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REVISED FINAL PHASE I RCRA FACILITY INVESTIGATION WORK PLAN SWMU 79 NAVY OPERATIONS ON CABRAS ISLAND

For NAVAL ACTIVITY PUERTO RICO
EPA I.D. No. PR2170027203
CEIBA, PUERTO RICO

Prepared for:

Department of the Navy
NAVFAC SOUTHEAST
North Charleston, South Carolina

Prepared by:

Michael Baker Jr., Inc.
Moon Township, PA

Contract No. N62470-10-D-3000
DO JM01

June 21, 2011

IQC for A/E Services for Multi-Media Environmental Compliance Engineering Support

REVISED FINAL

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DELIVERY ORDER JM01

Prepared by:

MICHAEL BAKER JR., INC.
Moon Township, Pennsylvania

I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all attachments and that this document and its attachments were prepared either by me personally or under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gather and present the information contained therein. I further certify, based on my personal knowledge or on my inquiry of those individuals immediately responsible for obtaining the information, that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowingly and willfully submitting a materially false statement.

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LIST OF ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
AFWTF	Atlantic Fleet Weapons Training Facility
Baker	Baker Environmental, Inc./Michael Baker Jr., Inc.
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
C	Copper
CCC	Continuous Criteria Concentrations
CCME	Canadian Council of Ministers of the Environment
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CERFA	Community Environmental Response Facilitation Act
CMS	Corrective Measures Study
CSF	Cancer Slope Factor
DMMP	Dredged Material Management Program
DO	Delivery Order
DRO	Diesel Range Organics
EC_{50}	Median Effective Concentration
Eco-SSL	Ecological Soil Screening Level
ECP	Environmental Condition of Property
EOD	Explosive Ordnance Disposal
EqP	Equilibrium Partitioning
ER-L	Effects-Range Low
ER-M	Effects-Range Median
ESL	Ecological Screening Level
FCVs	Final Chronic Values
ft	feet/foot
GPS	Global Positioning System
GRO	Gasoline Range Organics
HQ	Hazard Quotient
HSA	Hollow-Stem Augers
HUD	U.S. Development of Housing and Urban Development
IDW	Investigation Derived Waste
ILCR	Incremental Lifetime Cancer Risk
ISQG	Interim Freshwater Sediment Quality Guidelines
IUR	Inhalation Unit Risk
IHDIV	Indian Head Division
JATO	Jet Assisted Take-Off
kg	kilograms

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

L	Lead
LCP	Lead-Containing Paint
LEL	Lowest Effect Level
LC_{50}	Median Lethal Concentration
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observable Effect Level
LLPAH	Low-Level Polynuclear Aromatic Hydrocarbon
MATC	Maximum Acceptable Toxicant Concentration
MCL	Maximum Contaminant Level
MHSPE	Ministry of Housing, Spatial Planning and Environment
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPR	Naval Activity Puerto Rico
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
NAWQC	National Ambient Water Quality Criteria
NOAA	National Oceanic and Atmospheric Administration
NOEC	No Observed Effect Concentration
NOEL	No Observed Effect Level
NSRR	Naval Station Roosevelt Roads
NTR	Navy Technical Representative
NTU	Nephelometric Turbidity Unit
PAH	Polynuclear Aromatic Hydrocarbon
PEL	Probable Effect Levels
PMO	Project Management Office
PRWQS	Puerto Rico Water Quality Standards
PSQG	Provincial Sediment Quality Guidelines
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAB	Restoration Advisory Board
RAGS	Risk Assessment Guidance for Superfund
RCI	Reactivity, Corrosivity, Ignitibility
RCRA	Resource Conservation and Recovery Act
RfC	Inhalation Reference Concentrations
RfD	Reference Dose
RFI	RCRA Facility Investigation
RSL	Ready Service Locker

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

SCV	Secondary Chronic Values
SE	Southeast
SL	Screening Levels
SOP	Standard Operating Procedure
SQG	Sediment Quality Guidelines
SQAG	Sediment Quality Assessment Guidelines
SQUIRT	Screening Quick Reference Tables
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TEL	Threshold Effects Level
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbon
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UST	Underground Storage Tank
VOC	Volatile Organic Compound
XRF	X-Ray Fluorescence

1.0 INTRODUCTION

This document presents the activities required for the performance of a Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 79, the Navy Operations Area on Cabras Island located at Naval Activity Puerto Rico (NAPR), Ceiba, Puerto Rico. This work plan has been prepared by Michael Baker Jr., Inc. (Baker), for the Navy Base Realignment and Closure (BRAC) Program Management Office (PMO) Southeast (SE) office under contract with the Naval Facilities Engineering Command (NAVFAC), SE (Contract Number N62470-10-D-3000, Delivery Order [DO] JM01). This work plan was developed in accordance with the RCRA § 7003 Administrative Order on Consent (United States Environmental Protection Agency [USEPA] Docket No. 02-2007-7301 [USEPA, 2007a]). The work will be implemented in accordance with the Final RFI Management Plans (Baker, 1995), with updates to appropriate sampling and analytical methods as indicated in this Work Plan.

1.1 NAPR Description and History

NAPR occupies over 8,800 acres on the northern side of the east coast of Puerto Rico, along Vieques Passage with Vieques Island lying to the east about 10 miles off the harbor entrance (Figure 1-1). NAPR also occupies the immediately adjacent islands of Piñeros and Cabeza de Perro, as presented on Figure 1-2. The northern entrance to NAPR is about 35 miles east along the coast road (Route 3) from San Juan. The property consists of 3,938 acres of upland (developable) property and 4,955 acres of environmentally sensitive areas including wetlands, mangrove, and wildlife habitat. The closest large town is Fajardo (population approximately 41,000), which is about 5 miles north of NAPR off Route 3. Ceiba (population approximately 18,000) adjoins the west boundary of NAPR (Figure 1-1).

The facility was commissioned in 1943 as a Naval Operations Base, and finally re-designated a Naval Station in 1957. Naval Station Roosevelt Roads (NSRR) operated as a Naval Station from 1957 until March 31, 2004. NSRR was one of the largest naval facilities in the world with more than 100 miles of paved roads, approximately 1,300 buildings, a large scale airfield (Ofstie Field), a deep water port, and over 30 tenant commands. NSRR played a major role in providing communication support to the Atlantic and Caribbean areas and also served as a major training site for fleet exercises.

Section 8132 of fiscal year 2004 Defense Appropriations Act, signed into law on September 30, 2003, directed that NSRR be disestablished within 6 months, and that the real estate disposal/transfer be carried out in accordance with procedures contained in the BRAC Act of 1990. This legislation required that the base closure be conducted in accordance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), as amended by the Community Environmental Response Facilitation Act (CERFA). NSRR has undergone operational closure as of March 31, 2004 and has been designated as Naval Activity Puerto Rico. The mission of NAPR is to protect the physical assets remaining, comply with environmental regulations, and sustain the value of the property until final disposal of the property. NAPR will continue until the real estate disposal/transfer is completed.

The USEPA issued a RCRA § 7003 Administrative Order on Consent 'Consent Order' (USEPA Docket No. RCRA-02-2007-7301) to NAPR. The Order sets out the Navy's corrective action obligations under RCRA and replaces the 1994 RCRA permit for NAPR. Following a public comment period, the Consent Order became effective on January 29, 2007.

1.2 Site Description and History

SWMU 79, the Navy Operations Area at Cabras Island, is located on the eastern side of Cabras Island and encompasses 4.06 acres. Buildings 2004, 2037, 2065, 2353, Launch Pads 1793, 1794, 2013, and munitions and explosives storage boxes "Ready Storage Locker 1" / "Ready Storage Locker 2" (RSL1/RSL2) are located in this area. Located outside of the SWMU 79 boundary on the north central side of Cabras Island is Building 104 and Building 120. The site layout is shown on Figure 1-3.

Military operations on Cabras Island supported the Atlantic Fleet Weapons Training Facility (AFWTF) activities at NSRR and nearby Vieques and Culebra Islands. The building and pads on Cabras Island were used solely for support of drone launching activities. The drones were fueled off-site and transported to Cabras Island for launching; no other maintenance or fueling was conducted on the island. Drones were weighed and balanced, and jet assisted take-off (JATO) bottles were attached to the drones on the island at Building 2353, Drone Handling Building, and Building 2004, the Drone Balancing and Storage Facility. New JATO bottles were stored in munitions and explosives storage boxes (RSL1/RSL2) located on the exterior of Buildings 2004 and 2353. Radio communications and remote control launch activities were conducted out of Building 2065, Radio Communications Building. Electrical power for the operations was generated in Building 2037. Drones were remotely launched from launch pads 1793, 1794, and 2013 using JATO bottles to assist with take-off.

Located outside of the SWMU 79 on Cabras Island are Buildings 104 and 120. Building 104 historically was used for Officer's Beach House and Building 120 was used as an Officer's Bath House. Also located on Cabras Island, outside of SWMU 79 are multiple open sided cabanas and Brookings Breach.

In 2009, the Navy performed a Phase I/II Environmental Condition of Property (ECP) investigation on Cabras Island. The results of the ECP indicate the presence of surface soil contamination due to the past Navy use of the site (Baker, 2009). Accordingly, the Navy notified the USEPA of the newly discovered release of potential hazardous constituents (Department of the Navy, 2009).

During recent public meetings held in support of NAPR's cleanup program, concern has been raised regarding the presence of JATO bottles in the sea adjacent to Cabras Island. Investigation into the probable current location(s) of the used JATO bottles has been conducted during the preparation of this work plan. Available information regarding the current disposition of the bottles is provided in Section 2.2.2.

1.3 Objectives

The purpose of this Phase I RFI Work Plan for SWMU 79 is to confirm the presence of contamination due to past Navy operations. Specifically, the objectives of this Phase I RFI are as follows:

- Determine the presence or absence of contamination in the surface and shallow subsurface soil adjacent to Buildings 2004, 2037, and 2353 and Launch Pads 1793, 1794, and 2013 indentified during the ECP.
- At the request of the U.S. Coast Guard, determine the presence or absence of lead in the surface soil immediately adjacent to (within 12 feet) Buildings 104, 2004, and 2037 due to the use of lead based paint on these buildings.
- Determine the presence or absence of metals in the soil below the launch pads.

- Determine the presence or absence of groundwater contamination.
- Determine the presence or absence of open water sediment contamination on the eastern shoreline of Cabras Island.

1.4 Organization of the Phase I RFI Work Plan

This work plan is organized into seven sections. Section 1.0 of this document includes the site history and objectives of this RFI. Section 2.0 provides a description of the current conditions and use of the site, as well as a summary of previous investigations. Section 3.0 provides a description of the scope of investigations that will be utilized during the upcoming fieldwork. The proposed scope of investigations include soil sampling and analysis, monitoring well installation, groundwater sampling and analysis, sediment sampling and analysis, and collection/analysis of quality assurance/quality control (QA/QC) samples, as well as other investigation considerations. The reporting activities that will be conducted following the completion of the field investigation are described in Section 4.0. Section 5.0 discusses the proposed project schedule that will be followed for this data collection investigation. The site management structure that will be utilized during this investigation, including project team responsibilities and field reporting requirements, is presented in Section 6.0, while Section 7.0 presents the Work Plan references.

2.0 CURRENT CONDITIONS AND BASIS FOR A PHASE I RFI

The following sections provide a discussion of the current conditions that exist at SWMU 79, the previous investigations that have been conducted, and a description of the area to be investigated.

2.1 Current Site Conditions and Use

SWMU 79 is currently uninhabited, as is all of Cabras Island. Three concrete pads (Launch Pads 1793, 1794, and 2013), formerly used for military drone launch operations, are located within the SWMU. A generator building (Building 2037), with an associated double walled fiberglass underground storage tank (UST), is located near the center of SWMU 79 just southeast of an open warehouse structure (Building 2004). The Radio Communications Building (Building 2065) is located just south of Launch Pad 1793. A septic tank is located near the Drone Handling Building (Building 2353). Explosives storage trailers (RSL1/RSL2) are located between Building 2004 and Building 2353. The use of these buildings, concrete pads, and tanks were discontinued with the closure of NSRR, located adjacent to Cabras Island on the island of Puerto Rico. The locations of these buildings and pads are shown on Figure 1-3. No ongoing activities are occurring at the present time at this SWMU.

Located outside of the SWMU 79 boundary on the north central side of Cabras Island is Building 104 and Building 120. Building 104 historically was used for Officer's Beach House and Building 120 was used as an Officer's Bath House. Records indicate the Officer's Beach House is 2,411 square feet in size and was built in 1949. The building is an open-sided recreation pavilion. Just south of the Beach House is the Officer's Bath House. Records indicate the Bath House is 192 square feet in size, was built in 1955. Wastewater generated from these two buildings is collected in a septic tank which appears to serve as a holding tank only; evidence of a drain field was not apparent during the field reconnaissance. Currently the buildings are uninhabited, as is all of Cabras Island.

