescein and coincided with visual observation of Fluorescein dye between seep sample locations SP-1 and SP-2 (Figure 3-1). The Fluorescein dye was observed seeping from a fracture in the reef rock (Photos 3-1 and 3-2).

As presented in Figure 3-2, the concentration of Fluorescein detected at SP-1 was plotted over time and compared to fluctuating tides. The date and time (in hours) are shown along the x-axis, the Fluorescein concentrations are shown along the left y-axis, and the tidal elevations are shown along the right y-axis. The highest concentration of Fluorescein dye detected was 91 ppb on 17 June 2006 at 0:00. The concentration of Fluorescein at SP-1 started to decrease over time, but was still detectable at a concentration of 16.8 ppb after the second week of monitoring (Figure 3-2). All duplicate sample results were averaged and only the average values were used in Figure 3-2. The complete data set is presented in Table 3-1.

Although Fluorescein concentrations in samples collected from SP-1 from 16 through 30 June 2006 were denoted +++ (extremely positive) by the Crawford Hydrology Laboratory, there appears to be a correlation between the tidal cycle and the concentration of Fluorescein.

The Fluorescein concentrations are higher in samples collected after the highest high tide as the tide is transitioning to the lowest low tide of the cycle (Figure 3-2).

Similarly, the Fluorescein concentrations detected at SP-2 were plotted against their corresponding tidal elevations and are presented in Figure 3-3. Note that this figure uses a different vertical scale for Fluorescein concentrations than Figure 3-2. The highest Fluorescein concentration detected at SP-2 was 13 ppb, on 17 June 2006 at 00:05. This time corresponds with the same sample in which the highest Fluorescein concentration was detected at SP-1 (Table 3-1). The same correlation observed at SP-1, between the tidal cycle and the Fluorescein concentrations, is also present at SP-2. The concentration of Fluorescein is higher in samples collected after the highest high tide, as the tide is transitioning to the lowest low tide of the cycle (Figure 3-3). The concentrations of Fluorescein detected at SP-2 also decreased over time, but still were detectable at a concentration 0.5 ppb after the second week of monitoring (Figure 3-3).

As presented in Figures 3-4 through 3-8, though at a different scale than Figures 3-2 and 3-3, the concentrations of Fluorescein detected at SP-3, SP-4, SP-5, SP-6, and SP-7 decreased the further the seep sample location was from the dye injection point at the OD Unit. This is best depicted in Figure 3-9, where the concentrations of Fluorescein detected for all seep sample locations are presented. On a per-round basis, the concentrations of Fluorescein are the highest in samples from SP-1, the sample location closest to the OD Unit (Figure 3-9).

Furthermore, the farther the seep sample was located from the dye injection point, the smaller the correlation is between the tidal cycle and Fluorescein concentrations (Figures 3-4 through Figure 3-8).

As presented in Table 3-1, Tinopal CBS-X was not detected at concentrations exceeding background values in any of the dye receptor samples collected during this study. The precise explanation for the non-detection of Tinopal CBS-X can not be ascertained at this time, but is likely related to one or more factors: the higher elevation of the OB Unit, limited migration from the OB unit to the groundwater seeps, or the lack of a direct pathway connecting the OB Unit and the groundwater seeps found directly seaward.

3.4 Recommendations for Groundwater Monitoring Point

Hydraulic connectivity between the OB and OD Units and the downgradient seeps was evaluated based on the results of the charcoal receptor analysis. SP-1 and SP-4 are recommended as the representative groundwater monitoring point's downgradient from the OB/OD Range (Figure 3-10).

It is recommended that the groundwater monitoring samples be collected 30 to 60 minutes prior to the lowest low tide of the tidal cycle. This recommendation is based on the increased concentrations of Fluorescein detected in samples that were collected as the tide dropped after the highest high tide and data that seem to support that some seeps effectively "turn off" during extreme low tides (Figure 3-4). As the tide subsides to its low ebb it appears that groundwater effectively flushes out to the Pacific Ocean, effectively bypassing the sampling points.

Appendix E presents the groundwater sampling and analysis that was included in the final *Work Plan and Sampling and Analysis Plan for Dye Trace Study and Groundwater Monitoring at Open Burn and Open Detonation Range, Andersen AFB, Guam* (EA, 2006). In conformance with RCRA Permit GUS002, section IV.A.3, groundwater monitoring activities will commence following the Guam EPA approval of the downgradient groundwater monitoring point(s) shown in Figure 3-10.

3.4.1 OD Unit Recommendations

Seep sample location SP-1 is recommended as the groundwater monitoring point downgradient from the OD Unit (Figure 3-10). There is a clear indication of a groundwater pathway connecting the OD Unit and the groundwater seep at SP-1. This is the sample location where Fluorescein, the dye injected at the OD Unit, was consistently detected at the highest concentrations.

3.4.2 OB Unit Recommendations

A pathway of connectivity could not be established between the OB Unit and downgradient seeps. The OB Unit is most likely a hydrological isolated area without much migration of groundwater to the groundwater seeps located directly seaward. On the basis of field observations, SP-4 would be recommended as the groundwater monitoring point for the OB Unit as SP-4 is the groundwater seep sample located in the closest proximity to the OB Unit (Figure 3-10).

However, the OB unit has not been operational for years and the Air Force has no plans to bring the OB unit back into operation. The Air Force will propose the OB unit for closure and removal from the permit within Fiscal Year 07 and as such any required or necessary future groundwater monitoring requirements will need to be determined

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TABLE 3-1.
TINOPAL CBS-X AND FLUORESCHEIN DYE DETECTION RESULTS FROM THE OB/OD RANGE,
ANDERSEN AFB, GUAM.

Sample Information				Detected Dye Concentrations			
				Tinopal CBS-X		Fluorescein	
Date Collected	Sample Time	Seep Location	Sample Identification	ppb	Qualifiers	ppb	Qualifiers
6/10/06	1436		2 Hour Background	0.5	IB	ND	ND
6/10/06	1436		2 Hour Background Dup.	0.6	IB	ND	ND
6/10/06	1845		6 Hour Background	0.3	IB	ND	ND
6/10/06	1845		6 Hour Background Dup.	0.3	IB	ND	ND
6/11/06	0003		12 Hour Background	0.3	IB	0.006	IB
6/11/06	0003		12 Hour Background	0.3	IB	0.007	IB
6/16/06	0800	SP1	AAFBSP1 001	0.5	B	0.01	B
6/16/06	0953	SP1	AAFBSP1 008	0.5	B	0.006	B
6/16/06	1155	SP1	AAFBSP1 015	0.7	B	3.4	++
6/16/06	1400	SP1	AAFBSP1 022	0.1	B	11	+++
6/16/06	1600	SP1	AAFBSP1 029	0.6	B	0.1	+
6/16/06	1800	SP1	AAFBSP1 036	0.7	B	0.05	+
6/16/06	1955	SP1	AAFBSP1 043	0.7	B	0.009	B
6/16/06	2157	SP1	AAFBSP1 050	0.5	B	29	+++
6/16/06	2157	SP1	AAFBSP1 050-Dup.	0.2	B	20	+++
6/17/06	0000	SP1	AAFBSP1 057	0.7	B	91	+++
6/17/06	0202	SP1	AAFBSP1 064	0.6	B	58	+++
6/17/06	0409	SP1	AAFBSP1 071	0.7	B	71	+++
6/17/06	0606	SP1	AAFBSP1 078	0.1	B	47	+++
6/17/06	1158	SP1	AAFBSP1 085	0.7	B	85	+++
6/17/06	1815	SP1	AAFBSP1 092	0.8	B	26	+++
6/17/06	2354	SP1	AAFBSP1 099	0.9	B	37	+++
6/18/06	0600	SP1	AAFBSP1 106	0.1	B	62	+++
6/18/06	1155	SP1	AAFBSP1 113	0.5	B	34	+++
6/18/06	1801	SP1	AAFBSP1 120	0.6	B	17	+++
6/18/06	1801	SP1	AAFBSP1 120-Dup.	0.6	B	16	+++
6/19/06	2356	SP1	AAFBSP1 127	0.6	B	13	+++
6/19/06	0601	SP1	AAFBSP1 134	0.7	B	66	+++
6/19/06	1200	SP1	AAFBSP1 141	0.7	B	16	+++
6/19/06	1800	SP1	AAFBSP1 148	0.4	B	15	+++
6/19/06	2358	SP1	AAFBSP1 155	0.7	B	13	+++
6/20/06	0648	SP1	AAFBSP1 162	0.5	B	54	+++
6/20/06	1814	SP1	AAFBSP1 169	ND	ND	18	+++
6/21/06	0559	SP1	AAFBSP1 176	ND	ND	50	+++
6/21/06	1808	SP1	AAFBSP1 183	0.2	B	19	+++
6/22/06	0600	SP1	AAFBSP1 190	0.4	B	76	+++
6/22/06	0600	SP1	AAFBSP1 190-Dup.	0.3	B	70	+++
6/22/06	1803	SP1	AAFBSP1 197	0.3	B	19	+++
6/23/06	0600	SP1	AAFBSP1 204	0.1	B	73	+++
6/23/06	1840	SP1	AAFBSP1 211	0.3	B	16	+++
6/24/06	0608	SP1	AAFBSP1 218	0.4	B	64	+++
6/24/06	0632	SP1	AAFBSP1 225	0.7	B	16	+++
6/24/06	1820	SP1	AAFBSP2 232	0.3	B	40	+++
6/25/06	0629	SP1	AAFBSP2 239	0.6	B	17	+++
6/25/06	1828	SP1	AAFBSP3 246	0.5	B	61	+++
6/26/06	0617	SP1	AAFBSP3 253	0.8	B	18	+++
6/27/06	0555	SP1	AAFBSP3 260	0.3	B	48	+++
6/27/06	0555	SP1	AAFBSP3 260-Dup.	0.3	B	57	+++
6/27/06	1741	SP1	AAFBSP3 267	0.5	B	16	+++
6/28/06	0602	SP1	AAFBSP3 274	0.1	B	43	+++
6/28/06	1635	SP1	AAFBSP3 281	0.5	B	18	+++
6/29/06	0558	SP1	AAFBSP3 288	ND	ND	36	+++
6/29/06	1748	SP1	AAFBSP3 295	0.5	B	18	+++
6/30/06	0608	SP1	AAFBSP5 302	0.3	B	26	+++
6/30/06	1742	SP1	AAFBSP5 309	0.2	B	17	+++

TABLE 3-1.
TINOPAL CBS-X AND FLUORESC EIN DYE DETECTION RESULTS FROM THE OB/OD RANGE,
ANDERSEN AFB, GUAM.

Sample Information				Detected Dye Concentrations			
Date Collected	Sample Time	Seep Location	Sample Identification	Tinopal CBS-X		Fluorescein	
				ppb	Qualifiers	ppb	Qualifiers
6/16/06	0810	SP2	AAFBSP2 002	0.7	B	ND	ND
6/16/06	1000	SP2	AAFBSP2 009	0.5	B	ND	ND
6/16/06	1204	SP2	AAFBSP2 016	0.6	B	0.2	+
6/16/06	1403	SP2	AAFBSP2 023	0.8	B	0.2	+
6/16/06	1603	SP2	AAFBSP2 030	0.6	B	0.007	B
6/16/06	1603	SP2	AAFBSP2 030 - Dup.	0.5	B	0.007	B
6/16/06	1806	SP2	AAFBSP2 037	0.5	B	0.005	B
6/16/06	2000	SP2	AAFBSP2 044	0.6	B	0.007	B
6/16/06	2202	SP2	AAFBSP2 051	0.3	B	5.1	+++
6/17/06	0005	SP2	AAFBSP2 058	0.4	B	13	+++
6/17/06	0206	SP2	AAFBSP2 065	0.6	B	6.4	+++
6/17/06	0413	SP2	AAFBSP2 072	0.4	B	3.5	++
6/17/06	0610	SP2	AAFBSP2 079	ND	ND	1.8	++
6/17/06	1202	SP2	AAFBSP2 086	0.7	B	4.2	++
6/17/06	1819	SP2	AAFBSP2 093	0.4	B	0.6	++
6/17/06	0001	SP2	AAFBSP2 100	0.5	B	8.1	+++
6/17/06	0001	SP2	AAFBSP2 100-Dup.	ND	ND	5.5	+++
6/18/06	0603	SP2	AAFBSP2 107	ND	ND	9.6	+++
6/18/06	1200	SP2	AAFBSP2 114	0.3	B	2.1	++
6/18/06	1805	SP2	AAFBSP2 121	0.5	B	2.8	++
6/19/06	2359	SP2	AAFBSP2 128	0.7	B	1.6	++
6/19/06	0610	SP2	AAFBSP2 135	0.6	B	3.4	++
6/19/06	1203	SP2	AAFBSP2 142	0.5	B	0.2	+
6/19/06	1806	SP2	AAFBSP2 149	0.7	B	0.3	+
6/20/06	0001	SP2	AAFBSP2 156	0.3	B	1.7	++
6/20/06	0651	SP2	AAFBSP2 163	0.4	B	7.0	+++
6/20/06	1817	SP2	AAFBSP2 170	0.2	B	0.6	++
6/20/06	1817	SP2	AAFBSP2 170-Dup.	0.2	B	0.5	++
6/21/06	0606	SP2	AAFBSP2 177	ND	ND	6.3	++
6/21/06	1813	SP2	AAFBSP2 184	0.2	B	1.0	++
6/22/06	0607	SP2	AAFBSP2 191	0.6	B	5.8	++
6/22/06	1805	SP2	AAFBSP2 198	0.5	B	1.5	++
6/23/06	0603	SP2	AAFBSP2 205	0.2	B	6.9	+++
6/23/06	1843	SP2	AAFBSP2 212	0.3	B	2.0	++
6/24/06	0613	SP2	AAFBSP2 219	0.2	B	3.2	++
6/24/06	1759	SP2	AAFBSP2 226	0.1	B	1.1	++
6/25/06	0609	SP2	AAFBSP3 233	0.5	B	4.5	++
6/25/06	1805	SP2	AAFBSP3 240	0.5	B	0.7	+
6/25/06	1808	SP2	AAFBSP4 240-Dup.	0.3	B	0.8	++
6/26/06	0557	SP2	AAFBSP4 247	0.3	B	5.8	++
6/26/06	1800	SP2	AAFBSP4 254	0.2	B	0.8	++
6/27/06	0558	SP2	AAFBSP4 261	0.3	B	2.6	++
6/27/06	1744	SP2	AAFBSP4 268	0.3	B	2.0	++
6/28/06	0605	SP2	AAFBSP3 275	0.2	B	3.5	++
6/28/06	1642	SP2	AAFBSP3 282	0.2	B	0.7	++
6/29/06	0602	SP2	AAFBSP3 289	0.3	B	1.8	++
6/29/06	1751	SP2	AAFBSP3 296	0.1	B	0.9	++
6/30/06	0612	SP2	AAFBSP5 303	0.2	B	3.5	++
6/30/06	1745	SP2	AAFBSP5 310	ND	ND	0.6	+
6/30/06	1745	SP2	AAFBSP5 310-Dup.	0.2	B	0.5	+

TABLE 3-1.
TINOPAL CBS-X AND FLUORESCIEIN DYE DETECTION RESULTS FROM THE OB/OD RANGE,
ANDERSEN AFB, GUAM.

Sample Information				Detected Dye Concentrations			
Date Collected	Sample Time	Seep Location	Sample Identification	Tinopal CBS-X		Fluorescein	
				ppb	Qualifiers	ppb	Qualifiers
6/16/06	0815	SP3	AAFBSP3 003	0.7	B	ND	ND
6/16/06	1005	SP3	AAFBSP3 010	0.3	B	ND	ND
6/16/06	1005	SP3	AAFBSP3 010 Dup.	0.3	B	ND	ND
6/16/06	1206	SP3	AAFBSP3 017	0.5	B	ND	ND
6/16/06	1408	SP3	AAFBSP3 024	0.6	B	0.007	B
6/16/06	1605	SP3	AAFBSP3 031	0.8	B	0.005	B
6/16/06	1810	SP3	AAFBSP3 038	0.8	B	ND	ND
6/16/06	2002	SP3	AAFBSP3 045	0.7	B	0.008	B
6/16/06	2210	SP3	AAFBSP3 052	0.5	B	0.8	++
6/17/06	0007	SP3	AAFBSP3 059	0.8	B	5.0	+++
6/17/06	0210	SP3	AAFBSP3 066	0.3	B	3.0	++
6/17/06	0416	SP3	AAFBSP3 073	0.0	B	1.3	++
6/17/06	0613	SP3	AAFBSP3 080	ND	ND	0.6	++
6/17/06	0613	SP3	AAFBSP3 080-Dup.	ND	ND	0.8	++
6/17/06	1205	SP3	AAFBSP3 087	0.7	B	0.6	++
6/17/06	1820	SP3	AAFBSP3 094	0.7	B	0.04	B
6/18/06	0003	SP3	AAFBSP3 101	0.7	B	2.8	++
6/18/06	0605	SP3	AAFBSP3 108	0.5	B	0.6	++
6/18/06	1203	SP3	AAFBSP3 115	0.6	B	0.3	+
6/18/06	1807	SP3	AAFBSP3 122	0.4	B	0.03	B
6/19/06	0002	SP3	AAFBSP3 129	0.9	B	0.4	+
6/19/06	0613	SP3	AAFBSP3 136	0.7	B	1.5	++
6/19/06	1206	SP3	AAFBSP3 143	0.7	B	0.02	B
6/19/06	1809	SP3	AAFBSP3 150	0.5	B	0.02	B
6/19/06	1809	SP3	AAFBSP3 150-Dup.	0.8	B	0.02	B
6/20/06	0005	SP3	AAFBSP3 157	0.5	B	0.68	++
6/20/06	0653	SP3	AAFBSP3 164	0.4	B	2.2	++
6/20/06	1820	SP3	AAFBSP3 171	0.3	B	0.03	B
6/21/06	0609	SP3	AAFBSP3 178	0.3	B	2.4	+
6/21/06	1816	SP3	AAFBSP3 185	0.3	B	0.2	+
6/22/06	0607	SP3	AAFBSP3 192	0.5	B	0.9	++
6/22/06	1808	SP3	AAFBSP3 199	0.5	B	0.2	+
6/23/06	0606	SP3	AAFBSP3 206	0.0	B	0.9	++
6/23/06	1845	SP3	AAFBSP3 213	0.3	B	0.2	+
6/24/06	0613	SP3	AAFBSP3 220	0.4	B	1.2	++
6/24/06	0616	SP3	AAFBSP3 220-Dup.	0.3	B	1.2	++
6/24/06	1803	SP3	AAFBSP3 227	0.4	B	0.2	+
6/25/06	0612	SP3	AAFBSP4 234	0.6	B	0.9	++
6/25/06	1808	SP3	AAFBSP5 241	0.5	B	0.07	B
6/26/06	0601	SP3	AAFBSP5 248	0.5	B	1.1	++
6/26/06	1803	SP3	AAFBSP5 255	0.4	B	0.2	+
6/27/06	0600	SP3	AAFBSP5 262	0.7	B	0.6	+
6/27/06	1747	SP3	AAFBSP5 269	0.4	B	0.4	+
6/28/06	0608	SP3	AAFBSP3 276	0.4	B	0.7	+
6/28/06	1647	SP3	AAFBSP3 283	0.3	B	0.1	+
6/29/06	0604	SP3	AAFBSP3 290	0.3	B	0.4	+
6/29/06	0604	SP3	AAFBSP3 290-Dup.	0.5	B	0.5	+
6/29/06	1754	SP3	AAFBSP3 297	0.7	B	0.2	+
6/29/06	1754	SP3	AAFBSP3 297-Q	0.6	B	0.2	+
6/30/06	0614	SP3	AAFBSP5 304	0.3	B	1.5	++
6/30/06	1748	SP3	AAFBSP5 311	0.4	B	0.1	+

TABLE 3-1.
TINOPAL CBS-X AND FLUORESC EIN DYE DETECTION RESULTS FROM THE OB/OD RANGE,
ANDERSEN AFB, GUAM.

Sample Information				Detected Dye Concentrations			
Date Collected	Sample Time	Seep Location	Sample Identification	Tinopal CBS-X		Fluorescein	
				ppb	Qualifiers	ppb	Qualifiers
6/16/06	0820	SP4	AAFBSP4 004	0.4	B	ND	ND
6/16/06	1010	SP4	AAFBSP4 011	0.5	B	ND	ND
6/16/06	1210	SP4	AAFBSP4 018	0.5	B	ND	ND
6/16/06	1410	SP4	AAFBSP4 025	0.4	B	ND	ND
6/16/06	1608	SP4	AAFBSP4 032	0.7	B	ND	ND
6/16/06	1812	SP4	AAFBSP4 039	0.3	B	ND	ND
6/16/06	2004	SP4	AAFBSP4 046	0.1	B	ND	ND
6/16/06	2213	SP4	AAFBSP4 053	0.5	B	0.01	B
6/17/06	0010	SP4	AAFBSP4 060	0.4	B	0.6	++
6/17/06	0010	SP4	AAFBSP4 060-Dup.	0.6	B	0.8	++
6/17/06	0213	SP4	AAFBSP4 067	0.5	B	2.1	++
6/17/06	0213	SP4	AAFBSP4 067-Q	0.5	B	2.0	++
6/17/06	0420	SP4	AAFBSP4 074	0.0	B	1.3	++
6/17/06	0616	SP4	AAFBSP4 081	ND	ND	0.9	++
6/17/06	1208	SP4	AAFBSP4 088	0.5	B	0.7	++
6/17/06	1823	SP4	AAFBSP4 095	0.7	B	0.03	B
6/18/06	0006	SP4	AAFBSP4 102	0.6	B	0.2	+
6/18/06	0608	SP4	AAFBSP4 109	0.7	B	1.9	++
6/18/06	1208	SP4	AAFBSP4 116	0.2	B	0.3	+
6/18/06	1809	SP4	AAFBSP4 123	0.8	B	ND	ND
6/19/06	0005	SP4	AAFBSP4 130	0.9	B	0.02	B
6/19/06	0005	SP4	AAFBSP4 130-Dup.	0.4	B	0.01	B
6/19/06	0619	SP4	AAFBSP4 137	0.7	B	0.7	++
6/19/06	1208	SP4	AAFBSP4 144	0.5	B	0.07	+
6/19/06	1812	SP4	AAFBSP4 151	0.3	B	ND	ND
6/20/06	0007	SP4	AAFBSP4 158	0.3	B	0.02	B
6/20/06	0656	SP4	AAFBSP4 165	0.4	B	1.0	++
6/20/06	1823	SP4	AAFBSP4 172	0.2	B	0.04	B
6/21/06	0612	SP4	AAFBSP4 179	0.3	B	0.6	+
6/21/06	1818	SP4	AAFBSP4 186	ND	ND	0.1	+
6/22/06	0610	SP4	AAFBSP4 193	0.3	B	0.3	+
6/22/06	1812	SP4	AAFBSP4 200	0.4	B	0.06	B
6/23/06	0609	SP4	AAFBSP4 207	0.1	B	0.6	+
6/23/06	1848	SP4	AAFBSP4 214	ND	ND	0.08	+
6/24/06	0616	SP4	AAFBSP4 221	0.2	B	0.3	+
6/24/06	1805	SP4	AAFBSP4 228	0.7	B	0.2	+
6/25/06	0614	SP4	AAFBSP5 235	0.4	B	0.3	+
6/25/06	1812	SP4	AAFBSP6 242	0.4	B	ND	ND
6/26/06	0603	SP4	AAFBSP6 249	0.5	B	0.7	+
6/26/06	1806	SP4	AAFBSP6 256	0.4	B	0.2	+
6/27/06	0603	SP4	AAFBSP6 263	ND	ND	0.2	+
6/27/06	1749	SP4	AAFBSP6 270	0.3	B	0.1	+
6/27/06	1749	SP4	AAFBSP6 270-Dup.	0.5	B	0.1	+
6/28/06	0611	SP4	AAFBSP3 277	0.3	B	0.2	+
6/28/06	1655	SP4	AAFBSP3 284	0.6	B	0.06	B
6/29/06	0608	SP4	AAFBSP3 291	0.5	B	0.1	+
6/29/06	1756	SP4	AAFBSP5 298	0.3	B	0.03	B
6/30/06	0617	SP4	AAFBSP5 305	0.3	B	0.02	B
6/30/06	1752	SP4	AAFBSP5 312	0.3	B	0.03	B

TABLE 3-1.
TINOPAL CBS-X AND FLUORESC EIN DYE DETECTION RESULTS FROM THE OB/OD RANGE,
ANDERSEN AFB, GUAM.

Sample Information				Detected Dye Concentrations			
Date Collected	Sample Time	Seep Location	Sample Identification	Tinopal CBS-X		Fluorescein	
				ppb	Qualifiers	ppb	Qualifiers
6/16/06	0825	SP5	AAFBSP5 005	0.6	B	ND	ND
6/16/06	1013	SP5	AAFBSP5 012	0.3	B	ND	ND
6/16/06	1214	SP5	AAFBSP5 019	0.4	B	ND	ND
6/16/06	1415	SP5	AAFBSP5 026	0.5	B	ND	ND
6/16/06	1613	SP5	AAFBSP5 033	0.4	B	ND	ND
6/16/06	1816	SP5	AAFBSP5 040	0.7	B	ND	ND
6/16/06	1816	SP5	AAFBSP5 040-Dup.	0.8	B	ND	ND
6/16/06	2008	SP5	AAFBSP5 047	0.2	B	0.02	B
6/16/06	2218	SP5	AAFBSP5 054	0.4	B	0.03	B
6/17/06	0013	SP5	AAFBSP5 061	0.4	B	0.1	+
6/17/06	0217	SP5	AAFBSP5 068	0.4	B	0.7	++
6/17/06	0428	SP5	AAFBSP5 075	0.4	B	0.5	++
6/17/06	0620	SP5	AAFBSP5 082	ND	ND	0.3	+
6/17/06	1215	SP5	AAFBSP5 089	0.4	B	0.4	+
6/17/06	1826	SP5	AAFBSP5 096	0.2	B	0.007	B
6/18/06	0011	SP5	AAFBSP5 103	0.7	B	0.08	+
6/18/06	0612	SP5	AAFBSP5 110	0.4	B	0.7	++
6/18/06	0612	SP5	AAFBSP5 110-Dup.	0.7	B	0.5	++
6/18/06	1212	SP5	AAFBSP5 117	ND	ND	0.1	+
6/18/06	1813	SP5	AAFBSP5 124	0.7	B	ND	ND
6/19/06	0009	SP5	AAFBSP5 131	0.6	B	0.02	B
6/19/06	0623	SP5	AAFBSP5 138	0.5	B	0.1	+
6/19/06	1212	SP5	AAFBSP5 145	0.6	B	0.03	B
6/19/06	1817	SP5	AAFBSP5 152	0.6	B	ND	ND
6/20/06	0013	SP5	AAFBSP5 159	0.3	B	0.01	B
6/20/06	0700	SP5	AAFBSP5 166	0.4	B	0.1	+
6/20/06	1826	SP5	AAFBSP5 173	0.2	B	0.03	B
6/21/06	0616	SP5	AAFBSP5 180	0.6	B	0.2	+
6/21/06	0616	SP5	AAFBSP5 180-Dup.	0.6	B	0.10	+
6/21/06	1822	SP5	AAFBSP5 187	0.3	B	0.1	+
6/22/06	0612	SP5	AAFBSP5 194	0.5	B	0.04	B
6/22/06	1812	SP5	AAFBSP4 200-Dup.	0.3	B	0.07	+
6/22/06	1815	SP5	AAFBSP5 201	0.3	B	0.02	B
6/23/06	0610	SP5	AAFBSP5 208	ND	ND	0.10	+
6/23/06	1852	SP5	AAFBSP5 215	0.3	B	0.04	B
6/24/06	0619	SP5	AAFBSP5 222	0.5	B	0.1	+
6/24/06	1808	SP5	AAFBSP5 229	0.3	B	0.06	B
6/25/06	0617	SP5	AAFBSP6 236	0.3	B	0.04	B
6/25/06	1814	SP5	AAFBSP7 243	0.4	B	ND	ND
6/26/06	0606	SP5	AAFBSP7 250	0.5	B	0.06	B
6/26/06	0609	SP5	AAFBSP7 250-Dup.	0.5	B	0.07	+
6/26/06	1810	SP5	AAFBSP7 257	0.3	B	0.04	B
6/27/06	0607	SP5	AAFBSP7 264	0.2	B	0.02	B
6/27/06	1752	SP5	AAFBSP3 271	0.3	B	0.01	B
6/28/06	0615	SP5	AAFBSP3 278	0.3	B	0.08	+
6/28/06	1703	SP5	AAFBSP3 285	ND	ND	ND	ND
6/29/06	0612	SP5	AAFBSP3 292	0.3	B	0.01	B
6/29/06	1759	SP5	AAFBSP5 299	0.4	B	ND	ND
6/30/06	0621	SP5	AAFBSP5 306	0.4	B	0.22	+
6/30/06	1755	SP5	AAFBSP5 313	0.3	B	ND	ND

TABLE 3-1.
TINOPAL CBS-X AND FLUORESC EIN DYE DETECTION RESULTS FROM THE OB/OD RANGE,
ANDERSEN AFB, GUAM.

Sample Information				Detected Dye Concentrations			
Date Collected	Sample Time	Seep Location	Sample Identification	Tinopal CBS-X		Fluorescein	
				ppb	Qualifiers	ppb	Qualifiers
6/16/06	0830	SP6	AAFBSP6 006	0.7	B	ND	ND
6/16/06	1015	SP6	AAFBSP6 013	0.4	B	ND	ND
6/16/06	1217	SP6	AAFBSP6 020	0.6	B	ND	ND
6/16/06	1217	SP6	AAFBSP6 020 - Dup.	0.6	B	ND	ND
6/16/06	1418	SP6	AAFBSP6 027	0.6	B	ND	ND
6/16/06	1618	SP6	AAFBSP6 034	0.6	B	ND	ND
6/16/06	1820	SP6	AAFBSP6 041	ND	ND	ND	ND
6/16/06	2010	SP6	AAFBSP6 048	0.6	B	ND	ND
6/16/06	2222	SP6	AAFBSP6 055	0.5	B	0.02	B
6/17/06	0017	SP6	AAFBSP6 062	0.5	B	0.03	B
6/17/06	0224	SP6	AAFBSP6 069	0.7	B	0.2	+
6/17/06	0433	SP6	AAFBSP6 076	ND	ND	0.2	+
6/17/06	0624	SP6	AAFBSP6 083	ND	ND	0.2	+
6/17/06	1218	SP6	AAFBSP6 090	0.3	B	0.2	+
6/17/06	1218	SP6	AAFBSP6 090-Dup.	ND	ND	0.3	+
6/17/06	1829	SP6	AAFBSP6 097	0.6	B	0.03	B
6/18/06	0014	SP6	AAFBSP6 104	0.5	B	0.07	+
6/18/06	0615	SP6	AAFBSP6 111	0.7	B	0.2	+
6/18/06	1217	SP6	AAFBSP6 118	0.4	B	0.1	+
6/18/06	1806	SP6	AAFBSP6 125	0.8	B	ND	ND
6/19/06	0012	SP6	AAFBSP6 132	0.6	B	0.01	B
6/19/06	0626	SP6	AAFBSP6 139	0.5	B	0.08	+
6/19/06	1215	SP6	AAFBSP6 146	0.6	B	0.02	B
6/19/06	1821	SP6	AAFBSP6 153	0.4	B	ND	ND
6/20/06	0017	SP6	AAFBSP6 160	0.5	B	0.02	B
6/20/06	0017	SP6	AAFBSP6 160-Dup.	0.6	B	0.02	B
6/20/06	0703	SP6	AAFBSP6 167	0.5	B	0.05	B
6/20/06	1829	SP6	AAFBSP6 174	0.1	B	0.007	B
6/21/06	0619	SP6	AAFBSP6 181	0.6	B	0.07	B
6/21/06	1826	SP6	AAFBSP6 188	ND	ND	0.03	B
6/22/06	0616	SP6	AAFBSP6 195	0.5	B	0.03	B
6/22/06	1818	SP6	AAFBSP6 202	0.2	B	ND	ND
6/23/06	0613	SP6	AAFBSP6 209	ND	ND	0.07	+
6/23/06	1854	SP6	AAFBSP6 216	0.3	B	0.03	B
6/24/06	0623	SP6	AAFBSP6 223	0.3	B	0.1	+
6/24/06	1811	SP6	AAFBSP6 230	0.4	B	0.02	B
6/24/06	1815	SP6	AAFBSP6 230-Dup.	0.4	B	0.02	B
6/25/06	0621	SP6	AAFBSP7 237	0.3	B	0.02	B
6/25/06	1817	SP6	AAFBSP1 244	0.3	B	0.03	B
6/26/06	0609	SP6	AAFBSP1 251	0.4	B	0.06	B
6/26/06	1813	SP6	AAFBSP1 258	0.6	B	0.02	B
6/27/06	0611	SP6	AAFBSP1 265	0.3	B	0.03	B
6/27/06	1755	SP6	AAFBSP3 272	0.4	B	ND	ND
6/28/06	0618	SP6	AAFBSP3 279	0.3	B	0.008	B
6/28/06	1710	SP6	AAFBSP3 286	0.6	B	0.006	B
6/29/06	0615	SP6	AAFBSP3 293	0.5	B	0.01	B
6/29/06	1802	SP6	AAFBSP5 300	0.5	B	ND	ND
6/29/06	1802	SP6	AAFBSP5 300-Dup.	0.2	B	ND	ND
6/30/06	0624	SP6	AAFBSP5 307	0.6	B	0.06	B
6/30/06	1759	SP6	AAFBSP5 314	0.3	B	ND	ND

TABLE 3-1.
TINOPAL CBS-X AND FLUORESCIEIN DYE DETECTION RESULTS FROM THE OB/OD RANGE,
ANDERSEN AFB, GUAM.