2.1.1 Terrestrial and Aquatic Habitats

The upland habitat bounded by NAPR is classified as subtropical dry forest (Ewel and Witmore, 1973). Similar to other forested areas of Puerto Rico, this region was previously clear-cut in the early part of the century, primarily for pastureland (Geo-Marine, Inc., 1998). After acquisition by the Navy, a secondary growth of thick scrub, dominated by lead tree (*Leucaena* spp.), Christmas tree (*Randia aculeata*), sweet acacia (*Acacia farnesiana*), and Australian corkwood (*Sesbania grandiflora*) grew in the previously grazed sections (Geo-Marine, Inc., 1998). Secondary growth communities (upland coastal forest communities and coastal scrub forest communities) exist today throughout the station's undeveloped upland.

The upland vegetative community within undisturbed areas of SWMU 79 and surrounding areas is classified as a coastal scrub forest community. Specific vegetation occurring within the coastal scrub forest community has not been documented during previous investigations. However, based on observations recorded at other SWMUs containing similar upland habitat (i.e., SWMUs 1 and 2), herbaceous and shrub species, including *Panicum maximum* (guinea grass), lead tree (*Leucaena leucocephala*), almácigo (*Bursera simaruba*), Christmas tree (*Randia aculeate*are, are likely present. Dominant vegetation within the coastal scrub forest community will be documented during the Phase I RFI field investigation.

Cobana negra (*Stahlia monosperma*), a federally threatened tree species, is known to occur between the boundary of black mangrove communities and coastal upland forest communities. This species is also known to occur in coastal forests of southeastern Puerto Rico (Little and Wadsworth, 1964). A

single individual was encountered at NAPR during recent surveys conducted by Geo-Marine, Inc. (NAVFAC, 2006). This individual is located within a coastal scrub forest community near the Capehart housing area, west of American Circle (approximately 3.5 miles west of SWMU 79). No other plant species listed under the provisions of the Endangered Species Act of 1973 are known to occur or have the potential to occur at NAPR (Geo-Marine, Inc., 2000 and NAVFAC, 2006).

The aquatic habitats (open water marine and wetland habitat) occurring in the vicinity of SWMU 79 are depicted on Figure 2-1. The wetland units depicted on Figure 2-2, identified by the Cowardin Wetland Classification System (Cowardin et al., 1979; see Figure 2-3), were delineated by Geo-Marine, Inc. in December 1999 from 1993 color infrared and 1998 true color aerial photography. Twenty percent of the wetlands delineated by aerial photography were field checked by Geo-Marine, Inc. to verify the accuracy of the delineations. Field verification was based on the 1987 Corps of Engineers wetland delineation manual (United States Army Corps of Engineers [USACE], 1987). As evidenced by Figure 2-2, immediately adjacent to SWMU 79 is a wetland area nearly comparable in size (almost 4 acres). Two-thirds of this is an Estuarine, Intertidal, Scrub-Shrub, Broad-leaved Evergreen (E2SS3) unit, while within the boundaries of the E2SS3 lies an Estuarine, Subtidal, Open Water (E1OW) unit encompassing the other third of the wetland area. All of these estuarine wetland units are oriented toward the western side of the SWMU, intersecting the northwest SWMU boundary. Also on Cabras Island, a Marine, Intertidal, Unconsolidated Shore, Sand (M2US2) wetland unit lies approximately 300 feet west of the SWMU 79 border. The nearest down-gradient surface water body is the Caribbean Sea (immediately contiguous to the eastern boundary of SWMU 79). These wetland units are hydrologically connected to each other and the Caribbean Sea, but not to any other wetland units. Seagrass meadows around NAPR are dominated by a nearly continuous cover of turtle grass with a high abundance of calcareous green algae (*Avranvilla* spp., *Ventricaria ventricosa*, *Caulerpa* spp., *Valonia* spp., and *Udotea* spp.) (Reid et al., 2001). As evidenced by Figure 2-1, sea grass beds are prevalent around all of Cabras Island.

2.1.2 Biota

A description of the biota occurring within Puerto Rico and the landmass encompassed by NAPR (including the surrounding marine environment) is provided in the sections that follow. Although the specific terrestrial biota occurring at SWMU 79 have not been recorded during previous investigations, generalizations are provided based on available habitat. Specific biota occurring at SWMU 79 will be documented during the Phase I RFI field investigation.

2.1.2.1 Mammals

A total of 22 terrestrial mammal species are known historically from Puerto Rico; however, all mammals except bats (13 species) have been extirpated (Mac et al., 1998). The specific bat species known to occur in Puerto Rico are listed below. None of the bats found in Puerto Rico are exclusive to the island, nor are they listed under provisions of the Endangered Species Act of 1973.

- Fruit-eating bats: Jamaican fruit bat (*Artibeus jamaicensis*), Antillean fruit bat (*Brachyphylla cavernarum*), and red fig-eating bat (*Stenoderma rufum*)

- Nectivorous bats: brown flower bat (*Erophylla sezekoni bombifrons*) and greater Antillean long-tounged bat (*Monophyllus redmani*)

- Insectivorous bats: Antillean ghost-faced bat (*Mormoops blainvillii*), Parnell's mustached bat (*Pteronotus parnellii*), sooty mustached bat (*Pteronotus quadridens*), big brown bat

(*Eptesicus fuscus*), red bat (*Lasiurus borealis*), velvety free-tailed bat (*Molossus molossus*), and Brazilian free-tailed bat (*Tadarida brasiliensis*)

- Piscivorous bats: Mexican bulldog bat (*Noctilio leporinus*)

Of the endangered/threatened marine mammals that may occur in Puerto Rico, only the West Indian manatee is known to occur in the coastal waters surrounding NAPR (DoN, 2007). Manatee populations in Puerto Rico's coastal waters have been documented during three aerial surveys conducted from 1978 to 1979, 1984 to 1985, and in 1993 (United Nations Environmental Program [UNEP], 1995), a radio tracking study of manatee distribution and abundance (Reid and Kruer, 1998), and a year-long study of manatee distribution and abundance (Woods et al., 1984). Historical manatee sightings at NAPR are summarized on Figure 2-4. The figure (reproduced from DoN, 2007) includes information from most of the studies identified above. As evidenced by Figure 2-4, manatees have been sited within the waters of the Caribbean Sea surrounding SWMU 79. This can be attributed to the presence of seagrass around Cabras Island.

Several terrestrial mammals have been introduced into Puerto Rico, including the black rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), and small Indian mongoose (*Herpestes javanicus*). These nonindigenous mammals are nuisance species that have been implicated in the decline of native bird and reptile populations (Mac et al., 1998 and USFWS, 1996a).

2.1.2.2 Birds

A total of 239 bird species are native to Puerto Rico (Raffaele, 1989). This total includes breeding permanent residents and non-breeding migrants. In addition, many nonindigenous bird species have been introduced into Puerto Rico, including the shiny cowbird (*Molothrus bonariensis*) and several parrot species, such as the budgerigar (*Melopsittacus undulates*), orange-fronted parrot (*Aratinga canicularis*), and monk parrot (*Myiopsitta monaqchus*). Of the 239 species native to Puerto Rico, 12 are endemic to the island (Raffaele, 1989).

Numerous native and migratory bird species have been reported at NAPR (Geo-Marine, Inc., 1998). A list compiled from literature-based information pre-dating 1990 (see Table 2-1) includes the great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), little blue heron (*Florida caerulea*), black-crowned night heron (*Nycticorax nycticorax*), belted kingfisher (*Ceryle alcyon*), spotted sandpiper (*Actitis macularia*), greater yellowlegs (*Tringa melanoleauca*), black-bellied plover (*Squatarola squatarola*), clapper rail (*Rallus longirostris*), Royal tern (*Thalasseus maximus*), sandwich tern (*Thalasseus sandvicensis*), least tern (*Stema albifrons*), yellow warbler (*Dendroica petechia*), palm warbler (*Dendroica palmarum*), prairie warbler (*Dendroica discolar*), magnolia warbler (*Dendroica magnolia*), mourning dove (*Zenaida macroura*), red-legged thrush (*Mimocichla plumbea*), common nighthawk (*Chordeiles minor*), and red-tailed hawk (*Buteo jamaicensis*). Endemic species reported from NAPR include the Puerto Rican lizard cuckoo (*Saurothera vieilloti*), Puerto Rican flycatcher (*Myiarchus antillarum*), Puerto Rican woodpecker (*Malanerpes portoricensis*), Puerto Rican emerald (*Chlorostilbon maugaeus*), and yellow-shouldered blackbird (*Agelaius xanthomus*).

The yellow-shouldered blackbird is a federally endangered species. One of the principal reasons for the status of this species is attributed to parasitism by the nonindigenous shiny cowbird, which lays its eggs in blackbird nests and sometimes punctures the host's eggs (USFWS, 1983). Other factors contributing to the status of this species include nest predation by the introduced black rat, Norway rat, and mongoose, as well as habitat modification and destruction (USFWS 1996a). The entire land area of NAPR was declared critical habitat for the yellow-shouldered blackbird in 1976; however, a 1980 agreement with the USFWS exempted certain areas from this categorization (Geo-Marine, Inc.,

1998). Despite the potential feeding habitat (shrub layers) within the coastal scrub forest community present on Cabras Island (Geo-Marine, Inc., 2000), SWMU 79 is not located within the critical habitat designation for the yellow-shouldered blackbird. A study conducted by the Naval Facilities Engineering Service Center (NFESC, 1996) reported that the mangrove forests surrounding NAPR, the nearest of which is almost one mile from the SWMU, should be considered the most important nesting habitat for the yellow-shouldered blackbird (see Figure 2-1).

Other federally listed bird species that occur or have the potential to occur at NAPR are the roseate tern (*Sterna dougallii dougallii*) and piping plover (*Charadrius melodus*) (Geo-Marine, Inc., 1998). The piping plover is a rare, non-breeding winter visitor in Puerto Rico (Raffaele, 1989). This species breeds only in North America in three geographic regions (Atlantic Coast population [threatened], Great Lakes population [endangered], and Northern Great Plains population [threatened]; USFWS, 1996b). No piping plover observations were reported at NAPR during the 1990s or during sea turtle nesting surveys conducted in 2002 and 2004 (Geo-Marine, Inc., 2005). No historic evidence is available to indicate whether the roseate tern (threatened in Puerto Rico) has ever nested at NAPR and no roseate tern observations have been noted in or over coastal waters adjacent to NAPR (DoN, 2007). The nearest active roseate tern colony likely occurs on the eastern end of Vieques (more than 20 miles east of NAPR) (DoN, 2007). Based on the habitat preferences and observations recorded at NAPR, neither of these species has the potential to use the open water habitat surrounding SWMU 79 (i.e., the Caribbean Sea) as a food source.

2.1.2.3 Reptiles and Amphibians

A total of 23 amphibians and 47 reptiles are known from Puerto Rico and the adjacent waters (Mac et al., 1998). Fifteen of the amphibians and 29 of the reptiles are endemic, while four amphibian species and three reptilian species have been introduced (Mac et al., 1998). Puerto Rico's native amphibian species include 16 species of tiny frogs commonly called coquis. On the coastal lowlands, almost all coqui species are arboreal. The only amphibians listed under provisions of the Endangered Species Act of 1973 are the Puerto Rican crested toad (*Peltophryne lemur*) and the golden coqui (*Eleutherodactylus jasperi*). Both species are listed as threatened (USFWS, 2010). Distribution of the golden coqui is restricted to areas of dense bromeliad growth. All specimens to date have been collected from a small semicircular area of a 6-mile radius south of Cayey (approximately 30 miles southwest of NAPR), generally at elevations above 700 meters (USFWS, 1984). The Puerto Rican crested toad occurs at low elevations (below 200 meters) where there is exposed limestone or porous, well drained soil offering an abundance of fissures and cavities (USFWS, 1987). A single large population is known to exist from the southwest coast in Guánica Commonwealth Forest, while a small population is believed to survive on the north coast near Quebradillas, Arecibo, Barceloneta, Vega Baja, and Bayamón (USFWS, 1987). It also has been collected on the southeastern coastal plain near Coamo (USFWS, 1987). Given the habitat preferences and locations of known occurrences, these two species are not expected to occur at NAPR.

Puerto Rico's native reptilian species include 31 lizards, 8 snakes, 1 freshwater turtle, and 5 sea turtles (Mac et al., 1998). Of the five sea turtles, only the green sea turtle, hawksbill sea turtle (*Eretmochelys imbricata*), and loggerhead sea turtle (*Dermochelys coriacea*) nest within Puerto Rico. These three sea turtles, as well as the leatherback sea turtle (*Caretta caretta*) are listed under the provisions of the Endangered Species Act of 1973 (hawksbill sea turtle and leatherback sea turtle are listed as endangered, while the green sea turtle [Caribbean population] and loggerhead sea turtle are listed as threatened) (USFWS, 2010). Aerial surveys of turtles were performed from March 1984 through March 1995 along the Puerto Rican Coast. This information was summarized by Geo-Marine, Inc. (2005) in the Draft NAPR Disposal Environmental Assessment (EA). Figures 2-5 and 2-6 (reproduced from Geo-Marine, Inc., 2005) present cumulative sea turtle sightings and potential

turtle nesting sites at NAPR. Significant turtle observations were made near the mouth of the Ensenada Honda, the northern shore of Pineros Island, Pelican Bay, and the Medio Mundo Passage, with the frequency of turtle observations listed as green > hawksbill > loggerhead > leatherback. Sightings were also made on Cabras Island, near the western boundary of SWMU 79. Identical to the West Indian manatee, this can be attributed to the presence of seagrass (forage material) within this portion of the embayment.

The Puerto Rican boa (*Epicrates inornatus*) is a federally endangered species throughout its entire range (critical habitat has not been designated for this species [USFWS, 1986]). Four Puerto Rican boa sightings were reported at NAPR prior to 1999 and an additional four occurrences were reported between 2001 and 2003 (Geo-Marine, Inc., 2005). However, no boas were observed during 211 man-hours of surveys conducted within potential boa habitat in 2004 (Tolson, 2004). The Puerto Rican boa uses a variety of habitats but is most commonly found in Karst forest habitat (forested limestone hills). Based on the absence of preferred habitat, there is low probability of occurrence of this species at SWMU 79.

2.1.2.4 Fish and Aquatic Invertebrates

A diverse fish and invertebrate community can be found in the marine environment surrounding NAPR. This can be attributed to the varied habitats that include marine and estuarine open water habitat, mud flats, seagrass beds, and mangrove forests. The fish community is represented by stingrays, herrings, groupers, needlefish, mullets, barracudas, jacks, snappers, grunts, snooks, lizardfishes, parrotfishes, gobies, filefishes, wrasses, damselfishes, and butterflyfish (Geo-Marine, Inc., 1998). The benthic invertebrate community includes sponges, corals, anemones, sea cucumbers, sea stars, urchins, and crabs. A list of known species residing within the Ensenada Honda is not available from the literature.

2.2 Previous Investigations

The following sections discuss the previous investigations that have occurred at SWMU 79.

2.2.1 ECP Study

Sampling activities at SWMU 79 were conducted in 2009 as part of the Navy's Phase II ECP investigation for Cabras Island (Baker, 2009). These activities consisted of obtaining samples of surface and subsurface soil, sediment, concrete chip, and septic tank effluent.

The recognized on-site environmental concerns assessed as a result of the ECP study were the presence of low-level polynuclear aromatic hydrocarbons (LLPAHs) in the surface soil adjacent to Launch Pad 1794, metals in the surface soil adjacent to Launch Pads 1793, 1794, and 2013, lead and copper in the concrete barriers of Launch Pads 1793 and 1794, and metals in surface soil adjacent to Buildings 2004 and 2353. A review of the data obtained during the ECP investigation indicate elevated levels of metals exceeding, in many cases, ecological, human health, and background soil screening criteria in these areas. Analytical results from sediment samples taken from the edges of the pond located near the center of the island and samples taken from the septic tank effluent did not indicate the presence of contamination in these media. The results of the ECP investigation are shown on Tables 2-2 to 2-6 and the locations of the samples are depicted on Figure 2-7.

The results of a damaged lead-containing paint (LCP) assessment conducted as part of the ECP study indicate that Buildings 104, 2004, and 2037 contain damaged LCP. Therefore, as part of this Phase I

RFI, sampling will be performed to determine the presence or absence of lead contamination in the surface soil adjacent to these buildings.

There is one 600-gallon fiberglass UST located immediately south of Building 2037 on Cabras Island. This tank was monitored during its use with a Veeder Root system ensuring it was in compliance with the UST regulations in 40 CFR 280. This tank was used to supply diesel fuel to the emergency generator. The tank was installed in 1997 to replace a removed tank that was formerly at this location. Evidence of spills or leaks was not apparent during the January 2009 Phase I and Phase II ECP. However during field efforts, if evidence of a potential leak from this UST is evident, proposed sampling locations can be modified to capture the conditions at the area noted. Records indicate that the UST has not been formally closed with the Commonwealth of Puerto Rico and is scheduled to be removed from the site in 2011.

Because the sampling conducted under the ECP evaluation was intended to serve as a screening tool and was very limited in its extent, it was recommended that an expanded investigation be conducted within the former Navy Operations Area to identify the presence of contamination in the surface soil surrounding the buildings, and soil under the launch pads. The ECP concluded that samples should be analyzed for Appendix IX low level SVOCs (including LLPAHs), Appendix IX Metals, perchlorate and TPH GRO/DRO, in areas where contamination was prevalent. The results of the ECP study indicated that Navy Operations have impacted the environmental conditions on the eastern end of Cabras Island, now referred to as SWMU 79.

2.2.2 JATO Bottle Study

Questions regarding the nature and extent of possible contamination from JATO bottles released during drone launch operations were raised by the public during NAPR restoration advisory board (RAB) meetings. During the development of this Phase I RFI Work Plan for SWMU 79, information was provided by Navy experts on the chemical composition of used JATO bottles and the most likely location of the released bottles. These findings were presented during the NAPR RAB meeting held July 20, 2010 (Baker, 2010). A copy of the presentation is included as Appendix A of this Work Plan. Appendix A also contains other supporting data provided by Navy experts related to the JATO bottle construction, explosion characteristics, and horizontal modeling information.

The possibility of malfunction when launching the drone did exist. However, based on conversations with Navy representatives of Naval Sea Systems Command (NAVSEA) – Indian Head Division (IHDIV), when there is a misfire of one motor, which would create an uneven vector thrust; the drone would crash off course and be recovered by Navy personnel. When this occurrence happens, the Navy calls for an “explosive ordnance disposal” (EOD) to handle the misfired motor, and the remaining JATO bottle is eventually destroyed. Therefore when malfunction occurs, the misfired motors are recovered and handled by EOD.

Results of the JATO bottle study indicate that the JATO bottles are composed primarily (49.00%) of nitrocellulose which explodes at 165°F. Other components of the JATO bottles include: nitroglycerine (38.80%), Lead(L)Copper(C)-12-15 (3.30%), triacetin (3.25%), di-n-propyl-adipate (2.00%), 2-nitrodiphenylamine (2.00%), aluminum (1.50%), candelilla wax (0.1%), and carbon black (0.05%). Ignition tests performed on the JATO bottles indicate that temperatures within the JATO would reach temperatures exceeding 4,000°F during drone launch operation. Navy tests indicate at that temperature all propellant within the JATO bottle is annihilated.

Modeling was performed by Navy experts (Gonzalez, 2010) on the probable current location of the JATO bottles as part of the JATO study. Results of the modeling indicate that JATO bottles released

during drone launch operations are most likely propelled approximately 3,500 feet from the launch pads. The model completed by the Navy is also included in Appendix A. While the JATO bottles remain in the area where they landed after propulsion, the JATO study results indicate that the bottles exist in an inert state, and any potential hazardous constituents have disintegrated during propulsion.

2.3 Area of Investigation at SWMU 79

SWMU 79, The Navy Operations Area, composed of 4.06 acres on the eastern end of Cabras Island, will be investigated during this Phase I RFI. The scope of the investigation includes soil, groundwater, and open water sediment sampling and analysis. The full scope of the investigation can be found in Section 1.3. The soil investigation will focus on the determination of the extent of contamination in and around the areas where metals, semi-volatile organic compounds (SVOCs), and polynuclear aromatic hydrocarbons (PAHs) contaminated soil were identified during the ECP investigation. This includes the surface and subsurface soil adjacent to Buildings 2004, 2037, and 2353 and Launch Pads 1793, 1794, and 2013 including drainage areas surrounding the launch pads and apparent preferential surface water runoff pathways from the launch pads down gradient to the open water surrounding the eastern end of Cabras Island. Sample locations will be identified in the field based on site conditions. Soil samples will be obtained from locations within the drainage areas surrounding the launch pads and from the apparent preferential surface water runoff pathways from the launch pad area down gradient to the open water. Groundwater monitoring wells will be installed and groundwater will be sampled as part of this effort.

At the request of the U.S. Coast Guard (property owner of Cabras Island), surface soil adjacent to Building 104, located outside of the SWMU 79 boundary on the western side of Cabras Island, and Buildings 2004 and 2037 will be tested for the presence of lead due to the findings of the LCP assessment. Soil samples obtained from areas adjacent to the launch pads will be analyzed to determine potential contamination during the launching exercises.

3.0 SCOPE OF INVESTIGATION

The purpose of this Phase I RFI field investigation at SWMU 79 is to confirm the presence of contamination due to previous Navy operations. The approach to be taken for implementing this field investigation is dynamic through the use of field screening for metals in the soils at this site. During the ECP it was identified that metals contamination was present due to Navy operations. The soil sampling locations provided in this work plan are approximate and may be relocated pending the results of the field screening. This will be accomplished by:

- Identifying and marking sample locations for field screening the surface and subsurface soil around Buildings 2004, 2065 and 2353, the area surrounding Launch Pads 1793, 1794, and 2013 based on the results of the ECP study;

- Performing surface and subsurface soil sampling at these locations and screen the samples using an Innov-X Alpha XRF Analyzer and confirm the screening results with fixed-base laboratory analysis methods;

- Analyzing the surface and subsurface soil results from the Innov-X Alpha XRF Analyzer to determine if metals contamination is characterized and any patterns of contamination exist;

- Developing a strategy for placement of proposed groundwater monitoring wells in the field after reviewing the screening results;

- Obtain surface and subsurface samples to analyze for Appendix IX low level SVOCs (north of Launch Pad 1794), metals, Total Petroleum Hydrocarbons (TPH) Gasoline Range Organics (GRO) / Diesel Range Organics (DRO) (around Building 2037), and perchlorate based off the screening results and based on where contaminants were prevalent during the ECP investigation;

- Installing groundwater monitoring wells, obtain groundwater samples and laboratory data from approximately six monitoring wells within the SWMU 79 boundary (based on field conditions);

- Obtaining open water sediment samples within the area of the outfalls along the drainage pathways from the Naval Operations area to the open water and submitting samples to a fixed-base laboratory for analysis;

- Obtaining subsurface soil samples from the soil beneath the concrete launch pads; and

- Collecting surface soil samples adjacent to Building 104, located outside of the SWMU 79 boundary on the western side of Cabras Island, and Buildings 2004 and 2037 for the presence of lead.

Sample locations and procedures are discussed in greater detail in the following sections. Approved Standard Operating Procedures (SOPs) previously provided in the Final RFI Management Plans (Baker Environmental, Inc., 1995) will be followed for the proposed field work.

3.1 Sampling and Analysis Program

In order to meet the objectives of characterizing the extent of contamination within SWMU 79, soil, groundwater, and sediment sample analysis will be performed as described in the following sections.

3.1.1 Surface and Subsurface Soil Grid Program for Field Screening

Surface and subsurface soil samples will be collected from SWMU 79 for field screening for metals using XRF. The following outlines the specific sampling protocol.

Based on previous study results and drainage patterns as determined from site reconnaissance observations and aerial photography, the final locations of the samples will be determined during the field investigation. Figure 3-1 identifies the approximate location of 87 soil borings proposed to be advanced at SWMU 79. The locations presented on Figure 3-1 are approximate locations and a detailed evaluation of the site will be conducted to identify potential preferential surface drainage areas from the launch pads, buildings, roadways, etc…, depositional areas, drainage ways from the upland areas to the edge of the rocks leading to the open water below. This evaluation will be used in placement of the 87 soil boring locations across the site. The placement of these borings will also ensure that complete coverage across the site is captured. Surface soil samples are proposed for collection at all 87 locations. Subsurface soil samples are proposed for collection at all 87 locations, if the terrain allows.

Specific sampling points identified in this Work Plan will be loaded into the sub-meter field-grade global positioning system (GPS) device to aid in field locating where samples were proposed for collection. Sample point locations may then be adjusted based on field conditions/screening results. After sample locations are determined in the field and flagged, a surveyor (subcontractor) will obtain and record the locations of each sample, as described in Section 3.4.5.

If site topography allows, borings for this RFI will be advanced using a track-mounted 66DT Geoprobe rig capable of direct push and augering. If adverse site conditions (rocky conditions) do not allow for the Geoprobe rig to penetrate the subsurface adequately, then a hollow-stem auger rig will be utilized.