Sample Information				Detected Dye Concentrations			
Date Collected	Sample Time	Seep Location	Sample Identification	Tinopal CBS-X		Fluorescein	
				ppb	Qualifiers	ppb	Qualifiers
6/16/06	0840	SP7	AAFBSP7 007	0.6	B	ND	ND
6/16/06	1020	SP7	AAFBSP7 014	0.8	B	0.006	B
6/16/06	1221	SP7	AAFBSP7 021	0.4	B	ND	ND
6/16/06	1423	SP7	AAFBSP7 028	0.3	B	ND	ND
6/16/06	1622	SP7	AAFBSP7 035	0.7	B	ND	ND
6/16/06	1823	SP7	AAFBSP7 042	0.1	B	0.008	B
6/16/06	2016	SP7	AAFBSP7 049	0.7	B	0.006	B
6/16/06	2228	SP7	AAFBSP7 056	0.5	B	0.02	B
6/17/06	0023	SP7	AAFBSP7 063	0.5	B	0.04	B
6/17/06	0231	SP7	AAFBSP7 070	0.4	B	0.1	+
6/17/06	0231	SP7	AAFBSP7 070-Dup.	0.4	B	0.3	+
6/17/06	0438	SP7	AAFBSP7 077	ND	ND	0.2	+
6/17/06	0627	SP7	AAFBSP7 084	ND	ND	0.3	+
6/17/06	1224	SP7	AAFBSP7 091	ND	ND	0.3	+
6/17/06	1832	SP7	AAFBSP7 098	0.4	B	0.008	B
6/18/06	0019	SP7	AAFBSP7 105	0.5	B	0.04	B
6/18/06	0619	SP7	AAFBSP7 112	0.5	B	0.2	+
6/18/06	1221	SP7	AAFBSP7 119	0.5	B	0.07	+
6/18/06	1819	SP7	AAFBSP7 126	0.6	B	ND	ND
6/19/06	0016	SP7	AAFBSP7 133	0.6	B	0.01	B
6/19/06	0633	SP7	AAFBSP7 140	0.5	B	0.07	+
6/19/06	0633	SP7	AAFBSP7 140-Dup.	0.5	B	0.05	B
6/19/06	1218	SP7	AAFBSP7 147	0.8	B	0.01	B
6/19/06	1825	SP7	AAFBSP7 154	0.6	B	ND	ND
6/20/06	0022	SP7	AAFBSP7 161	0.4	B	ND	ND
6/20/06	0705	SP7	AAFBSP7 168	0.4	B	0.04	B
6/20/06	1833	SP7	AAFBSP7 175	0.5	B	ND	ND
6/21/06	0623	SP7	AAFBSP7 182	0.4	B	0.05	B
6/21/06	1830	SP7	AAFBSP7 189	0.1	B	0.07	B
6/22/06	0619	SP7	AAFBSP7 196	0.2	B	0.03	B
6/22/06	1825	SP7	AAFBSP7 203	ND	ND	0.006	B
6/23/06	0619	SP7	AAFBSP7 210	0.5	B	0.06	B
6/23/06	0619	SP7	AAFBSP7 210-Dup.	0.5	B	0.06	B
6/23/06	1858	SP7	AAFBSP7 217	0.2	B	0.02	B
6/24/06	0627	SP7	AAFBSP7 224	0.3	B	0.04	B
6/24/06	1815	SP7	AAFBSP7 231	0.3	B	0.03	B
6/25/06	0624	SP7	AAFBSP1 238	0.7	B	0.03	B
6/25/06	1821	SP7	AAFBSP2 245	0.3	B	ND	ND
6/26/06	0613	SP7	AAFBSP2 252	0.2	B	0.03	B
6/26/06	1833	SP7	AAFBSP2 259	0.3	B	0.02	B
6/27/06	0615	SP7	AAFBSP2 266	0.2	B	0.03	B
6/27/06	1758	SP7	AAFBSP3 273	0.6	B	ND	ND
6/28/06	0621	SP7	AAFBSP3 280	0.4	B	0.02	B
6/28/06	0621	SP7	AAFBSP3 280-Dup.	0.2	B	0.01	B
6/28/06	1718	SP7	AAFBSP3 287	0.5	B	0.01	B
6/29/06	0621	SP7	AAFBSP3 294	0.3	B	0.009	B
6/29/06	1805	SP7	AAFBSP5 301	0.2	B	0.005	B
6/30/06	0628	SP7	AAFBSP5 308	0.2	B	0.01	B
6/30/06	1803	SP7	AAFBSP5 315	0.3	B	0.005	B
6/30/06	1715	IRP-52B	AAFBIRP52B	0.8	B	0.005	B
6/30/06	1715	IRP-52BQ	AAFBIRP52B	0.6	B	0.005	B
7/1/06	0815	TB-1	AAFBTBI	1.4	B	0.02	B

Notes:
 ppb = parts per billion ++ = True Positive after two consecutive hits over ten times the initial background levels.
 Dup = Duplicate Sample ++ = Very Positive Detection Limits: Fluorescein = 0.005 ppb
 ND = Non-Detect +++ = Extremely Positive Tinopal CBS-X = 0.1 ppb
 IB = Initial Background Concentration B = Background Concentration

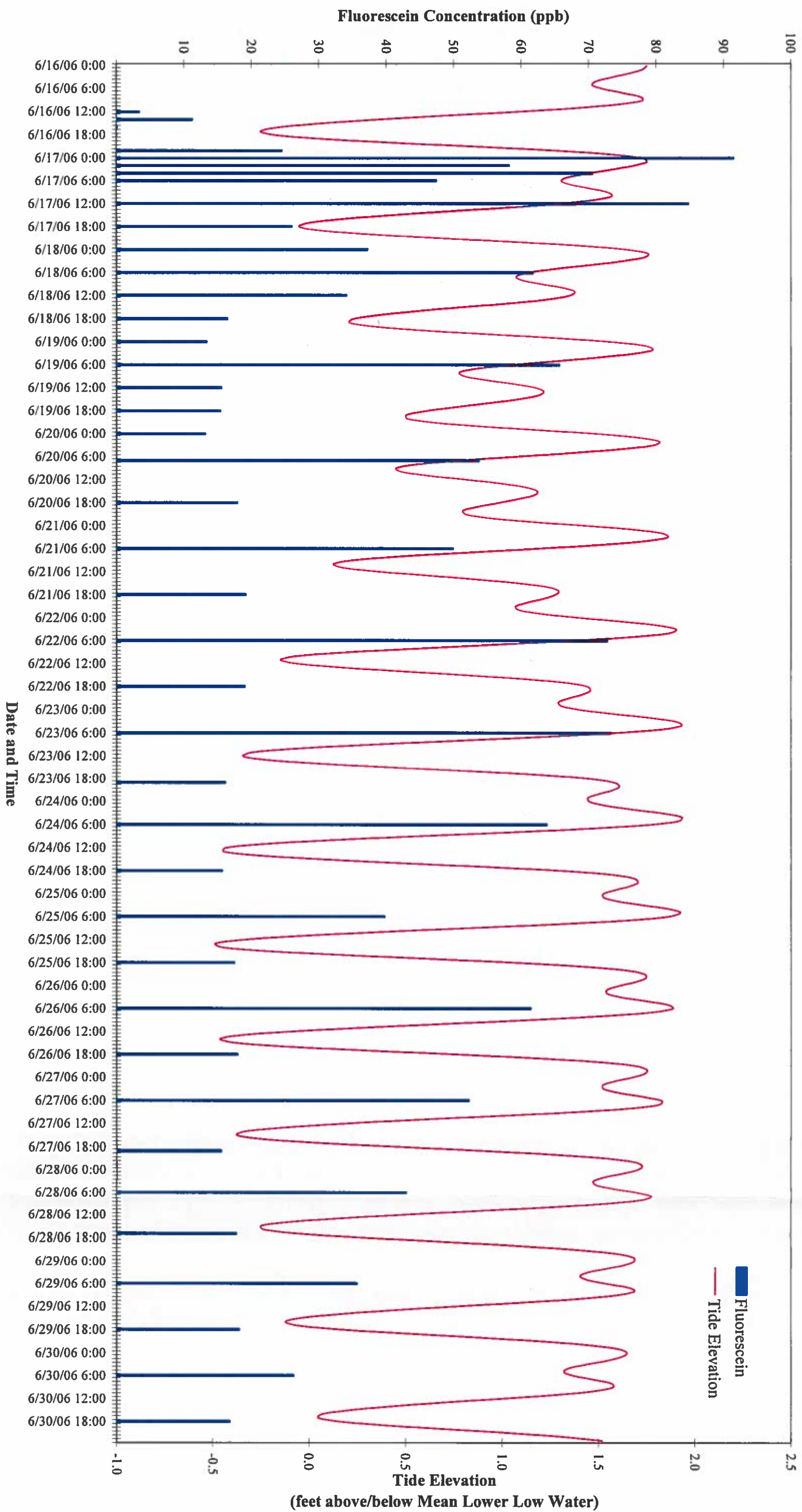


Figure 3-2. Fluorescein Concentrations from Seep Sample Location SP-1 and Tidal Elevations.

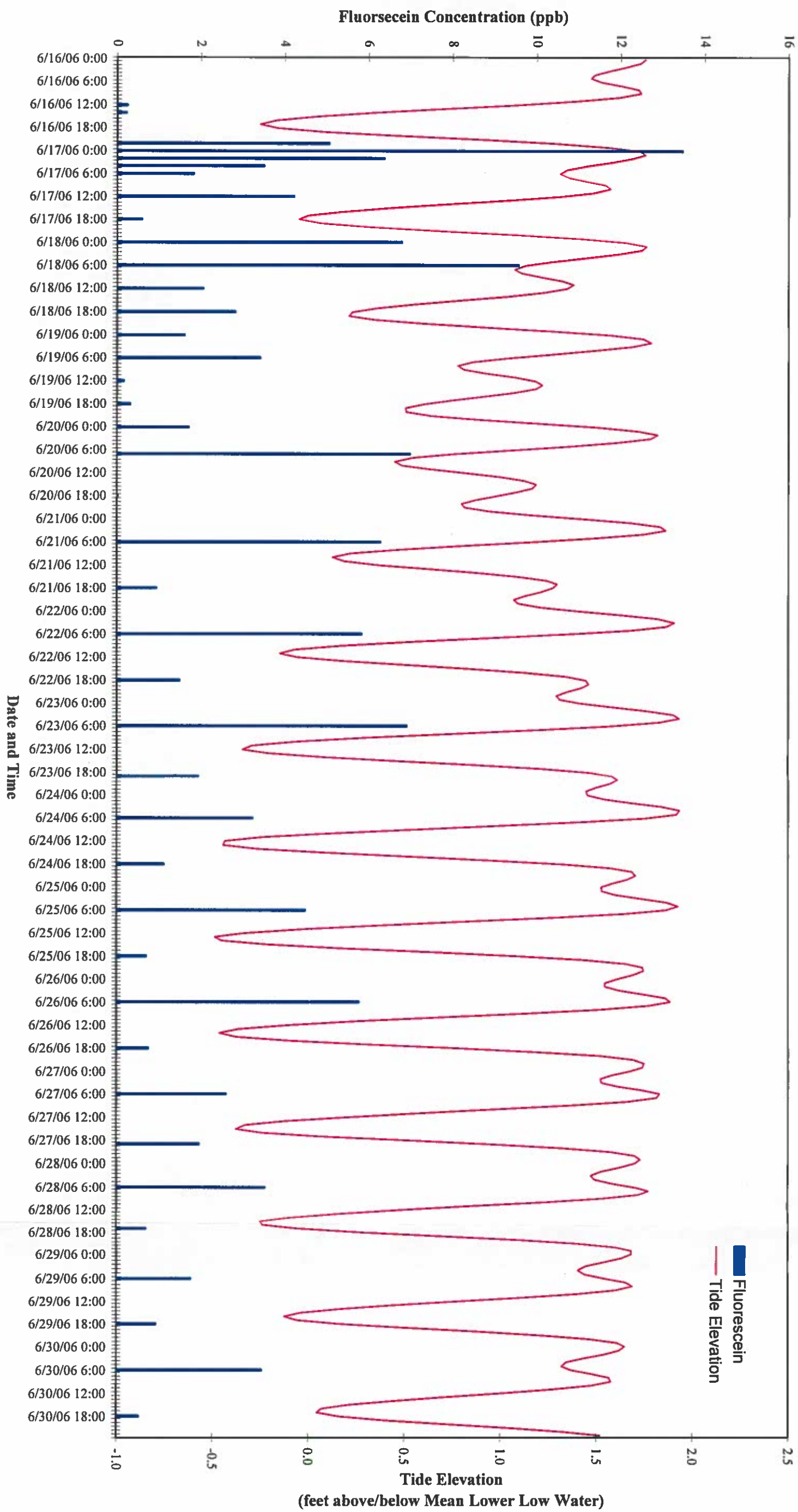


Figure 3-3. Fluorescein Concentrations from Seep Sample Location SP-2 and Tidal Elevations.

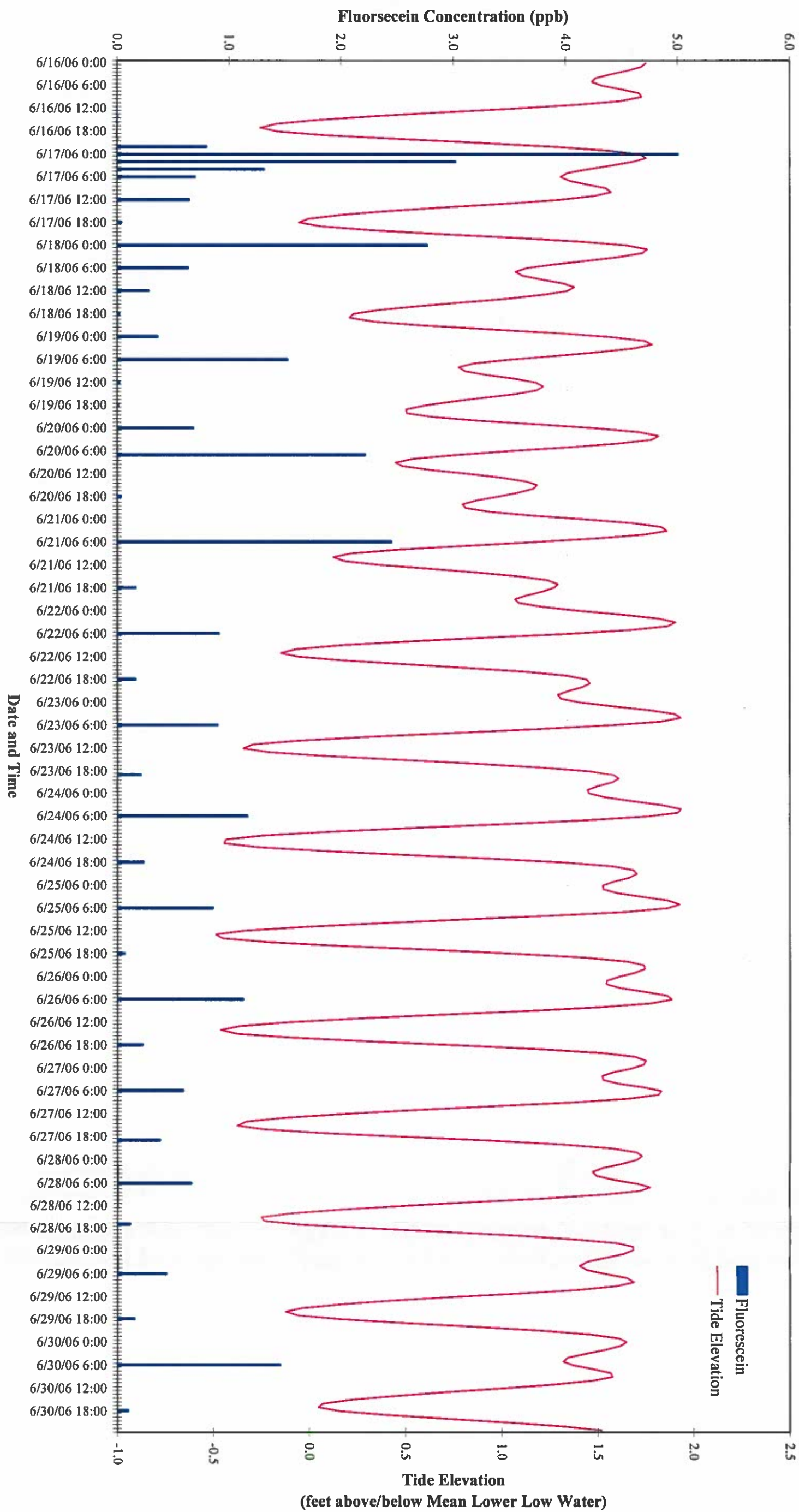
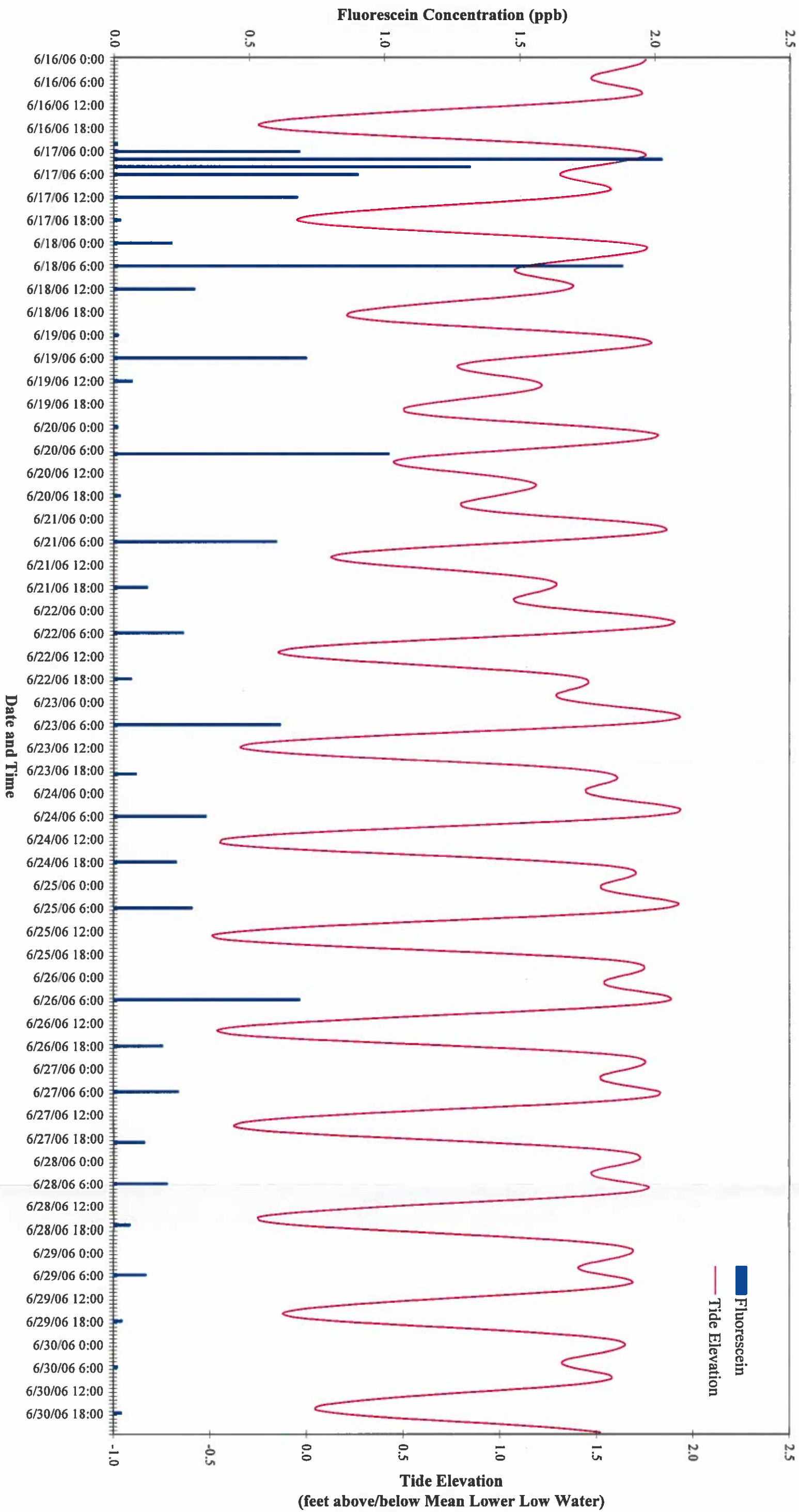


Figure 3-4. Fluorescein Concentrations from Seep Sample Location SP-3 and Tidal Elevations.

Figure 3-5. Fluorescein Concentrations from Seep Sample Location SP-4 and Tidal Elevations.



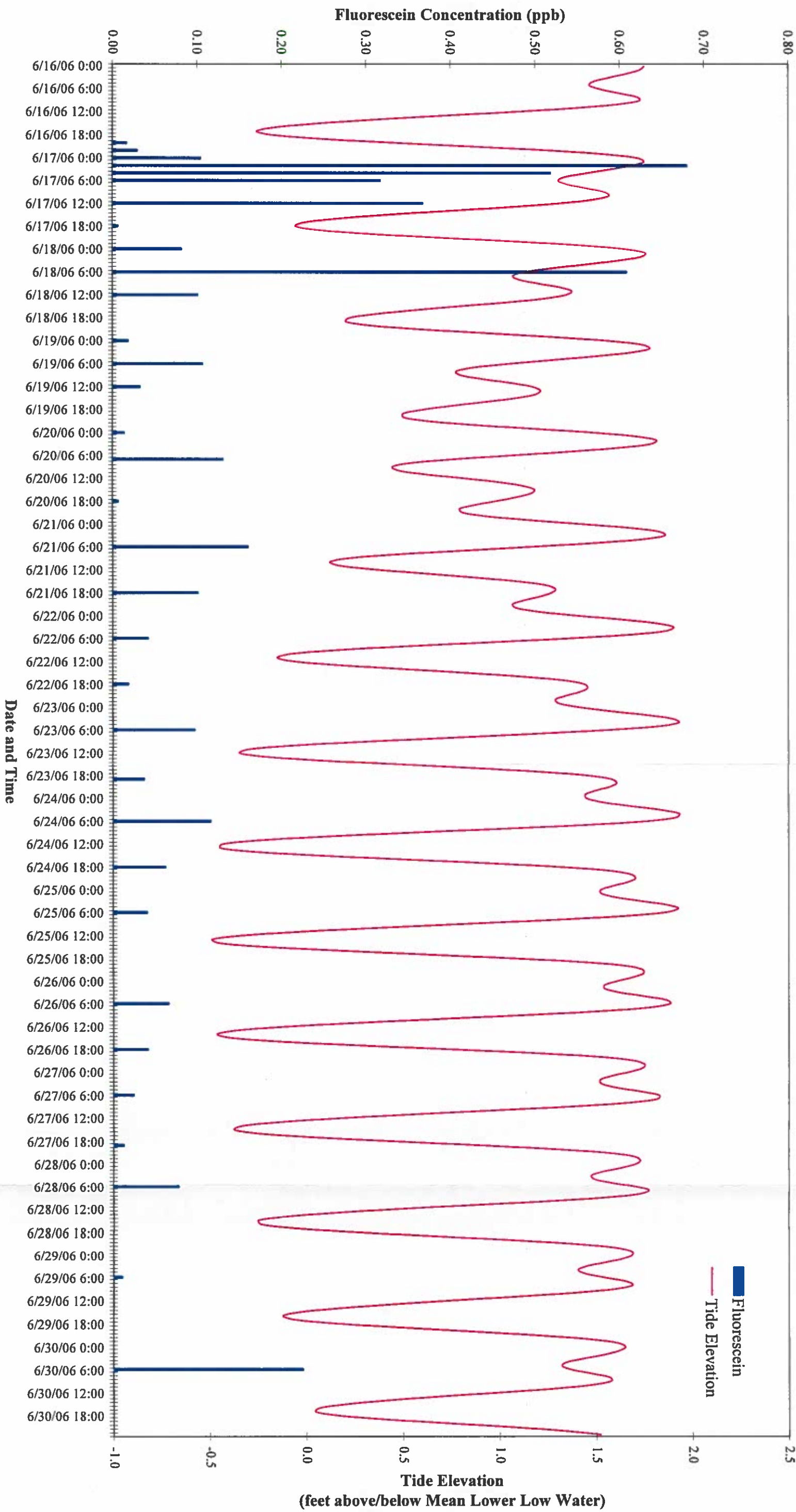


Figure 3-6. Fluorescein Concentrations from Seep Sample Location SP-5 and Tidal Elevations.

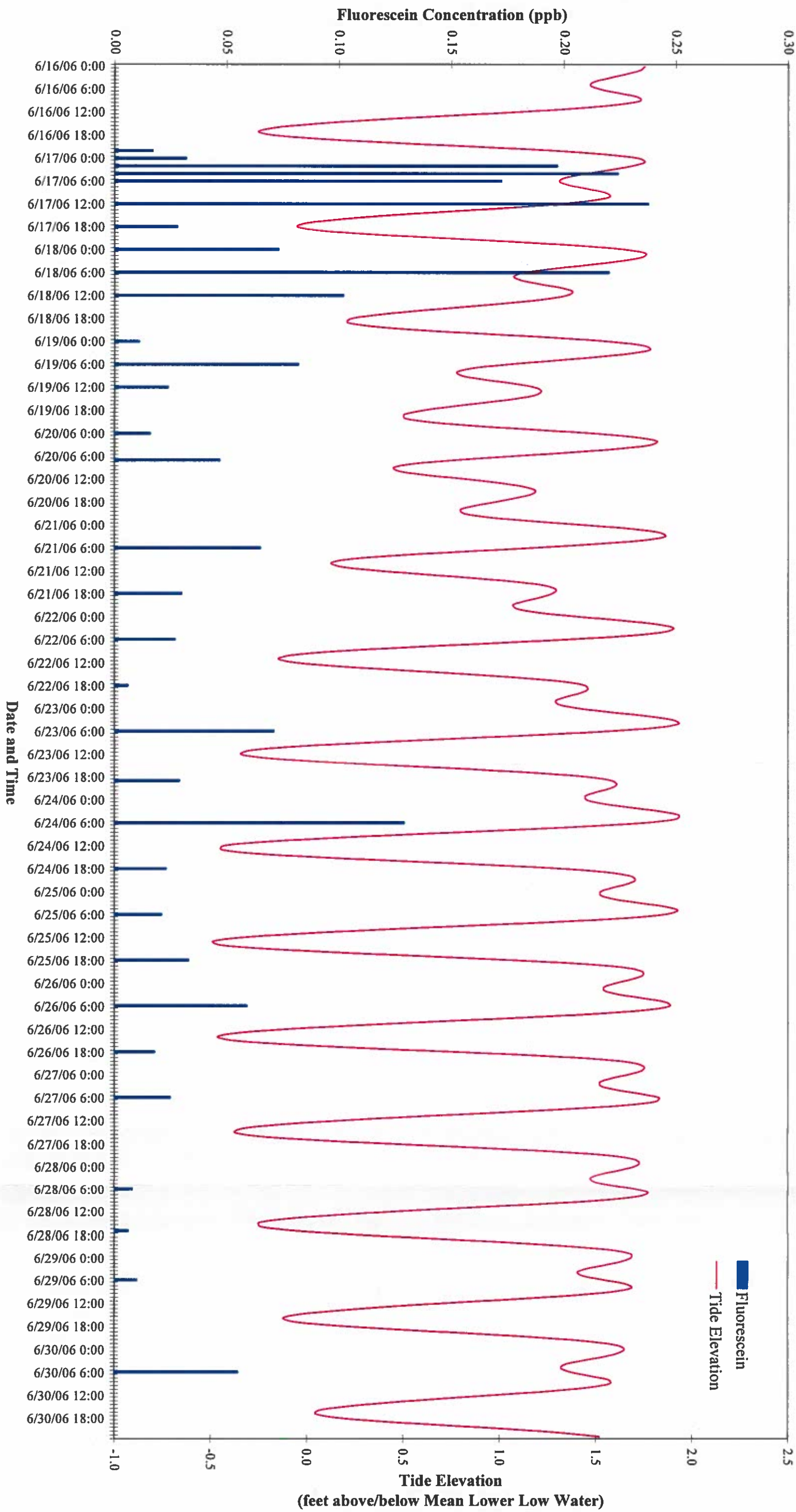


Figure 3-7. Fluorescein Concentrations from Seep Sample Location SP-6 and Tidal Elevations.

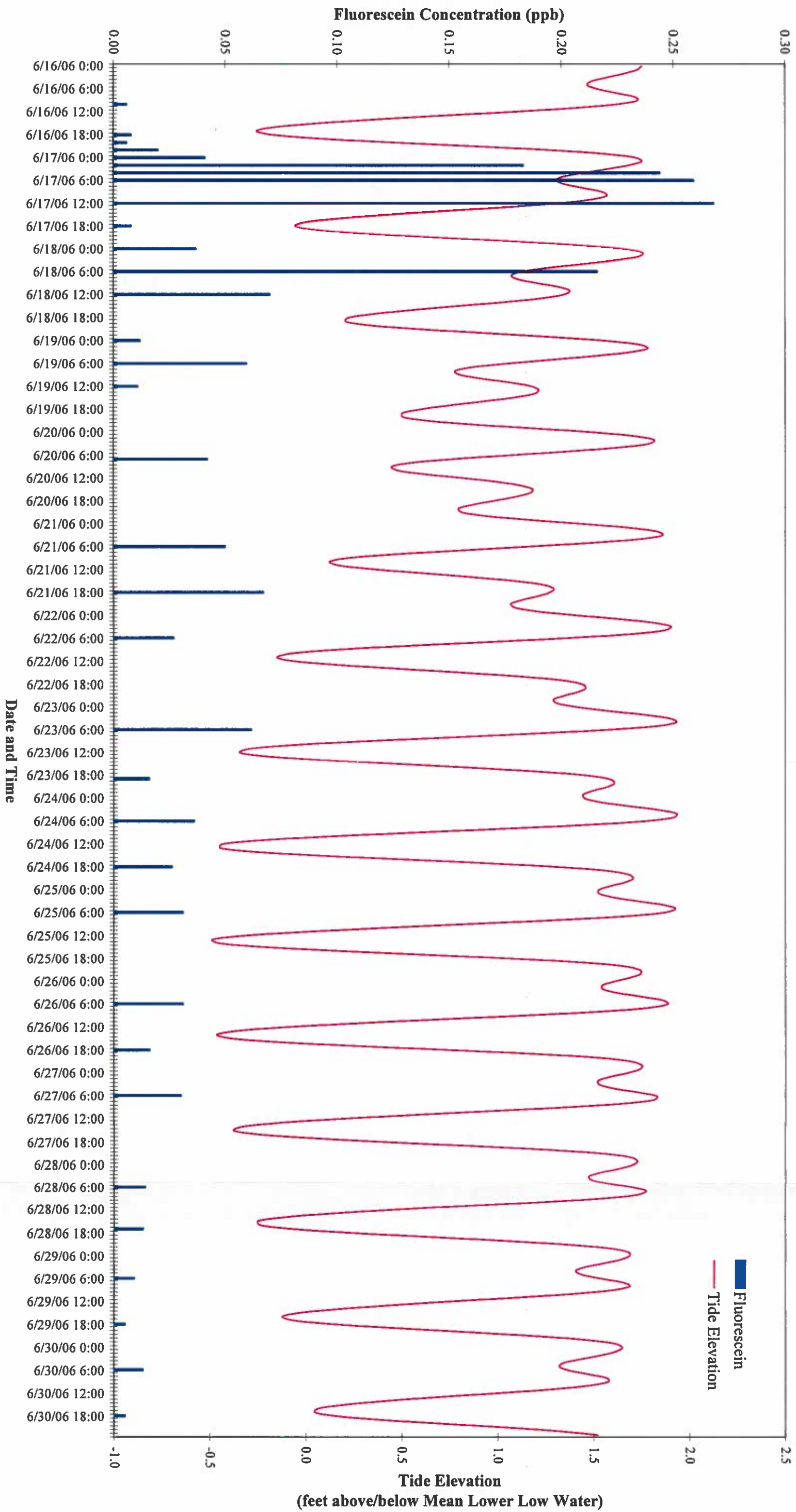


Figure 3-8. Fluorescein Concentrations from Seep Sample Location SP-7 and Tidal Elevations.