Subsurface samples will be collected from a two-foot interval, from 1 to 3 feet bgs. Care will be taken to achieve maximum recovery so that a good stratigraphic profile can be developed, but it should be noted that this may not be realistic at all the locations because of the subsurface conditions expected to be encountered there. A boring log will be prepared indicating blow counts, lithology, water occurrence, FID/PID readings, and miscellaneous (visual and olfactory) observations. One surface soil sample (0 to 1 foot bgs) and one subsurface soil sample (1 to 3 feet bgs) will be collected from each boring location, if site topography and terrain allow. The soil samples will be placed in an unused clear glass jar for XRF analysis as described below. The surface and subsurface samples will be screened in the field by XRF for metals as presented in Table 3-1.

The soil sample designations will include the SWMU location followed by extensions to reflect the depth at which the sample was obtained. For the purposes of this work plan, two-foot discrete depths will be used except for surface soil. Sample identification extensions will follow the pattern shown below.

79SB01-00 – SWMU 79 sample
79SB01-00 – Soil boring sample
79SB01-00 – Soil boring location identifier

79SB01-00 – 0 to 1 foot bgs (surface soil) sampling interval

Subsurface soil samples will be designated as follows:

79SB01-01 – First subsurface sampling interval, 1 to 3 feet bgs

Sample identification extensions will follow the pattern shown above.

Following sample collection, each borehole will be backfilled with the remaining soil to the extent practicable, in order to minimize the burden of waste disposal. The surface of the borehole will then be patched with bentonite grout.

3.1.2 XRF Testing of Soils

Surface and subsurface soil analysis will be conducted using a field XRF instrument, evaluating the data, and confirming the XRF results with fixed-base laboratory analysis.

3.1.2.1 XRF Testing

By obtaining the appropriately labeled glass jar from the soil sample location, the surface and subsurface soil samples will be collected for XRF screening and confirmatory fixed-base laboratory analysis. Place sample onto an aluminum pan. Remove any large stones or debris. Keep in mind that finer and more homogeneous material will yield more accurate results. Using a disposable stainless steel spoon homogenize the sample in the aluminum pan. After the sample is mixed, place the sample into a labeled, 16 oz clear glass, wide mouth jar.

Moisture content may affect the accuracy of analysis of soil and sediment sample analyses. When the moisture content is between 5 and 20 percent, the overall error from moisture may be minimal. If the sample appears to have moisture content above 20%, an increased accuracy can be obtained by letting the sample dry in the sun before testing. If the sample appears to have high moisture content, remove 50-100 grams of the sample from the 16 oz clear glass jar and place the sample into another clear glass jar. Allow the 50-100 grams of sample to dry in the sun, before performing the XRF test on the sample.

Once the sample has been placed into a 16 oz clear glass, wide mouth jar, the top of the jar is covered with a thin plastic film to protect the probe window. The XRF analyst will then obtain at least two measurements from the top of the jar in accordance with instrument manufacturer's directions, as detailed in Appendix E. If the relative percent difference between measurements is greater than or equal to 20 percent, the sample will be re-homogenized and the XRF testing procedure will be repeated. When the relative percent difference between measurements is less than 20 percent, the average of the measurements will be used as the representative results for that sample. The XRF analyst should maintain consistent positioning of the sample in front of the probe window of the device to minimize a potential source of error (x-ray signal decreases as the distance from the radioactive source increases). This error is minimized by maintaining the same distance between the device and each sample. For the best results, the window of the probe should be in direct contact with the sample in the glass jar, which means that the sample should be flat and smooth to provide a good contact surface.

The samples will be screened for chromium, copper, lead and zinc only. All measurements and results will be recorded in the dedicated field logbook as well as auto-saved in the XRF device for downloading after the entire XRF sampling event.

3.1.2.2 Data Evaluation

The data obtained from the XRF analysis for metals will be evaluated to determine if there are any patterns associated with the results. The field results will be plotted on a map of the site to assist in determining if patterns are present. An evaluation of the field results will be used to determine if the metals contamination in the soils has been delineated. Additional samples may be collected and analyzed by XRF if the evaluation determines that additional samples are required.

The biased-grid sampling approach that will be used for soil sample collection ensures that the areas of interest will be sufficiently sampled to meet the objectives of a Phase I RFI. However, it may be desirable at some locations, based on a review of the field screening results, to collect additional screening samples to provide better resolution regarding the extent of contamination. When additional information/samples are desired (i.e. to delineate areas where concentrations exceed applicable screening levels, etc.) the step-out approach will be used at an interval half the distance of adjacent sample locations. This approach will ensure that additional samples do not overlap existing/proposed sample locations and the additional information obtained between sample locations will further refine the biased-grid sampling approach. The step-out approach will be in the four directions directly north, south, west and east of the sample point where additional information is desired. The step-out approach will be adjusted as appropriate based on field conditions, location of structures, etc. Additional samples will continue until it is deemed necessary (i.e. samples of low contamination are found) based on an interpretation of the field screening data by the field geologist and the Site Manager and on professional judgment.

Once the XRF analysis for metals is complete, the next phase (as discussed in Section 3.1.3) of the field investigation is to sample surface and subsurface soil from twelve soil boring locations, to be sent for laboratory fixed-based analysis. This evaluation of twelve surface and subsurface soil borings is a independent task from the XRF confirmation samples sent for fixed-base analysis.

3.1.2.3 Fixed-Base Laboratory Confirmation

To evaluate the accuracy of the analysis being conducted by the XRF instrument, confirmation samples will be submitted to the fixed-base laboratory for Appendix IX metals. The fixed-based laboratory confirmation of the XRF analysis samples is to evaluate the accuracy of the analysis being conducted by the XRF instrument, and to form the basis of site delineation and future data evaluation/decision making. Twenty percent of the surface soil and subsurface soil samples analyzed by XRF will be selected and be sent to the fixed-base laboratory for confirmatory analysis. The selection of the confirmatory samples will include a range of low level, medium level, and high level detections for confirmatory analysis. This range will assist to determine the accuracy of the XRF analysis compared to the fixed-base results. The soil from the clear glass jars will be placed in the appropriate sample container and placed on ice in a cooler for shipment to the laboratory.

A direct comparison of field XRF testing results will be performed against the laboratory testing results for determining the data quality of the field results. The average result from the series of XRF tests will be plotted against the laboratory result. A correlation curve will be determined per each parameter, and the curve will be used to "correct" the field XRF testing results from SWMU 79. The correlation curve developed from this analysis will incorporate the bias in the XRF result due to sample preparation, and instrument ability. In this way, the bias from in-situ testing will be removed, on average, from the field XRF test results. The correction factor will be presented along with the corrected data.

3.1.3 Surface & Subsurface Soil Sampling Program for Fixed-Base Analysis

Following the recommendation from the evaluation of the XRF analysis (see Section 3.1.2.2) an additional twelve soil borings will be advanced at SWMU 79. Six of the proposed twelve soil boring locations (79SB88 to 79SB93) have been pre-determined, based on locations of previous PAH exceedances, as well as previous site reconnaissance. The locations of the six pre-determined soil boring locations are shown on Figure 3-2. The six remaining soil boring locations (79SB94 to 79SB99) will be selected in the field based off the evaluation of the XRF analysis which yielded areas of potential high metal contamination. Surface and subsurface soil samples will be collected at all twelve locations. The following outlines the specific sampling protocol.

If site topography allows, borings for this RFI will be advanced using a track-mounted 66DT Geoprobe rig capable of direct push and augering. If adverse site conditions (rocky conditions) do not allow for the Geoprobe rig to penetrate the subsurface adequately, then a hollow-stem auger rig will be utilized. If drill rig access to sampling locations is limited due to terrain or site conditions, than the samples will be obtained through the use of hand augers.

Care will be taken to achieve maximum recovery so that a good stratigraphic profile can be developed, but it should be noted that this may not be realistic at some of the upland locations because of the subsurface conditions expected to be encountered there. A boring log will be prepared indicating blow counts, lithology, water occurrence, FID/PID readings, and miscellaneous (visual and olfactory) observations. One surface soil sample (0 to 1 foot bgs) and a minimum of one subsurface sample will be collected from each boring location, at a two-foot interval, if site topography and terrain allow.

If FID/PID screening and visual/olfactory observations do not indicate contamination at any of the soil intervals screened during boring installation, then the subsurface soil samples for laboratory analysis will be collected at the 2-foot interval immediately above the water table.

If FID/PID screening and visual/olfactory observations do indicate contamination at the surface soil sample, then the subsurface soil samples for laboratory analysis will be collected at the 1 to 3 foot interval and at the 2-foot interval immediately above the water table.

All samples (except those requiring TPH GRO analysis) must be homogenized prior to being submitted to the laboratory for fix-based analysis. The soil collected will be prepared by homogenizing the individual aliquot in a disposal aluminum pan, using a disposable stainless steel spoon. The surface and subsurface samples will be analyzed for Appendix IX metals, and perchlorate as presented in Table 3-1. In addition, three pre-determined soil boring locations (79SB88, 79SB89, and 79SB90) will be analyzed for Appendix IX low level SVOCs and three pre-determined soil boring locations (79SB91, 79SB92 and 79SB93) will be analyzed for TPH DRO/GRO, as presented in Table 3-1. Soil boring locations 79SB88, 79SB89, and 79SB90 are located at the northern edge of Launch Pad 1794. These three borings surround CABSS01 where PAH exceedances were identified during the ECP investigation and will determine the extent of contamination around the northern edge of Launch Pad 1794. Soil boring locations 79SB91, 79SB92, and 71SB93 are located northwest of Building 2037. These three borings surround CABSS04 where TPH exceedance was identified during the ECP investigation and will determine the extent of contamination northwest of Building 2037. The soil samples intended for TPH GRO analysis will be collected as grab samples to minimize volatilization. Three 5-gram subsamples will be collected per sample location using a Terra Core™ sampler and placed into separate pre-weighed 40-mL VOA vials (one pre-preserved with methanol and the remaining two with deionized water) containing a magnetic stir bar. The sealed vials will be packed in coolers and placed on ice to maintain a temperature of 4° Celsius.

Following sample collection, each borehole that is not converted to a monitoring well will be backfilled with the remaining soil to the extent practicable, in order to minimize the burden of waste disposal. The surface of the borehole will then be patched with bentonite grout.

Samples will be packed in ice and shipped next day air to the "fixed base" laboratory. Because of previously encountered delays associated with sample shipments from Puerto Rico to the United States, additional insurance to cover re-sampling costs should be claimed on the bill of laden. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt.

All analysis at the laboratory will be performed using current methodologies as presented in Table 3-2. All analytical work performed on the mainland of the United States must be certified by a licensed Puerto Rico chemist. The specific laboratory and third party validator, are to be determined at a later date. Standard Operating Procedures used by the analytical laboratory will be requested from the laboratory after selection.

3.1.4 Monitoring Well Installation

Approximately six permanent monitoring wells will be installed within the soil borings advanced at SWMU 79. The locations of these monitoring wells will be field-determined based upon historical data from the ECP, field screening XRF results, and best coverage to collect groundwater contours for SWMU 79. When placing the monitoring wells, maximum consideration will be given to areas that show highest levels and aerial extent of hits from the XRF screening results. Additionally, consideration will be given to monitoring well placement, so that groundwater gradient can be evaluated for the entire SWMU 79 aerial coverage area.

The monitoring well location designation will correspond to the soil boring location. For example, if a permanent well were to be installed at soil boring location 79SB04, then the well identification would be 79MW04.

Monitoring wells will be installed using hollow-stem augers (HSAs) or air rotary techniques, depending on the underlying stratigraphy. The wells will be constructed of 2-inch inner diameter (ID), Schedule 40 Polyvinyl chloride (PVC), with flush joint threads. Well screens will be 10-feet long and installed to straddle the water table. New wells will have well construction records prepared for them, or at a minimum, the well construction details should be added to the appropriate boring log.

- Soil sampling will be conducted in order to classify the soil during well installation. Upon completion of soil sampling, the borehole will be reamed as necessary to the desired depth using the prescribed drilling method. The well construction materials will be installed through the HSAs, casing, or in an open borehole.

- The well screen and bottom cap will be set at the bottom of the borehole. The screen will be connected to threaded, flush-joint, riser. An expandable, water tight locking cap or slip-cap with a vent hole will be placed at the top of the casing.

- The annular space around the well screen will be backfilled with a well-graded, fine to medium sand as the HSAs or casing are being withdrawn from the borehole. The sand will extend to

approximately 2 feet above the top of the screened interval. The thickness of the sand above the screened interval may be reduced if the well is too shallow to allow for placement of adequate sealing material.

- An approximately 2-foot thick sodium bentonite seal (minimum of 6 inches for very shallow wells) will be placed above the sand pack. If bentonite pellets or chips are used, they will be sized appropriately given the well and borehole diameter and placed in a careful manner that will prevent bridging. The bentonite will be hydrated with potable water, as necessary.

- The annular space above the bentonite seal will be backfilled with cement/bentonite grout to prevent surface and near subsurface water from infiltrating into the screened groundwater monitoring zone. The grout will consist of five to ten percent (by dry weight) of bentonite powder and seven gallons of potable water per 94-pound bag of portland cement. For very shallow wells, the cement/bentonite grout may be omitted.

- The depth intervals of all backfilled materials will be measured with a weighted measuring tape to the nearest 0.1-foot and recorded in the field logbook.

- Wells with 2 to 3 feet of "stickup" above ground surface. Steel protective casing will be placed over the riser and surrounded by a concrete pad. The pad will be a minimum of 2 feet by 2 feet (length x width) and 6 inches in thickness (with 2 inches set into the ground outside the casing), and extending 2 feet bgs inside the annular space around the well. If water table conditions prevent having a 24-inch thick bentonite seal, the concrete pad depth in the annular space around the well may be decreased. Steel bollards will be installed around the concrete pad as additional protection and painted a bright color to aid in visibility.

- All wells will have a locking cap installed on the PVC riser or protective steel casing.

Each new permanent monitor well will be developed using pumping and surging methods (Baker, 1995) after allowing suitable time for the cement/bentonite grout to cure (a minimum of 24 hours). The purpose of well development is to restore the permeability of the formation which may have been reduced by the drilling operations and to remove fine-grained materials that may have entered/accumulated in the well or filter pack. The wells will be developed until the discharged water runs relatively clear of fine-grained materials. It should be noted that the water in some wells does not clear with continued development. Typical limits placed on well development will include clarity of water based on visual determination and any one or a combination of the following:

- A maximum time period (typically two hours for shallow wells).

- A maximum borehole volume (typically three to five borehole volumes plus the amount of any water added during the drilling or installation process).

- Stability of pH, specific conductance, and temperature measurements (typically less than ten percent change between three successive measurements).

- Clarity based on turbidity measurements (typically less than 20 Nephelometric Turbidity Units [NTU]).

A record of the well development will be completed to document the development process. Monitoring well installation and well development procedures will be conducted following the procedures in Final RCRA Facility Investigation Management Plans (Baker, 1995).

3.1.5 Groundwater Sampling and Analysis Program

The groundwater sampling will be used to aid in characterization of the groundwater to determine whether or not it has been impacted by prior activities at SWMU 79. A minimum of 24 hours after well development, groundwater samples shall be collected (from approximately six locations) and analyzed for Appendix IX low level SVOCs, metals (total and dissolved), salinity, and perchlorate (See Table 3-1). TPH GRO and DRO are not proposed to be analyzed for because there is no indication of a release at or near the subject area. However, if one or all of the three soil borings around the generator building (Building 2037) indicate there is a potential for fuel in the soils, the groundwater will be analyzed for TPH GRO and DRO.

The groundwater will be sampled using a low flow sampling technique to the extent practicable, in view of the slow recharge experienced at several NAPR sites. Appendix B includes a detailed description of low-flow sampling technique. Low-flow sampling shall be achieved using a portable positive displacement bladder pump with an adjustable low-flow rate pump controller. Field parameters of pH, temperature, turbidity, conductivity, dissolved oxygen, and oxidation-reduction potential will be obtained with appropriate instrumentation during sampling if enough volume of groundwater is present. The groundwater samples will be placed into the appropriate laboratory supplied containers. The groundwater samples will be filtered in the field for the dissolved metals analysis. Prior to sampling, a synoptic set of static water levels will also be recorded in order to obtain data to more accurately interpret the groundwater flow direction at the SWMU.

Sample identification extensions will follow the pattern below:

79GW01	SMWU 79
79GW01	Groundwater Sample
79GW01	Groundwater sample obtained from 79MW01

It should be noted that the exact sample identification extension will be directly correlated to the corresponding soil boring and monitoring well location.

Samples will be packed in ice and shipped next day air to the "fixed base" laboratory. Because of previously encountered delays associated with sample shipments from Puerto Rico to the United States, additional insurance to cover re-sampling costs should be claimed on the bill of laden. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt.

All analyses at the laboratory will be performed using current methodologies as presented in Table 3-2. All analytical work performed on the mainland of the United States must be certified by a licensed Puerto Rico chemist. The specific laboratory and validator, will be determined at a later date.

3.1.6 Open Water Sediment Sampling

Open water sediment sampling is planned for the shoreline sediments surrounding the Navy Operations Area of Cabras Island. The following subsections describe how the sampling locations will be determined in the field and how the samples will be collected.

3.1.6.1 XRF Data Evaluation

The surface and subsurface data analysis discussed in Section 3.1.2.2 will be utilized to assist in determining if the potential exists for metals contaminated soils to migrate from the upland Navy Operations area to the sediments below in the open water environment. This analysis will consist of evaluating the spatial extent of contamination from the launch pads towards the outer perimeter of the island. This information will be utilized to determine sampling locations for the open water sediment samples.

3.1.6.2 Preferential Drainage Pathway Evaluation

The launch pad areas will be inspected for preferential pathways for runoff from the launch pads to the edges of the upland area to the open water below. This evaluation along with the XRF data evaluation presented above will be utilized in placement of the open water sediment sample locations around the island. Approximate drainage pathways based on site drainage patterns observed during site reconnaissance visits and aerial photography are presented on Figure 3-3.

3.1.6.3 Open Water Sediment Sampling Program

Ten open water sediment samples were located based on site drainage patterns observed during site reconnaissance visits and aerial photography. The open water sediment samples are 40 to 60 feet apart at the five drainage outlets, which will indicate if containments of concern are present beyond the drainage outlets. These locations are indicated on Figure 3-3. The exact locations of the sediment samples will be field-determined based on the XRF data evaluation and preferential

drainage pathway evaluation; Figure 3-3 shall only be used as a guide in locating the open water sediment samples.

Sample identification extensions will be as follows:

79OWSD01	SMWU 79
79OWSD01	Open Water Sediment
79OWSD01	Open Water Sediment sample location identifier

The ten sediment samples will be submitted for analysis of:

- Appendix IX low level SVOCs
- Appendix IX Metals
- Total Organic Carbon (TOC)
- Perchlorate

Samples will be collected in depositional areas preferably at low tide. Samples will be collected by an enclosed sampling device (such as a petite ponar), sediment core liner or a stainless steel spoon. The sediment sample collected will be prepared by homogenizing the individual aliquot in a disposal aluminum pan, using a disposable stainless steel spoon. All samples must be homogenized prior to being submitted to the laboratory for fix-based analysis. Down gradient locations will be sampled first to prohibit cross-contamination. All pertinent sampling information such as sediment description (e.g., color and texture), sample number and location, presence or absence of aquatic invertebrates, and the time of sample collection will be recorded in the field logbook. The sample will be placed into appropriate jars and sent to the fixed-base laboratory for analysis. Sediment sampling will be conducted following the procedures in the Final RCRA Facility Investigation Management Plans (Baker, 1995).

Table 3-1 summarizes the samples that will be collected and the associated analyses. As discussed previously, all analyses at the laboratory will be performed using current methodologies as presented in Table 3-2. All analytical work conducted on the mainland of the United States of America must be certified by a chemist licensed in Puerto Rico. The specific laboratory and third party validator, will be determined at a later date. SOPs used by the analytical laboratory will be requested from the laboratory after selection.

Samples will be packed in ice and shipped next day air to the fixed-base laboratory. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt of samples by the laboratory.

3.1.7 Subsurface Soil Sampling Program at Launch Pads

The ECP study results indicated the presence of metals in two of the concrete launch pads. Subsurface soil samples will be taken from beneath all three launch pads during this Phase I RFI to verify the presence or absence of metals in the subsurface soils beneath all three slabs. The proposed analyses selection is based on the results of the detected laboratory results from the Phase II ECP Report.

Subsurface soil samples will be collected below each of the three launch pads to evaluate for the presence of Appendix IX low-level SVOCs, Appendix IX metals, and perchlorate in the soil below

the concrete pads. One subsurface soil sample will be taken below each of the concrete slabs within the first two-feet of soil. The subsurface soil samples obtained below the concrete slab will be submitted to the fixed-base laboratory for analysis. The proposed subsurface soil sample locations will be located in front of the concrete deflection barrier that was sampled during the ECP investigation as shown on Figure 3-4. Subsurface soil sample 79SB100 through 79SB102 will be collected underneath the concrete slabs from each launch area.

Sample identification extensions for the subsurface soils below the concrete slabs will follow the same pattern presented previously in Section 3.1.3.

The soil samples obtained from below the concrete slab will be analyzed for:

- Appendix IX low-level SVOCs
- Appendix IX Metals
- Perchlorate

Table 3-1 summarizes the samples that will be collected and the associated analyses. As discussed previously, all analyses at the laboratory will be performed using current methodologies as presented in Table 3-2. All analytical work conducted on the mainland of the United States of America must be certified by a chemist licensed in Puerto Rico. The specific laboratory and third party validator will be determined at a later date. SOPs used by the analytical laboratory will be requested from the laboratory after selection.

Samples will be packed in ice and shipped next day air to the fixed-base laboratory. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt or samples by the laboratory.

3.1.8 Surface Soil Sampling Program Near Buildings 104, 2004, and 2037

Because damaged lead-based paint was identified within Buildings 104, 2004, and 2037 during the LCP assessment as part of the ECP study, the U.S. Coast Guard requested that surface soil samples be obtained during the Phase I RFI within 12 feet of the perimeter of each of the three buildings as shown on Figure 3-5. The surface soils will be collected from the drip line along the building as per the U.S. Development of Housing and Urban Development (HUD) requirements. A hand auger will be used to obtain the samples within the first twelve inches of the surface to evaluate for the presence of lead in the surface soil.

A total of 13 surface soil samples will be collected for lead analysis: four samples will be collected around Building 104, six samples around Building 2004 and three samples around Building 2037. The samples taken for fixed-base laboratory analysis will be identified as 79SS01 through 79SS13 and follow the sample designation:

79SS13	SMWU 79
79SS13	Surface Soil Sample
79SS13	Soil Sample obtained at Surface Soil Location 13

The samples will be collected and submitted to the fixed-base laboratory for lead analysis only. Table 3-1 summarizes the samples that will be collected and the associated analyses. As discussed previously, all analyses at the laboratory will be performed using current methodologies as presented

in Table 3-2. All analytical work conducted on the mainland of the United States of America must be certified by a chemist licensed in Puerto Rico. The specific laboratory and third party validator, as well as the certified licensed chemist, will be determined at a later date. SOPs used by the analytical laboratory will be requested from the laboratory after selection.

Samples will be packed in ice and shipped next day air to the fixed-base laboratory. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt of samples by the laboratory.

3.2 Quality Assurance / Quality Control Samples

Field specific Quality Assurance/Quality Control (QA/QC) procedures are given below. QA/QC samples will be analyzed for parameters as shown in Table 3-3 by analytical methods presented in Table 3-2. QA/QC samples collected during these investigations will include trip blanks, equipment rinsate samples, field blank samples, field duplicate samples, and matrix spike/matrix spike duplicates (MS/MSD), as discussed below.

3.2.1 Trip Blanks

Trip blank samples will be required to accompany the samples submitted to the laboratory for TPH GRO analysis. One trip blank sample will accompany each cooler containing samples requiring the TPH GRO analysis.

3.2.2 Equipment Rinsates

Equipment rinsate samples are collected from analyte-free water rinse of decontaminated and disposable equipment. Equipment rinsate blanks will be collected on a daily basis and submitted to a fixed-base analytical laboratory for analysis. The total number of equipment rinsate samples to be collected will be dependent on the length of the field investigation. The results from the equipment rinsate samples will be used to determine if the sampling equipment was free of contamination. The equipment rinsate samples are analyzed for the same parameters as the related samples. It is anticipated that a total of four equipment rinsates will be collected. These samples will be associated with the surface and subsurface soil, groundwater, and sediment sampling equipment. The samples will be obtained from a stainless steel spoon for collection of soil and sediment, a split spoon sampler, hand auger, or macro core liner for collection of subsurface soil, and from the Teflon-lined tubing or groundwater pump used during the collection of groundwater These samples will be analyzed for the analytes presented in Table 3-3.

3.2.3 Field Blanks

Field blank samples consist of the source water used in equipment decontamination procedures. At a minimum, one field blank for each source of water must be collected and analyzed for the same parameters as the related samples. It is anticipated that three different sources of water (i.e., NAPR potable water source, store-bought distilled water, and laboratory-grade de-ionized water) will be used for this investigation as shown in Table 3-3.

3.2.4 Field Duplicates

Field duplicate samples of the surface soil, subsurface soil, groundwater, and sediment samples will be collected during the same time the corresponding environmental sample is collected. One duplicate sample will be collected at a frequency of ten percent of environmental samples collected per media.