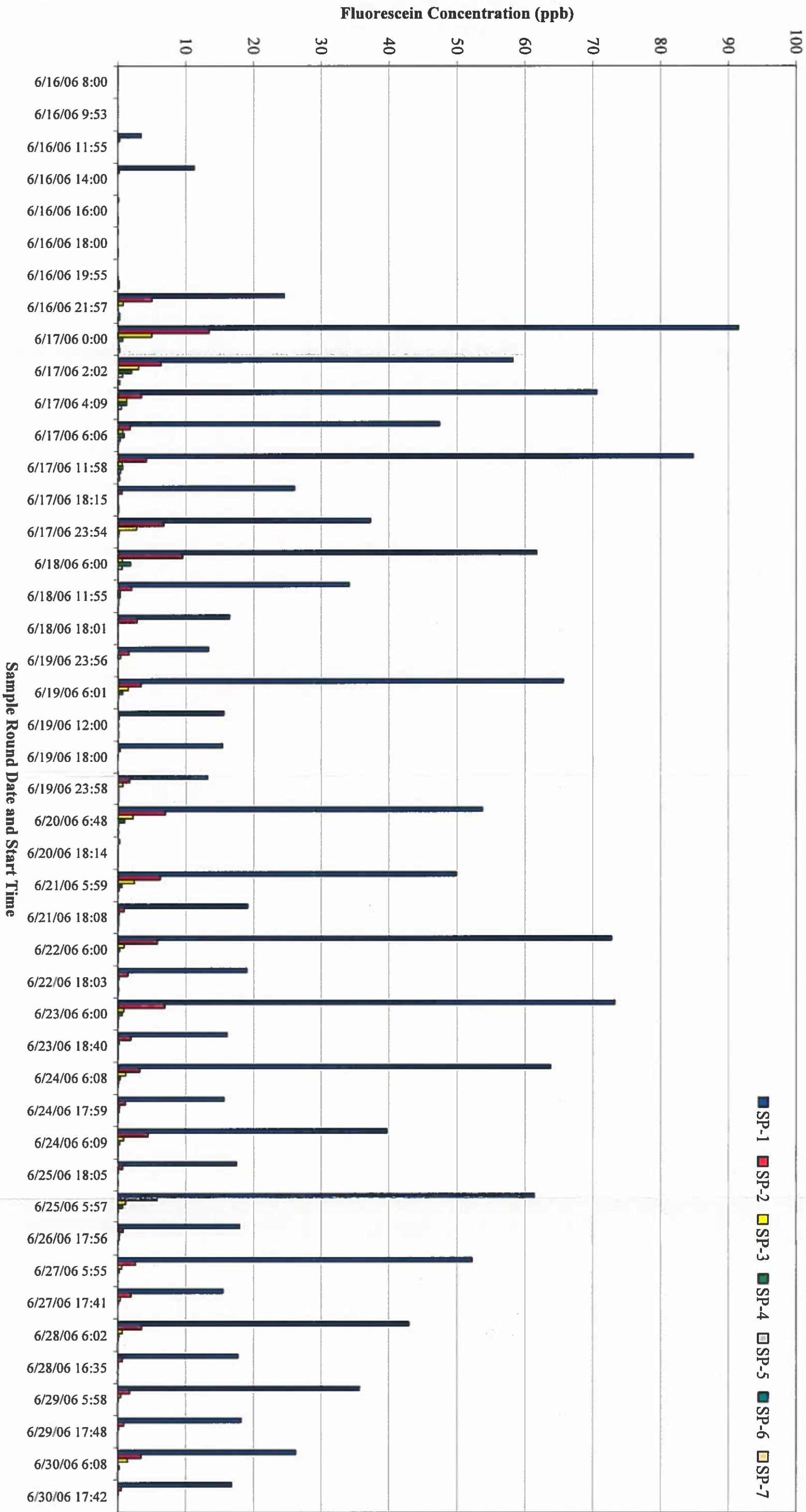


Figure 3-9. Fluorescein Concentrations from all Seep Sample Locations.



Photo 3-1. Visual identification of Fluorescein Dye at time of breakthrough, Andersen AFB, Guam.

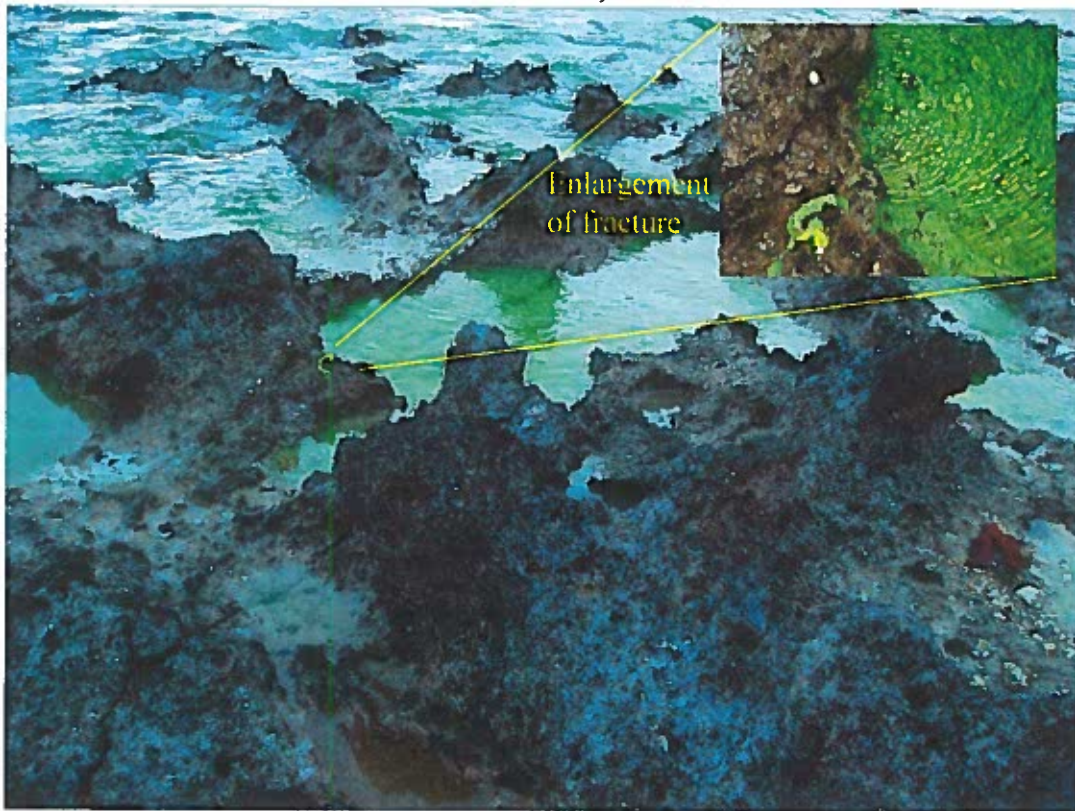


Photo 3-2. Fracture where Fluorescein Dye was visually identified seeping from, Andersen AFB, Guam.

4. REFERENCES

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APPENDIX A

MATERIAL SAFETY DATA SHEETS FOR SELECTED DYES



Material Safety Data Sheet
(FLUORESCEIN)
15174 URANINE C

CHEMCENTRAL/Dyes & Pigments
13395 Huron River Drive
Romulus, MI 48174

REVISION DATE: 12-6-00
CHEMTREC: 800-424-9300
EMERGENCY: 734-941-4800

SECTION I - IDENTIFICATION

TRADE NAME: 15174 URANINE C
CHEMICAL NAME: Acid Yellow 73 CAS# 6417-85-2
CHEMICAL FAMILY: Xanthene

SECTION II - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENT	PERCENT	CAS NUMBER	PEL
NONE as per 29CFR part 1910.1200 or Sara Title III			

HMIS HAZARD RATINGS (if applicable):

HEALTH: 1
FIRE 0
REACTIVITY 0

SECTION III - PHYSICAL DATA

APPEARANCE: Orange powder, no characteristic odor.
BOILING POINT: N/A
MELTING POINT: N/A
FREEZING POINT: N/A
VAPOR PRESSURE: N/A
VAPOR DENSITY (AIR=1): N/A
SPECIFIC GRAVITY: Approximately 1
pH: N/A
SOLUBILITY IN WATER: Moderate
VOLATILITY: N/A

SECTION IV - FIRE AND EXPLOSION DATA

FLASH POINT: N/A
EXTINGUISHING MEDIA: Water fog, CO2, or Dry chemical.
FIRE FIGHT PROCEDURES: ... Fire fighters should be equipped with self contained breathing apparatus
and turnout gear.
UNUSUAL FIRE HAZARD: Adequate ventilation and clean up must be maintained to minimize dust
accumulation. May form explosive dust/air mixture.

Material Safety Data Sheet
(FLUORESCEIN)
15174 URANINE C

SECTION V - REACTIVITY DATA

STABILITY: Stable
CONDITIONS TO AVOID: N/A
HAZARDOUS POLYMERIZATION: Does not occur
POLYMERIZATION TO AVOID: N/A
INCOMPATIBILITY: Avoid contact with strong oxidizing agents
DECOMPOSITION: Carbon monoxide, Carbon dioxide, and oxides of Nitrogen and Sulfur.

SECTION VI - HEALTH DATA

THRESHOLD LIMIT VALUE: .. Not Established
OVER EXPOSURE EFFECTS: Contact with eyes may result in severe irritation. Contact with skin may result in irritation. Ingestion may result in gastric disturbances. Inhalation of dust may irritate respiratory tract.

SECTION VII FIRST AID

FIRST AID PROCEDURES: Flush eyes with flowing water at least 15 minutes. If irritation develops, consult a physician. Wash affected skin areas thoroughly with soap and water. If irritation develops, consult a physician. Remove and launder contaminated clothing before reuse.

If swallowed, dilute with water and induce vomiting. Get immediate medical attention. If inhaled, move to fresh air. Aid in breathing, if necessary, and get medical attention.

****NEVER GIVE FLUIDS OR INDUCE VOMITING IF PATIENT IS UNCONSCIOUS OR HAS CONVULSIONS.****

SECTION VIII EMPLOYEE PROTECTION

RESPIRATORY PROTECTION: NIOSH/OSHA approved dust respirator as necessary.
PROTECTIVE GLOVES: To prevent skin contact.
EYE PROTECTION: Goggles.
ADDITIONAL MEASURES: Eye wash fountains should be easily accessible.
HANDLING AND STORAGE: ... Keep away from excessive heat and moisture. Keep containers closed.
VENTILATION: Local exhaust to control dusts.

SECTION IX - SPILL AND DISPOSAL DATA

SPILL: Spills should be contained and placed in suitable containers.
WASTE DISPOSAL: Do not discharge into sewers or waterways. Dispose of in accordance with local regulations.

Material Safety Data Sheet
(FLUORESCEIN)
15174 URANINE C

SECTION X - TRANSPORTATION DATA

PROPER SHIPPING NAME: Ink Material NMFC Item #101720

HAZARD CLASS AND LABEL: MFR LABEL ONLY

UN NUMBER: N/A

REPORTABLE QUANTITY: N/A

SECTION XI - ADDITIONAL INFORMATION

FOOT NOTES: This information is furnished without warranty, representation, or license of any kind, except that it is accurate to the best of CHEMCENTRAL Corporation's knowledge or obtained from sources believed by CHEMCENTRAL Corporation to be accurate.

The CHEMCENTRAL Corporation does not assume any legal responsibility for use or reliance upon same. Customers are encouraged to conduct their own tests. Before using any product, read its label.

Ciba Specialty Chemicals Corporation
 Consumer Care
 P. O. Box 2444
 High Point, NC 27261-2444
 24-Hour Health/Environmental Emergency Phone: 1-800-873-1138



Ciba

Material Safety Data Sheet

TINOPAL CBS-X

Value beyond chemistry

MSDS No: 58

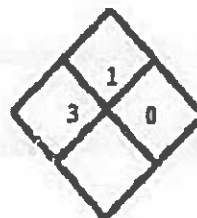
Date Printed: 03/23/00

Effective Date: 1/5/00

1. PRODUCT IDENTIFICATION

Chemical Family: Distyryl Biphenyl Derivative

Intended Use: Whitening Agent for Laundry Detergents



NFPA RATING

Health	3
Flammability	1
Reactivity	0
Protective Equipment	E

HMS RATING

Product Name(s):
 TINOPAL CBS-X
 TINOPAL CBS-X BULK BAG
 TINOPAL CBS-X SP

Product Code:
 1562352EK
 1562374GJ
 1562538ES

2. COMPOSITION / INFORMATION ON INGREDIENTS

CAS No.	Common Name: INCI Name:	ACGIH/PPM		OSHA/PPM		% by Wt. 89 - 91
		TWA	STEL	PEL		
27344-41-8	Disodium Distyrylbiphenyl Disulfonate	None	None	None		89 - 91
	Dermal: Not evaluated Inhalation: Not evaluated Ingestion: Not evaluated					
7647-14-5	Sodium chloride	None	None	None		6 - 8
	Dermal: Not evaluated Inhalation: Not evaluated Ingestion: Not evaluated					

3. HAZARDS IDENTIFICATION

Route(s) of Entry: Inhalation and dermal.

Potential Health Effects: Corrosive. Causes eye burns.

Carcinogenicity (NTP): Not listed.

Effective Date: 1/5/00

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Carcinogenicity (IARC): Not listed.

Carcinogenicity (OSHA): Not listed.

4. FIRST AID MEASURES

Ingestion: If conscious, give plenty of water to drink. Get medical attention. If unconscious, do not give anything to drink. Get immediate medical attention.

Skin: Wash with mild soap and water. If irritation occurs, get medical attention. If clothing is contaminated, remove and wash before reuse.

Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Eyes: Flush eyes with water for at least 15 minutes. Get medical attention.

5. FIRE FIGHTING MEASURES

Flash Point:	Not applicable
Flammable Limits in Air (Lower - % by volume):	Not applicable
Flammable Limits in Air (Upper - % by volume):	Not applicable
Auto-Ignition Temperature:	Not evaluated
TDG Flammability Class (Canada):	TDG Classification in Sect. 14

General Hazards: None known.

Fire Fighting Equipment: Use self contained breathing apparatus

Fire Fighting Extinguishing Media: Carbon dioxide, dry chemical, foam, water.

Fire and Explosion Hazards: No unusual hazards.

Hazardous Combustion Products: Burning may produce oxides of carbon, nitrogen or sulfur.

Explosive Data-Sensitivity to Mechanical Impact: Not evaluated.

Explosive Data-Static Discharge: Not evaluated.

Emergency Response Guidebook Information: None

6. ACCIDENTAL RELEASE MEASURES

Accidental Release Measures: Shovel into approved disposal container. Vacuum contaminated area. Avoid creating dusty conditions.

7. HANDLING AND STORAGE

Effective Date: 1/5/00

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DANGER! Corrosive - Causes eye burns. Do not get in eyes. Wear chemical goggles. Avoid breathing dust, vapor, or mist. Keep container closed. For industrial use only.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Personal Protective Equipment: Wear appropriate equipment to prevent probability of exposure and personal contact. Deluge safety shower and eye wash should be located near work area.

Eye Protection: Wear splash-proof chemical goggles.

Skin Protection: Wear impervious gloves as a standard handling procedure.

Respiratory Protection: In cases where there is a likelihood of inhalation exposure to the powder (dust), wear a NIOSH approved dust respirator.

Engineering Controls: Local exhaust recommended, mechanical exhaust acceptable.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Form:	Granular
Color:	Yellow-green
Odor:	Odorless
Odor Threshold:	Not evaluated
Solubility in Water:	25 g/l at 30°C (86 °F)
Vapor Pressure:	Not applicable
Specific Gravity:	Not applicable
Boiling Point:	Not applicable
Melting Point:	Not applicable
Freezing Point:	Not applicable
Decomposition Temperature:	Not applicable
Evaporation Rate:	Not applicable
Bulk Density:	Not applicable
Vapor Density:	Not applicable
pH:	7 - 8.5 @ 1 g/l
Coefficient of water/oil:	Not evaluated

Volatile(s): Not evaluated

10. STABILITY AND REACTIVITY

Stability: Stable

Incompatibility: None known.

Hazardous Decomposition Products: Burning may produce oxides of carbon, nitrogen or sulfur.

Hazardous Polymerization: Will not occur.

Effective Date: 1/5/00

TINOPAL CBS-X

Ciba Specialty Chemicals Corporation
Consumer Care

11. TOXICOLOGICAL INFORMATION

Eye Irritation: (Rabbits) Corrosive (Full Strength)

(Rabbits) A primary eye irritation study showed a 1 % solution of Tinopal CBS-X to be non-irritating to the eye.

Skin Irritation: (Rabbits) not an irritant

Inhalation Toxicity: (Rats) with ground material, 70-75% of particles < 3 microns: $LC_{50} = 3920 \text{ mg/m}^3$ air. This data is provided as supplemental information only. Because the average particle size of the product as sold exceeds 75 microns (and thus, are not respirable), we do not believe an inhalation hazard exists.

Sensitization: RIPT (Humans) - Not a skin irritant, fatiguing agent or sensitizer

Chronic/Carcinogenicity: In a two year lifetime feeding study (rat) conducted on the active ingredient, no dose related effects were found at levels of 5,000 ppm in the diet (equivalent to 0.4 lbs/day/life of the product as sold for humans). This level far exceeds any potential human exposure that could occur during normal handling and use. Dose related effects were found in the pancreas of both female and male rats at levels of 50,000 ppm (5% of the diet). This dose level was considered to be excessive and of no significance in the assessment of risk to humans.

Photocarcinogenicity: Hairless mice exposed dermally to lifetime daily doses of 0.1 % aqueous suspension of Tinopal CBS-X and 20 minutes of simulated sunlight did not have a tumorigenic response or other adverse dose-related effects.

Teratology: Doses of 0 or 1000 mg/kg by weight administered by gavage to rats on each of gestation days 6 through 15 did not adversely affect dams, embryos, or fetuses at 1000 mg/kg by weight/day.

Reproduction: Not evaluated.

Mutagenicity: Tinopal CBS-X did not induce mutations in a standard Ames assay. The in-vitro chromosome aberration assay likewise was negative at doses of 5, 50, or 100 ug/mL in the absence of metabolic activation. However, in the presence of the S9 mix, a significantly increased aberration rate was observed at the 50-ug/mL dose at 7-hours and 28-hours after fixation but not at 18-hours. The reliability of this effect is moderated by the absence of a dose-related increase in the aberration rate, and at 50 ug/mL and 100 ug/mL, plating efficiency was decreased and cytotoxicity was increased.

In vivo assays did not show mutagenic or clastogenic effects. The mouse micronucleus test, hamster (in vivo) chromosome aberration assay, and a dominant lethal assay in mice were all negative. Our overall conclusion is Tinopal CBS-X is not mutagenic.

Acute Oral Effects: (Rats) $LD_{50} > 5,000 \text{ mg/kg}$

Acute Dermal Toxicity: Acute Dermal (Rabbits) $LD_{50} > 2,000 \text{ mg/kg}$

Additional Information: An in vitro skin penetration study indicated Tinopal CBS-X did not penetrate the dermal barrier.

12. ECOLOGICAL INFORMATION

Biodegradability: Bioelimination: 20 - 30% TOC/DOC Analysis (OECD 303A (mod))

Bioconcentration/accumulation: soil-bound Tinopal CBS-X did not readily accumulate in bean plant parts. Fish in a flow-through microcosm did take up the labeled Tinopal CBS-X but it was rapidly eliminated - bioconcentration is not anticipated.

Ecotoxicity: Fish toxicity: $LC_{50} = 76 \text{ mg/l}$ (96 HR) Zebra Fish

Fish toxicity: $LC_{50} = 130 \text{ mg/l}$ (96 HR) (Trout)

Daphnia Toxicity: $BC_{50} > 1000 \text{ mg/l}$ (24 HR)

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Algae toxicity: EC50 = 8 mg/l (96 HR)

Earthworm (*Eisenia foetida foetida*): LC50 > 1000 mg/l (14-D)

Biological Oxygen Demand (BOD5): 0.0 g/g

Chemical Oxygen Demand (COD): 1.76 g/g

Activated Sludge Respiration Inhibition Test: Inhibition > 100 mg/l

Additional Information: TOC = 50%

Aqueous photolysis of a 4000 ppm solution was measurable within 1 hour and complete within 48 hours. The degradation products are biodegradable and showed limited adsorption to suspended solids.

13. DISPOSAL CONSIDERATIONS

Waste Disposal Method: Bury or incinerate in approved site or facility in accordance with local, state (provincial) and federal regulations.

Container Disposal Information: Emptied container may contain product residue and should not be reused.

RCRA Hazard Class: Refer to Section 15: Regulatory Information for RCRA status.

14. TRANSPORT INFORMATION

DOT:

Proper Shipping Name:

Not Regulated

IATA:

Proper Shipping Name:

Not Regulated

IMDG:

Proper Shipping Name:

Not Regulated

TDG:

Proper Shipping Name:

Not Regulated

15. REGULATORY INFORMATION

US Federal Regulations:

Chemical Weapons Convention (CWC): This product does not contain any chemicals listed under the Chemical Weapons Convention Schedule of Chemicals.

Clean Air Act - Hazardous Air Pollutants (HAP): This product does not contain any hazardous air pollutants (HAP), as defined by the U.S. Clean Air Act Section 12 (40 CFR 61).

Clean Air Act - Ozone Depleting Substances (ODS): This product neither contains, nor was manufactured with, a Class I or Class II ozone depleting substance (ODS), as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpt. A, App. A+B).

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Clean Water Act - Priority Pollutants (PP): This product does not contain any priority pollutants listed under the U.S. Clean Water Act Section 307 (2)(1) Priority Pollutant List (40 CFR 401.15).

Occupational Safety and Health Act (OSHA): This product is hazardous under the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200.

Resource Conservation and Recovery Act (RCRA): This product is not considered to be hazardous waste under RCRA (40 CFR 261).

SARA Title III: Section 302 - Extremely Hazardous Substances (EHS): This product does not contain any chemicals regulated under Section 302 (40 CFR 355) as extremely hazardous substances.

SARA Title III: Section 304 - CERCLA: This product does not contain any chemicals regulated under Section 304 (40 CFR 302) as hazardous chemicals for emergency release notification ("CERCLA" List).

SARA Title III: Section 311/312 - Hazard Communication Standard (HCS): Immediate

SARA Title III: Section 313 Toxic Chemical List (TCL): This product does not contain any chemicals for routine annual toxic chemical release reporting under Section 313 (40 CFR 372).

TSCA Section 5(e) - Consent Order / SNUR: This product is not subject to a Section 5(e) Consent Order or Significant New Use Rule (SNUR).

TSCA Section 8(b) - Inventory Status: All chemical(s) comprising this product are either exempt or listed on the TSCA inventory.

TSCA Section 12(b) - Export Notification: This product does not contain any chemical(s) that are subject to a Section 12(b) export notification.

International Regulations:

Canadian Inventory Status: This product contains only chemicals that are currently listed on the Canadian Domestic Substance List.

Canadian WHMIS: This product contains the following chemicals listed on the Canadian WHMIS Ingredient Disclosure List.

Chemical Name: Benzenesulfonic acid, 2,2'-([1,1'-biphenyl]-4,4'-diyl-di-2,1-ethenediyl)bis-, disodium salt

CASRN: 27344-41-8

Percent in Composition: 89 - 91 % by wt

Controlled product, Class D2B, E

State Regulations:

California Proposition 65: This product does not contain any chemicals currently on the California list of Known Carcinogens and Reproductive Toxins.

Massachusetts Right-to-Know: This product does not contain any chemicals which are subject to Massachusetts Right-to-Know disclosure requirement.

New Jersey Right-to-Know: The following is required composition information:

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Chemical Name: Benzenesulfonic acid, 2,2'-([1,1'-biphenyl]-4,4'-diyl-di-2,1-ethenediyl)bis-, disodium salt
Common Name: INCI Name: Disodium Distyrylbiphenyl Disulfonate
CASRN: 27344-41-8

Chemical Name: Sodium chloride (NaCl)
Common Name: Sodium chloride
CASRN: 7647-14-5

Chemical Name: Water
Common Name: Water
CASRN: 7732-18-5

Pennsylvania Right-to-Know: The following is required composition information:

Chemical Name: Benzenesulfonic acid, 2,2'-([1,1'-biphenyl]-4,4'-diyl-di-2,1-ethenediyl)bis-, disodium salt
Common Name: INCI Name: Disodium Distyrylbiphenyl Disulfonate
CASRN: 27344-41-8
Comment: Not on Pennsylvania Hazardous Substance List

Chemical Name: Sodium chloride (NaCl)
Common Name: Sodium chloride
CASRN: 7647-14-5
Comment: Not on Pennsylvania Hazardous Substance List

Chemical Name: Water
Common Name: Water
CASRN: 7732-18-5
Comment: Not on Pennsylvania Hazardous Substance List

16. OTHER INFORMATION

MSDS No:	58
Prepared By:	Reba Lemons
Approved By:	Frances E. Knight
Title:	Manager, Product Registration
Approved Date:	01/05/00
Supersedes Date:	10/15/99

Revision Summary: Changes in Section(s): 11

Disclaimer: For further information, please contact:
Product Stewardship Team:

Phone: (336) 801-2373
Fax: (336) 801-2056

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind expressed or implied is made with respect to the information contained herein. This material safety data sheet was prepared to comply with the OSHA Hazard Communication Standard (29 CFR 1910.1200) and with the Workplace Hazardous Materials Information System (WHMIS).

This supersedes any previous information.

Effective Date: 1/5/00

TINOPAL CBS-X

**Ciba Specialty Chemicals Corporation
Consumer Care**

APPENDIX B

MIRAFI FW404 SPECIFICATIONS





Mirafi[®] FW404

Mirafi[®] FW404 is composed of high-tenacity polypropylene monofilament yarns, which are woven into a stable network such that the yarns retain their relative position. FW404 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Wide Width Tensile Strength	ASTM D 4595	kN/m (lbs/ft)	44 (3000)	40 (2760)
Grab Tensile Strength	ASTM D 4632	kN (lbs)	1.78 (400)	1.40 (315)
Grab Tensile Elongation	ASTM D 4632	%	15	15
Trapezoid Tear Strength	ASTM D 4533	kN (lbs)	0.67 (150)	0.73 (165)
Mullen Burst Strength	ASTM D 3786	kPa (psi)	5506 (800)	
Puncture Strength	ASTM D 4833	kN (lbs)	0.67 (150)	
Apparent Opening Size (AOS)	ASTM D 4751	mm (U.S. Sieve)	0.425 (40)	
Percent Open Area	COE-22125-86	%	1	
Permittivity	ASTM D 4491	sec ⁻¹	0.90	
Permeability	ASTM D 4491	cm/sec	0.068	
Flow Rate	ASTM D 4491	l/min/m ² (gal/min/ft ²)	2852 (70)	
Abrasion Resistance	ASTM D 4833	% retained	60 (typical)	
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	90	

Physical Properties	Test Method	Unit	Typical Value
Mass/Unit Area	ASTM D 5261	g/m ² (oz/yd ²)	271 (8.0)
Thickness	ASTM D 5199	mm (mils)	0.89 (35)
Roll Dimensions (width x length)	--	m (ft)	4.5 (15) x 91 (300)
Roll Area	--	m ² (yd ²)	418 (500)
Estimated Roll Weight	---	kg (lbs)	120 (265)

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APPENDIX C

CRAWFORD HYDROLOGY LABORATORY

KARST GROUNDWATER INVESTIGATION

RESEARCH PROCEDURES



KARST GROUNDWATER INVESTIGATION RESEARCH PROCEDURES

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Crawford Hydrology Laboratory

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or join us on the World Wide Web at:
<http://www.dyetracing.com>

Revised March 2001

KARST GROUNDWATER INVESTIGATION RESEARCH PROCEDURES

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KARST GROUNDWATER INVESTIGATION RESEARCH PROCEDURES

Crawford Hydrology Lab

1. INTRODUCTION

The following proposed research procedure has been used by Crawford to investigate the flow of groundwater in karst aquifers on numerous occasions since 1970.

2. PHASE I: SCOPE OF WORK

The scope of work consists of a review of literature, field survey for the karst hydrogeologic inventory, dye receptor placement, retrieval, and analysis for the background fluorescence study, and a potentiometric surface investigation.

2.1 Delineation of Study Area

The study area must extend in all directions away from the site until one of the following conditions is met:

1. The water table has been established by measurement to be higher than at the proposed dye injection location on site.
2. A definite discharge boundary has been reached, such as a large perennial stream.

Typically, the study area will cover several square miles, and sometimes it may even cover 80 square miles or more.

2.2 Review of Literature

Prior to initiating the field survey, a desktop study will be conducted to identify and review, as available, the following types of resources pertaining to karst features in the study area.

- Aerial photographs
- Geologic maps
- Flood maps
- Cave maps
- Topographic maps
- Soil surveys
- Storm water reports
- Previous reports about the site
- Maps showing locations of water and sewer pipes

References will be sought from state and federal agencies, and local caving organizations. Pertinent information from these resources will be transferred to a working base map for planning of the subsequent field survey.

2.3 Karst Hydrogeologic Inventory

The field survey for the Karst Hydrogeologic Inventory will be conducted under conditions ranging from moderate to high flow during a wet period such that the dominant resurgence points are active. The survey will be conducted by walking or floating all streams and associated impoundments (lakes, ponds) in the study area to visually identify karst features including but not limited to:

- Springs
- Sinkholes
- Sinking streams
- Soil springs
- Swallets
- Caves
- Seeps
- Karst windows

The features will be located on a 7.5-minute series topographic map. Each feature will be given a name and a unique inventory number. General information and physical characteristics of the feature will be recorded on the Karst Feature Inventory Form. The physical characteristics of resurgence point water will include a measurement of the discharge volume and measurement of the discharge temperature, specific conductance, and pH. The feature will be photographed to complete the inventory record.

Precise vertical and horizontal locations of the key resurgence points and any features potentially indicating groundwater elevations will be surveyed. Elevations will be measured to the nearest 0.01 foot referenced to the National Geodetic Vertical Datum of 1929 or local datum as available.

The equipment needed for the field survey includes the following:

1. Base maps and air photos for plotting features (7.5 minute topographic quadrangles)
2. Inventory forms
3. Meters for the measurement of temperature, pH, and specific conductivity
4. Decontamination kit
5. Camera for taking two photos of each spring and surface stream location (one from about 10-15 feet and one from about 100 feet)
6. Flagging to mark features for surveying and/or monitoring
7. A 200-foot tape measure for locating features and measuring stream reaches
8. Flow Probe, stream velocity meter, for taking a quick measurement of spring discharge. This is a current meter on a stick. We measure the spring velocity at one

to three locations and measure the width and depth with a retractable carpenter's tape (it should not take more than 3 minutes to take this measurement).

9. Thigh-high rubber waders for walking streams

2.4 Background Fluorescence Investigation

The Background Fluorescence Monitoring task will involve the monitoring of resurgence points and streams in the study area for background concentrations of dye from previous dye traces, pollution, and natural interference. As part of this effort, local, state, and federal agencies will be contacted to inquire whether they have recently conducted, are conducting, or plan to conduct a dye trace study in the study area or any area potentially influencing the study area. The results of the monitoring will be used to evaluate the appropriate dyes and dye concentrations to be used if the dye tracer investigation is needed.

Dye receptors will be placed at or shortly after the time of the hydrogeologic inventory and will be retrieved after a period of approximately one week. Because of background fluctuation, particularly in urban and/or industrial areas, it may be necessary to measure background weekly over a two or three week period. All monitoring activities will be conducted in accordance with the Dye Receptor Deployment and Retrieval Procedures (Appendix I) and the Quality Assurance Quality Control Plan (Appendix II).

The receptors will consist of small packets constructed of fiberglass screen mesh with activated coconut charcoal. The receptors will be secured in the main flow of the stream or resurgence point using a system of floaters and sinkers as needed with black nylon twine (for low visibility). In small springs or streams, the channel may be altered by moving rocks or by other minor means in order to maximize flow past the receptor. In shallow water, the receptors may be shielded to minimize photochemical decay of dyes in the sunlight. Receptors will be secured so that they can be retrieved under high water conditions.

Upon retrieval, each dye receptor will be washed off in the stream, placed in a clearly labeled, sealable, plastic bag, and stored in a cooler to reduce exposure to sunlight. The receptors will be delivered to the analytical laboratory (Crawford Hydrology Laboratory) for analysis. The receptors will be prepared in accordance with the QA/QC plan (Appendix II) and analyzed for the presence of dyes that may be used during the Phase II investigation. The dyes most often used by Crawford Hydrology Laboratory are:

- **Fluorescein** (Acid Yellow 73)
- **Sulphorhodamine B** (Acid Red 52)
- **D&C Red #28**
- **Rhodamine WT** (Acid Red 388)
- **D&C Green #8**
- **Lissamine FF**
- **Eosine** (Acid Red 87)
- **Tinopal CBS-X** (Fabric brightening agent 351)
- **FD&C Red #3**
- **Solophenol 500%** (Direct Yellow 96)
- **Palanil Luminous Red G**

2.5 Matrix Interference Investigation

A matrix interference investigation may be needed previous to selection of the dye or dyes to be used. This involves a laboratory investigation to measure the potential impact of chemicals in the groundwater on the dye concentration, the absorption of the dye by the charcoal or the release of dye from the charcoal during elution. Appendix IV outlines the procedures used to conduct this investigation.

2.6 Hydrogeologic Investigation and Lineament Analysis

An investigation of the geology of the study area will be made. This will include a review of literature, geologic maps and well logs and a field investigation. The field investigation is necessary to confirm the accuracy of the geologic map and to identify important geologic features not on the map, such as joint sets, prominent bedding plane partings, chert or shale beds that might constitute confining layers, etc.

A lineament analysis will be performed for the area within and surrounding the study area. Lineaments and fracture traces will be identified from topographic and geologic maps, the county soil atlas and aerial photographs. This information combined with field measurements of joints, strike and dip, etc. will provide indicators of possible groundwater flow routes. It will also provide important information for locating monitoring wells if needed. A map will be prepared showing the lineaments identified in the area.

2.7 Mapping of Potentiometric Surface of the Uppermost Karst Aquifer

All accessible water wells and monitoring wells in the area will be measured during a dry period and the depth to water subtracted from the ground surface elevation. The ground surface elevations will be measured to 0.01 foot by leveling from benchmarks. In addition to wells, the elevations of springs, karst windows and selected points along streams and lakes will also be measured by leveling. These elevations and terrain features, such as, topography, sinkhole distribution, sinking streams, cave locations, etc. will be used to construct a map of the water table for the uppermost aquifer. If sufficient wells are available, it may be possible to delimit groundwater basin divides.