3.2.5 Matrix Spike / Matrix Spike Duplicates

MS/MSDs are laboratory derived and are collected to evaluate the matrix effect of the sample upon the analytical methodology. One MS/MSD will be collected for every 20 samples collected of a similar matrix.

3.3 Data Validation

All mainland laboratory data generated by this investigation will be subjected to independent, third party validation. The USEPA Region II Data Validation Standard Operating Procedures will be followed. The specific data validator will be determined at a later date.

3.4 Other Investigation Considerations

During the investigation, the following activities will be performed:

- Clearing and Grubbing
- Utility Clearance
- Investigation Derived Waste (IDW) Management
- Decontamination
- Surveying
- Health and Safety Procedures
- Chain of Custody

Each of these activities is discussed in the following sections.

3.4.1 Clearing and Grubbing

It may be necessary for site clearing to be performed so the Geoprobe 66DT rig can gain access to delineate the suspected contamination. One day of site clearing will be performed by the direct push subcontractor.

3.4.2 Utility Clearance

The contractor conducting the implementation of this Work Plan will be responsible for clearing all proposed soil boring and well locations.

3.4.3 Investigation Derived Waste Management

The generation of IDW associated with soil sampling and monitoring well installation, including soil cuttings and decontamination fluids, will be collected and stored temporarily in 55-gallon drums. If contamination is indicated, as determined by the field manager, the soil cuttings associated with that soil boring will be stored temporarily in a 55-gallon drum. All the soil cuttings for soil borings that show evidence of contamination will be placed in the same drum with proper label on the drums

exterior. There will not be one drum for each soil boring and a composite sample will be collected and submitted for laboratory analysis.

Two IDW samples will be collected during this investigation. One composite aqueous sample will be collected from all drums containing decontamination fluid (from sampling equipment and drill rig) in accordance with surface water sampling procedures. One composite soil sample will be collected from all drums containing drill cuttings.

A composite soil sample will be compiled from individual discrete (grab) samples of equal volume collected from each of the 55-gallon drums of containerized IDW soil. Each individual discrete soil sample will be placed into a disposable aluminum pie pan (or other appropriate container) and thoroughly homogenized prior to filling the appropriate laboratory provided sample containers. A portion of the soil sample will be separated prior to homogenizing for the volatile analysis and placed in the appropriate laboratory provided sample containers. The solids sample will be analyzed for toxicity characteristic leaching procedure (TCLP) metals, TCLP volatiles, and reactivity, corrosivity, and ignitability (RCI) as shown on Table 3-3, using methods presented in Table 3-2.

The IDW composite aqueous sample will be collected similar to the soil composite sample with the exception that the individual discrete (grab) samples of equal volume collected from each of the 55-gallon drums of containerized IDW water will be placed directly into the appropriate laboratory provided sample containers. The water samples will be analyzed for VOCs, metals, and RCI as shown in Table 3-3, using methods presented in Table 3-2.

These samples will provide the necessary data to be able to dispose of the generated IDW at an appropriate disposal facility. Upon completion of the field program, the drums will be moved and stored per the direction of Public Works Department personnel. The soil and water IDW will be removed and disposed of from the site by an approved vendor upon receipt and review of the IDW sample analytical data.

Disposable boring installation equipment (i.e. macro-core liners), disposable sampling equipment (i.e. stainless steel spoons, polyethylene tubing, etc.), and personal protective equipment (i.e. plastic gloves) shall be stored during the field program in large plastic bags for disposal at an appropriate disposal facility upon completion of the field program.

3.4.4 Decontamination

All reusable (non-dedicated and non-disposable) soil sampling and monitoring well installation equipment (i.e. augers, bits, split-spoon samplers, etc.), will be decontaminated between each sampling location following the procedures given in the Final RCRA Facility Investigation Management Plans (Baker, 1995). The drill rigs will be decontaminated before arriving at the site and before leaving the site. The remaining contaminant-free sampling equipment and materials utilized during this investigation will be disposable.

3.4.5 Surveying

After sample locations are determined in the field and flagged, a surveyor (subcontractor) will obtain and record the locations of each sample. Traditional survey equipment or survey grade GPS unit will be utilized to obtain vertical (+/- 0.01 foot) and horizontal (+/- 0.1 foot) locations and top of PVC elevations of the monitoring well(s).

3.4.6 Health and Safety Procedures

The health and safety procedures previously presented in the RFI Management Plans (Baker, 1995) will be employed during this investigation.

3.4.7 Chain-of-Custody

Chain-of-Custody procedures will be followed to ensure a documented, traceable link between measurement results and the sample/parameter that they represent. These procedures are intended to provide a legally acceptable record of sample preparation, storage, and analysis. Chain-of-Custody procedures are provided in the approved Standard Operating Procedures (SOPs) F302 which have been previously submitted in the Final RFI Management Plans (Baker Environmental, Inc., 1995).

A chain-of-custody form will be completed for each shipment in which the samples are shipped. After the samples are properly packaged, the shipping container will be sealed and prepared for shipment to the analytical laboratory.

4.0 REPORTING

This section outlines the reporting activities that are associated with the field investigation. The Phase I RFI report will include:

- Introduction
- Background
- Physical Characteristics of Study Area
- Phase I RFI Activities
- Physical Results
- Analytical Results
- Conclusions and Recommendations
- References

The RFI report sections are discussed in the following subsections.

4.1 Introduction

The introduction will provide a regulatory framework for NAPR and SWMU 79, as well as a discussion of current conditions.

4.2 Background

The background will consist of a discussion of the historical background of any investigations conducted previously at SWMU 79.

4.3 Physical Characteristics of Study Area

This section will provide the environmental setting, including the regional and site-specific geology and hydrogeology. Regional and local climatic conditions that may be relevant to the environmental impacts of the contaminated media at the site will also be discussed, as relevant.

4.4 Phase I RFI Activities

This section will summarize the results of the previous investigation and describe the basis for this Phase I RFI investigation. This section will also describe the field activities of the most recent investigation to fulfill the Phase I RFI Work Plan objectives for the SWMU. This will include a description of the sample locations, sample collection and handling procedures, QA/QC procedures, and analytical methods used. This section will also discuss any problems encountered including any deviations from the work plan and problem resolution.

4.5 Physical Results

The physical characteristics of the SWMU will be recorded in the field. This section will provide a discussion of current site conditions and site-specific geology and hydrogeology.

4.6 Analytical Results

This section will present analytical results of the environmental media and interpretation of the data to characterize the contaminants present in the soil, sediment, and groundwater. Analytical results for

environmental media will be compared to the appropriate ecological, human health, and background screening values, as discussed in the following sections.

4.6.1 Media-Specific Ecological Screening Values

The sections that follow describe the various criteria and toxicological benchmarks that will be used as ecological-base media-specific screening values for chemicals in soil (surface and subsurface soil), groundwater, and sediment. The media-specific screening values, listed in Tables 4-1 (soil), 4-2 (groundwater), and 4-3 (sediment) represent conservative exposure thresholds above which adverse ecological effects may occur. In some instances, the laboratory reporting limit for a given compound may exceed the ecological sediment screening value. For this Phase I RFI, all compounds exceeding ecological screening values will be identified and discussed in the data evaluation section of the report. For future ecological risk assessments (ERA) that may be conducted as part of a CMS, the risks for non-detected chemicals will be quantified. If necessary, non-detected chemicals with maximum reporting limits greater than ecological screening values will be identified as ecological chemicals of potential concern (COPCs) in Step 2 of a screening-level ERA (SERA) and undergo additional evaluation in Step 3a of a baseline ecological risk assessment (BERA).

4.6.1.1 Soil Screening Values

The literature-based toxicological benchmarks selected as screening values for chemicals in surface soil (0.0 to 1.0-foot depth interval) and subsurface soil (1.0 to 3.0-foot depth interval) are summarized in Table 4-1. USEPA ecological soil screening levels (Eco-SSLs) (documentation available at http://www.epa.gov/ecotox/ecossl/) were preferentially used as soil screening values. Subsurface soil deeper than three feet shall not be retained for use in the Screening Level Ecological Risk Assessment (SLERA) at SWMU 79.

Eco-SSLs have been developed for eight receptor groups: plants, soil invertebrates, avian herbivores, avian ground insectivores, avian carnivores, mammalian herbivores, mammalian ground insectivores, and mammalian carnivores. For a given chemical, the lowest Eco-SSL value for plants, soil invertebrates, avian herbivores, avian ground insectivores, avian carnivores, mammalian herbivores was selected as the soil screening value. Eco-SSLs for mammalian ground insectivores were not considered for soil screening value development because there are no mammalian ground insectivores in Puerto Rico (mammalian insectivores are limited to aerial insectivores [i.e., bats]). As discussed in Guidance for Developing Ecological Soil Screening Levels (USEPA, 2005), aerial and arboreal insectivorous birds and mammals were excluded from Eco-SSL development because they are considered inappropriate (i.e., they do not have a clear or indirect exposure pathway link to soil [indirect exposure pathways involve ingestion of prey that have direct contact with soil]). Eco-SSLs for mammalian carnivores also were not considered for soil screening value development because there are no carnivorous mammals on Puerto Rico. With the exception of bats, the terrestrial mammals represented by potentially complete exposure pathways are limited to nonindigenous, nuisance species (i.e., Norway rat, black rat, and mongoose) that have been implicated in the decline of native reptilian and bird populations (Mac et al., 1998 and United States Fish and Wildlife Service [USFWS], 1996). Eco-SSLs for mammalian herbivores are considered appropriate for soil screening value development based on the presence of fruit-eating and nectivorous bats in Puerto Rico.

For those chemicals lacking plant, soil invertebrate, avian herbivore, avian ground insectivore, avian carnivore, or mammalian herbivore Eco-SSLs, the literature-based toxicological benchmarks listed below were used as soil screening values.

- Toxicological thresholds for earthworms and microorganisms (Efroymson et al., 1997a).
- Toxicological thresholds for plants (Efroymson et al., 1997b).

Identical to the Eco-SSLs, when more than one screening value was available for a given chemical from Efroymson et al. (1997a and 1997b), the lowest value was selected as the soil screening value. For those chemicals lacking plant, soil invertebrate, avian herbivore, avian ground insectivore, avian carnivore, or mammalian herbivore Eco-SSL and a toxicological threshold from Efroymson et al.

(1997a and 1997b), the following literature-based values, listed in their order of decreasing preference, were used as soil screening values:

- Toxicity reference values for plants and invertebrates listed in USEPA (1999a).
- Soil standards developed by the Ministry of Housing, Spatial Planning and Environment (MHSPE) (2000).
- Canadian soil quality guidelines (agricultural land use) developed by the Canadian Council of Ministers of the Environment (CCME) (2007).

Soil screening values based on MHSPE soil standards represent an average of the target and intervention soil standards. Values are based on a default organic carbon content of 2.0 percent, which represents the minimum adjustment range (2.0 to 30.0 percent). Soil screening values developed by CCME soil quality guidelines were given the lowest preference since many are background-based interim guidelines that do not represent effect-based concentrations.

4.6.1.2 Groundwater Screening Values

Because the Caribbean Sea represents a potential discharge point for SWMU 79 groundwater, the groundwater analytical data for samples collected during the Phase I RFI field investigation will be compared to the marine toxicological thresholds listed in Table 4-2.