2.8 Preparation of Maps and Report

A) A Phase I report will be prepared that will discuss the following:

1. Previous research
2. Hydrogeologic inventory
3. Lineament analysis
4. Potentiometric surface

5. Background fluorescence
6. Hydrogeology
7. Karst groundwater basins
8. Hypothesized groundwater flow from site to a spring or springs
9. Hypothesized movement of contaminants within the aquifer.

B) A report that will discuss whether a Phase II dye tracer study is needed or not.

C) If a Phase II dye tracer study is needed then a detailed work plan will be prepared outlining all aspects of the Phase II investigation.

3. PHASE II: SCOPE OF WORK

A more detailed Scope of Work for the Phase II Dye Trace Investigation will be prepared, if needed, as part of the Phase I Karst Investigation. The following is a general outline of the research procedure to be used. The Phase I Karst Investigation will result in all the preliminary work for the dye trace including:

- a) Karst Hydrogeologic Inventory
- b) Hydrogeologic Investigation and Lineament Analysis
- c) Mapping of the Potentiometric Surface
- d) Background Fluorescence Investigation.

Also, the kinds and quantities of dyes will have been determined as part of the Phase I investigation as well as the selection of all dye receptor locations.

3.1 Background Fluorescence

Unless the dye trace can be started within two weeks of the collection of the background dye receptors for Phase I, a second Background Fluorescence Investigation will be necessary. Since background fluorescence can change, it is important to know the background fluorescence the week previous to dye injection. Because of background fluctuation, particularly in urban and/or industrial areas, it may be necessary to measure background levels weekly over a two or three week period, previous to dye injection

3.2 Class V Injection Well Permit

In Tennessee, the injection of a dye into subsurface waters requires authorization as a Class V Underground Injection Well from the Tennessee Division of Water Supply (TDWS). Therefore, the appropriate application will be made to TDWS and written authorization received from that agency prior to the initiation of any injection of dye at a site in Tennessee. In Kentucky, the

Kentucky Division of Water must be notified in advance of the trace. In other states, the State Division of Water will be contacted and permission obtained from the appropriate state agency previous to dye injection.

3.3 Dye Injection

After the completion of the analysis of the background dye receptors, and the placement of dye receptors in all springs, karst windows, cave streams, lakes, surface streams, monitoring wells and selected water wells, dye will be injected directly into a sinking stream, sinkhole, well, or hole excavated in the soil.

If a sinking stream or sinkhole can be located in the appropriate place for dye injection, it will be used. However, it is usually necessary to either dig a dye injection pit with a backhoe or drill an injection well. If it is more than about 17 feet to bedrock, then an injection well will be the only choice. It may not be necessary to drill a new well, however. Capacity tests can be performed on all existing monitoring wells, and if they will take water at a sufficient rate for dye injection and flushing, then it may be possible to use one or more of them for dye injection. If not, then it will be necessary to drill an injection well (which could also serve as a monitoring well). The well or wells will be drilled at sites where there is a good chance of intersecting a karst conduit. Such sites are where lineaments intersect, or where geophysical techniques (microgravity or natural potential) have identified them as favorable. Water from a hose or a water truck will be used to flush the dye past the soil into a bedrock crevice that leads to a cave stream. Usually about 500 gallons of water are injected into the hole or well to make sure that it drains sufficiently and to wet the soil so that less dye will be sorbed by clays. The dye is then injected and flushed with at least 2,000 gallons of water. Usually three or four dye traces can be performed simultaneously by using different dyes.

3.4 Dye Receptor Placement and Retrieval

Activated coconut charcoal dye receptors will be retrieved and fresh ones installed weekly (usually within 4 to 10 days depending on weather and other factors). If time-of-travel data are needed, they may be exchanged more frequently during the first two weeks. Additional information about dye receptor construction, placement, retrieval and transport is included in Appendix I. Usually, dye receptors are exchanged weekly for at least two months after the first detection of dye at a spring. This is necessary to allow sufficient time for the dye to reach other receptor locations. If the karst aquifer has turbulent flow through well-developed bedrock conduits, the dye will usually resurge from a spring or springs within one week. However, if the dye must travel through a laminar flow, porous-media aquifer, even for a short distance, it could be months before the first arrival of dye at a spring.

3.5 Quantitative Dye Trace

This involves installing ISCO automatic water samplers at the hypothesized spring or springs. The collected samples are then analyzed on a Shimadzu spectrofluorophotometer RF 5301PC. This provides a graph of the complete dye breakthrough curve at the spring or springs (Figure 3.5.1). A quantitative trace is often performed simultaneously with the qualitative dye receptor trace. It provides more definitive proof of dye flow to a spring since the dye concentration in the water is measured during the entire passage of the dye cloud as it flows from the spring. A quantitative

trace is usually performed if there is a chance of litigation in the courts and/or if very important decisions are to be made based on the results of the dye trace.

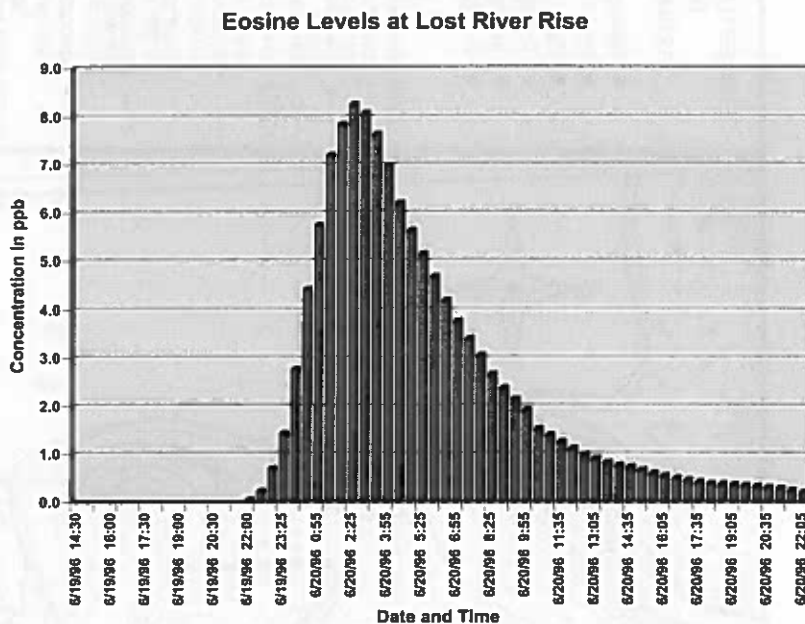


Figure 3.5.1

3.6 Laboratory Analysis

Dye receptors and water samples will be analyzed at the Crawford Hydrology Laboratory. The procedures used in the dye analysis and the QA/QC Plan are described in Appendix II.

3.7 Report, Map of Groundwater Flow and Cross-Sectional Profiles

The results of the Phase II Dye Tracer Investigation will be presented in the form of a report and a map showing the generalized route taken by the dye or dyes from the injection site or sites to a spring or springs. The potentiometric map will be used to estimate the route of the dye through the karst aquifer from the injection site to the spring or springs. Figure 3.7.1 is an example of a finished map containing dye receptor locations, potentiometric surface, dye trace results, and groundwater drainage divides. Cross-sectional profiles will be created so that relations can be made between the geology, hydrology and dye trace data. Figure 3.7.2 is an example of a cross-sectional profile along a traverse.

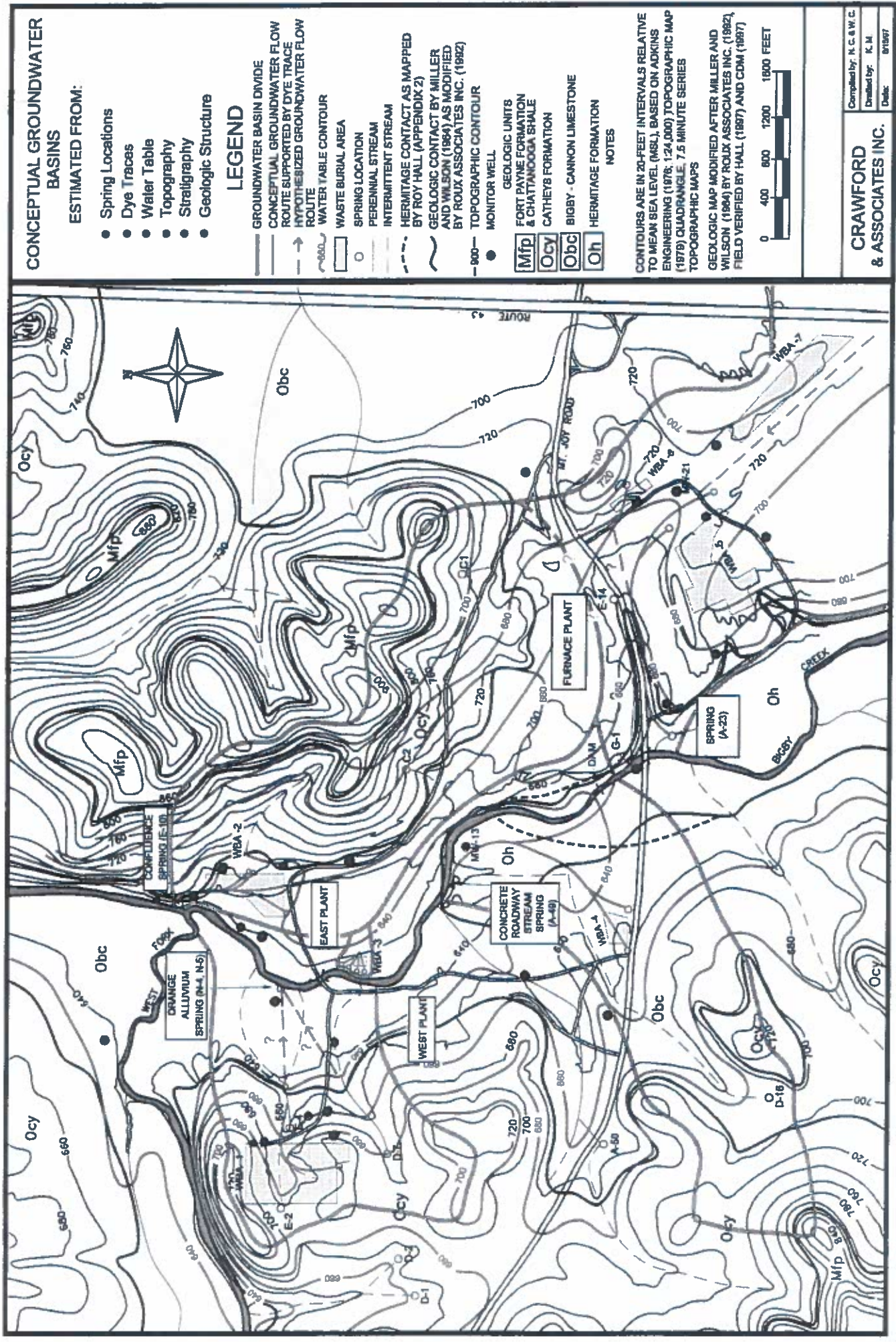


Figure 3.7.1

SITE CONCEPTUAL HYDROGEOLOGIC MODEL

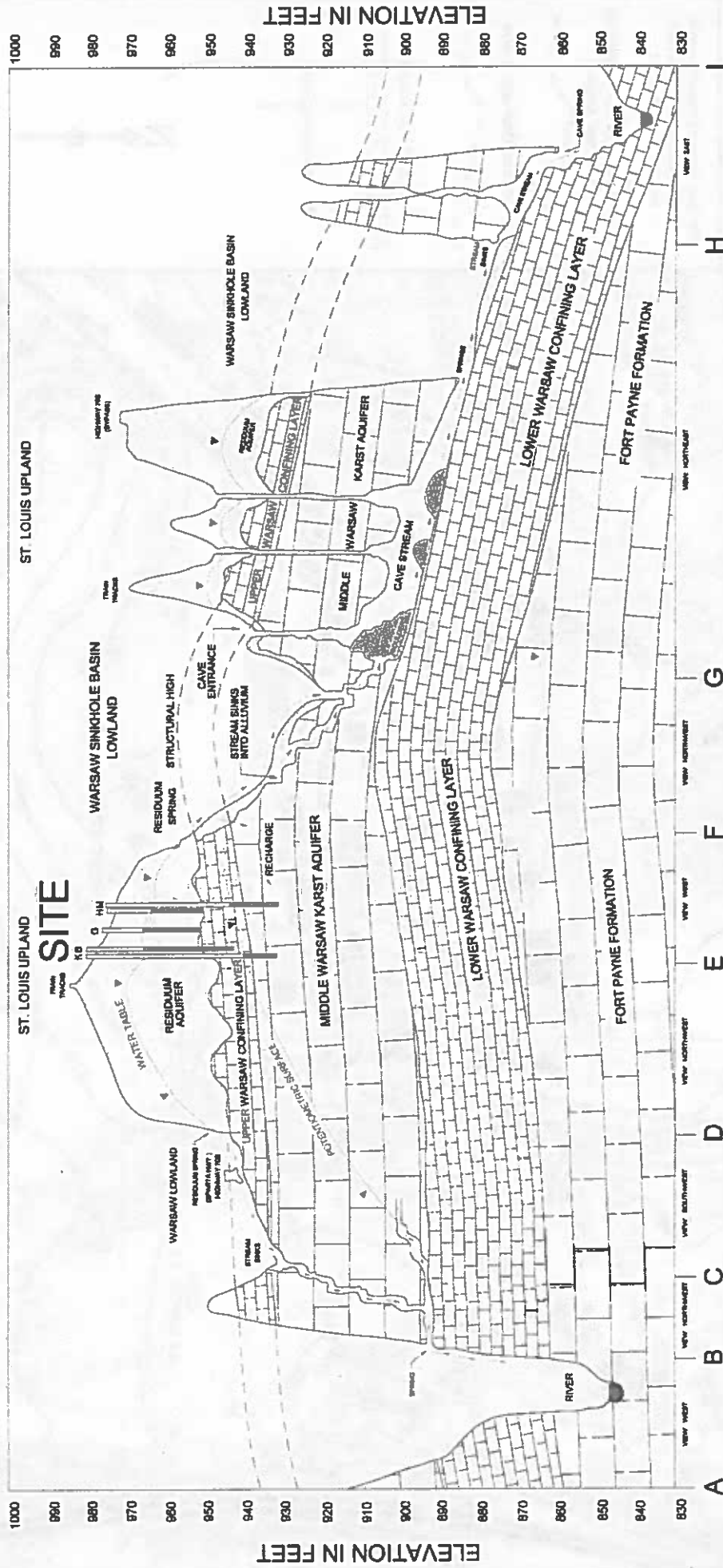


Figure 3.7.2

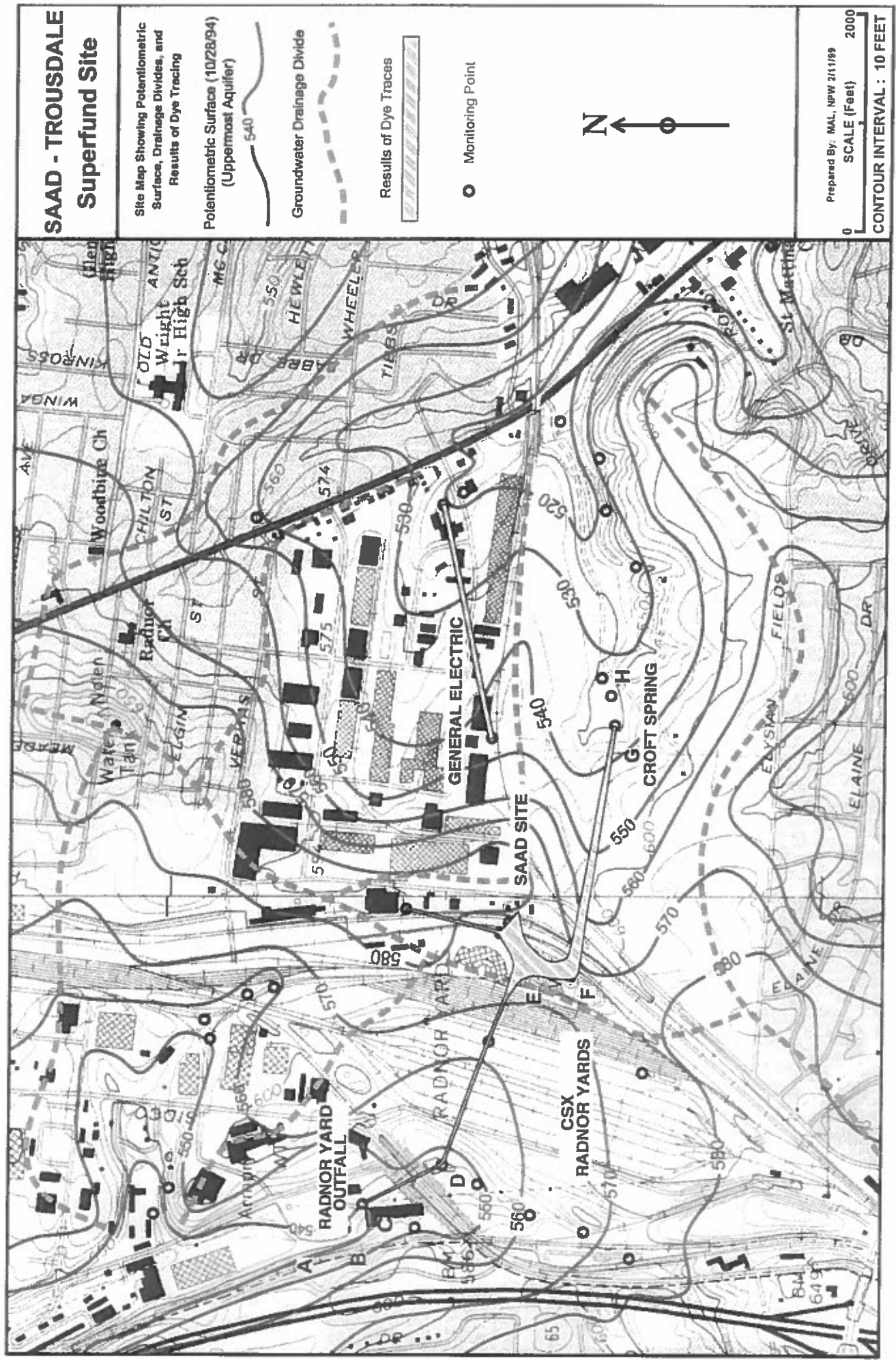


Figure 3.7.3

APPENDIX I

DYE RECEPTOR DEPLOYMENT AND RETRIEVAL

DYE RECEPTOR DEPLOYMENT AND RETRIEVAL

1. Receptor Construction

The receptors will consist of small packets constructed of vinyl-coated fiberglass screen mesh. The mesh is filled with 10 grams of activated coconut charcoal. Receptors will be prepared in advance in a dye-free environment and individually packaged in sealed polyethylene bags.

2. Grab Sample Vials

Grab sample vials are made of borosilicate glass suitable for fluorometric analysis. The caps used are PTFE lined to prevent contamination by fluorescent molecules that can leech out of standard rubber-lined caps.

3. Receptor Placement

Receptors (along with the grab sample vials) will be sealed in a polyethylene bag inside a cooler or other watertight container under chain-of-custody procedures for transportation to the site. The detectors will be inspected for signs of damage prior to deployment. Disposable latex gloves will be worn when handling the receptors in order to avoid transferring dyes from clothing and other items. Fresh gloves will be used for the placement of each receptor.

The receptors will be deployed in the water flow of the stream or resurgence point to be monitored. The receptors will be secured using a system of weights, floats, and tethers as necessary to secure the receptor in a location where flow past the receptor is maximized and exposure to sunlight is minimized. In areas accessible to the public, it may be necessary to make the receptor anchoring system inconspicuous in order to avoid tampering. In small springs or streams, the channel may be altered by moving rocks or by other minor means in order to maximize flow past the receptor. In shallow water, the receptors may be shielded to minimize photochemical decay of dyes in the sunlight. Receptors will be secured so that they can be retrieved under high water conditions.

Two dye receptors will be deployed at separate nearby locations at all key resurgence and stream points and at any site accessible to the public. This provides a backup in the event that the primary receptor is lost or stolen. Duplicate receptors from 10 percent of the receptor locations will be analyzed to evaluate quality control.

4. Receptor and Grab Sample Retrieval and Transport

When retrieving the receptor, the condition of the stream or resurgence point will be carefully examined for the presence of dye or evidence of tampering or other disturbance. The receptor will be retrieved from the spring by means of its tether. Where wading is necessary, the receptor will be approached from downstream and rubber boots will be thoroughly decontaminated prior to

reuse. Disposable latex gloves will be worn during handling of each receptor, even if it is a duplicate receptor. The receptor will be rinsed in the water from which it was removed to clean it of accumulated sediment. The receptor will be placed in a labeled, sealable, polyethylene bag. The grab sample will be taken from the location the dye receptor was occupying prior to collection. If this is not feasible, then the sample should be taken from a location as close to the receptor as possible. The vial is then placed in the same bag as the dye receptor and placed in a closed container to shield it from sunlight. The receptor bag will be labeled (with a permanent ink marker) with the following data:

- Project name
- Sample identification numbers (derivative of the inventory number)
- Name of monitored point
- Date and time of retrieval
- Initials of staff collecting the receptor

Dye absorbed onto charcoal receptors is extremely stable at ambient temperatures. Retrieved receptors will be transported under chain of custody procedures at ambient temperatures in a dark, sealed container, such as a sample cooler. If holding time of the receptors is more than 24 hours they will be refrigerated to prevent mold growth.

APPENDIX II

LABORATORY PROCEDURES

AND

QUALITY ASSURANCE/QUALITY CONTROL PLAN

1. Sample Custody

[illegible]

One copy of the chain-of-custody form is added to the laboratory custody records and a second copy is taped to the sample container and locked in a refrigerator. Water samples collected with an ISCO Automatic Water Sampler are kept in the sampler bottom, which is custody sealed and noted on the Chain-of-custody form.

Samples are kept in a locked refrigerator in a laboratory to which no one but laboratory personnel have access.

3. Documentation

Each dye receptor is kept in its original, labeled, sealed, polyethylene, zip-lock bag until it is removed from the refrigerator. The bags are opened one at a time and the receptor removed. It is washed in a high-speed jet of tap water to remove excess sediment, a typed laboratory identification tag containing the project name, site location number and collection date are stapled to it and it is then placed in an oven. A tag with the project name, site location number and collection date is attached to each water sample bottle. The bottles are then placed in a container labeled with the project name and collection date. ISCO Automatic Water Sampler bottoms are opened and the Quantitative Dye Trace form (Figure 3.1) is removed and inspected.

Crawford Hydrology Laboratory					
* Groundwater Hydrologists, Geologists, Environmental Scientists					
* Laboratory Services					
ISCO AUTOMATIC WATER SAMPLER CHAIN OF CUSTODY FORM					
Job: _____		Site: _____			
Time: _____		Day: _____		Date: _____	
Sampler Bottles Changed by: _____					
Sample #1	Time: _____	Day: _____	Date: _____		
Sample #2	Time: _____	Day: _____	Date: _____		
Last Sample #	Time: _____	Day: _____	Date: _____		
Sampling Interval: _____ hours					
Battery Status: _____		Battery Last Changed on: _____			
Staff Gage Reading: _____					
NOTES: _____					
Note: This form must be attached to ISCO Sampler Bottom Carrying Case at all times. Replace with new form after washing bottles.					
Relinquished by (Signature):	Date:	Received by (Signature):	Relinquished by (Signature):	Date:	Received by (Signature):
Representing:	Time:	Representing:	Representing:	Time:	Representing:
Relinquished by (Signature):	Date:	Received by (Signature):	Relinquished by (Signature):	Date:	Received by (Signature):
Representing:	Time:	Representing:	Representing:	Time:	Representing:

Figure 3.1

4. Instrumentation

After the elution of the activated charcoal receptors, the elutant is analyzed quantitatively for dye on a Shimadzu Model RF 5301PC scanning spectrofluorophotometer (Figure 4.1). Water samples are also analyzed on the Shimadzu Model RF 5301PC.

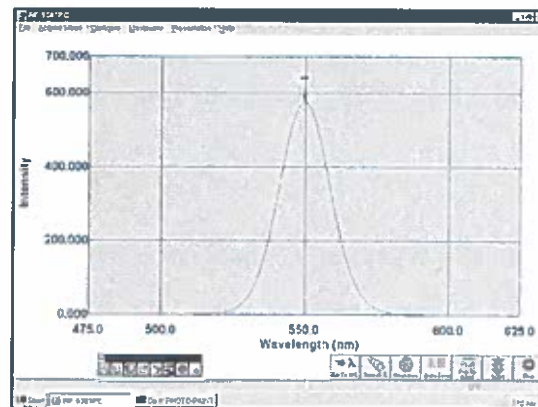


Figure 4.1

5. Charcoal Testing

5.1 Preparation

1. Charcoal dye receptors are washed under a high-speed jet of tap water to remove as much sediment as possible.
2. A typed label containing the site location name, sample number, and date of collection are stapled to each receptor.
3. The receptors are placed in an oven and dried for 12 hours at 49° C.
4. 0.5 grams of charcoal is weighed and placed into a disposable plastic container that is labeled with the sample identification number.
5. The remainder of the charcoal is returned to its original zip-lock bag and stored until the dye trace investigation is complete.
6. 5.0 ml of Smart solution (an eluent consisting of 1-propanol 100% assay, distilled water, and ammonium hydroxide 28-30% assay mixed at a ratio of 5:3:2) is added to the charcoal and the plastic container is capped.
7. After 30 minutes, all of the elutant is transferred into a KIMAX[®] 51 borosilicate glass test tubes that is then sealed with a polypropylene cap.
8. The sample trays are then placed in a constant temperature bath, covered to prevent photochemical decay and allowed to equilibrate to the 30° C analysis temperature.
9. The test tube is then placed in the Shimadzu RF 5301PC spectrofluorophotometer for analysis by synchronous scanning.

5.2 Analysis

Analysis on a scanning spectrofluorophotometer provides the lowest detection limits and most reliable dye analysis. For a typical analysis for Tinopal CBS-X Direct Yellow 96, Fluorescein, Rhodamine WT, Eosine, FD&C Red 3, D&C Red 28 or Sulphorhodamine B, a synchronous scan is performed where the excitation and emission monochromators are kept at a fixed wavelength separation during the scan. The emission spectra from the synchronous scan is displayed on the monitor and plotted on a laser printer (Figure 5.2.1).

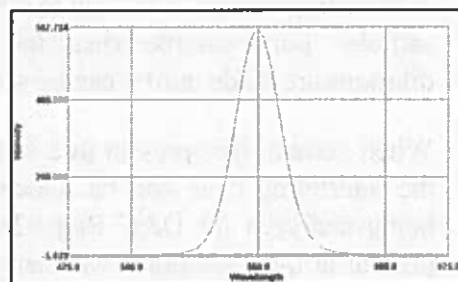


Figure 5.2.1

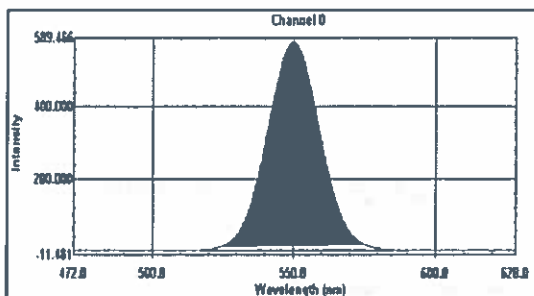
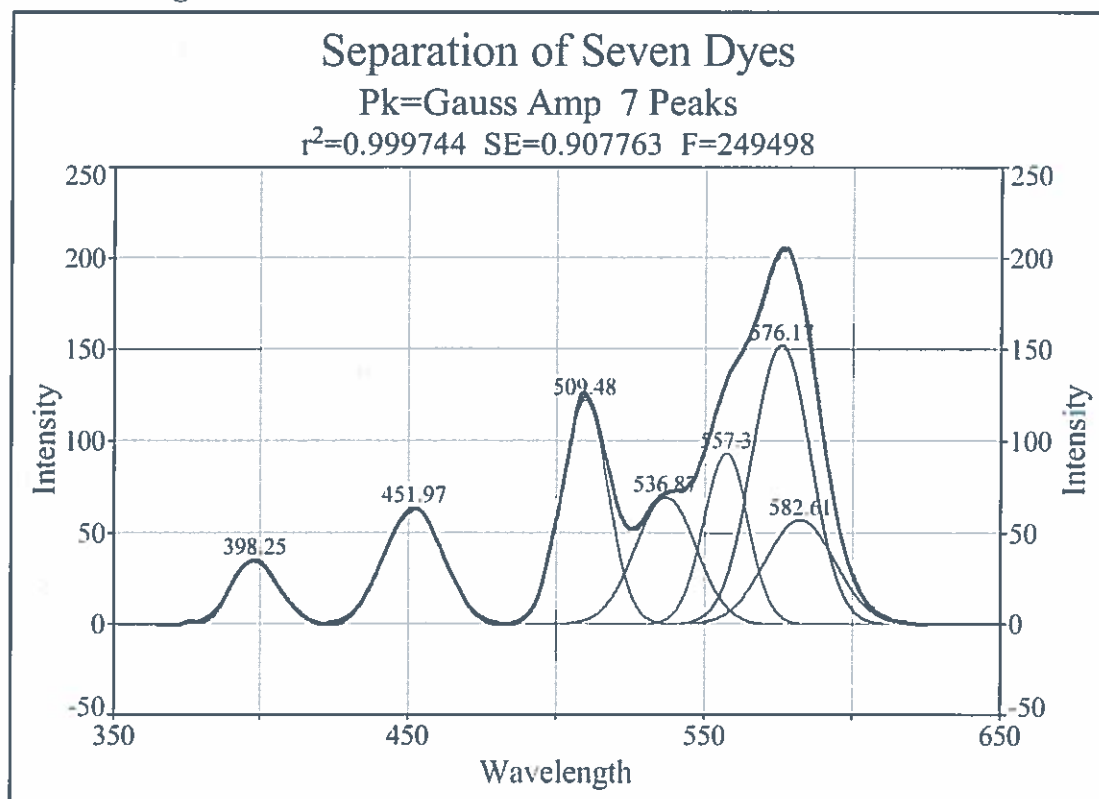


Figure 5.2.2

The printout has the file number, sample identifier, job name, date collected and scanning parameters at the bottom of the page. If the scan indicates positive results for fluorescent dye, a second printout is made utilizing spectrum integration and calibration curves stored in the computer to determine the concentration of the dye in question (Figure 5.2.2). If the emission spectra from two or more dyes overlap, then the



spectra for each dye is separated by use of a non-linear curve-fitting computer program specifically designed for spectral separation (Figure 5.2.3). Spectrum integration and calibration curves stored in the computer are then used to determine the concentration of each individual dye present in the sample. For a sample where the concentration is approaching the quenching threshold, serial dilutions are made until it can be scanned without quenching occurring.

When certain dyes present in a sample interfere with the identification of others, one or more of the interfering dyes will be selectively destroyed in that particular sample. When a sample is being analyzed for D&C Red #28 and Sulphorhodamine B simultaneously, anytime a peak is present in the appropriate wavelength range, the sample will be modified in order to separate the two peaks further. Other types of special analyses include Stoke's Shift variation, excitation spectrum scans, and emission spectrum scans.

6. Water Sample Testing

6.1 Preparation

1. Water samples are removed from locked refrigerator.
2. A typed laboratory identification tag containing the project name, site location number and collection date is taped to each sample bottle.
3. A 3.0 ml aliquot is withdrawn from the bottle using a disposable polyethylene pipette and placed into a KIMAX®51 borosilicate glass test tube which is then sealed with a polypropylene cap.
4. The sample trays are then placed in a constant temperature bath, covered to prevent photochemical decay and allowed to equilibrate to the 30° C analysis temperature
5. The test tube is then placed in the Shimadzu RF 5301PC spectrofluorophotometer for analysis by synchronous scanning.

6.2 Analysis

The analysis for water samples is performed by synchronous scanning on the spectrofluorophotometer. The synchronous scanning technique is similar to the analysis for eluted charcoal samples with the scanning parameters adjusted to compensate for shifts in the excitation and emission maximum wavelengths as well as differences in the Stoke's shift caused by the differences in pH and polarity of water as compared to elutant. The emission spectra from the synchronous scan is displayed on the monitor and plotted on a laser printer. The printout has the sample identifier, job name, date collected and scanning parameters at the bottom of the page. If the scan indicates positive results for fluorescent dye, a second printout is made utilizing spectrum integration and calibration curves stored in the computer to determine the concentration of the dye in question. If the emission spectra from two or more dyes overlap, then the spectra for each dye is separated by use of a non-linear curve-fitting computer program specifically designed for spectral separation. Spectrum integration is then used to determine the concentration of each individual dye present in the sample. For a sample where the concentration is approaching the quenching threshold, serial dilutions will be made until it can be scanned without quenching occurring.

7. Dye Quantification

7.1 Standards

The standards for analysis of water samples are prepared in distilled water. Standards for eluted charcoal sample analysis are prepared in the eluent to be used for eluting the dye from the

charcoal. This is usually the Smart solution since research by Crawford and Associates (Turner, 1993) indicates that it elutes more dye from the charcoal than other eluents tested. The dye concentration in the dye sample used for standard preparation is based upon the dye assay figures provided by the dye manufacturer. The Crawford Hydrology Laboratory contacts the dye manufacturer and obtains the exact figures each time standards are made.

7.2 Notes on Dye Quantification

Dye concentrations are expressed in ppb. Although the dye concentration in water samples expressed in ppb is an accurate quantitative measurement of the amount of dye in the stream at the time the sample was collected, the same is not true for the eluted charcoal samples. It is only semi-quantitative compared with the actual quantity of dye in the water passing over the receptor. The quantity of dye absorbed by the charcoal is a function of the dye concentration in the water and the quantity, velocity, temperature and duration of exposure. Turbidity and the quantity and species of molecules competing with the dye for the charcoal acceptor sites can reduce the quantity of dye absorbed onto the charcoal. Also, the quantity of dye eluted from the charcoal is dependent on the amount of charcoal and eluent used, the type of eluent, whether the charcoal is wet or dry before elution, and the length of time the charcoal is eluted before being analyzed. The laboratory procedures can be standardized but the exposure variabilities while the receptor is in the stream cannot be. Although, dye concentrations for eluted samples are measured and recorded in ppb, these values will virtually always be much higher than the dye concentrations ever reached in the stream. Also, because of the several water exposure variables, the concentration of dye absorbed by the charcoal does not even accurately represent the quantity of dye that flowed in the stream past the dye receptor. Analysis of two dye receptors placed in the same general area of the same stream for the same time period will often result in large differences when expressed in ppb. Therefore, the following abbreviations are used to express the dye concentration in more general terms rather than ppb:

ND	Below Quantitation Limit
+	Positive
++	Very Positive
+++	Extremely Positive
B	Background
NS	Dye receptor not recovered

Although dye concentrations obtained from charcoal dye receptors do not accurately reflect the concentration in the source water, detection of dye at a sufficient concentration above background levels does constitute a positive trace. If a quantitative dye trace is necessary, it must be based on dye analysis of water samples, not charcoal. The Crawford Hydrology Laboratory frequently performs quantitative traces by collecting water samples with an ISCO automatic water sampler. This method provides a dye breakthrough curve, which is an accurate measurement of the dye concentration in the stream as the dye cloud passes the monitoring site.

8. Criteria for Interpreting Results of Synchronous Scanning

Interpretation of dye tracing data is not the same as interpreting the results of chemical analyses. Background levels of dye are often present above the quantitation limits of the fluorescent dyes used for tracing. One of the reasons for these background levels is due to the commercial use of the various dyes used for tracing. Non-toxic fluorescent dyes are rare. For this reason, the dyes used for tracing can often be found in products ranging from food coloring to toilet bowl cleaners. Another reason for these background levels is the extremely low detection limits of fluorescent dyes. Virtually any tracer will have background levels if one can measure at very low concentrations. Figure 8.1 is a histogram of dye levels from an actual dye trace where background dye was present. This particular dye was not even used for the trace, nor had any other dye trace

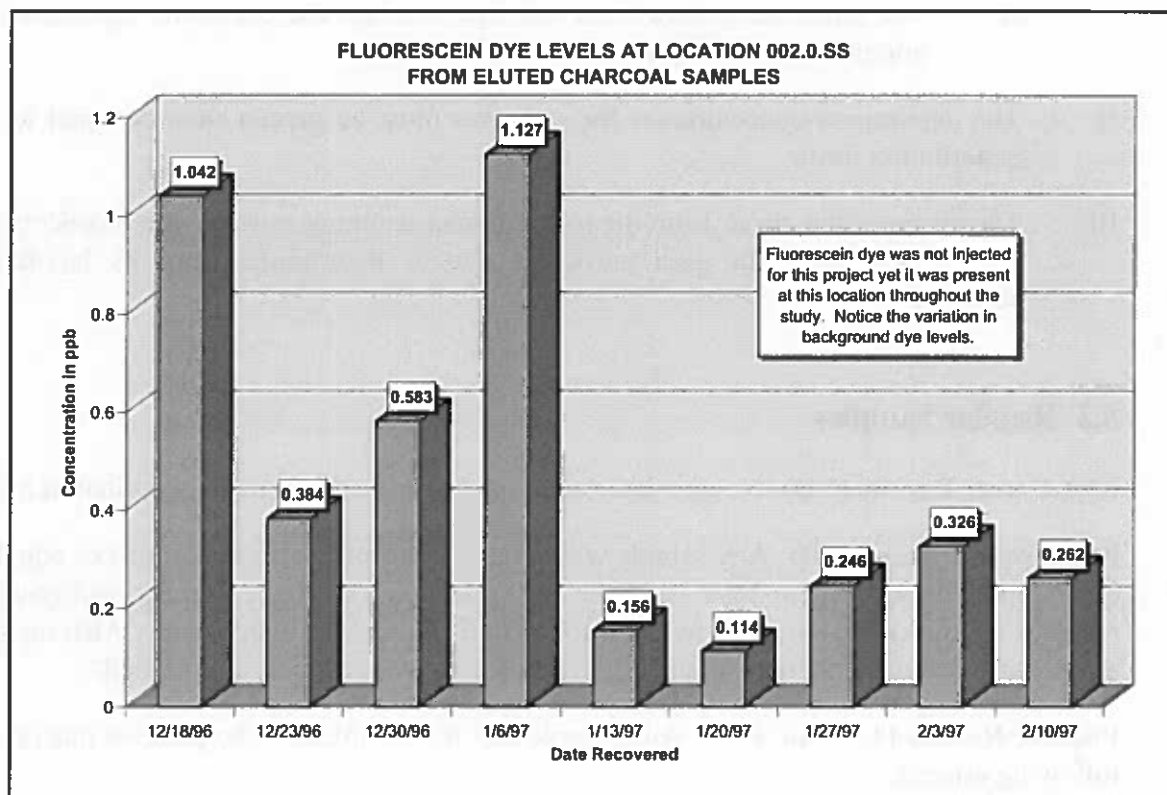


Figure 8.1

been performed in this area in the past. Background levels often fluctuate more in karst aquifers and to this end, Crawford and Associates, Inc. developed a standard protocol used to determine what is background, what is positive, and what is negative (non-detect). This protocol is based upon the results of over 900 dye tracer investigations Dr. Crawford has performed over the last 20 years. It has been used for dye tracer studies at numerous State and EPA Superfund sites as well as at Industrial Sites.

8.1 Background Samples

In order for background fluorescence to be recorded, it must meet the following conditions:

- I. The recorded peak of the curve must be within + or - 5 nm for Fluorescein, Eosine, FD&C Red 3, D&C Red 28, Rhodamine WT and Sulphorhodamine B and within + or - 10 nm for D&C Green 8, Direct Yellow 96 and Tinopal CBS-X (Optical Brightener). The only times exceptions may be made are:
 - A. A water sample collected at the same location verifies the presence of the dye in question.
 - B. The emission spectra from one dye overlaps the excitation spectra of another dye, causing a shift in peak position.
- II. The determined concentration for each dye must be greater than or equal to the quantitation limit.
- III. The shape of the curve from the synchronous scanning must be the characteristic symmetrical shape of each particular dye as determined from its laboratory standard.

8.2 Regular Samples

Non-Detect Results (ND)- No dye detected at or above the determined quantitation limit.

Background Results (B)- Any sample which has a concentration greater than or equal to the quantitation limit, but less than 10 times the concentration of the highest background dye receptor analyzed shall be reported as Background (B) on the report sheet. Also included is any sample that does not meet the qualification for a positive result designation.

Positive Results (+, ++ or +++)- Any sample that is determined to be positive must meet the following criteria:

- I. The recorded peak of the curve must be within + or - 5 nm for Fluorescein, Eosine, FD&C Red 3, D&C Red 28, Rhodamine WT and Sulphorhodamine B and within + or - 10 nm for D&C Green 8, Direct Yellow 96 and Tinopal CBS-X (Optical Brightener). The only times exceptions may be made are:
 - A. A water sample collected at the same location verifies the presence of the dye in question.
 - B. The emission spectrum from one dye overlaps the excitation spectra of another dye, causing a shift in peak position.

- II. The determined concentration for each dye must be greater than or equal to 10 times the quantitation limit. This means that for a dye with a quantitation limit of 0.01 parts per billion, no sample can be designated Positive (+) unless its concentration is greater than or equal to 0.10 parts per billion.
- III. A sample must have a concentration 10 times the concentration of the highest background dye receptor analyzed before being reported as Positive (+) on the report sheet.
- IV. The concentration of the dye eluted from the charcoal must display a rise and fall, similar to a dye breakthrough, over a period of time (Figure 8.2.1). Consequently, no location shall be called positive if there is only one occasion when the dye concentration met the above criteria. A minimum of two positives is needed in order to say that a particular location had a positive trace. If only one sample qualifies for a positive designation, then the location will either be designated as a potential positive, or the trace will be repeated.

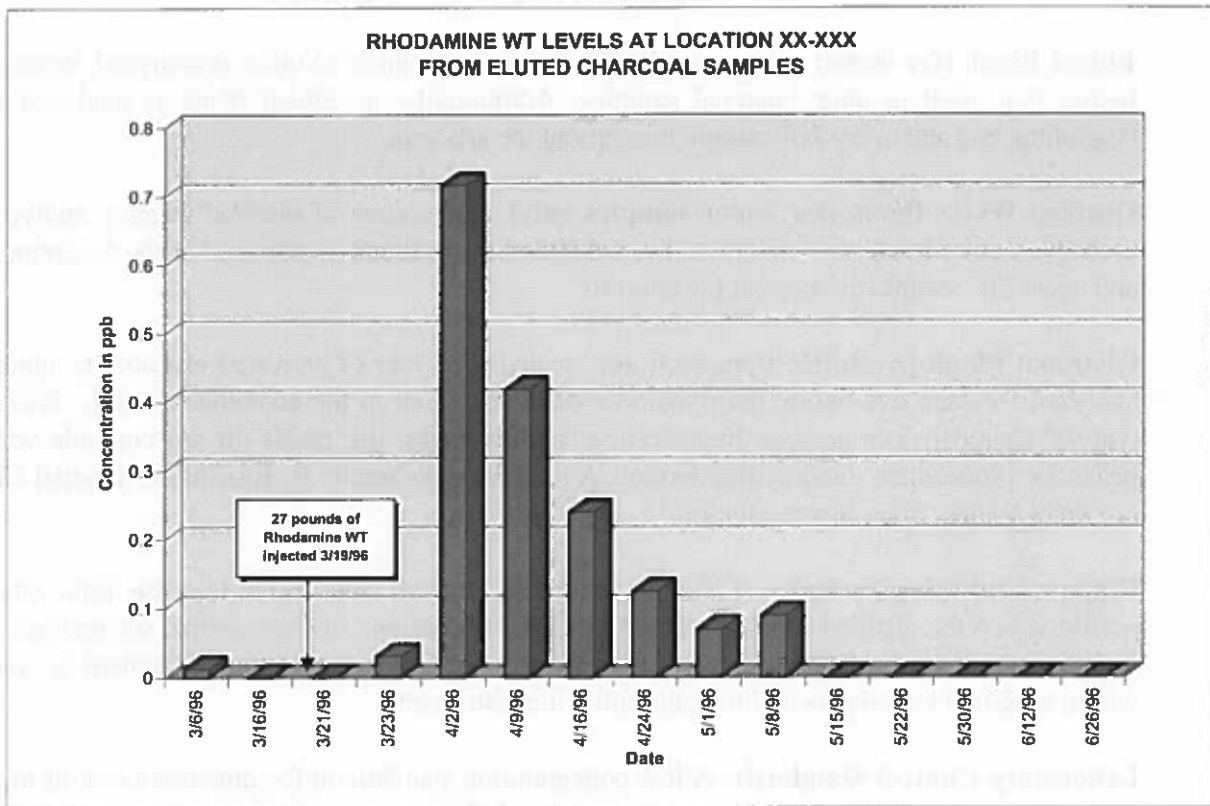


Figure 8.2.1

- V. The shape of the curve from the synchronous scanning must be the characteristic symmetrical shape of each particular dye as determined from its laboratory standard.
- VI. The presence of dye at a particular location must not be attributable to any source other than the dye injected for the purpose of conducting the dye trace.

9. Quality Control Samples

9.1 Field Duplicates

Duplicate dye receptors are placed at 20 percent or more of the sites to be monitored. The second receptor serves as a back-up in the event that the primary receptor is lost or stolen. The secondary receptors are analyzed as duplicates for at least 10 percent of the total dye receptor locations.

9.2 Trip Blanks

At least two trip blanks are prepared in the laboratory and sent along with the new dye receptors to the field. The trip blanks are then kept with the old dye receptors as they are being collected in the field, returned to the laboratory, and analyzed.

10. Laboratory QA/QC Samples

Eluent Blank (for eluted samples only)- Each batch of eluent solution is analyzed for each dye before it is used to elute charcoal samples. Additionally, an eluent blank is analyzed at the beginning, end and every 20th sample throughout the analysis.

Distilled Water Blank (for water samples only)- Each batch of distilled water is analyzed for each dye before it is used. Additionally, a distilled water blank is analyzed at the beginning, end and every 20th sample throughout the analysis.

Charcoal Blank- A sample from each new sealed container of activated charcoal is eluted and analyzed for each dye before the remainder of the charcoal in the container is used. While this type of charcoal does possess fluorescence characteristics, the peaks do not coincide with the peaks for Fluorescein, Eosine, Rhodamine WT, Sulphorhodamine B, Lissamine, Tinopal CBS-X or Direct Yellow 96 in Smart solution.

Raman Scattering Sample- A Raman scattering pattern and signal-to-noise ratio check is performed on the distilled water blank at the beginning and end of each sample set analysis. This is the method recommended by the manufacturer for insuring that the instrument is working within specified parameters and for calibrating the instrument.

Laboratory Control Standards- A low concentration standard, at the quantitation limit for each of the dyes to be analyzed, is analyzed before and after each set of samples. This demonstrates that the Shimadzu is capable of detection at the minimum detection limit and provides data that can be used to determine the accuracy and precision of the analysis. One low concentration standard is also analyzed after every 20 samples.

11. Analysis Order

Analysis will be performed in the presumed sequence of no dye to low dye to high dye concentration as follows:

1. Distilled water blank
2. Eluent blank
3. Laboratory control standard for each dye
4. Trip blank
5. Samples of presumed low concentration
6. Samples of presumed high concentration
7. Distilled water blank
8. Laboratory control standard for each dye

APPENDIX III

FLUORESCENT CHARACTERISTICS OF TRACER DYES

FLUORESCENCE CHARACTERISTICS OF TRACER DYES

EMISSION WAVELENGTHS FOR DYES

ELUTED SAMPLES

Tinopal CBS-X.....	395.8 nm
Solophenol 500 (Direct Yellow 96)	450.2 nm
D&C Green #8	494.6 nm
Fluorescein	515.8 nm
Eosine.....	541.4 nm
FD&C Red #3	550.2 nm
D&C Red #28.....	564.8 nm
Rhodamine WT	567.8 nm
Sulphorhodamine B.....	578.6 nm

WATER SAMPLES

Tinopal CBS-X.....	394.4 nm
Solophenol 500 (Direct Yellow 96)	449.2 nm
D&C Green #8	490.2 nm
Fluorescein	509.8 nm
Eosine.....	535.4 nm
FD&C Red #3	546.2 nm
D&C Red #28.....	556.2 nm
Rhodamine WT	576.2 nm
Sulphorhodamine B.....	583.2 nm

APPENDIX IV

MATRIX INTERFERENCE INVESTIGATION

MATRIX INTERFERENCE INVESTIGATION RESEARCH PROCEDURES

1. SAMPLE COLLECTION

A water sample will be collected from each monitoring location and dye injection point for which matrix interference testing is desired. The selection of these locations will be based on:

1. pH and conductivity readings
2. Abnormal water color or odor
3. Results of previous analytical testing
4. The size and location of the hydrologic feature.

A water sample volume of at least 500 ml will be taken in a clean, well-labeled container. The label will contain the name and inventory number of the hydrologic feature, the job name, date and time of sample collection, and initials of persons collecting sample. Along with water samples from selected monitoring locations, a 500 ml volume of distilled water will be used as a control mechanism. This control sample will be processed using the same procedures as the matrix interference samples. The control sample will be used to quantify any effects the contaminants may have had upon dyes being tested

2. BACKGROUND DYE LEVELS

The water samples will be tested for background levels of selected dyes by synchronous scanning on a Shimadzu RF-5301 PC Spectrofluorophotometer. A 3 ml aliquot of water from each sample location will be analyzed in accordance with Crawford Hydrology Laboratory Procedures and Quality Assurance/Quality Control Plan (Appendix II).

3. SPIKED WATER SAMPLES

Standard concentrations of dye with which to spike the water samples will be made. The target spike concentration will be 1 ppb. A standard concentration of 10 ppb for each dye to be tested will be created first. Beginning with the control sample, 90 grams of water from each sample location will be placed in an appropriately labeled flask. Next, 10 grams of 10 ppb dye standard will be added for each dye which testing is desired. This will result in the water samples having a dye concentration of 1 ppb. Only two dyes will be tested in an individual flask. Although all charcoal dyes used by Crawford and Associates can be analyzed for simultaneously, this requires Peakfit analysis, which is very time consuming. Therefore, from one to three flasks containing spiked water samples will be used. The sample flasks will then be agitated to ensure thorough mixing of dye. Afterwards, 3 ml. aliquots will be removed from the labeled flasks with disposable transfer pipettes and placed in labeled KIMAX®51 borosilicate glass test tubes.

These samples will be analyzed in accordance with the Crawford Hydrology Laboratory Procedures and Quality Assurance/Quality Control Plan (Appendix II) to assess what extent the contaminants have impacted the dye in the water.

4. SPIKED CHARCOAL SAMPLES

Charcoal packets containing 1.5 grams of activated coconut charcoal will be placed in each spiked solution. The charcoal packets will remain within the flasks for two hours. They will then be individually removed, processed, and analyzed in accordance with the Crawford Hydrology Laboratory Procedures and Quality Assurance/Quality Control Plan (Appendix II).

5. RESIDUAL DYE

A 3 ml aliquot of water will be removed from each of the spiked solutions and placed into labeled culture tubes. These will then be analyzed in accordance with the Crawford Hydrology Laboratory Procedures and Quality Assurance/Quality Control Plan (Appendix II). This analysis is performed to obtain the concentrations of dye remaining in the spiked solution after removal of the charcoal.

6. MATRIX INTERFERENCE REPORT

The results from each of the four scanning events will be recorded and plotted. Results are then analyzed to assess the impact of contaminants upon tested dyes. A small report will be generated that addresses the impact of matrix interference on each of the dyes tested. Dye type and quantity injected will be determined, in part, by the information included in this report.

APPENDIX D

CLEARANCE REQUEST FORM 103



BASE CIVIL ENGINEERING WORK CLEARANCE REQUEST (See Instructions on Reverse)				DATE PREPARED	
1. Clearance is requested to proceed with work at _____					
on Work Order No. _____, Contract No. _____, involving excavation or utility disturbance per attached sketch. This area <input type="checkbox"/> has <input type="checkbox"/> has not been staked or clearly marked.					
2. TYPE OF FACILITY/WORK INVOLVED					
<input type="checkbox"/> A. PAVEMENTS		<input type="checkbox"/> D. FIRE DETECTION & PROTECTION SYSTEMS		<input type="checkbox"/> G. AIRCRAFT OR VEHICULAR TRAFFIC FLOW	
<input type="checkbox"/> B. DRAINAGE SYSTEMS		<input type="checkbox"/> E. UTILITY <input type="checkbox"/> OVERHEAD <input type="checkbox"/> UNDERGROUND		<input type="checkbox"/> H. SECURITY	
<input type="checkbox"/> C. RAILROAD TRACKS		<input type="checkbox"/> F. COMM <input type="checkbox"/> OVERHEAD <input type="checkbox"/> UNDERGROUND		<input type="checkbox"/> I. OTHER	
3. DATE CLEARANCE REQUIRED			4. DATE OF CLEARANCE		
5. SIGNATURE OF REQUESTING OFFICIAL			6. TELEPHONE NO.		7. ORGANIZATION
ORGANIZATION		REMARKS (Use Reverse for additional comments)		REVIEWER'S NAME AND INITIALS	
8 B A S E C I V I L E N G I N E E R I N G	A. ELECTRICAL DISTRIBUTION	CES ELECTRICAL SHOP BLDG 20010 PH 366-4275 (AIRFIELD WORK)			
	B. STEAM DISTRIBUTION	N/A		N/A	
	C. WATER DISTRIBUTION	CES UTILITIES SHOP BLDG 18001 PH 366-4305			
	D. POL DISTRIBUTION	CES LIQUID FUELS BLDG 26215 PH 366-8225			
	E. SEWER DISTRIBUTION	CES UTILITIES SHOP BLDG 18001 PH 366-4305			
	F. ENVIRONMENTAL	CES ENVIRONMENTAL BLDG 18001 PH 366-2556			
	G. PAVEMENTS/ GROUNDS	CES EQUIPMENT SHOP BLDG 20021 PH 366-2483			
	H. FIRE PROTECTION	F.D. TECH SERVICES BLDG 1722A PH 366-5261			
	I. ZONE HVAC	CES HVAC SHOP BLDG 18001 PH 366-5083			
	J. OTHER (Specify) 36 CES/ Customer Support	CES Customer Support BLDG 18001 PH 366-2915-17			
9. SECURITY POLICE		POLICE SERVICES BLDG 23020 PH 366-4510			
10. SAFETY		WING SAFETY BLDG 23003 PH 366-7233			
11. COMMUNICATIONS		CABLE MAINTENANCE BLDG 25008 PH 366-2626			
12. BASE OPERATIONS		ON / NEAR AIRFIELD BLDG 17002 PH 366-4188			
13. CABLE TV		Marionnas Cable Vision (See Attached Form) PH 635-4041			
14. COMMERCIAL UTILITY COMPANY		Guani Telephone Auth. (See Attached Form) PH 647-6297			
<input checked="" type="checkbox"/> TELEPHONE		DZSP21 FACILITIES ENGINEERING PH 333-2951 (See Attached Form)			
<input type="checkbox"/> GAS					
<input checked="" type="checkbox"/> ELECTRIC					
15. OTHER (Specify) _____					
16. REQUESTED CLEARANCE <input type="checkbox"/> APPROVED <input type="checkbox"/> DISAPPROVED					
17. TYPED NAME AND SIGNATURE OF APPROVING OFFICER (Chief of Operations Flight or Chief of Engineering Flight)					17a. DATE SIGNED

INSTRUCTIONS

The SCE work clearance request is used for any work (contract or in-house) that may disrupt aircraft or vehicular traffic flow, base utility services, protection provided by fire and intrusion alarm system, or routine activities of the installation. This form is used to coordinate the required work with key base activities and keep customer inconvenience to a minimum. It is also used to identify potentially hazardous work conditions in an attempt to prevent accidents. The work clearance request is processed just prior to the start of work. If delays are encountered and the conditions at the job site change (or may have changed) this work clearance request must be reprocessed.

15. REMARKS. (This section must describe specific precautionary measure to be taken before and during work accomplishment. Specific comments concerning the approved method of excavation, hand or powered equipment, should be included.)



**Base Civil Engineer Work Clearance Request
COMPLIANCE WITH THIS PUBLICATION IS MANDATORY**

OPR: 36 CES/CEOQC
TSgt David Lawrence

This Operating Instruction (OI) outlines the procedures to process a Base Civil Engineer (BCE) Work Clearance Request (AF Form 103). It applies to all DOD personnel and contractors working on Andersen AFB property.

1. **PURPOSE:** The BCE work clearance request is used for any excavation that breaks the crust of the earth or any work that may disrupt aircraft or vehicular traffic flow, base utility (electric, water, sewer, gas, services or protection provided by fire and intrusion alarm systems). The AFF 103 is not an approval document to perform work. The form is used to coordinate the required work with key base activities and keep customer inconvenience to a minimum. It is also used to identify potentially hazardous work conditions in an attempt to prevent accidents. The work clearance request is processed just prior to the start of work. If delays are encountered and the conditions at the job site change (or may have changed) this work clearance request must be reprocessed.

2. **REQUESTER:** The requester will ensure the AF Form 103 is filled out accurately and in its entirety to include:

2.1 Blocks 1 – 7 must be completed thoroughly, accurately and legibly.

2.2 The requester will obtain all coordination indicated in sections 3 and 4 listed. Failure to do so will prolong the approval process.

2.4 The requester will also provide a site map provided by 36 CES/CEC with the area affected drawn in including accurate dimensions.

2.5 The requester will mark any excavation areas exactly using white paint at the job site

3. COORDINATION FOR EXCAVATION

3.1 BCE agencies will review the request and identify any possible conflicts or utility lines within 50 feet of the proposed work. Either "CLEAR" or "LINES IN AREA" will be annotated in the appropriate coordination block and continued in block 18 (reverse) if necessary. BCE shops will mark all utilities within 20 feet of the proposed site within 72 hours of excavation in accordance with paragraphs 6 and 7. Shop concurrence and adherence to this guidance is indicated by signing off in the indicated block.

3.2 Blocks 8 – 12 must be coordinated by all agencies indicated. The coordinating agency will note any possible conflicts or utilities within 50' of the proposed work in their coordination block and continue in Block 18 (reverse) if required. Only utilities within 20 feet require marking. Security Forces, Base Safety, Communications Squadron and Base Operations have concerns outside of utility protection. These agencies will coordinate on the AFF 103 and identify potential problems and requirements as

necessary.

3.3 Blocks 13 – 15; Commercial Utilities: The following off-base agencies require paperwork processing outside of the AFF 332. Examples are included as attachments 1 -3. Coordination through these agencies are required. Procedures are as follows:

3.3.1 Guam Telephone Authority: Attachment 1 must be filled out completely and either hand carried or faxed to GTA. Their offices are located on Marianas Blvd in Dededo. Phone number: 647-6297. Fax number: 644-2006

3.3.2 Marianas Cable Vision: Attachment 2 must be filled out completely and either hand carried or faxed to MCV. Their offices are located on Harmon Loop. Phone number: 653-4628 Fax number: 632-1500.

3.3.3 Raytheon Technical Services Guam is a sub contractor to Navy Public Works Center and is responsible for the electrical distribution system on and around Andersen AFB with exception to the airfield. Attachment 3 must be filled out completely and either hand carried or faxed to Raytheon. Office hours are Mon through Fri 0730 to 1630. Their offices are located in building 103, COMNAVMAR, upper deck (2nd floor). Phone number: 339-8296. Fax number: 333-2113

3.4 Block 18 (reverse) will also indicate the method (hand or powered equipment), length, width and depth of the excavation.

4. COORDINATION FOR UTILITY OUTAGES

4.1 Only the following blocks are required for utility outages:

- 8A Electrical Distribution
- 8H Fire Protection
- 8I HVAC
- 8J Other (36 CES/CEOI)
- 9 Security Police
- 11 Communications
- 14 Raytheon
- 15 Other (36 CES/CEC)

4.2 Block 18 (reverse) must list the buildings affected, the person contacted at each facility and any public announcement method used.

5. APPROVAL: The Operations Flight Chief is the approval authority for all AF Forms 103 regardless of the originating agency. At least 2 duty days must be allowed for the approval.

6. EXCAVATION

6.1 A copy of the APPROVED permit shall be maintained on the work site and within each piece of equipment excavating at all times.

6.2. The excavators shall HAND DIG within 5 feet of utility markings. This will minimize possible damage to the utilities until it is exposed.

7. STANDARD COLOR CODE FOR UTILITY MARKING

7.1. Each organization or utility that has subsurface installations on Andersen AFB shall mark those utilities using the following color code:

7.1.2. RED: electric power, primary and secondary transmission installations, and cathodic protection.

7.1.3. YELLOW: propane gas and oil distribution and transmission installations, or installations containing or transporting dangerous materials, products or steam.

7.1.4. ORANGE: telephone and telegraph systems, cable television, police and fire communication installations.

7.1.5. BLUE: water lines, refrigerant lines, and chilled water lines.

7.1.6. GREEN: sanitary sewers, slurry pipelines, building sewers, and storm drains.

7.1.7. WHITE: all individuals, in-house and contractors working on Andersen AFB, shall mark the excavation area with white paint and or flags prior to any markings of utilities.

7.1.8. Abandoned Utilities: shall be marked using the same color code with "ABD" added in black bold lettering

8. MARKING UTILITIES

8.1 Within 20 feet of excavation. Every 10 – 15 feet paint a one foot line in the running direction of the buried utility in open fields or grass common areas; flags are optional in these areas.

8.2 Place flags in tall grass, bushy and jungle areas.

8.3 Use roosters (colored tops) and nails in gravel roadways.

8.4 Use 1 ½ inch diameter dots (color-coded) in all asphalt roadways, sidewalks, and the top or back side of curbs and gutters.

8.5 Mark an 18-inch to 3-foot circle around phone pedestals, electrical transformers and section cans. Locations where utilities cross and go off in more than one direction, place an 18-inch to 3-foot circle with arrows indicating direction.

MARVIN SMITH, Lt Col, USAF
Commander

Attachments:

- 1: Guam Telephone Authority
- 2: Marianas Cable Vision
- 3: Raytheon Technical Services



P.O. Box 9008
Tamuning, Guam 96911

624 North Marine Corps Drive
Tamuning, Guam 96911

EXCAVATION CLEARANCE

REQUEST NO. _____

DATE: _____

REQUESTOR: _____

EXCAVATION CONDUCTED BY: _____

PROJECT SITE: _____

DATE OF CONSTRUCTION: _____

SCOPE OF WORK: _____

JOB SITE CONTACT PERSON: _____ TEL. NO.: _____

GTA SCHEDULED DATE: _____ TIME: _____

The GTA hereby grants the undersigned excavation clearance under the auspices of Public Law 25-34 Section 3, Section 71110 of Chapter 71 and Section 6, Section 71109 of Chapter 71.

As the Authority will merely be marking the actual routing of its buried cable, the undersigned shall not excavate within 1.5 feet on either side of said cables, and shall take extreme caution when excavating around said markings;

Barring unforeseen weather conditions, the undersigned shall insure that all previously established markings are visible, and shall immediately request from the Authority for subsequent reestablishment. Accordingly, the Authority solely grants clearances to the immediate area requiring excavation and shall grant further clearance upon completion of the first request, and will not entertain extremely-sizeable developments that it has deemed to require revisiting; clearance are only valid for a period of 5 days from date of issue.



P.O. Box 9008
Tamuning, Guam 96911

624 North Marine Corps Drive
Tamuning, Guam 96911

Requirements

- Audit & Collection must approve applicant for Cable Clearance.
- If approved by Audit & Collection, the Compliance Officer will contact customer to see if encroachment permit is needed for the project. The Compliance Officer will sign the Cable Clearance for request for DPW's approval.
- When approved by DPW the customer must call GTA to be scheduled 24 hours (excluding weekends and holidays) before start of project because of the 5-day work period from date of issue.
- The Compliance Officers will mark all GTA facilities one (1) foot or more if needed (Footage distance depends on project to be cleared)
- Approved Excavation Clearance Form must be at the Job Site along with the DPW Permit.
- In the event of damages, and for clarification purposes, the undersigned hereby acknowledges complete liability to the following, two (2) restoration costs:

Section 3- Civil Penalties. (If no clearance given) Any person who violates any provision may be subject to a civil penalty not to exceed Five Thousand Dollars (\$5,000.00) for the first violation, and not to exceed Ten Thousand Dollars (\$10,000.00) for each successive violation within a five (5) year period; and

Section 6- Cost of Repairing. Any person who damages a utility line or roadway is subject to pay for all costs incurred by the operator to restore the utility or roadway to its original condition. If the operator of a utility fails to present the contractor within sixty (60) days after the damage has been repaired, the utility operator may not withhold excavating clearance for other projects which clearance have been requested.

- For purposes of minimizing repeat offenders, and pending resolution to outstanding receivables of a similar nature, the Authority shall not grant future clearances to the undersigned for it and other projects.
 - In order to identify the precise location requiring clearance, the undersigned is required to meet with GTA's Right-Of-Way personnel at the Proposed Site for markings of GTA buried cables upon set date and time.
 - A copy of the approved GTA clearance must be readily available at said site. At random, the Authority may perform field inspections, however it does not relieve the undersigned from the above compliances.
-



P.O. Box 9008
Tamuning, Guam 96911

624 North Marine Corps Drive
Tamuning, Guam 96911

- Permit Agreement for the undersigned to submit for a Highway Encroachment Permit only from DPW Highway Division due to the five (5) working day period.
- Undersigned will take full responsibility for any subcontractor or original contractor liability for damaging GTA facilities. All incurred costs caused by these contractors shall be paid in full by the undersigned and left at the burden of the undersigned to recover his loss.
- Provide work vicinity or excavation site map on page 4.

I have read and understand the requirements as quoted above and acknowledge my responsibility in accordance with set policy.

Print Full Name

Signature

Date

NOTE: In the event of cable damage, immediately contact GTA Right-of-Way personnel at 647-6214/15/17. After working hours, please call 411.

Requestor excavating within the five (5) day period will need to call GTA Compliance Right-of-Way Section for a mark on all GTA Facilities 24 to 48 hours prior to start of excavation.



P.O. Box 9008
Tamuning, Guam 96911

624 North Marine Corps Drive
Tamuning, Guam 96911

Application For DPW Highway Encroachment Permits Clearance Only.

GTA Clearance Granted: YES _____ NO _____

Date Approved: _____ Approved By: _____

If disapproved, please specify why _____

Customer must call GTA for Cable Marking 24 to 48 hours before start of project.