Puerto Rico Water Quality Standards (PRWQS) for Class SB coastal and estuarine waters listed in the Puerto Rico Water Quality Standards Regulation (PRWQSR) dated March 31, 2010 (PREQB, 2010) were preferentially used as groundwater screening values. PRWQS for Class SB coastal and estuarine waters were selected based on the classifications contained within Rule 1302.1 of the PRWQSR. For those chemicals lacking PRWQS for Class SB coastal and estuarine waters, groundwater screening values were identified from the following information listed in their order of decreasing preference:

- Chronic saltwater National Ambient Water Quality Criteria (NAWQC) (USEPA, 2009a)

- Final Chronic Values (FCVs) for saltwater contained in ECO Update Volume 3, Number 2 (USEPA, 1996)

- USEPA Region 4 chronic screening values for saltwater contained in Ecological Risk Assessment Bulletins – Supplement to Risk Assessment Guidance for Superfund (RAGS) (USEPA, 2001)

- Minimum chronic toxicity test endpoints (No Observed Effect Concentration [NOEC], No Observed Effect Level [NOEL], and Maximum Acceptable Toxicant Concentration [MATC] values) for marine species reported in the ECOTOX Database System (USEPA, 2007b)

- Chronic Lowest Observable Effect Levels (LOELs) for saltwater contained in National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQUIRTs) (Buchman, 2008) with a safety factor of 10 (Wentsel et al., 1996)

The order of preference was selected based on their level of protection. For example, FCVs would be expected to offer a greater degree of protection than a single species NOEC, MATC, or LOEL since their derivation considers a larger toxicological database. In the absence of the above-mentioned FCVs, USEPA Region 4 chronic screening values, chronic test endpoints, and chronic LOELs, screening values were derived from the acute literature values listed below:

- Acute LOELs for saltwater contained in NOAA SQUIRTs (Buchman, 2008)

- Acute toxicity test endpoints (NOEC, NOEL, LOEL, Lowest Observed Effect Concentration [LOEC], median lethal concentration [LC_{50}], and median effective concentration [EC_{50}] values) for marine species contained in the ECOTOX Database System (USEPA, 2007b)

- LC_{50} values for marine species contained in Superfund Chemical Matrix (USEPA, 2004)

Chronic-based screening values were extrapolated from acute NOEC, NOEL, LOEC, LOEL, LC_{50}, and EC_{50} values as follows:

- An uncertainty factor of 30 was used to convert an acute NOEC or NOEL a chronic-based screening value (Wentsel et al., 1996)

- An uncertainty factor of 50 was used to convert an Acute LOEC or LOEL to a chronic-based screening value (Wentsel et al., 1996)

- An uncertainty factor of 100 was used to convert an EC_{50} or LC_{50} to a chronic-based screening value (Wentsel et al., 1996)

When acute toxicity data were used to extrapolate a chronic screening value, NOECs/NOELs were given preference over LOECs/LOELs, LOECs/LOELs were given preference over LC_{50} and EC_{50} values, and EC_{50} values were given preference over LC_{50} values. When more than one value was available from the literature for a given test endpoint (e.g., NOEC), the minimum value was conservatively used to extrapolate a chronic screening value.

As evidenced by Table 4-2, the total recoverable screening values selected for arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc are PRWQS for Class SD surface waters, while the total recoverable screening value selected for mercury is a USEPA saltwater NAWQC (CCC value). PRWQSR has adopted USEPA total recoverable NAWQC as PRWQS for arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc (the PRWQSR for these eight metals are identical to the total recoverable CCC values listed in National Recommended Water Quality Criteria [USEPA, 2009a]). Because groundwater samples collected at SWMU 79 will be analyzed for total recoverable and dissolved metals, dissolved screening values also were identified from the literature. PRWQS expressed in terms of the dissolved metal in the water column are not available from the PRWQSR. However, USEPA saltwater CCC values for arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc, as well as mercury, can be expressed as dissolved or total recoverable concentrations (USEPA, 2009a). Therefore, screening values for these nine metals, expressed in terms of the dissolved metal in the water column, were derived by multiplying total recoverable PRWQS/USEPA CCC values by the saltwater conversion factors listed below (USEPA, 2009a):

- Arsenic: 1.000
- Cadmium: 0.994
- Chromium: 0.993
- Copper: 0.830
- Lead: 0.951
- Mercury: 0.850
- Nickel: 0.990
- Selenium: 0.998
- Zinc: 0.946

Total recoverable screening values were conservatively used to screen dissolved analytical data for those metals lacking screening values expressed as dissolved concentrations (i.e., antimony, barium, beryllium, cobalt, silver, thallium, tin, and vanadium).

Chronic-based screening values were extrapolated from acute NOEC, NOEL, LOEC, LOEL, LC_{50}, and EC_{50} values using the safety factors from Wentsel et al. (1996) identified above.

In some cases, acute and/or chronic saltwater LOELs for chemical classes [e.g., Polynuclear Aromatic Hydrocarbons [PAHs]) were available from the literature (Buchman, 2008). A saltwater LOEL based on a chemical class was used as the groundwater screening value only if that chemical lacked freshwater and saltwater literature-based benchmarks and/or toxicity test endpoints.

4.6.1.3 Sediment Screening Values

The marine and estuarine bulk sediment toxicological benchmarks listed below were preferentially used as sediment screening values:

- Effects-Range low (ER-L) marine and estuarine sediment quality guidelines (SQGs) (Long and Morgan, 1991 and Long et al., 1995).
- Threshold Effects Level (TEL) marine sediment quality assessment guidelines (SQAGs) (MacDonald, 1994).
- Apparent Effects Threshold (AET) marine SQGs (Buchman, 2008).

A description of ER-L, TEL, and AET values and the methods used in their derivation are provided in the paragraphs that follow.

ER-L marine and estuarine SQGs. Long and Morgan (1991) developed effects-based SQGs using literature-based data from Equilibrium Partitioning (EqP) modeling, spiked-sediment toxicity tests, and matched sediment chemistry and biological effects measures. For a given chemical, the data were arranged in ascending order of concentration with each data entry assigned an "effects" or "no effects" descriptor, and the 10th percentile and 50th percentile concentrations of the "effects" data were calculated. The 10th and 50th percentiles of the "effects" data represent the ER-L and Effects Range-Median (ER-M), respectively. The ER-L and the ER-M delineate three concentration ranges for a given chemical. The concentration range below the ER-L value represents a minimal effects range (i.e., the concentration range in which effects would be rarely observed). Concentrations equal to or greater than the ER-L but less than the ER-M represent a possible effects range within which effects would occasionally occur, while concentrations greater than the ER-M represent a probable-effects range within which effects would frequently occur. The ER-L and ER-M values were recalculated by Long et al. (1995) after omitting a small amount of freshwater data included in the original calculations (Long and Morgan, 1991) and incorporating more recent marine and estuarine data from the literature. With the exception of antimony, ER-Ls based on marine only SQGs from Long et al. (1995) were considered for use as sediment screening values. In the case of antimony, an ER-L value is not available from Long et al. (1995). Therefore the ER-L value reported by Long and Morgan (1991) was considered as a potential sediment screening value.

TEL marine SQAGs for Florida coastal waters. The updated and revised data set used by Long et al. (1995) also was used by MacDonald (1994) to calculate SQAGs for Florida coastal waters (TELs and Probable Effect Levels [PELs]). Unlike the methodology used by Long and Morgan (1991) to derive ER-L and ER-M values, the derivation of TELs and PELs took into consideration the "no effects" data set. Specifically, TELs were derived by calculating the geometric mean of the 15th percentile in the "effects" data set and the 50th percentile in the "no effects" data set, while PELs were

derived by calculating the geometric mean of the 50th percentile in the "effects" data set and the 85th percentile in the "no effects" data set.

Identical to ER-Ls and ER-Ms, TELs and PELs delineate three concentration ranges for a given chemical. The TEL represents the upper limit of the range of sediment concentrations dominated by "no effects" data. Within this range, concentrations are not considered to represent significant hazards to sediment-associated biota. The PEL represents the lower limit of the range of sediment concentrations that are usually or always associated with adverse biological effects. The range of concentrations that could be associated with biological effects is delineated by the TEL and PEL. Within this range of concentrations, adverse biological effects are possible. Only TELs were considered for use as sediment screening values.

AET marine SQGs. The AET method, developed by Tetra Tech, Inc (1986), associates chemical concentrations in sediments with adverse biological effects (lethal and sub-lethal toxicity as measured using sediment toxicity tests or changes in benthic macroinvertebrate abundance and community structure as measured by *in situ* biological surveys). For a given chemical and measurement of biological effect (biological indicator), the AET value represents the sediment concentration above which statistically significant biological effects are always observed. The AET values shown in Table 4-3 represent minimum AET values from a suite of seven biological indicators (amphipod mortality, oyster larval abnormality, Microtox luminescence, benthic macroinvertebrate abundance, bivalve larvae mortality/abnormality, Echinoderm larvae mortality/abnormality, and juvenile polychaete growth). It is noted that the AET values developed by Buchman (2008) are interim values subject to change.

Minimum, chemical-specific AET values are used by the Washington State Department of Ecology (1995) as sediment management standards for Puget Sound. Minimum AET values also are used by the United States Army Corps of Engineers (USACE) (USEPA/USACE, 1998) as "reason to believe" guidance for screening levels for the Dredged Material Management Program (DMMP). The DMMP screening levels are implemented for use in Puget Sound and Grays Harbor/Willapa Bay in the State of Washington. Current Washington State Department of Ecology sediment management standards and USACE DMMP screening levels do not reflect the interim AET values reported by Buchman (2008).

For a given chemical, when more than one toxicological threshold was available from the sources listed above (i.e., Long et al., 1995, MacDonald, 1994, and Buchman, 2008), the minimum value was conservatively selected as the sediment screening value. For those organic chemicals lacking literature-based marine and estuarine toxicological benchmarks, EqP-based screening values were either developed using USEPA methodology (USEPA, 1993 and 1996 [see Appendix B] or identified from the literature (Di Toro and McGrath, 2000). For a given chemical, when an EqP-based value was derived in accordance with USEPA (1993 and 1996) methodology and a value also was available from Di Toro and McGrath (2000), the minimum value was selected as the sediment screening value. It is noted that consideration was given to the following literature-based freshwater toxicological thresholds for chemicals lacking marine and estuarine bulk sediment values: (1) consensus-based SQGs for freshwater (MacDonald et al., 2000), (2) SQAGs for Florida inland waters (MacDonald et al., 2003), (3) Ontario Ministry of the Environment Lowest Effect Level (LEL) Provincial sediment quality guidelines (PSQGs) (Persaud et al., 1993), and (4) Canadian interim freshwater sediment quality guidelines (ISQGs) (CCME, 2002). However, no values were available from these sources.

4.6.2 Human Health Screening Values

Applicable human health criteria for soils include USEPA Regional Industrial Screening Levels (SLs) and USEPA Regional Residential SLs (USEPA, 2010), and the upper limit of means background levels (inorganics only) (Baker, 2010b). In the absence of human health screening criteria specific to sediment, USEPA Regional Residential and Industrial Soil SLs (USEPA, 2010) are conservatively used along with NAPR sediment background levels (Baker, 2010b). Applicable human health criteria for groundwater are USEPA Regional Tap Water SLs, Federal Drinking Water Maximum Contaminant Levels (MCLs) (USEPA, 2009b), and any inorganic background levels present in the groundwater at NAPR (Baker, 2010b). In some instances, the laboratory reporting limit for a given compound may exceed the human health screening value for a given media. For this Phase I RFI, all compounds exceeding human health screening values will be identified and discussed in the data evaluation section of the report. For future human health risk assessments that may be conducted as part of a CMS, the non-detected chemicals will be evaluated qualitatively and discussed as an uncertainty.

4.6.2.1 Regional Screening Levels

The Regional SLs were developed by the USEPA to support the risk assessment screening process, while improving consistency across USEPA Regions and incorporating updated guidance in a timely manner. The Regional SL Table was developed with the Department of Energy's Oak Ridge National Laboratory under an Interagency Agreement as an update of the individual screening tables that had previously been maintained by Regions 3, 4, and 9. As recommended by the USEPA, these Regional SLs are to replace all other screening values.

The Regional SL Table contains risk-based screening levels derived from standardized equations (representing ingestion, dermal contact, and inhalation exposure pathways), calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties. The SLs contained in the Regional SL Table are generic; they are calculated without site-specific information. Regional SLs should be viewed as Agency guidelines, not legally enforceable standards. The SLs for potentially carcinogenic chemicals are based on a target Incremental Lifetime Cancer Risk (ILCR) of $1x10^{-06}$. The SLs for noncarcinogens are based on a target hazard quotient (HQ) of 1.0. However, in order to account for cumulative risk from multiple chemicals in a medium, the noncarcinogenic SLs will be divided by a factor of 10, yielding a target HQ of 0.1. For potential carcinogens, the toxicity criteria applicable to the derivation of SL values are oral Cancer Slope Factors (CSFs) and inhalation unit risk (IUR) factors; for noncarcinogens, they are chronic oral reference doses (RfDs) and inhalation reference concentrations (RfCs). These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. The Regional SL Table is updated periodically to reflect such changes. It should be noted that the most recent Regional SL Table update available at this time is from May 2010 (USEPA, 2010). However, the most current version available at the time the Phase I RFI is completed will be used for screening purposes.

4.6.2.2 Federal Drinking Water MCLs

Federal Drinking Water MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCL Goals are calculated based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kilograms [kg]) consuming 2 liters of water per day. MCLs consider both the MCL Goal and the technical feasibility of removing the contaminant from the public water supply. Accordingly, MCLs are established as close to the MCL Goal as technically feasible (USEPA, 2009b).

4.6.2.3 Puerto Rico Water Quality Standards

PRWQS are regulations designed to enhance maintain and preserve the quality of the waters of Puerto Rico. Rule 1303 establishes water quality standards and use classifications promulgated for the protection of the uses assigned to the classifications of the coastal, surface, estuarine, wetlands, and ground waters of the Commonwealth. In Rules 1303.1 (I) (1), 1303.1 (I) (2), 1303.1 (I) (3), 1303.1 (I) (4), and1303.1 (I) (5) specific substances are identified for which numeric water quality standards have been established (PREQB, 2010).