DPW Encroachment Permit No. _____

- Customer must call GTA at the above numbers when approved by DPW to be schedule for Cable Clearance for marking of all GTA facilities.
-

GTA Audit & Collection Clearance:

Approved By: _____ Approval No. _____

If disapproved, please specify why _____

GTA Facilities Marked? YES _____ NO _____

If no, please explain why _____

GTA Official _____ Date _____

PRINT NAME/SIGNATURE



P.O. Box 9008
Tamuning, Guam 96911
624 North Marine Corps Drive
Tamuning, Guam 96911

WORK VICINITY or EXCAVATION SITE MAP

ATTACHMENT 2
MARIANAS CABLE VISION
Request for Underground Cable Locates

Date of request: Request taken

Company Name:

Company Address:

Contact person:

Phone #
W
Home

Date / Time Request:

Scope of Work:

Address / Location:

	Fiber	Coaxial	Service Drop	
Cable involved:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
		.500	.750	

No Cable Involved: _____ Signature _____

Date Completed: _____ Completion Report Technician _____
(Print name)

Time completed: _____ Signature _____

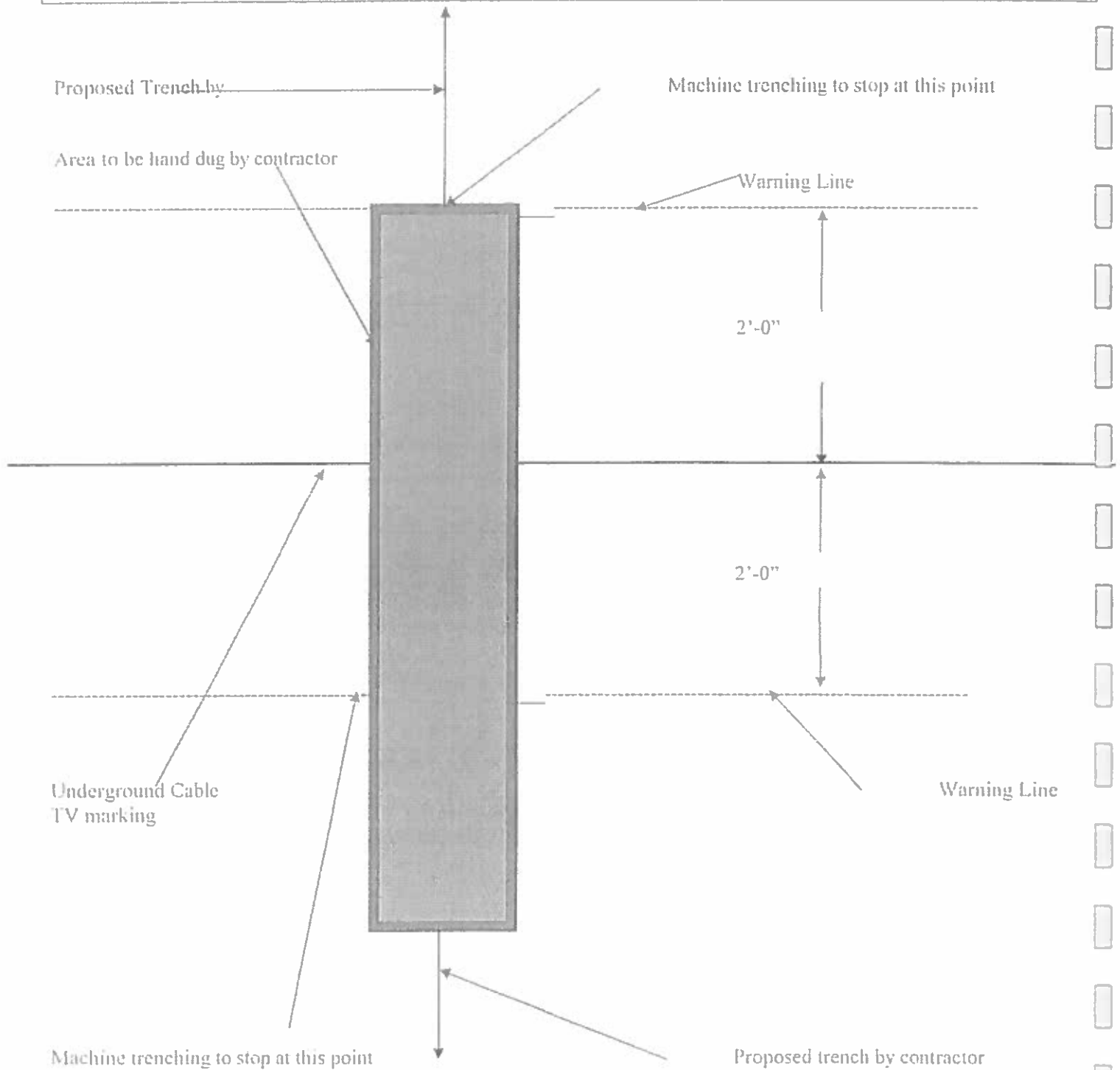
Type of mark used: Paint Survey Ribbon

Important Notice: Contractor acknowledges that machine trenching should stop two (2) feet both side of cable TV in hand dig the remaining area. See attached drawing for detail.

Contractor Signature: _____
Print name: _____

Date: _____
Page 1 of 2

DIGGING INSTRUCTION OVER UNDERGROUND CABLE TV



Received By: _____

Date: _____

ATTACHMENT 3

APPENDIX E

GROUNDWATER MONITORING



THE UNITED STATES AIR FORCE



FINAL

**WORK PLAN AND SAMPLING AND ANALYSIS PLAN
FOR
DYE TRACE STUDY AND GROUNDWATER
MONITORING
AT
OPEN BURN AND OPEN DETONATION RANGE
ANDERSEN AIR FORCE BASE, GUAM**

May 2006

The following section is verbatim from the final Work Plan and Sampling and Analysis Plan for Dye Trace Study and Groundwater Monitoring at Open Burn and Open Detonation Range, Andersen AFB, Guam (EA, 2006).

3.0 GROUNDWATER MONITORING

This section is provided at this stage to establish a mutually agreed upon methodology for the groundwater sampling. In conformance with RCRA Permit GUS002, section IV.A.3, Andersen AFB will submit the result of the DTS with an application for Permit Modification to detail the proposed design, construction, and maintenance of the groundwater monitoring program to examine the quality of the shallow unconfined aquifer beneath the OB/OD for Guam EPA review and approval.

Groundwater monitoring activities will commence following completion of the DTS and Guam EPA approval of the two (2) downgradient groundwater monitoring points. Groundwater monitoring will consist of two rounds of groundwater sampling, conducted approximately six (6) months apart, to correspond with Guam's wet and dry seasons. The wet season extends from July to November and the dry season extends from December to June (Western Regional Climate Center [WRCC], 2005).

Groundwater samples will be at the two (2) downgradient seeps and one (1) upgradient groundwater monitoring point. As discussed earlier in Sections 1.2.6 and 1.2.7, the area upgradient of the OB/OD Range consists of essential wildlife habitats and has the potential for cultural resources. As such, the Air Force and Guam EPA have agreed not to disturb that area, and have selected monitoring well IRP-52B as the upgradient monitoring point (Figure 2-1). IRP-52B, which is located 2,000 feet upgradient of the OB/OD Range, was installed in 1995, and has been sampled on a semi-annual basis since its installation (Appendix G). This well serves as a good background sampling location as no contaminants of concern (COCs) that have been monitored as part of the Basewide Monitoring Program have been detected in groundwater samples at concentrations exceeding the pertinent Maximum Contaminant Levels (MCLs) (EA Engineering, Science and Technology, Inc. [EA], 2005a). However, groundwater samples collected from this well have not been analyzed for explosive residues (SW8330) to date, but will as part of this study.

3.1 Sampling Objectives and Rationale

The specific objectives of the groundwater monitoring are to:

- Collect and evaluate ambient ocean water samples with respect to the target analyte list referenced in the RCRA Permit Part B.
- Collect two (2) rounds of groundwater samples from two (2) downgradient seeps and one (1) upgradient groundwater monitoring point to evaluate the quality of the groundwater with respect to the target analyte list referenced in the RCRA Permit Part B.

All media sampling and field activities will be conducted in accordance with the following approved Basewide documents and their addenda:

- Basewide Health and Safety Plan (HASP) (EA, 2004)
- Basewide SOPs (EA, 2005b)
- Basewide Quality Assurance Project Plan (QAPP) (EA, 2005c)
- Basewide SAP (EA, 2005d)

In the following sections the anticipated field conditions, proposed sample quantities, sample media, analytical parameters, and field procedures/methodologies are presented. The following subsections briefly discuss the types of sampling that will occur during the implementation of the site investigation, and the methods to be used for collection and handling of the samples, including chain-of-custody requirements and quality control samples. The SOPs for sampling techniques are provided in Appendix E. The project-specific analyte list and method reporting limits for seep and groundwater samples are presented in Table 3-1.

TABLE 3-1. RCRA PART B PERMIT TARGET ANALYTE LIST AND ANALYTICAL METHODS

Analyte	Analytical Method
Explosive Residue for Cyclotrimethylene Trinitramine	SW8330
Lead	SW6020
Mercury	SW7470A

3.2 Upgradient Groundwater Well Sampling

One groundwater sample will be collected from monitoring well IRP-52B (Figure 2-1) during each of the two sampling events. The analytical results from the groundwater sample will be used to evaluate groundwater quality upgradient of the OB/OD Range. The groundwater sample will be analyzed for the parameters listed in Table 3-1. All sampling activities will be recorded in a field logbook and all sampling data will be recorded on a field sampling form (SOP #006, *Monitoring Well and Production Well Sampling*, Appendix E).

Prior to collecting a sample at IRP-52B, groundwater will be purged from the well using a low flow portable stainless steel submersible pump. After the monitoring well has been purged, the sample will be collected into appropriate containers using the same stainless steel submersible pump.

The procedures that will be followed for collecting groundwater samples from IRP-52B are described in SOP #006, which is presented in Appendix E. Field measurements of temperature, pH, salinity, chloride, and conductivity will be recorded while purging the monitoring well prior to collecting a groundwater sample (SOP #010, *On-Site Water Quality Testing*, Appendix E). After samples have been collected, the samples will be properly labeled, packed, and shipped to the laboratory for analysis (SOP #026, Appendix E).

Decontamination procedures have been developed in an attempt to eliminate cross-contamination and reduce the risk of contaminants being carried off site. The procedures for decontamination are discussed in SOP #028, *Decontamination of Equipment and Materials Not Used for Sampling* and in SOP #029, *Decontamination of Sampling Equipment* (Appendix E).

3.3 Downgradient Seep Sampling

Two seep samples (including one (1) duplicate sample) will be collected from along the coastline of the OB/OD Range, at locations based on results of the DTS described in Section 2. In order to assure that the seep samples have as little marine water as possible mixed in them, the seep samples will be collected during the lowest daily tide as predicted in the charts published by the University of Guam Marine Laboratory (Table 2-1 and Appendix A).

The seep samples will be analyzed for parameters listed in Table 3-1. The seep samples will be collected in accordance with *Surface Water Sampling* (SOP #007, Appendix E), with the exception of the chloride measurements. According to SOP #007, the field chloride readings should be maintained at a concentration of less than 1,000 milligrams per liter (mg/L). However, due to the location of the seeps and the influence of tidal mixing, and based on past seep sampling experience (Foster Wheeler Environmental Corporation [FWENC]/EA, 2001), chloride concentrations may likely range between 500 and 5,000 mg/L. As a provision the chloride meter will be capable of reading 5,000 mg/L. A reading of 5,000 mg/L or less will be used to constitute a fresh water seep sample (FWENC/EA, 2001).

3.4 Sample Handling Methods and Procedures

This section provides information regarding the sample numbering system, sample shipment procedures, laboratory protocol, and quality control (QC) samples.

3.4.1 Sample Numbering System

Sample identification numbers will be affixed to each sample container and entered on the chain-of-custody form. The sample number will uniquely identify the sample to a specified location. A sample identification system has been developed to provide uniform sample classification throughout Andersen AFB investigations, and to assist project personnel in interpretation of data reports and field notes.

Both field samples and duplicate samples will be labeled in the same manner, and each sample may be identified using a maximum 14-character code.

AAFBMBOBODL001

- The first four characters (**AAFB**) represent that samples were collected for Andersen AFB.
- The next characters (**MB**) identify that samples were collected at the Main Base.

- The following code (**OBOD**) represents the OB or OD unit from which the sample was collected.
- The next single alpha character (**L**) indicates the type of sample. The "L" code signifies the type of sample is for liquid.
- The last three digits (**001**) are sequential identification numbers between 1 and 999 for samples to be collected during this investigation.

For samples requiring multiple containers, a single sample number will apply to every container for that sample. The sample number, along with the date and time of sample collection, will be recorded in the field logbook, on the sample log sheet, and on the sample label affixed to every container.

3.4.2 Sample Handling

The analytical procedures to be used by the laboratory will be those listed in the RCRA Part B Permit. These procedures are found in *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods EPA-SW-846, December 1996*. Table 3-2 presents the requirements for containers, preservation techniques, sample volumes, and holding times for the respective sample methods.

TABLE 3-2. REQUIREMENTS FOR CONTAINERS, PRESERVATION TECHNIQUES, SAMPLE VOLUMES, AND HOLDING TIMES

Analysis	Analytical Method	Sample Container/Size	Preservation	Holding Time
Explosive Residue for Cyclotrimethylene Trinitramine	SW8330	(2) 1-liter amber glass	Cool to 4±2 degrees Celsius (°C)	7 days to extraction, analyze within 40 days after extraction
Lead	SW6020	(1) 1-liter high density plastic	HNO ₃ to pH<2	180 days until analysis
Mercury	SW7470A	(1) 1-liter high density plastic	HNO ₃ to pH<2	28 days until analysis

3.4.3 Sample Shipment Procedures and Laboratory Protocol

All collected samples will be packaged and shipped to the analytical laboratory in a manner that will ensure the safety and accountability of each sample, and all procedures will be in accordance with applicable federal and territorial requirements. All shipments will be in compliance with applicable packaging, labeling, and shipping requirements as indicated in SOP #026, *Sample Packing and Shipping*, and SOP #027, *Sample Custody Procedures* (Appendix E).

Samples will be placed in coolers at the time of collection. These coolers will be used to maintain the samples at a temperature of approximately 4°C. All packaging and chain-of-custody records will be completed following the steps outlined in SOPs #026 and #027. The coolers will be transported from the field office to a freight forwarder for shipment to a certified analytical laboratory located on the United States mainland.

Once the sample coolers have been sent, all chain-of-custody and shipping documents will be faxed and/or e-mailed to the recipient at the transit re-packing facility, to the laboratory project manager, and to the project manager of the Andersen AFB site investigation.

3.4.4 Quality Assurance/Quality Control Samples

Quality Assurance (QA)/QC samples will be collected in the field and submitted to the laboratory following both the Basewide QAPP (EA, 2005c) and Basewide SAP (EA, 2005d). A description of the types of field QA/QC samples that will be collected are summarized below.

3.4.4.1 Field Duplicate

Field duplicate samples will be collected in the field and submitted blind to the project laboratory. The duplicate sample is used to check for the natural sample variance, and consistency of field collection techniques and laboratory analyses. Field duplicate samples will be collected and analyzed for the same COCs as the original sample.

A sufficient volume of water will be necessary to fill two sample containers when collecting a field duplicate sample. One sample will be submitted to the laboratory as the project sample, and one sample will be submitted to the same laboratory as a blind duplicate sample.

3.4.4.2 Equipment Rinsate Blank

Equipment rinsate blank samples will be collected by pouring laboratory-provided “analyte free” water over non-dedicated sampling equipment that comes in direct contact with the sample media. Equipment rinsate blank samples will not be collected when dedicated disposable sampling equipment is used. Equipment rinsate blank samples are used to assess the efficiency of the decontamination process and possible cross-contamination between samples.

Sample identification numbers will be affixed to each sample container and entered on the chain-of-custody form. The sample number will uniquely identify the sample to a specified sample day. Equipment blank samples will be labeled in the manner to identify the sample to a specific date that can be referenced against specific sample sets.

EB-012806

- The first two characters (EB) represent equipment blank.
- The next six characters identify the date the trip blank sample was collected.
- The last two characters identify the sequential number of samples collected from that specific day.

3.5 Record Keeping

Records of daily field activities will be maintained in field logbooks by all field staff. The daily activity records will include the initials of personnel at the site, weather conditions, sampling related activities, health and safety data, and the description and location of all observations related to the site.

4. REFERENCES

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APPENDIX E

STANDARD OPERATING PROCEDURES

SOP 006 – Monitoring Well and Production Well Sampling

SOP 007 – Surface Water Sampling

SOP 010 – On-Site Water Quality Testing

SOP 025 – Sample Preservation

SOP 026 – Sample Packing and Shipping

SOP 027 – Sample Custody Procedures

SOP 029 – Decontamination of Sampling Equipment

SOP 034 – Investigative Derived Waste Management



MONITORING WELL AND PRODUCTION WELL SAMPLING

1.0 SCOPE AND APPLICATION

Analytical samples collected from groundwater monitoring wells, open boreholes, and water supply production wells provide vital information that can be used in the evaluation of groundwater quality and movement in the aquifer. Samples are to be collected from monitoring wells and open boreholes specifically equipped for the low-flow purging and sampling technique, and from the tap at production wells. This standard operating procedure (SOP) describes the equipment, procedures, and precautions necessary to assure that representative groundwater samples are obtained when using these sampling techniques. Four procedures are outlined below: A) Dedicated Pump Sampling From Monitoring Wells Using the Low-Flow Purging and Sampling Technique, B) Production Well Sampling From Wellhead Taps, C) Portable Pump Low-Flow Sampling From Monitoring Wells, and D) General Sampling Procedures. Monitoring well sampling will not begin sooner than 24 hours after well development for new monitoring wells.

2.0 EQUIPMENT

- Health and safety equipment
- Decontamination equipment
- Portable air compressor or optional compressed air tanks
- Pre-preserved sample bottles
- Redox, pH, conductivity/temperature, dissolved oxygen, chloride, and turbidity meter(s)
- Field logbook and indelible ink pen
- Cooler and ice packs or blue ice packs
- Tank to containerize purge water
- Portable decontaminated pump
- Flow-through cell/chamber
- Photographic camera and film or digital camera

3.0 PROCEDURES

- 3.1 Read Health and Safety Plan and comply with applicable requirements and procedures.
- 3.2 Calibrate water quality instruments and pH, redox, conductivity/temperature, dissolved oxygen, chloride, and turbidity meter(s) prior to measurement of these parameters, using SOP #010. Record results on the equipment log sheet.
- 3.3 Lay sampling equipment and sample bottles on a portable work table, or on a sheet of plastic.
- 3.4 When using portable pumps, remove well cap.
- 3.5 Using an electronic water level meter (see SOP #009), measure the depth to the water from the reference point on the top of the well casing and record the depth in hundredths of a foot in the field logbook and groundwater sampling log (Attachment A).

Dedicated Pump Sampling From Monitoring Wells and Open Boreholes Using Low-Flow Purging and Sampling Technique

Attach the air supply line to the portable compressed air source. The air supply can be obtained by using a portable air compressor, or by using compressed nitrogen in tanks. If using a portable compressor with an internal combustion engine, be sure that the compressor is located downwind of the monitoring well and sample location. The air supply source should not exceed 150 pounds per square inch (psi).

MONITORING WELL AND PRODUCTION WELL SAMPLING

- 3.6 The purge volume, using the low-flow purging and sampling technique, will consist of purging pump and tubing volumes, plus any additional water, until stabilization of water parameters is achieved.

- 3.6.1 Equation for determining one purge volume:

$$V = 7.48 [\pi r_p^2 L + VP]$$

where: V = One purge volume in gallons
L = length of the piston pump discharge line (to land surface) in feet
 r_p = inside radius of discharge line in feet
VP = Volume of pump supplied by manufacturer

- 3.7 Obtain a groundwater sample at the initiation of low-flow purging and sampling by starting the piston pump and collecting a sample from the discharge line. Measure the temperature, redox, conductivity, dissolved oxygen, and pH of the sample using a flow-through cell. Measure turbidity and chlorides from grab samples collected once every 2 gallons. Start pumping the well at 0.5 gallons per minute (gpm), and monitor the water level to ensure no drawdown occurs. If drawdown is observed, reduce the flow rate. Continue monitoring water level and field parameters approximately once every tubing and pump volume. Record the results in the field logbook and transfer this information to the groundwater sampling log (Attachment A). Continue purging until field parameters have stabilized, and a minimum of 2 pump and tubing volumes have been removed. Water chemistry is considered to have stabilized if the following conditions have been met for three consecutive readings:

- Turbidity is less than 50 NTU,
- Change in temperature is within $\pm 1^\circ\text{C}$,
- pH \pm is within 0.1 units,
- Conductivity is within ± 5 percent, and
- Dissolved oxygen varies $\pm 10\%$.

After two pump and tubing volumes have been purged and field parameters have stabilized, disconnect the discharge line from the flow-through cell. Collect a VOA sample by slowly filling each vial with water from the discharge line; however, prior to collecting VOA samples with the piston pump, reduce the flow-rate of the piston pump to minimize aeration and reduce the potential for overfilling VOA vials. Continue sample collection as specified in Step 3.10. Record sampling data (time and date of collection, containers used, preservatives, etc.) in the field logbook and transfer this information to the groundwater sampling log (Attachment A).

All purge water derived from the monitoring wells will be handled according to SOP #034.

B) Production Well Sampling From Wellhead Taps

- 3.8 Production well samples will be collected directly from the tap at the wellhead. Purging is not required during this sampling event, unless the well is not being pumped at the time of sampling. The tap should be opened and let run for approximately 5 minutes prior to sample collection. If the pump is not on, the pump will be turned on to purge approximately 3 to 5 well volumes. Field parameters will be monitored as specified in Section 3.7 of this SOP.

C) Portable Pump Sampling From Monitoring Wells and Boreholes Using the Low-Flow Purging and Sampling Technique

MONITORING WELL AND PRODUCTION WELL SAMPLING

3.9 For samples collected using the portable pump system, remove the well cap and measuring groundwater elevation as specified in SOP #009 and record the values in the field logbook, and then transfer information to groundwater sampling log sheet.

3.9.1 Attach the air supply line to the portable compressed air source. The air supply can be obtained by using a portable air compressor, or by using compressed nitrogen in tanks. If using a portable compressor with an internal combustion engine, be sure that the compressor is located downwind of the monitoring well and sample location. The air supply source should not exceed 150 psi.

3.9.2 Carefully lower the sample pump down the borehole/well to:

- 5 to 10 feet below the water table surface, for water table wells (shallow) and uncased boreholes.
- 5 to 10 feet above the transition zone for deep boreholes and monitoring wells, or
- The mid point of the well screen, for wells screened near the base of freshwater lens.

3.9.3 Use the air pressure regulator to begin pump operation by slowly increasing the air pressure until the pump begins cycling, and make adjustments until the desired flow-rate is obtained.

Note: Allow a few minutes for the water-discharge tube to fill, and for the flow meter to begin operating. There will be a time lapse between pump start-up and water flow registering on the flow meter. The following procedures can be used to determine when the pump starts cycling.

- a. Listen for a soft clicking sound at the wellhead.
- b. Observe the pressure gauge on the portable pump control panel, or on the exhaust line, for a slight needle fluctuation as the pump cycles.
- c. Place finger over the air exhaust line (open end tube located inside the reel core). A slight air-flow indicates pump cycling has begun.

3.9.4 The following methods should be used for regulating the flow-rate when water is flowing through the meter.

- a. Increase the air pressure driving the pump in order to increase the flow-rate.
- b. Decrease the air pressure driving the pump in order to decrease the flow-rate.

3.9.5 The pump unit is equipped with a flow-meter that has adjustable valves (black knobs at bottom of meter) that can be used to measure extremely low flow-rates when desired.

- a. Flow-meter valve operation: Turn knob-counter clockwise several times for full open position.
- b. Turn valve clockwise, for restricted to fully closed position.

3.9.6 Start pumping the well at about 0.5 gallons per minute (gpm). Monitor the water level to determine if there is any drawdown in the water level, and monitor and record field parameters and water level approximately once every 2 gallons.

With pump operating, obtain a groundwater sample at the initiation of the low-flow purging and sampling. Measure temperature, turbidity, pH, conductivity, redox, and dissolved oxygen of the

MONITORING WELL AND PRODUCTION WELL SAMPLING

sample. Record the results in the field logbook and transfer this information to the groundwater-sampling log (Attachment A). Continue purging until the field parameters have stabilized, and a minimum of two pump column- and tubing-volumes have been removed. Water chemistry is considered stabilized when the following conditions have been met for three consecutive readings:

- The turbidity is less than 50 NTUs,
- Change in temperature is within $\pm 1^{\circ}\text{C}$,
- pH is within ± 0.1 units,
- Dissolved oxygen is within $\pm 10\%$, and
- Conductivity is within $\pm 5\%$.

After at least two tubing volumes have been purged and field parameters have been stabilized, collect a VOA sample by slowly filling the vials. As noted previously, prior to collecting VOA samples, the flow-rate of the piston pump should be reduced, in order to minimize aeration and reduce the potential for overfilling VOA vials.

D) General Sampling Procedures

- 3.10 Samples will be collected in the following order: volatiles, semivolatiles, pesticides, and inorganic parameters. When collecting samples, if the sample bottles have been pre-preserved or designated for oil and grease analysis, the samples will be collected directly into the bottle.

For VOA samples, fill the vial directly from the discharge tubing. The VOA vials should be slowly and carefully filled until a convex meniscus is present above the top of the vial, in order to minimize the entrainment of air. Carefully screw on the cap. Invert and carefully tap the sample vial to determine if air bubbles are present. If air is present in the vial, dump the water sample into a bucket and resample using a new VOA vial.

If the stabilized turbidity is less than 50 NTUs, collect an unfiltered groundwater sample. If the stabilized turbidity reading is above 50 NTU, then both filtered/unfiltered groundwater samples shall be collected. The filtered sample shall be collected immediately after the unfiltered sample by adding a $0.45\ \mu\text{M}$ filter to the sample discharge line. Allow approximately 500 ml of water to pass through the filter before collecting the filtered sample.

Record the required information for each sample in the field logbook and transfer this information to the groundwater-sampling log (Attachment A). Immediately place the sample into a cooler with ice. Refer to SOP #025 for sample preservation procedures, and to SOPs #026 and #027 for sample packing/shipping and sample custody procedures, respectively.

For sampling events where non-dedicated pumps are used, equipment blanks are required for 5% of the total samples (i.e., 1 every 20 samples) or as required in the field sampling plan. This sample should be comprised of Type II reagent grade water cycled through the pump, and analyzed for the same parameters as the samples.

- 3.11 After sampling each well with the portable sampling pumps, decontaminate pump as follows:

- With the tubing on the pump reel, scrub the outside of the pump and the tubing (submerged below the water table) with a detergent solution consisting of potable water and Liquinox[®], or equivalent laboratory grade detergent.
- Then place the pump in a clean drum, bucket, or other suitable container filled with a solution of potable water and Liquinox[®].

MONITORING WELL AND PRODUCTION WELL SAMPLING

- Start the pump and pump the solution through the tubing. The water and detergent solution can be recycled in the container.
- Continue pumping for about a 15-minute cycle. After circulating for 15-minutes, transfer the solution to the bulk IDW holding tank.
- Rinse the outside of the pump with potable water and place the pump in a clean container filled with only potable water, and purge at least three to five tubing-volumes.
- Do not recycle rinse water back into the drum.
- Decontamination and rinse water is to be changed after each well, and will be handled in accordance with SOP #034.

The remainder of the tubing column that was not in contact with groundwater will be thoroughly rinsed with carbon-filtered water, to ensure that sufficient water is applied to rinse the outside of the tubing. This rinse water will be allowed to fall onto the ground.

Potable water should be obtained from a routinely tested source such as the Andersen AFB water supply system.

- 3.12 At the end of each day of sampling, pumps will be decontaminated in accordance with the procedures outlined in 3.11, wrapped or contained in plastic, and stored in an appropriate storage area. Pumps should not be stored in an area where volatile sources (e.g., household cleaning chemicals, fuels, oils) are present; pumps shall not be stored without appropriate decontamination. Prior to use, the outside of the pump and tubing should be thoroughly rinsed with carbon-filtered water.

4.0 INVESTIGATIVE DERIVED WASTE MANAGEMENT

- 4.1 Purged water and decontamination fluid shall be handled in accordance with SOP #034.
- 4.2 Measure the chloride concentrations of all purged water, using a chloride meter, prior to disposal of purge water onto the ground. If field chloride measurements exceed the USEPA National Secondary Drinking Water Regulation (NSDWR or secondary standard) value of 250 mg/l, then the purge water will be containerized and transported from the well to a temporary storage tank located at a designated staging area on Andersen AFB.

5.0 PRECAUTIONS

- 5.1 If turbidity measurements are greater than 50 NTUs, reduce pumping rate.
- 5.2 If turbidity is stable and less than 50 NTUs, collect an unfiltered groundwater sample. If turbidity is stable but greater than 50 NTUs, collect both filtered and unfiltered groundwater samples.
- 5.3 Protect equipment from contamination by storing on plastic sheeting or portable table.
- 5.4 Use a clean pair of gloves for each sampling location.
- 5.5 Avoid activities at the wellhead that may result in the introduction of foreign materials into the well.

MONITORING WELL AND PRODUCTION WELL SAMPLING

6.0 REFERENCES

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7.0 ATTACHMENTS

Attachment A - Groundwater Sampling Log

Final: January 24, 1994
Revision 1: April 21, 1995
Revision 2: August 7, 1995
Revision 3: December 20, 1996
Revision 4: January 2005

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SURFACE WATER SAMPLING

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) is to be followed when collecting surface water samples from surface water bodies or fresh water seeps occurring along the shoreline.

2.0 EQUIPMENT

- Sample bottles
- Test tube or other small diameter transfer bottle
- Labels and water proof marking pen
- Field log book, Surface Water Sample Log Sheet, and pen
- Photographic camera and film or digital camera
- Personal protection equipment
- Field chloride, pH, conductivity/salinity/temperature meters
- Personal protection equipment
- Cooler and ice packs
- Portable peristaltic pump with Teflon® hose
- In-line filter system
- Subsurface grab sampler
- Preservative chemicals

3.0 PROCEDURES

3.1 Read Health and Safety Plan and follow applicable requirements and procedures.

3.2 The Project/Task Manager will select surface water sampling locations.

3.3 For freshwater seeps near the shoreline, it may be necessary to scoop a depression in the beach sediment to allow a pool of water to form. Allow sediment to settle out, then fill the sample bottles as described in step 3.5. If a depression cannot be scooped out, a new location will be chosen for sample collection.

3.4 Check chloride concentration of seeps before sampling. If the chloride concentration is 1,000 mg/L or greater, a surface water sample will not be collected at this location, and a new location will be selected. If the chloride concentration is less than 1,000 mg/L, then sampling procedures may commence.

3.5 The surface water will be collected into sample bottles as follows:

3.5.1 Collect surface water samples for volatile organic analysis (VOA) by first using a transfer container (test tube or unpreserved transfer bottle). Since VOA vials are pre-preserved, using VOA vials to collect a direct sample from the flow could result in the loss of the preservative, so care should be taken during this process. Transfer water sample from the transfer bottle to the VOA vials until a convex meniscus is achieved, then place the cap on sample bottle and check for air bubbles by gently tapping sides and inverting sample bottle. If air bubbles are observed in the vials, then the sample must be discarded and a new sample collected in new VOA vials. To prevent loss of preservative do not overfill the vials. After sample collection, place VOA vials in cooler containing ice.

3.5.2 The transfer container used to fill the VOA containers can also be used to fill the remaining sample bottles. If flow is minimal or does not allow collection with a transfer bottle, it may be necessary to use a battery- or hand-operated peristaltic pump with Teflon® hose to collect all remaining sample bottles. Suspend the suction end of the hose in the surface water to be

SURFACE WATER SAMPLING

sampled. Start the pump and adjust the flow-rate to minimize aeration and reduce the potential for overfilling the sample bottles. Fill the sample bottles directly from the effluent tubing. To prevent loss of preservative do not overfill the sample containers.

- 3.5.3 Collect a sample and record chloride, pH, conductivity, salinity, and temperature measurements.
- 3.5.4 Samples collected for dissolved metals analysis will first be collected in a suitable, non-preserved transfer-container, and then will be filtered using an in-line disposable 0.45 micron filter into a preserved sample container. Set up the filtration apparatus and use the hand pump to pump the sample through the filter. Add the required preservatives for other samples immediately after collecting the sample. Samples collected for total metals analysis will not be filtered.
- 3.5.6 Document sampling with photographs, and record the following information in the field/site logbook and on the Sample Log Sheet (Attachment A):
- | | |
|--------------------------|------------------------------|
| - Sample Method | - Location of Collection |
| - Depth Sampled | - Sample Number |
| - Sample Date and Time | - Sampled By |
| - Type of Sample | - Water Quality Measurements |
| - Photograph Location(s) | - Map Location/Coordinates |
- 3.5.7 If it is not possible to collect the surface water sample directly into the sample bottle(s) due to physical constraints, collect the sample using a grab sampler. This sampling device uses a sample bottle/container attached to a pole, which can be telescoped for collecting samples where water entry is not feasible or warranted.
- 3.5.8 Record the required information for each sample on a sample log sheet (Attachment A). Immediately place the sample into a cooler containing ice. Refer to SOP #025 for sample preservation procedures, and SOPs #026 and #027, respectively, for sample packing and shipping, and sample custody procedures.

4.0 PRECAUTIONS

- 4.1 Use gloves and appropriate foot wear when collecting surface water samples, and use other personal protective equipment outlined in the site Health and Safety Plan.

5.0 REFERENCES

USEPA, 1987. A Compendium of Superfund Field Operations Methods, Office of Emergency and Remedial Response, Office of Water Programs Enforcement, Washington, DC 20460, (EPA/540/P-87/001).

USEPA, 2002. Standard Operating Procedures, SOP 2013 Surface Water Sampling, USEPA Environmental Response Team, 17 December.

6.0 ATTACHMENTS

Attachment A – Surface Water Sample Log Sheet

SURFACE WATER SAMPLE LOG SHEET

Sample Location: _____ Sample Number: _____ Media: _____

Company Name:		Sample Data - Field Measurements					
Completed By:		pH	Conduct.	Temp (°C)	Cl⁻ (mg/L)	Salinity %	
Sample Method:							
Depth Sampled:		Sample Description:					
Sample Date & Time:							
Sampled By:							
Signature:							
Type of Sample:		Sample Location Description:					
<input type="checkbox"/> Grab							
<input type="checkbox"/> Composite							
Analysis		Method Number	Minimum Volume Required	Preserv. Required	Holding Time	X Mark where applies	
RDX		EPA 8330	1 L	4°C			
Mercury		EPA 6010/6020/7421	500 mL	HNO ₃	180 days		
Lead		EPA 6010/6020/7470A	500 mL	HNO ₃	180 days		
Notes:		Chain of Custody #: Airbill #: Date Shipped: Time Shipped: Laboratory: Laboratory Location: Volume/Bottles:					

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ON-SITE WATER QUALITY TESTING

1.0 pH MEASUREMENT – SCOPE AND APPLICATION

This standard operating procedure (SOP) will be used to obtain pH readings for all aqueous solutions, including groundwater, drinking water, saline water, and seeps. pH is a measurement of the hydrogen ion activity in a solution and indicates the acidity or alkalinity of an aqueous sample.

Measurements of pH can be used to check the quality and corrosivity of water samples, and to correlate other chemical analyses to determine probable sources.

1.1 EQUIPMENT

- Portable, field pH meter with probes for pH and temperature measurements
- Field pH meters (i.e., Hydrolab®, YSI®, or equivalent) will be used with digital readout and resolution to 0.01 pH units
- Buffer solutions of pH 4, 7, and 10
- Deionized water in squirt bottle
- Beakers or other suitable containers
- Field logbook and indelible pen

1.2 PROCEDURES

- 1.2.1 Read Health and Safety Plan and comply with applicable requirements and procedures.
- 1.2.2 Decontaminate equipment by rinsing with deionized water.
- 1.2.3 The instrument will be cleaned, checked, and calibrated according to the equipment operations manual.
- 1.2.4 When applicable, immerse the tip of the pH electrode in carbon-filtered, potable water at least one hour prior to calibration.
- 1.2.5 The pH meter shall be calibrated once a week, or after every 10 samples. At least two buffer solutions that bracket the expected sample pH shall be used (e.g., 7.0 and 10.0). Record calibration result in calibration daily log sheet (Attachment A).
- 1.2.6 Obtain the water sample in a beaker, after having rinsed with source water.
- 1.2.7 Rinse electrode with deionized water.
- 1.2.8 Immerse the electrode in water sample. Make sure water surface is one-inch above electrode for proper measurement. Allow sample to stabilize and record pH and temperature readings in field logbook.
- 1.2.9 Following field measurements:
 - 1.2.9.1 Report and log any problems on the calibration daily log sheet (Attachment A).
 - 1.2.9.2 Clean all dirt off meter and inside carrying case.
 - 1.2.9.3 Clean electrode and store in deionized water, or as required by manufacturer.

ON-SITE WATER QUALITY TESTING

1.3 PRECAUTIONS

- When calibrating the meter, use pH buffers 4 and 7 for samples where pH is anticipated <7, and buffers 7 and 10 when pH is anticipated >7.
- Measurement of pH is temperature dependent. Therefore, the buffer temperature should be within 2 degrees C of sample temperatures.
- Weak organic or inorganic salts, and oil and grease, interfere with pH measurements. If oil and grease are visible, note it on the Sample Log Sheet.
- Accuracy and precision are dependent on the instrument used; refer to manufacturer's manual. Expected accuracy and precision are +/- 0.1 pH units.
- Refer to operation manual for recommended maintenance.
- Keep instrument and water sample out of direct sunlight.

1.4 REFERENCES

Refer to 6.0 of this SOP.

1.5 ATTACHMENTS

Attachment A - Equipment Calibration Daily Log Sheet

ON-SITE WATER QUALITY TESTING

2.0 SPECIFIC CONDUCTANCE – SCOPE AND APPLICATION

This standard operating procedure is to be used to obtain specific conductance measurements for aqueous solutions, including drinking water, groundwater, saline water, and samples from seeps. Specific conductance is the ability of a solution to pass an electrical current. The current is primarily carried by dissolved inorganic anions such as chlorides, nitrates, and sulfates, as well as cations such as sodium, calcium, and magnesium.

2.1 EQUIPMENT

- Health and Safety equipment
- Decontamination equipment
- Conductivity meter and electrode (i.e., Hydrolab®, YSI® or equivalent)
- Carbon-filtered or deionized water in squirt or spray bottle
- Standard potassium chloride (KCl) solution (0.01 N) if instrument requires calibration
- Field logbook and indelible pen

2.2 PROCEDURES

- 2.2.1 Read Health and Safety Plan and comply with applicable requirements and procedures.
- 2.2.2 Decontaminate the equipment by rinsing with carbon-filtered water after each measurement.
- 2.2.3 Calibrate probe with standard KCl 0.01N solution, and clean probe according to manufacturer's recommendations. Recalibration should be performed once every 10 samples or once a week.
- 2.2.4 Calibrate the instrument according to the manufacturer's manual, using at least two standard solutions that bracket the expected sample value or range. Calibration readings should be $\pm 5\%$ of the standard.

2.3 PRECAUTIONS

- Refer to operations manual for recommendations on calibration and maintenance.
- Keep instrument and water sample out of direct sunlight.

2.4 REFERENCES

Refer to 6.0 of this SOP.

2.5 ATTACHMENTS

Attachment A - Equipment Calibration Daily Log Sheet

ON-SITE WATER QUALITY TESTING

3.0 TEMPERATURE MEASUREMENTS – SCOPE AND APPLICATION

This procedure is used to obtain temperature readings for a liquid sample. Temperature measurements will be taken using a digital portable meter. This may be a separate meter, or it may be in combination with the pH or specific conductance meters.

3.1 EQUIPMENT

- Decontamination equipment
- Temperature meter
- Carbon-filtered water with spray or squirt bottle
- Beakers
- Field logbook and indelible pen

3.2 PROCEDURE

3.2.1 Read Health and Safety Plan and comply with applicable requirements and procedures.

3.2.2 Multi-probe instruments (i.e., Hydrolab®, YSI®, or equivalent) typically have factory-calibrated temperature probes. For those probes that are not factory-calibrated, calibrate meter according to manufacturer's operation manual. When calibrating, use temperatures that bracket the expected range of sample temperatures. Record on calibration daily log sheet (Attachment A).

3.2.3 Following calibration, rinse temperature probe with deionized water.

3.3 PRECAUTIONS

- Refer to manufacturer's operation manual for maintenance and calibration (if needed).
- Keep dirt off meter when not in use. Clean probe and meter prior to leaving site and before probe is immersed in another sample.
- Keep instrument and water sample out of direct sunlight.

3.4 REFERENCES

Refer to 6.0 of this SOP.

3.5 ATTACHMENTS

Attachment A - Equipment Calibration Daily Log Sheet

ON-SITE WATER QUALITY TESTING

4.0 TURBIDITY MEASUREMENTS – SCOPE AND APPLICATION

This standard operating procedure will be used to obtain turbidity measurements during well development and purging, prior to groundwater sampling.

Turbidity units will be measured using digital reading meters (i.e., Hydrolab®, YSI®, or equivalent) with accuracy of +/- 0.05 NTUs. This testing procedure is in accordance with accepted EPA methods for analysis.

All development water will be checked for NTUs using standard turbidity meters. The recommended acceptance/rejection value of 50 NTUs is based on the need to minimize biochemical activity, and possible interference with groundwater sample quality.

4.1 EQUIPMENT

- Portable field turbidity meter
- Calibration solutions of known NTUs
- Decontamination equipment
- Sample vials
- Field logbook and indelible pen

4.2 PROCEDURES

- 4.2.1 Read Health and Safety Plan and comply with applicable requirements and procedures.
- 4.2.2 Check and calibrate turbidity meter, prior to use, every 10 samples or once a week. Calibration of the instrument will be in accordance with the meter's manufacturer's operations manual, using solution s of NTUs within the expected range of sample turbidities (i.e., 0-50 NTUs). Record calibration measurements on the calibration daily log sheet (Attachment A).
- 4.2.3 Check batteries to ensure operation of the meter and keep a spare set available.
- 4.2.4 Collect water sample in special vial designed for use with the turbidity meter, or use a flow-through cell designed for use with the turbidity meter. Keep these types of containers clean to assure accurate readings.
- 4.2.5 Operate the meter in accordance with manufacturer's operation manual, and record measurements in field/site logbook.
- 4.2.6 Record turbidity reading in field/site logbook and transfer information to log sheet.
- 4.2.7 Decontaminate the equipment by rinsing with carbon-filtered water after each measurement.

4.3 PRECAUTIONS

- Refer to manufacturer's operation manual for maintenance and calibration procedures
- Keep instrument and water sample out of direct sunlight.

4.4 REFERENCES

Refer to 6.0 of this SOP.

ON-SITE WATER QUALITY TESTING

4.5 ATTACHMENTS

Attachment A - Equipment Calibration Daily Log Sheet

Final: January 24, 1994
Revision 1: April 21, 1995
Revision 2: December 20, 1996
Revision 3: January 2005

ON-SITE WATER QUALITY TESTING

5.0 CHLORIDE MEASUREMENTS – SCOPE AND APPLICATION

This standard operating procedure will be used to obtain chloride readings for all aqueous solutions including groundwater, drinking water, drilling fluids, saline or brackish water, and seeps.

Measurements of the chloride content will be measured directly, in order to determine if brackish or saline waters are encountered during borehole drilling, while testing seeps, during groundwater sampling, and when determining if derived waste drilling fluids and other collected water can meet discharge requirements.

5.1 EQUIPMENT

- Portable field chloride meter for measuring chloride content in mg/L. Field chloride meter with digital readout (i.e., Orion, Acorn) will be used.
- Chloride calibration solutions of 500 mg/L and 1,000 mg/L
- Deionized water in squirt bottle
- Beakers or other suitable containers
- Field logbook and indelible pen

5.2 PROCEDURES

- 5.2.1 Read Health and Safety Plan and comply with applicable requirements and procedures.
- 5.2.2 Decontaminate equipment by rinsing with deionized water after each measurement.
- 5.2.3 Use a two-standard calibration sequence as outlined in the meter's operations and maintenance manual. Use a calibration solution of 100 mg/L and 1,000 mg/L.
- 5.2.4 Calibrate the instrument at the beginning of each sampling day according to manufacturer's operation manual. Clean the probe according to manufacturer's recommendations. Record data and time of calibration on calibration daily log sheet (Attachment A).
- 5.2.5 Collect water sample in beaker and immerse chloride probe. Allow probe reading to stabilize and record chloride reading in logbook.

5.3 PRECAUTIONS

- Use fresh standards that have not expired.
- Refer to operation manual for recommended maintenance.
- Keep instrument and water sample out of direct sunlight.

5.4 REFERENCES

Refer to 6.0 of this SOP.

5.5 ATTACHMENTS

Attachment A - Equipment Calibration Daily Log Sheet

ON-SITE WATER QUALITY TESTING

6.0 REFERENCES

- Aller, L., T.W. Bennett, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nielson, 1989. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. National Water Well Association, Dublin, OH, pp. 398pp.
- American Public Health Association, 1992. Standard Methods for the Examination of Water and Wastewater. 1992. 18th Edition, 1015 Fifteenth Street, NW, Washington , DC 20005.
- Driscoll, Fletcher, G., 1987. Groundwater and Wells, 2nd Edition, Johnson Division, St. Paul, MN. 1089pp.
- Novotny, Vladimir, and Gordon Chesters, 1981. Handbook of Nonpoint Pollution, Sources and Management. Van Nostrand Reinhold Company, New York, 555pp.
- USEPA/NWWA, 1986. RCRA Ground Water Monitoring Technical Enforcement Guidance Document. National Water Well Association, Dublin, OH. 207pp., + app.
- USEPA, 1999. Methods and Guidance for the Analysis of Water, Version 2. Environmental Protection Agency, Washington, DC. Office of the Assistant Administrator for Water. EPA/821/C-99/004. May
- U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition. Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Dept. of the Interior, Reston, VA.

Attachment A

EQUIPMENT CALIBRATION DAILY LOG SHEET

Equipment Type and Serial No.	Date/Time	Calibrated by	Initial Measurement	Final Measurement
Hydrolab®				pH 4 =
Scout®				pH 7 =
				pH 10 =
			Redox pH7 = mV	difference:
			Redox pH4 = mV	
			445 µs std	Cond = µs
			7.86 mg/L std	DO = mg/L
			40 NTU std	NTU =
Hydrolab®				pH 4 =
Scout®				pH 7 =
				pH 10 =
			Redox pH7 = mV	difference:
			Redox pH4 = mV	
			445 µs std	Cond = µs
			7.86 mg/L std	DO = mg/L
			40 NTU std	NTU =

EQUIPMENT CALIBRATION DAILY LOG SHEET

Equipment Type and Serial No.	Date/Time	Calibrated by	Initial Measurement	Final Measurement
Chloride Meter			100 ppm = ppm	100 ppm = ppm
			1,000 ppm = ppm	1,000 ppm = ppm
				Slope:
Chloride Meter			100 ppm = ppm	100 ppm = ppm
			1,000 ppm = ppm	1,000 ppm = ppm
				Slope:
Chloride Meter			100 ppm = ppm	100 ppm = ppm
			1,000 ppm = ppm	1,000 ppm = ppm
				Slope:
Chloride Meter			100 ppm = ppm	100 ppm = ppm
			1,000 ppm = ppm	1,000 ppm = ppm
				Slope:
Chloride Meter			100 ppm = ppm	100 ppm = ppm
			1,000 ppm = ppm	1,000 ppm = ppm
				Slope:
Chloride Meter			100 ppm = ppm	100 ppm = ppm
			1,000 ppm = ppm	1,000 ppm = ppm
				Slope:

SAMPLE PRESERVATION

1.0 SCOPE AND APPLICATION

Preservation techniques are usually limited to pH control, chemical addition(s), and refrigerating/freezing. Their purposes are to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects. This standard operating procedure (SOP) discusses container and preservative requirements for samples that may be collected at Andersen AFB, Guam.

2.0 EQUIPMENT

- pH paper (wide range and narrow range)
- Pipettes or eye droppers
- 1:1 sulfuric acid solution
- 1:1 dilution of concentrated HCl
- Undiluted concentrated nitric acid
- Sodium hydroxide (NaOH) pellets
- Coolers or refrigerator
- Ice
- Field logbook and indelible ink pens
- Photographic camera and film or digital camera

3.0 PROCEDURES

The following subsections describe the procedures for preparing and adding chemical preservatives. Table 5.1.2-1 in the Basewide Quality Assurance Project Plan (QAPP) indicates the specific analytes which require these preservatives.

3.1 Addition of Acid (H₂SO₄, HCl or HNO₃) or Base

Addition of the following acids or bases may be specified for sample preservation:

Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of conc. HCl	6N	5-10 ml
H ₂ SO ₄	1:1 dilution of conc. H ₂ SO ₄	18N	2-5 ml
HNO ₃	Undiluted conc. HNO ₃	16N	2-5 ml
NaOH	400g Solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that water is initially pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

These reagents should be analytical reagent (AR) grade and should be diluted to the required concentration with double-distilled, deionized water in the laboratory of the remedial investigation contractor or the laboratory performing the analyses or by field personnel if necessary. This procedure should be followed prior to conducting any field sampling.

SAMPLE PRESERVATION

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition should proceed as follows:

- 3.1.1 Check initial pH of sample with wide range (0-14) pH paper.
- 3.1.2 Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- 3.1.3 Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

3.2 Cyanide Preservation

Pre-sample preservation is required to prevent oxidizing agents such as chlorine from decomposing most of the cyanides. To test for oxidizing agents, place a drop of the sample on potassium iodide-starch test paper (KI-starch paper); a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described above.

Sulfide will adversely affect cyanide analyses. To test for sulfide, place a drop of the sample on lead acetate test paper previously moistened with acetic acid buffer solution (pH 4). Darkening of the paper indicates the presence of sulfide. If sulfide is present, add cadmium nitrate powder (to form a yellow cadmium sulfide precipitate) until the lead acetate test yields negative results. Filter the sample to remove precipitate and add NaOH solution to the filtrate (to raise pH above 12). Avoid a large excess of cadmium and a long contact time in order to minimize a loss by complexation or occlusion of cyanide on the precipitated material.

3.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH solution (1-2 drops). The 2N zinc acetate solution is made by dissolving 220g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

3.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection. If the sample is suspected to contain residual chlorine, a Hach test kit such as a model CN-70 should be used to examine the sample. If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

SAMPLE PRESERVATION

3.5 Field Filtration

When the objective is to determine concentrations of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45-micron membrane inline filtration system immediately after collection. Filters must be pre-rinsed with deionized water. Discard the first 20 to 50 mL of filtrate from each sample used to rinse the filter and filtration apparatus. This technique minimizes the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle and is immediately acidified to pH 2.0 or less with analytical reagent grade nitric acid. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified. Filtration equipment must be cleaned between samples in a manner similar to field sampling equipment.

Samples used for determining temperature, and pH should not be filtered. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

3.6 Pre-preserved VOA bottles

Before VOA bottles are used, the pH should be tested to make sure it is within parameters < 2.

4.0 PRECAUTIONS

4.1 Protective gloves and goggles will be worn when handling chemical preservatives.

5.0 REFERENCES

American Public Health Association, 1992. Standard Methods for the Examination of Water and Wastewater. 1992. 18th Edition, 1015 Fifteenth Street, NW, Washington, DC 20005.

USEPA, 2004. " Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; National Primary Drinking Water Regulations; and National Secondary Drinking Water Regulations; Analysis and Sampling Procedures." Federal Register, Vol. 69 Number 66, Pages 18165-18226. April.

USEPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. USEPA-EMSL, Cincinnati, OH.

6.0 ATTACHMENTS

None.

Final: January 24, 1994
Revision 1: April 21, 1995
Revision 2: December 20, 1996
Revision 3: January 2005

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SAMPLE PACKING AND SHIPPING

1.0 SCOPE AND APPLICATION

This procedure is applicable to the packing and shipping of samples of all media types. Proper packing/shipping is critical to the sample Chain-of-Custody, as well as protection of the shipper and carrier.

The properly labeled samples are placed in plastic bags, put in a cooler with bubble wrap and ice, which is then taped shut. Custody seals are applied and the samples are shipped to the laboratory.

2.0 EQUIPMENT

- Plastic reseal able bags
- Custody seals
- Strapping tape
- Clear tape
- Bubble wrap
- Ice cooler and ice
- Grease or china marking pencil
- "This Side Up" and "Fragile" labels
- Bubble wrap or other packing/cushioning material
- Health and Safety Equipment

3.0 PROCEDURE

3.1 Read the Health and Safety Plan and comply with applicable requirements and procedures.

3.2 Prepare cooler(s) for shipment.

- Tape drain(s) shut with duct tape or equivalent.
- Affix "This Side Up" and "Fragile" labels on all four sides of each cooler.
- Place mailing labels, with laboratory address atop of cooler(s).
- Line inside of cooler(s) with bubble wrap making sure bottom layer is at least ½ inch thick.
- Place appropriate packing lists, applicable permits and corresponding custody seals atop each cooler.

3.3 Arrange the decontaminated sample containers in groups by sample number.

3.4 Secure the appropriate sample identification/label to the sample containers.

3.5 Secure the container caps/lids with strapping tape or equivalent.

3.6 Arrange the containers in front of their assigned coolers.

3.7 Wrap all glass container in bubble wrap, and seal each container in a separate plastic reseal able bags.

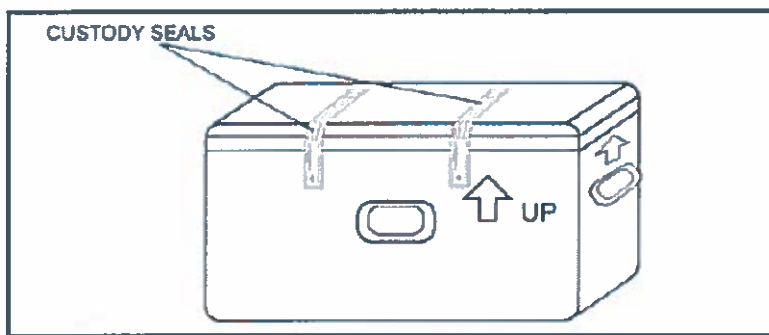
3.8 Arrange the containers in each cooler so that they do not touch (place bubble wrap between the samples as appropriate).

3.9 If ice is required to preserve the samples, it should be repackaged in double ziploc bags and placed on and around the containers (especially the VOA vials).

3.10 Fill the remaining space with bubble wrap or poly foam liner on top of the samples).

SAMPLE PACKING AND SHIPPING

- 3.11 Sign the Chain-of-Custody (COC) Record Form (or obtain the signature) and indicate the time and date it will be relinquished to the overnight carrier.
- 3.12 Separate the copies of the forms. One copy accompanies the cooler and one copy is held in Project files. Photocopy the COC if more than one cooler is sent. Each cooler should have a copy of COC, indicating shipper and waybill number.
- 3.13 Close the lid and latch the cooler.
- 3.14 Sign and date the custody seal. Carefully peel the custody seals from their backings and place them intact over the edge of the cooler (right front and left back). Cover the seals with clear packaging tape.



- 3.15 Tape the cooler shut on both ends, making several complete revolutions with packaging tape.
- 3.16 Attach all applicable permits, including United States Department of Agriculture (USDA) soil permit and compliance agreement, proforma invoice, and shipping waybill.
- 3.17 Relinquish the cooler(s) to the laboratory, the overnight carrier, or commercial airlines.
- 3.18 Email the laboratory to inform them that a shipment was sent. Attach a copy or scan of the COCs to the email and provide the following information:
 - Your name
 - Project name
 - Number of samples sent to each laboratory for analysis
 - Airbill numbers

This must be done immediately following sample shipment.

4.0 PRECAUTIONS

Perform sample packing and shipping with experienced/qualified personnel.

5.0 REFERENCES

U.S. Department of Transportation, 1999. Hazardous Materials Transportation Act, 49 CFR Parts 171, 173, 177, 178, 180 (Volume 64, Number 54) March 22.

6.0 ATTACHMENTS

None.

SAMPLE CUSTODY PROCEDURES

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the necessary steps for transferring samples through the use of chain-of-custody (COC) Record Forms. A COC Record Form is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis. Use of the COC Record Form creates a written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This guideline identifies the necessary custody records and describes their completion.

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The COC procedures track the evidence from the time and place it is first obtained to the courtroom. These procedures also provide an auditable trail for the evidence as it is moved and/or passes from the custody of one individual to another. In addition, procedures for consistent and detailed records facilitate the admission of evidence under Rule 803(b) of the Federal Rules of Evidence (P.L. 93-575).

2.0 EQUIPMENT

- COC Record Forms
- Indelible ink pen
- Site logbook

3.0 PROCEDURES

3.1 The following information must be written in the sample logbook when in-situ measurements or samples for laboratory analysis are collected:

- project code
- station number
- location of station
- date and time of measurement
- samples used if any
- field observations (include date and time)
- level of personal protection (if required)
- equipment used to make physical measurements and collect samples
- calibration data for equipment used.

Measurements and observations shall be recorded using black or blue waterproof ink.

3.2 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to another location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Basewide Sampling and Analysis Plan (SAP). Each sample container is identified by a sample label.

The sampler fills out the following information on the sample label:

- Sample Number - The unique sample number identifying this sample.
- Date - An eight-digit number indicating the month, day, and year of sample collection; e.g., 06/08/2004.

SAMPLE CUSTODY PROCEDURES

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Matrix - Water, Soil, Sediment, Sludge, Leachate.
- Sample Type - Grab or Composite.
- Preservation - Type, quantity, and concentration of preservative added.
- Analysis - Same as Analyses on Sample Identification Tag.
- Sampled By - Name of the sampler.

3.3 COC Procedures

After collection, separation, identification, and preservation, the sample is maintained under COC procedures until it is in the custody of the analytical laboratory and has been stored or disposed of (Attachment A).

3.4 Field Custody Procedures

- 3.4.1 Samples are collected as described in the field sampling plan (FSP). Care must be taken to record precisely the sample location and to ensure that the sample number on the label exactly matches those numbers on the sample log sheet and the COC Record Form (Attachment A).
- 3.4.2 The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- 3.4.3 When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook or by use of a dry erase board or equivalent.
- 3.4.4 Sample labels are to be completed for each sample using waterproof ink unless prohibited by weather conditions.

3.5 Transfer of Custody and Shipment

Samples are accompanied by a COC Record Form (Attachment A). When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The COC Record Form is completed as follows:

- 3.5.1 Enter header information (project number and name) for each station number, enter date, time, composite/grab, station location, number of containers, analytical parameters.
- 3.5.2 The signature of the sampler goes in the "person assuming responsibility for sample" column.
- 3.5.3 Sign, date, and enter the time under "Relinquished by" entry.
- 3.5.4 Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- 3.5.5 Enter the bill-of-lading or airbill number under COC if appropriate.

SAMPLE CUSTODY PROCEDURES

- 3.5.6 Place the original (top, signed copy) of the COC Record Form, secured with packaging tape to the top inside of the appropriate sample shipping package. Typically the cooler with any VOC samples would contain the copy. Retain another copy with field records.
- 3.5.7 Shipping containers should be secured to ensure samples have not been disturbed during transport by using nylon strapping tape and custody seals. The custody seals should be placed on the containers so that they cannot be opened without breaking the seal.
- 3.5.8 Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers usually will not accept responsibility for handling COC Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic resealable bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the COC Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout the sample preparation and analysis.

4.0 PRECAUTIONS

- 4.1 Duplicate or field spike samples shall not be identified as such on the label, as this may compromise the quality control function.
- 4.2 Complete information must be supplied.
- 4.3 Cross-out errors with single line and initial.

5.0 REFERENCES

USEPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

USEPA, 1996. Sampler's Guide to the Contract Laboratory Program, Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R-96/032.

6.0 ATTACHMENTS

Attachment A - COC Record Form

January 5

DECONTAMINATION OF SAMPLING EQUIPMENT

1.0 SCOPE AND APPLICATIONS

The purpose of this standard operating procedure (SOP) is to provide a methodology, protocol, and reference information on the proper decontamination procedures to be used on sampling equipment. Decontaminate sampling equipment used at sites that directly or indirectly contacts contaminated media at a designated area within the boundaries of the site. All decontamination activities should be documented (see Attachment A) and all efforts will be made to minimize generation of wastes during decontamination.

2.0 EQUIPMENT

- Health and Safety Plan
- Alconox or equivalent laboratory grade detergent
- Scrub brushes
- Buckets
- Pesticide grade methanol (or equivalent)
- Reagent Grade II DI rinse water
- Aluminum foil
- Plastic sheeting
- Pen and logbook
- Reagent Grade 10 percent nitric acid rinse
- Decontamination Log Sheet (Attachment A)

3.0 PROCEDURES

Soil/Sediment/Sludge Sampling Equipment

- 3.1 Read the Health and Safety Plan and comply with applicable requirements and procedures.
- 3.2 Use the following procedure to decontaminate sampling devices such as trowels and hand augers prior to mobilizing to a sampling location.
 - 3.2.1 Scrub the equipment with a solution of potable water and Alconox, or equivalent laboratory grade detergent. Rinse equipment with copious quantities of potable water rinse. High performance liquid chromatography (HPLC) Grade water or distilled water purchased in stores is not an acceptable substitute for Reagent Grade II water.
 - 3.2.2 Rinse equipment with pesticide-grade methanol if organic contamination is a concern.
 - 3.2.3 Rinse equipment with 10 percent nitric acid rinse if inorganic contamination is of concern.
 - 3.2.4 Rinse equipment with Reagent Grade II water.
 - 3.2.5 Air dry equipment on a clean surface such as, stainless steel, or oil-free aluminum foil. If the sampling device will not be used immediately after being decontaminated, wrap it in aluminum foil.
 - 3.2.6 Document decontamination procedures on decontamination log sheet (Attachment A) and in logbook.
- 3.3 Collect and containerize decontamination fluids and transport them to the designated derived waste management storage area.

DECONTAMINATION OF SAMPLING EQUIPMENT

Portable Groundwater Sampling Equipment

3.4 After sampling each well with the portable sampling pumps, decontaminate the pump as follows:

- With the tubing on the pump reel, scrub the outside of the pump and the tubing (submerged below the water table) with a detergent solution consisting of potable water and Liquinox[®], or equivalent laboratory grade detergent.
- Then place the pump in a clean drum, bucket, or other suitable container filled with a solution of potable water and Liquinox[®].
- Start the pump and pump the solution through the tubing. The water and detergent solution can be recycled in the container.
- Continue pumping for about a 15-minute cycle. After circulating for 15-minutes, transfer the solution to the bulk IDW holding tank.
- Rinse the outside of the pump with potable water and place the pump in a clean container filled with only potable water, and purge at least three to five tubing-volumes.
- Do not recycle rinse water back into the drum.
- Decontamination and rinse water is to be changed after each well, and will be handled in accordance with SOP #034.

The remainder of the tubing column that was not in contact with groundwater will be thoroughly rinsed with carbon-filtered water, to ensure that sufficient water is applied to rinse the outside of the tubing. This rinse water will be allowed to fall onto the ground.

Potable water should be obtained from a routinely tested source such as the Andersen AFB water supply system.

3.5 At the end of each day of sampling, pumps will be decontaminated in accordance with the procedures outlined in 3.11 of SOP #06, wrapped or contained in plastic, and stored in an appropriate storage area. Pumps should not be stored in an area where volatile sources (e.g., household cleaning chemicals, fuels, oils) are present; pumps shall not be stored without appropriate decontamination. Prior to use, the outside of the pump and tubing should be thoroughly rinsed with carbon-filtered water.

4.0 PRECAUTIONS

Hexane is not to be used as a rinse solvent according to Guam Environmental Protection Agency (GEPA).

5.0 REFERENCES

Department of the Air Force, 1991 (reprint). Handbook to Support the Installation Restoration Program (IRP) Statements of Work, Volume I - Remedial Investigation/Feasibility (RI/FS).

USEPA, 1987. Region II Environmental Services Division Monitoring Management Branch, "CERCLA QAPJP Review Guidance", April.

USEPA, 1986. Region IV Environmental Services Division Engineering Support Branch, "Standard Operating Procedures and Quality Assurance Manual", April 1.

USEPA, 1994. Standard Operating Procedures, SOP 2006 Sample Equipment Decontamination, USEPA Environmental Response Team, August 11.

6.0 ATTACHMENTS

Attachment	A	-	Decontamination	Log	Sheet.
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DECONTAMINATION LOG SHEET (SOP-28 and 29)

SOP: 029
Page 3 of 3
Attachment A

Contract Number: _____

Date: _____

Delivery Order: _____

Site Location: _____

Recorded By	Checked By (including Date)
-------------	-----------------------------

Decontamination after Borehole/Well/Soil Gas/Soil sampling point(s):

Decontamination Checklist:

Equipment	Purpose of Use*	Steam/ Hot Water Rinse	Liquinox® /Water Rinse	Potable Water Rinse	Type II Reagent Water Rinse	Other Water Rinse	Isopropanol/ HNO3 (dilution) Rinse
Drill Rig/Bit							
Augers							
Soil Sampler							
Pump (type)							
Bailer							
Hand Auger							
Stainless Steel Spoon							
Stainless Steel Bowl							
Other							

- Use Key: GS = Groundwater Sampling; SS = Soil Sampling; SG= Soil Gas Installation/Sampling; WP= Well Purging.

Decontamination Procedure Checklist (Mark Y for Yes and N for No, If No explain in comments):	Yes	No
Placed washing tubs on plastic sheeting?		
Scrubbed sampling equipment in Liquinox®/water until all visible dirt/grim, grease, oil, ... etc. have been removed?		
Rinsed sampling equipment with a final rinse using the designated water listed in the table above?		
Placed decontaminated equipment on clean plastic sheeting for drying and transport?		
Placed decontamination fluids in sealed container?		

Comments (e.g. Initial decontamination, Between Locations, or Last Decontamination for the Day):

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INVESTIGATIVE DERIVED WASTE MANAGEMENT

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the procedures for handling of investigative derived wastes (IDW) at Andersen AFB. IDW will be generated as a result of groundwater sampling, decontamination of sampling equipment, test excavations, borehole drilling, well development, and aquifer pump tests. Other IDW associated with drilling and sampling activities includes the generation of decontamination fluids and personal protective equipment (PPE).

The need to containerize groundwater will be based on the primary Chemicals of Concern (i.e., volatile organic compounds [VOCs]). Water generated during drilling will be screened every 20 feet using an organic vapor analyzer (OVA) (either a photoionization detector [PID] or flame ionization detector [FID]). Water will be directed to a staged roll-off bin or other suitable storage container. Water samples will be collected and sent for laboratory analysis for VOCs under a quick turn around time (TAT) to limit the storage time of the IDW. If the water contains VOCs, it will be directed to a designated storage tank or other suitable container. If the water does not contain VOCs, the water will be directed to an unlined trench if derived from drilling or decontamination procedures. Water derived from well development or purging activities will be containerized for later disposal in the publicly owned treatment works (POTW) upon receiving Base approval.

2.0 EQUIPMENT

- Health and Safety equipment
- Decontamination equipment
- Sample bottles for water and soils or drill cuttings
- Field logbook and indelible ink pen
- Organic vapor analyzer (either a photoionization detector [PID] or flame ionization detector [FID])
- Plastic sheeting and/or tarps
- Roll-off bins
- Waste container tanks
- Chloride meter

3.0 PROCEDURES

3.1 CUTTINGS AND SOILS FROM DEEP BOREHOLE DRILLING USING AIR ROTARY

3.1.1 Read Health and Safety Plan

3.1.2 Calibrate all Health and Safety and water quality monitoring equipment according to manufacturers' recommendations.

3.1.3 Cuttings derived from borehole drilling will be directed to a lined and sealed roll-off bin for ease in handling and separating from the water used in the drilling process or water derived from the aquifer. The water will be pumped out of the roll-off bins into tanks designated for water storage. Attachment A contains an IDW decision chart for handling cuttings from above the water table.

Roll-offs will be decontaminated in the same manner as the drilling equipment and as outlined in SOP #028 for equipment not used in sampling activities prior to and between uses. The roll-offs will be cleaned using high-pressure steam and this water collected and tested for contaminants of concern at the particular site.

3.1.4 Drill cuttings will be screened using a FID or PID every 20 feet of drilling. Because water is added to assist in the drilling, the cuttings will remain in the roll-off until after the water is

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INVESTIGATIVE DERIVED WASTE MANAGEMENT

pumped off. An FID or PID will be used to monitor the cuttings and to segregate suspected hazardous from non-hazardous cuttings. Cuttings that exhibit headspace readings for organic compounds equal to or greater than 5 parts per million (ppm) above ambient background readings will be presumed to be potentially hazardous and will be segregated.

Plastic sheeting or tarps that are of sufficient size to completely cover the open portion of the roll-off (without overlapping or seams), will be placed over the top of the roll-off bin(s) and secured at the end of each work day or if work is stopped because of rain or inclement weather conditions. This is to preclude any rainwater from entering the roll-off and mixing with the IDW. Water will be screened at the end of each day for headspace using the FID or PID and handled according to step 3.3 of this SOP.

- 3.1.5 After pumping off groundwater, cuttings will be placed on and covered with plastic in the vicinity of the borehole.
- 3.1.6 Groundwater will be screened with the PID or FID meter by taking headspace analysis of the water vapor. Section 3.3.3 of this IDW SOP describes the procedures for handling the groundwater produced during the drilling activities.
- 3.1.7 Cuttings with headspace concentrations below the 5 parts per million (ppm) ambient background conditions will be spread out on the ground and left on-site, be placed in an open trench and covered, or taken to the Base Landfill.
- 3.1.8 Cuttings that are potentially hazardous (headspace >5ppm above background) will be removed from the roll-off container and placed on and covered with plastic sheeting until samples can be analyzed.
- 3.1.9 If the cuttings have headspace >5ppm above background, a composite sample will be collected from the cuttings pile and will be analyzed for RCRA hazardous waste characteristics Toxicity Characteristic Leaching Procedure (TCLP), including VOCs.
- 3.1.10 Cuttings that exhibit elevated analyte concentrations above RCRA threshold limits will be consolidated, containerized, and transported to a hazardous waste accumulation facility at Andersen AFB, or may be handled by the contractor (contract specific).
- 3.1.11 Cuttings that are analyzed and report concentrations below RCRA threshold limits for organic compounds will be disposed of on the ground at the well site or placed in an open trench and covered.

3.2 CUTTINGS AND SOILS FROM SHALLOW BOREHOLE DRILLING USING HOLLOW-STEM AUGERS

- 3.2.1 Read Health and Safety Plan
- 3.2.2 Calibrate all Health and Safety monitoring equipment according to manufacturers' recommendations.
- 3.2.3 Drill cuttings will be screened using a FID or PID to segregate suspected hazardous from non-hazardous cuttings. Cuttings that exhibit headspace greater than 5 ppm above ambient background readings will be presumed to be potentially hazardous and will be segregated into 55-gallon drums or other suitable container. Cuttings that are potentially hazardous will

INVESTIGATIVE DERIVED WASTE MANAGEMENT

remain in the 55-gallon drum and be placed in a designated staging area until the analytical results are received for the associated samples.

- 3.2.4 Cuttings that are below the 5 ppm ambient background conditions will be spread out on the ground on site or disposed at the Base Landfill.
- 3.2.5 Cuttings that are analyzed and contain chemical concentrations above RCRA threshold limits will be collected, containerized and transported to the designated hazardous waste accumulation area on Andersen AFB until they can be disposed off island.
- 3.2.6 Cuttings that are analyzed and contain chemical concentrations below RCRA threshold limits for organic compounds will be disposed of on the ground at the site or at the Base Landfill.

3.3 SOILS AND MATERIALS FROM TEST EXCAVATIONS

- 3.3.1 Read Health and Safety Plan
- 3.3.2 Calibrate all Health and Safety monitoring equipment according to manufacturers' recommendations.
- 3.3.3 Soils and materials excavated from waste piles and fill areas with a backhoe or equivalent will be screened with a FID or PID.
- 3.3.4 Headspace values that are below the 5 ppm ambient background conditions will be placed back into the excavation.
- 3.3.5 If the headspace readings are 5 ppm or more above ambient background concentrations, the materials will placed back into the excavation, covered with plastic sheeting, covered with soil, and the location will be marked and surveyed for future reference.

3.4 GROUNDWATER

3.4.1 Drilling and Development Fluids

Water produced during drilling, well development, and groundwater-sampling activities will be collected for headspace analysis. Attachment B contains an IDW decision chart for handling drilling water derived from below the water table, and Attachment C contains an IDW decision chart for handling water derived from well development, well purging, and decontamination activities. Field screening will be performed to direct potentially contaminated water to storage tanks designated for further testing.

- 3.4.1.1 Using a sample bottle of at least 8-ounce capacity, obtain a grab sample from the drilling cyclone, discharge tubing (from well purging) or pipe discharge (for aquifer testing activities). Fill the sample bottle half full of water, place a piece of aluminum foil over the top of the bottle and cap.
- 3.4.1.2 Perform the headspace analysis by allowing the sample to equilibrate for not less than 15 minutes and not longer than 1 hour. Remove the cap and punch the FID or PID probe through the aluminum foil. Make sure not to submerge the probe in the water sample. Obtain the reading and record in the borehole/well specific field logbook.

INVESTIGATIVE DERIVED WASTE MANAGEMENT

3.4.1.3 Groundwater produced during drilling will be separated from the drill cuttings by collecting the cuttings and water in roll-off bins. At the end of the workday, a sample will be collected for VOC analysis as specified in Step 3.2.2. A submersible type pump will then be used to pump the water from the collection roll-off bin to an intermediate storage tank or other suitable container staged at each borehole location. If the results of the analytical sample are negative for VOCs or below the Safe Drinking Water Act, Maximum Contaminant Levels (MCLs), the water can either be discharged to an unlined pit or into the POTW.

3.4.1.4 During drilling activities, a water sample will be collected every 20 feet of drilling once in the groundwater for VOC headspace analysis on the water vapor using a PID or FID meter. A water sample will be collected from the cuttings discharge following the procedures outlined in Step 3.2.1.1 and 3.2.1.2 of this SOP. Attachment B contains a decision flow chart for handling drilling water derived from below the water table.

If the well is being developed, water will be directed to a temporary bulk storage tank. At the completion of the well development, a water sample will be collected and analyzed for VOCs using an off-island analytical laboratory and quick turnaround time (TAT).

3.4.1.5 Drilling water will be directed into a roll-off bin and when the container is half filled a water sample will be collected and shipped to an off-island laboratory for VOC analysis under quick TAT.

3.4.1.6 If the analytical results for the water sample has VOC concentrations above the Safe Drinking Water Act MCLs, but below RCRA limits, the corresponding water will be directed to a dedicated tank/container until it can be transported to a POTW for disposal, using the attached POTW Disposal Authorization Form (Attachment D).

3.4.1.7 If the analytical results for the water sample have VOC concentrations below MCLs the corresponding water can be directed to an unlined trench or pit or discharged to the POTW, using the attached POTW Disposal Authorization Form (Attachment D).

3.4.2 Sampling Purge Water

3.4.2.1 For purge water collected during groundwater sampling activities, the water will be collected in bulk storage containers/drums or directed to the ground surface at each well using the procedures. If low-flow sample techniques are utilized approximately 55-gallons of purge water will be produced for each well.

3.4.2.2 If wells with historic analytical data indicate that the water does not pose a risk to human health or the environment and is not a CERCLA or RCRA hazardous waste, then the water from those wells will be directed to the ground surface next to and in a downgradient direction from the well.

3.4.2.3 If the historic analytical data indicates any analytes above regulatory limits (Safe Drinking Water Act MCLs) for the respective well or chloride measurements are above 250 mg/l (Secondary MCL value), then the purge water will be placed in a container or drum and will be transported from the well to a temporary storage tank located at a designated staging area on Andersen AFB. As needed or at the end of the groundwater sampling round, the purge water bulk tank contents will be sampled and sent to an off-island laboratory for VOC analysis.

INVESTIGATIVE DERIVED WASTE MANAGEMENT

- 3.4.2.4 If the analytical results for the water sample has VOC concentrations above the Safe Drinking Water Act, MCLs, but below RCRA limits, the corresponding water will be directed to a dedicated tank/container until it is transported to a POTW for disposal and treatment upon Andersen AFB approval. using the attached POTW Disposal Authorization Form (Attachment D).
- 3.4.2.5 If the analytical results for the water sample have VOC concentrations below MCLs the corresponding water can be transported to the POTW, upon Andersen AFB approval, using the attached POTW Disposal Authorization Form (Attachment D).

4.0 PRECAUTIONS

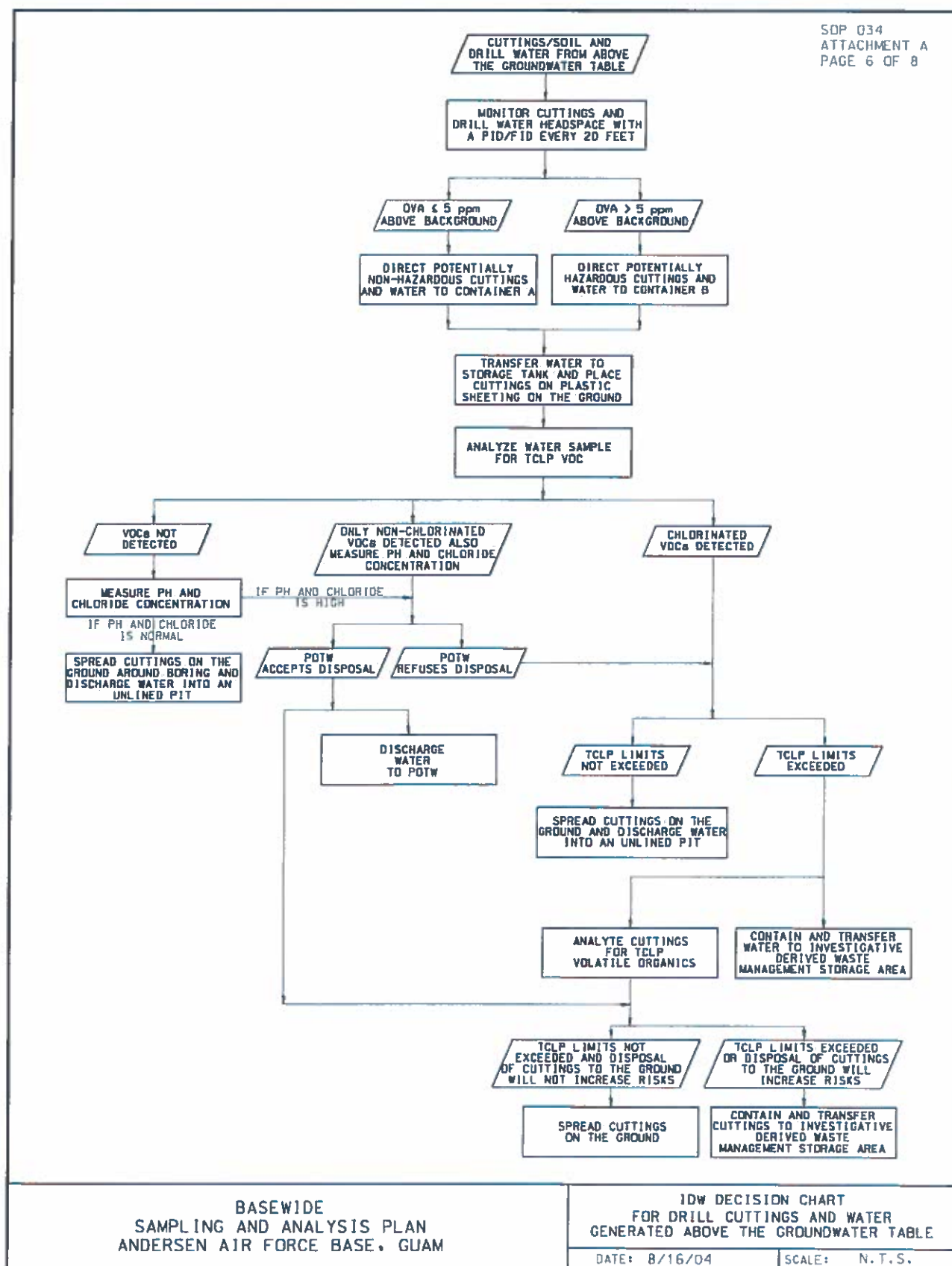
- Read all relevant health and safety plan, work plan and sampling and analysis plan (SAP) documents.
- Read all appropriate SOPs.
- Make sure monitoring instruments are properly calibrated and SOPs are followed for calibration.
- Ensure that proper containment is provided for cuttings that are derived from below the water table. Excess water could run off the plastic sheeting and onto the ground prior to approved disposal. A small berm or dike will be constructed by using cuttings that are approved for disposal, crushed coral, or soils.

5.0 REFERENCES

- AFCEE, 1993. Handbook to Support the Installation Restoration Program (IRP) Statements of Work, Volume 1 - Remedial Investigation/Feasibility Studies (RI/FS), September.
- USEPA, 1987. Data Quality Objectives for Remedial Response Activities, Volume 1.
- USEPA, 1991. Management of Investigative-Derived Wastes During Site Inspections, EPA/540/G-91/009. OERR Directive 9345.3-02. May.

6.0 ATTACHMENTS

- Attachment A - IDW Decision Chart for Drill Cuttings and Water Generated Above the Water Table
- Attachment B - IDW Decision Chart for Drill Cuttings and Water Generated Drilling Below the Water Table
- Attachment C - IDW Decision Chart for Development, Purge and Decontamination Water
- Attachment D - POTW Disposal Authorization Form



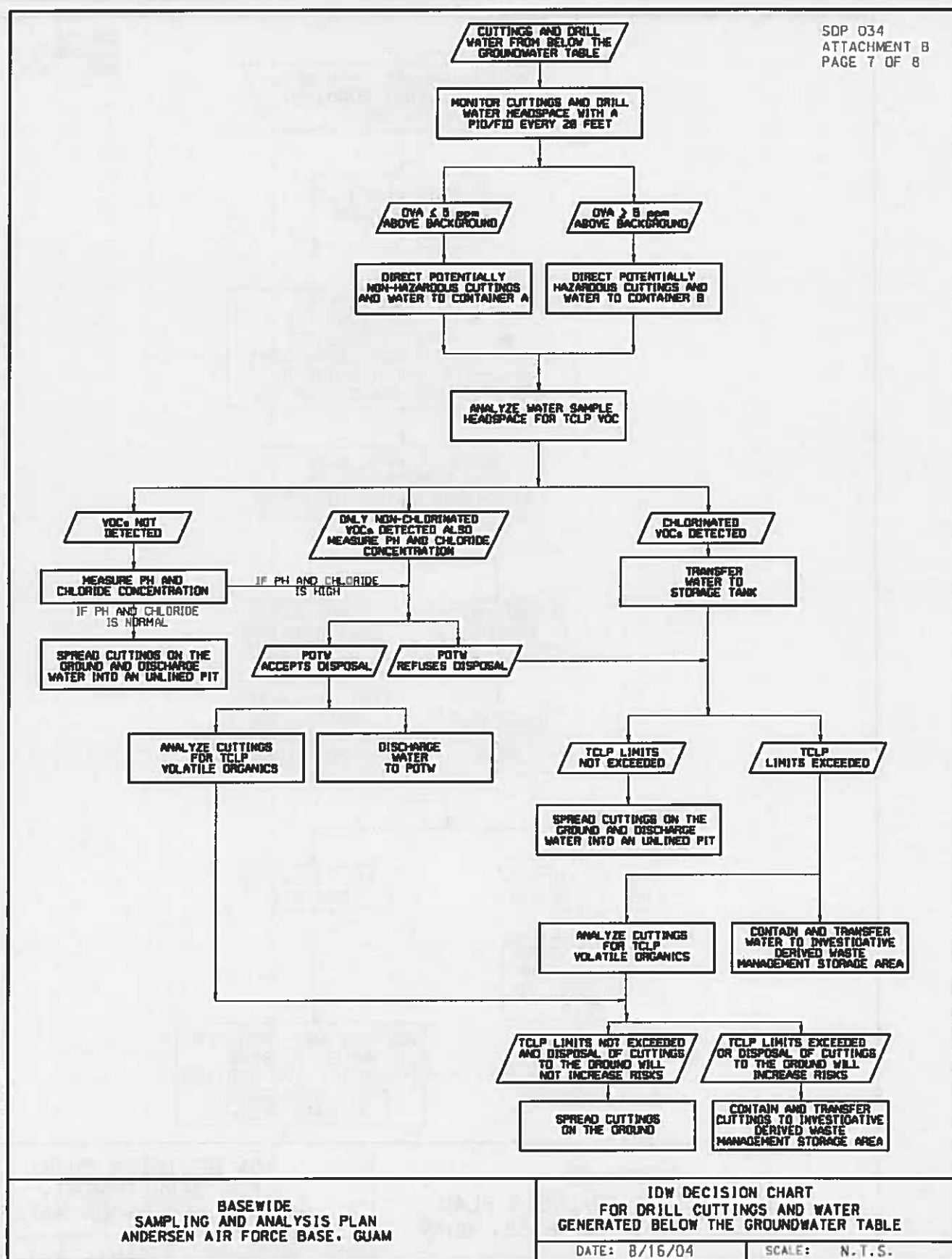
BASEWIDE
SAMPLING AND ANALYSIS PLAN
ANDERSEN AIR FORCE BASE, GUAM

IDW DECISION CHART
FOR DRILL CUTTINGS AND WATER
GENERATED ABOVE THE GROUNDWATER TABLE

DATE: 8/16/04

SCALE: N.T.S.

Final: January 24, 1994
Revision 1: April 21, 1995
Revision 2: August 4, 1995
Revision 3: December 20, 1996
Revision 4: January 2005



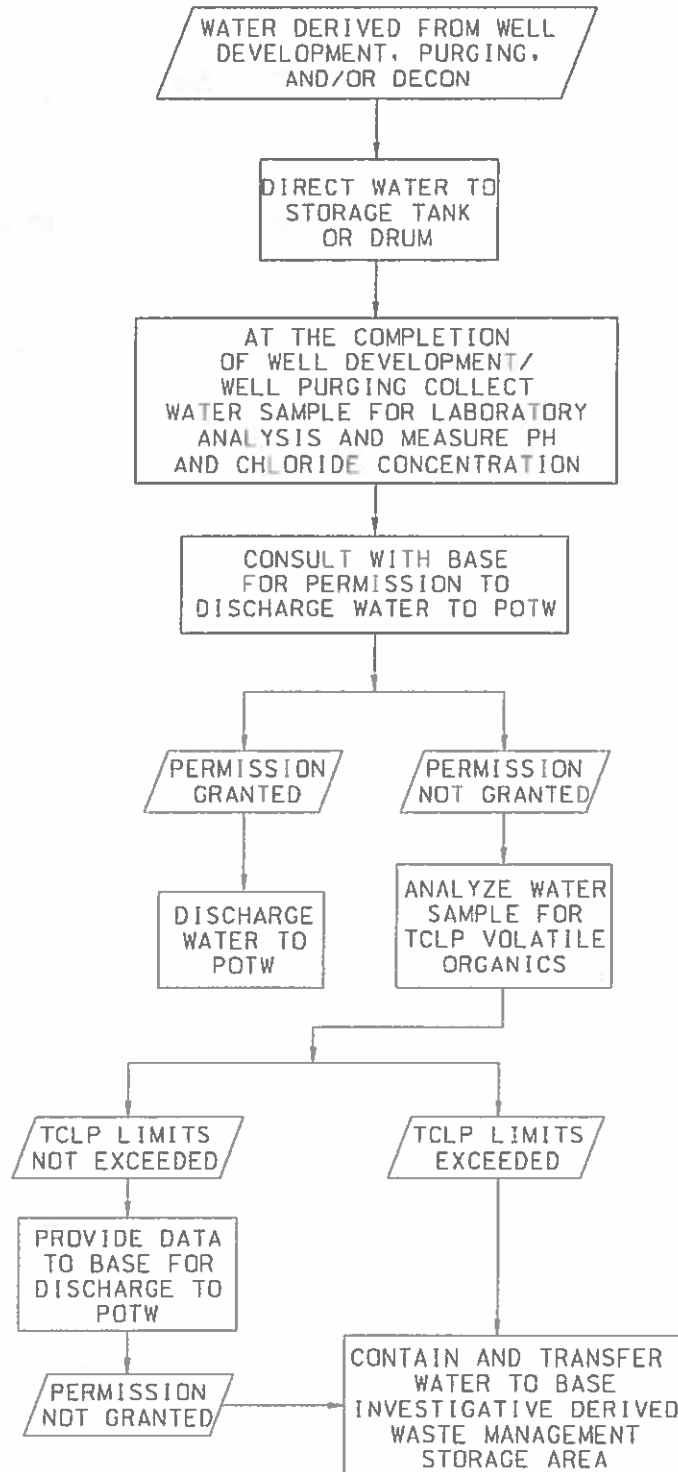
BASEWIDE
SAMPLING AND ANALYSIS PLAN
ANDERSEN AIR FORCE BASE, GUAM

IDW DECISION CHART
FOR DRILL CUTTINGS AND WATER
GENERATED BELOW THE GROUNDWATER TABLE

DATE: 8/16/04

SCALE: N.T.S.

Final: January 24, 1994
Revision 1: April 21, 1995
Revision 2: August 4, 1995
Revision 3: December 20, 1996
Revision 4: January 2005



BASEWIDE
SAMPLING AND ANALYSIS PLAN
ANDERSEN AIR FORCE BASE, GUAM

IDW DECISION CHART
FOR DEVELOPMENT,
PURGE, AND DECON WATER

DATE: 8/16/04

SCALE: N.T.S.

Final: January 24, 1994
Revision 1: April 21, 1995
Revision 2: August 4, 1995
Revision 3: December 20, 1996
Revision 4: January 2005

POTW DISPOSAL AUTHORIZATION FORM

SECTION 1. GENERAL INFORMATION						
Office Location:				Date:		
Project Number:				Company:		
Contract Number:						
Contractor Supervisor on Duty:						
Contractor Site Supervisor:						
SECTION 2. INVESTIGATIVE DERIVED WASTE (IDW)						
Source of IDW:						
Generation Date(s):						
Generation Method:						
Matrix:	Drill Cutting	Soil	Decon Water	Purge Water	Other:	
Quantity / Volume:						
SECTION 3. ANALYTICAL RESULTS						
OVA Headspace Reading:			ppm			
Chloride measurement:			mg/L			
pH:						
Laboratory Analytical Results: (See Attached)						
Other:						
CERCLA HAZARDOUS SUBSTANCE? YES NO						
SECTION 4. DISCHARGE LOCATION						
Sewage Lift Station:		On-site Pit:		Base Landfill:	Other:	
SECTION 5. APPLICABLE REGULATIONS						
(DOT, USEPA, Guam EPA, OSHA, CERCLA, RCRA, TSCA, SDWA)						
Transport Supplier:						
USEPA Transporter Identification Number:						
Applicable Placards:						
Estimated Transportation Costs: \$						
SECTION 5. AUTHORIZATION TO DISPOSE/TRANSPORT (at least two needed)						
PROJECT MANAGER						
Print Name:			Signature:		Date:	
PROGRAM MANAGER						
Print Name:			Signature:		Date:	
CES/CEV MANAGER						
Print Name:			Signature:		Date:	

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APPENDIX G

**GROUNDWATER ANALYTICAL RESULTS FOR
MONITORING WELL IRP-52**



GROUNDWATER ANALYTICAL RESULTS, MAIN BASE OPERABLE UNIT, ANDERSEN AFB, GUAM
MONITORING WELL IRP-52

Sample Identifier		IRP-52										IRP-52		IRP-52		IRP-52		IRP-52	
Sample Date		11/10/1997										11/10/1997		11/10/1997		11/10/1997		11/10/1997	
Sampling Round		Round 5										Round 5		Round 5		Round 5		Round 5	
Method		Units										Duplicate		Duplicate		Duplicate		Duplicate	
Analyte		USEPA MCLs																	
VOLATILE ORGANIC COMPOUNDS		2002																	
8260	ACETONE											<5	<5	<5	<5	<5	<5	<5	<5
8260	CARBON DISULFIDE											7	<1	<1	<1	<1	<1	<1	<1
8260	CHLOROMETHANE																		
8260	METHYL ETHYL KETONE											<5	<5	<5	<5	<5	<5	<5	<5
8260	TETRACHLOROETHENE (PCE)											0.3 J	0.4 J	0.3 J	0.3 J	0.3 J	0.3 J	0.3 J	0.3 J
8260	TOLUENE											<1	<1	<1	<1	<1	<1	<1	<1
8260	TRICHLOROETHENE (TCE)											0.8 J	0.8 J	0.7 J	0.7 J	0.7 J	0.7 J	0.7 J	0.7 J
SEMIVOLATILE ORGANIC COMPOUNDS																			
8270	BIS(2-ETHYLHEXYL)PHTHALATE																		
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)																			
8310	BENZO(A)PYRENE											<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PESTICIDES/PCBs																			
8080/8081	DIELDRIN											0.058	0.039	0.05	0.05	0.046	0.053	0.031	<0.02
8080/8081	P,P'-DDD											<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11
INORGANICS																			
6010	ALUMINUM											137 B	76.7 B	91.5 BN	98.9 BN	56.1 B	116 B	<65	18 B†
6010/7041	ANTIMONY											<2	<2	<24	<24	2.4 B†	1.2 B	1 B	<6
6010/7060	ARSENIC											<2	<2	<1	<1	<1	2 B	<2	<5
6010	BARIUM											<14	<22	<4	<4	<4	<4	<8	1 B
6010	CALCIUM											67400	64200	58000	60800	62800	65800	54200 E	51400
6010	CHROMIUM, TOTAL											<6	65.6	79.7 N	42.2 BN	10 B	27.7	31.8	56.8
6010	COBALT											<50	<50	<50	<50	<50	<50	<50	<50
6010	COPPER											<50	<50	<50	<50	<50	<50	<50	<50
6010	IRON											170	309	299 N	134 N	<52	163	109	191
6010/7421	LEAD											<1	<1	2.7 B	1.3 B	1.1 B	3 †	1.3 B†	1.6 B
6010	MAGNESIUM											15400	15300	14500 N	15000 N	14600	15200	15200	15300
6010	MANGANESE											7.9 B	<6	<8	<8	<8	6.4 B	<2	8.3 B
7470	MERCURY											<0.2	<0.2	<0.1	0.14 B	<0.1	<0.1	<0.1	<1
6010	NICKEL											<15	43.3 B	61.5 BN	64.3 BN	24.6 B	42.5	40.6	41.8 B
6010	POTASSIUM											2490 B	2070 B	2720 BN	2710 BN	4170 B	4530	7620	9570
6010/7740	SELENIUM											1.6 B	<1	<0.7	<0.7	2 B	<2	<2	1.2 B
6010/7740	SILVER											<50	<50	<50	<50	<50	<50	<50	<50
6010	SODIUM											52500	49300	48700 EN	50900 EN	51300	54500	40600 E	36300
6010	VANADIUM																		
6010	ZINC											62.4	<12	<12	<12	<12	<12	<12	7.2 B
901x/335 x	CYANIDE											<0.01	<0.01	0.012	0.012	<0.01	<0.01	<0.01	<0.02
WATER QUALITY PARAMETERS																			
310.1	ALKALINITY, BICARBONATE											208	185	181	187	178	189	185	182
310.1	ALKALINITY, CARBONATE											0.6 J	0.9	1.3	1.4	<0.4	0.64	0.42	<10
310.1	ALKALINITY, TOTAL											208	185	181	187	178	—	185	182
325.2/9056	CHLORIDE											112	135	91.6	92.9	85.1	95	88.6	63
375.4/9056	SULFATE											16.3	14.2	14.6	16.2	18.9	5.7	22.5	15
160.1	TOTAL DISSOLVED SOLIDS											405	505	350	356	354	298	356	291

GROUNDWATER ANALYTICAL RESULTS, MAIN BASE OPERABLE UNIT, ANDERSEN AFB, GUAM

MONITORING WELL IRP-52

Sample Identifier		2002										
Sample Date	Sampling Round	Method	Analyte	Units	USEPA MCLs	IRP-52 5/7/2008 Round 10	IRP-52 11/2/2000 Round 11	IRP-52 5/1/2001 Round 12	IRP-52 11/1/2001 Round 13	IRP-52 4/29/2002 Round 14	IRP-52 10/28/2002 Round 15	IRP-52 5/1/2003 Round 16
VOLATILE ORGANIC COMPOUNDS												
8260	ACETONE			µg/L	N/A	<5	<1.4	1.6 F	2.8	<5	<5	1.3
8260	CARBON DISULFIDE			µg/L	N/A	<1	<0.1	<0.1	---	<1	<1	<1
8260	CHLOROMETHANE			µg/L	N/A	---	2.6	4.6	0.3	<1	0.7 J	<1
8260	METHYL ETHYL KETONE			µg/L	N/A	<5	<5	<5	<5	<5	<5	0.9
8260	TETRACHLOROETHENE (PCE)			µg/L	5 F	0.22 J	0.3 F	0.2 F	0.3	<1	0.3 J	0.3
8260	TOLUENE			µg/L	1000	<1	<1	<1	<1	<1	<1	0.5
8260	TRICHLOROETHENE (TCE)			µg/L	5 F	0.49 J	0.6 F	1.4	0.6	<1	<1	0.4
SEMI-VOLATILE ORGANIC COMPOUNDS												
8270	BIS(2-ETHYLHEXYL)PHTHALATE			µg/L	10 RL	9 J	ND	---	---	---	---	---
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)												
8310	BENZO(A)PYRENE			µg/L	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.042 J
PESTICIDES/PCBs												
8080/8081	DIELDRIN			µg/L	N/A	0.03 P	<0.007	<0.007	0.031	0.051 P	<0.02	0.06 P
8080/8081	P,P'-DDD			µg/L	N/A	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	0.01 J
INORGANICS												
6010	ALUMINUM			µg/L	N/A	<17	29.2 F	16.1 F	17.5	<500	27.8 B	17 B
6010/7041	ANTIMONY			µg/L	6 F	<1.3	<0.6	---	---	<6	<6	0.6 B
6010/7060	ARSENIC			µg/L	10	<0.6	<0.7	<0.7	1.1	<5	<5	<5
6010	BARIUM			µg/L	2,000 F	2.2 B	2.2 F	<2.0	2.1	1.6 B	1.8 B	4 B
6010	CALCIUM			µg/L	N/A	49,200	63,300	49,800	62,200	60,500	55,900	58,800
6010	CHROMIUM, TOTAL			µg/L	100 F	36.4 B	37 F	27.5 F	17.5	6.3 B	51.5	6.9 B
6010	COBALT			µg/L	N/A	<50	<50	<50	2.4	<50	<50	<50
6010	COPPER			µg/L	1300	<50	<50	<50	<50	<50	<50	2.2 B
6010	IRON			µg/L	N/A	115	142	155	83.1	45.8 B	149	29 B
6010/7421	LEAD			µg/L	15 TT	1.3 B	<0.8	<0.3	<5	<5	<5	<5
6010	MAGNESIUM			µg/L	N/A	13,900	17,400	15,500	17,300	15,300	15,700	14,600
6010	MANGANESE			µg/L	N/A	5 B	9.2 F	10.1 F	6	5.3 B	9.7 B	3 B
7470	MERCURY			µg/L	2 F	<0.1	<0.1	---	<1	---	<2	<1
6010	NICKEL			µg/L	N/A	31.3 B	77.1 F	58.4 F	41	34.8 B	61.4 B	19.5 B
6010	POTASSIUM			µg/L	N/A	7,470	6,820	6,820	5,420	4880 B	5,780	4330 B
6010/7740	SELENIUM			µg/L	50 F	<0.4	<0.8	<0.7	<5	<5	<5	<5
6010/7740	SILVER			µg/L	N/A	<50	<50	<50	5.7	<50	2 B	4 B
6010	SODIUM			µg/L	N/A	36,100	62,000	40,200	63,000	53,800	47,200	47,700
6010	VANADIUM			µg/L	N/A	1 B	<1	<1.0	2	<80	<80	1.8 B
6010	ZINC			µg/L	N/A	10.1 B	30.4	35.8	3.4	42.9	4.2 B	7.4 B
901x/335.x	CYANIDE			mg/L	0.2 F	<0.002	<0.002	<0.004	<0.02	<0.02	<0.02	---
WATER QUALITY PARAMETERS												
310.1	ALKALINITY, BICARBONATE			mg/L	N/A	175	188	174	188	174	170	---
310.1	ALKALINITY, CARBONATE			mg/L	N/A	---	<2	<5.0	<2	---	---	---
310.1	ALKALINITY, TOTAL			mg/L	N/A	175	188	174	188	174	170	---
325.2/9056	CHLORIDE			mg/L	N/A	61.07	97.2	61.2	109.4	83.51	74.1	---
375.4/9056	SULFATE			mg/L	N/A	13.14	17.99	13.06	19.67	15.5	14.7	---
160.1	TOTAL DISSOLVED SOLIDS			mg/L	N/A	298	374	---	---	---	---	---