Puerto Rico Water Quality Standards for Class SG (groundwater intended for use as a source of drinking water supply and agricultural uses including irrigation) listed in the PRWQS regulation amended March 31, 2010 are also included as groundwater screening values. PRWQS values will be used in place of the Federal Drinking Water Quality Standards, when more stringent.

4.6.2 Background Screening Values

For a given medium (i.e., soil and groundwater), analytical data for inorganic chemicals exceeding one or more of the screening values (human health or ecological) will be compared to NAPR background analytical data as developed in the *Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds* (Baker, 2010b).

4.7 Conclusions and Recommendations

Information from the physical and analytical results (nature and extent of contamination) will be synthesized into conclusions regarding site conditions. Recommendations will be made from these conclusions as to whether a Full RFI is need to further delineate contamination or whether a Corrective Measures Study (CMS) is needed or the SWMU can proceed toward corrective action complete. If the conclusions from the Phase I RFI indicate exceedances of human health and/or ecological screening values and background screening values, then a Full RFI will be completed. The Full RFI report will recommend moving the SWMU to a CMS with the preparation of a Draft CMS Work Plan. A HHRA and ERA will be conducted as part of the CMS and the CMS Work Plan will present the specific methodology that will be employed for conducting these assessments.

All data from the laboratory will be certified by a Puerto Rican Chemist and laboratory data will be validated to ensure data usability. Only usable data as determined by the 3rd party data validator will be included in the evaluation and the conclusions and recommendations sections of the report. Data validation reports will be included as an appendix to the Phase I RFI report and will discuss:

- Overall Evaluation of the Data
- Potential Usability Issues
- Data Completeness
- Technical Holding Times
- Initial and Continuing Calibrations
- Method and QC Blanks
- Laboratory Control Samples
- Matrix Spikes
- Quantitation and Data Qualifications

The data validation reports in the Phase I RFI report will include discussions on surrogates, internal standards, post digest spikes, field duplicates, the extent of outlier exceedances, which results were affected, and how results were qualified.

4.8 References

Source material used in the development of the Phase I RFI Report will be documented in the References section of the report.

5.0 SCHEDULE

A schedule for the implementation of this Work Plan is provided as Figure 5-1.

It should be noted that this schedule is dependent upon USEPA review time. Many other factors can also extend the schedule such as resampling due to unforeseen issues, weather delays in the field, or if consensus cannot be reached on how the USEPA's comments are to be incorporated.

6.0 SITE MANAGEMENT

An organizational chart presenting the proposed staffing for this project is provided on Figure 6-1. This section also outlines the responsibilities and reporting requirements of field personnel and staff.

6.1 Project Team Responsibilities

Mr. Mark Kimes, P.E., Activity Coordinator for all work in Puerto Rico, will manage the Baker Project Team. His responsibilities will be to direct the technical performance of the project staff, costs and schedule, ensuring that QA/QC procedures are followed during the course of the project. He will maintain communication with the BRAC PMO SE Navy Technical Representative (NTR), Mr. Mark Davidson. Mr. John Mentz will administer overall QA/QC for this project.

The field activities of this project will consist of one field team managed by the Mr. Adam Gailey. Mr. Gailey's responsibilities include directing the field team and subcontractors. Mr. Rick Aschenbrenner, P.G. will direct the reporting effort associated with the field investigation, ensuring that all necessary staffing is utilized to assist in developing the RFI Report for SWMU 79.

6.2 Field Reporting Requirements

The Geologist will maintain a daily summary of each day's field activities. The following information will be included in this summary:

- Baker and subcontractor personnel on site
- Major activities of the day
- Samples collected
- Problems encountered
- Other pertinent site information

The Geologist will receive direction from the Activity Manager regarding any changes in scope of the investigation.

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TABLES

TABLE 2-1
LIST OF BIRDS REPORTED FROM OR HAVING THE POTENTIAL TO OCCUR AT
NAVAL ACTIVITY PUERTO RICO
SWMU 79 –CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Common Name [(1)]		
Pied-billed grebe	Red-billed tropicbird	Brown pelican [(2)]
Brown booby	Magnificent frigatebird	Great blue heron
Louisiana heron	Snowy egret	Great egret
Striated heron	Little blue heron	Cattle egret
Least bittern	Yellow-crowned night heron	Black-crowned night heron
White-cheeked pintail	Blue-winged teal	American widgeon
Red-tailed hawk	Osprey	Merlin
Clapper rail	American coot	Caribbean coot
Common gallinule	Piping plover [(3)(4)]	Semipalmated plover
Black-bellied plover	Wilson's plover	Killdeer
Ruddy turnstone	Black-necked stilt	Whimbrel
Spotted sandpiper	Semipalmated sandpiper	Short-billed dowitcher
Greater yellowlegs	Lesser yellowlegs	Willet
Stilt sandpiper	Pectoral sandpiper	Laughing gull
Royal tern	Sandwich tern	Bridled tern
Least tern	Brown noddy	White-winged dove
Zenaida dove	White-crowned pigeon	Mourning dove
Red-necked pigeon	Common ground dove	Bridled quail dove
Ruddy quail dove	Caribbean parakeet	Smooth-billed ani
Yellow-billed cuckoo	Mangrove cuckoo	Short-eared owl
Chuck-will's-widow	Common nighthawk	Antillean crested hummingbird
Green-throated carib	Antillean mango	Belted kingfisher

TABLE 2-1
LIST OF BIRDS REPORTED FROM OR HAVING THE POTENTIAL TO OCCUR AT NAVAL ACTIVITY PUERTO RICO
SWMU 62 – FORMER BUNDY DISPOSAL AREA
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Common Name [1]		
Gray kingbird	Loggerhead kingbird	Stolid flycatcher
Caribbean elaenia	Purple martin	Cave swallow
Barn swallow	Northern mockingbird	Pearly-eyed thrasher
Red-legged thrush	Black-whiskered vireo	American redstart
Parula warbler	Prairie warbler	Yellow warbler
Magnolia warbler	Cape May warbler	Black-throated blue warbler
Adelaide's warbler	Palm warbler	Black and white warbler
Ovenbird	Northern water thrush	Bananaquit
Striped-headed tanager	Shiny cowbird	Black-cowled oriole
Greater Antillean grackle	Yellow-shouldered blackbird [2]	Hooded manakin
Yellow-faced grassquit	Black-faced grassquit	Least sandpiper
Western sandpiper	Puerto Rican woodpecker	Rock dove
Puerto Rican emerald	Puerto Rican flycatcher	Pin-tailed whydah
Spice finch	Ruddy duck	Peregrine falcon
Marbled godwit	Puerto Rican lizard cuckoo	Prothonotary warbler
Green-winged teal	Orange-cheeked waxbill	Roseate tern [3][4]
Least grebe	West Indian whistling duck	Puerto Rican screech owl
Puerto Rican tody	Green heron	

Notes:

[1] List of birds taken from Geo-Marine, Inc. (1998).
[2] Federally-designated endangered species.
[3] Federally-designated threatened species.
[4] Species has the potential to occur at Naval Activity Puerto Rico.

TABLE 2-2

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Soil Screening Values	NAPR Basewide Background [1]	CABSB01 CABSB01-00 1/21/2009 0.0-1.0	CABSS01 CABSS01 1/18/2009 0.0-1.0	CABSS02 CABSS02 1/18/2009 0.0-1.0	CABSS03 CABSS03 1/18/2009 0.0-1.0
Volatile Organic Compounds (ug/kg)								
Acetone	6,100,000 [2]	61,000,000 [2]	NE	NE	100 R	23 J	57	5.1 U
Chloroform	300	1,500	1,002 [7]	NE	0.5 U	0.6 U	0.56 J	0.58 U
Methylene Chloride	11,000	54,000	1,004 [7]	NE	1 UJ	1.2 U	0.99 U	1.2 U
Semivolatile Organic Compounds (ug/kg)								
2-Methylnaphthalene	31,000 [2]	410,000 [2]	NE	NE	1.9 U	2.4 J	1.9 U	2.3 U
Anthracene	1,700,000 [2]	17,000,000 [2]	NE	NE	1.9 U	6.9 J	1.9 U	2.3 U
Benzo[a]anthracene	150	2,100	NE	NE	1.9 U	140	4.7 J	13 J
Benzo[a]pyrene	15	210	NE	NE	1.9 UJ	***390***	6.5 J	2.3 UJ
Benzo[b]fluoranthene	150	2,100	NE	NE	1.9 UJ	**460**	11	57 J
Benzo[g,h,i]perylene	170,000 [2][3]	1,700,000 [2][3]	NE	NE	1.9 UJ	470 J	4.7 J	2.3 UJ
Benzo[k]fluoranthene	1,500	21,000	NE	NE	1.9 UJ	270	8.5	2.3 UJ
Bis(2-ethylhexyl) phthalate	35,000	120,000	6,010 [7]	NE	21 J	200 J	1200 J	170 J
Chrysene	15,000	210,000	NE	NE	1.9 U	320	9.2	40 J
Dibenz(a,h)anthracene	15	210	NE	NE	0.63 UJ	**140** J	2.8 J	0.79 UJ
Dimethyl phthalate	NE	NE	200,000 [11]	NE	7 U	7.6 U	52	8.8 U
Fluoranthene	230,000 [2]	2,200,000 [2]	NE	NE	1.1 J	86	6.2 J	12
Naphthalene	3,900	20,000	NE	NE	1.9 U	2.5 J	2.7 J	2.8 J
Phenanthrene	NE	NE	NE	NE	1.9 U	14	3.2 J	3.4 J
Pyrene	170,000 [2]	1,700,000 [2]	NE	NE	1.9 U	160	6.7 J	26 J
Low/High Moleular Weight PAHs (ug/kg)								
Low Molecular Weight PAHs	NE	NE	29,000 [5]	NE	37.3	930	1283	264
High Molecular Weight PAHs	NE	NE	18,000 [6]	NE	74.7	1860	2566	528

TABLE 2-2

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Soil Screening Values	NAPR Basewide Background [1]	CABSB01 CABSB01-00 1/21/2009 0.0-1.0	CABSS01 CABSS01 1/18/2009 0.0-1.0	CABSS02 CABSS02 1/18/2009 0.0-1.0	CABSS03 CABSS03 1/18/2009 0.0-1.0
PCBs (ug/kg)								
None detected (from CABSS04-00 or CABSS04-00D)								
Metals (mg/kg)								
Antimony	3.1	41	78 [9]	3.17	0.31 UJ	1.1 J	**8.7** J	2.8 J
Arsenic	0.39	1.6	18 [8]	2.65	***3.3*** J	***4.7*** J	***21*** J	***3.2*** J
Barium	1,500 [2]	19,000 [2]	330 [9]	199	69 J	100 J	51 J	71 J
Beryllium	16 [2]	200 [2]	40 [9]	0.59	0.17	0.26	0.3	0.24
Cadmium	7 [2]	81 [2]	32 [8]	1.02	0.33	**7.1**	**20**	3.4
Chromium	280	1,400	57 [10]	49.8	21	**410** J	**690** J	49 J
Cobalt	2.3 [2]	30 [2]	13 [8]	46.2	**15**	**20**	**26**	**18**
Copper	310 [2]	4,100 [2]	70 [8]	168	72 J	120 J	230 J	290 J
Lead	400 [4]	800 [4]	120 [8]	22	16	***1500***	***2200***	150
Mercury	2.3 [2]	31 [2]	0.1 [11]	0.109	0.015 J	0.024	0.029	0.046
Nickel	160 [2]	2,000 [2]	38 [8]	20.7	11	27 J	110 J	19 J
Selenium	39 [2]	510 [2]	0.52 [8]	1.48	0.5	0.31 J	0.27 J	1
Silver	39 [2]	510 [2]	560 [8]	NE	0.069 U	0.16 U	0.34	0.59
Thallium	0.51	6.6	1 [14]	NE	0.12 U	0.13 U	0.12 U	0.17 J
Tin	4,700	61,000	50 [14]	3.76	3.9 U	4.9 J	6.7 J	5.1 U
Vanadium	55 [2]	720 [2]	10 [12]	259	**110**	**100**	**68**	**160**
Zinc	2,300 [2]	31,000 [2]	120 [9]	115	46 J	700 J	1100 J	480 J
TPH DRO and GRO (mg/kg)								
Diesel Range Organics	NE	NE	NE	NE	66	23	53	6.7 U
Gasoline Range Organics	NE	NE	NE	NE	0.063 J	0.078 U	0.057 U	0.068 U
Total TPH	100 [13]	NE	NE	NE	66.1 J	23	53	6.8 U

TABLE 2-2

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Soil Screening Values	NAPR Basewide Background [1]	CABSS04 CABSS04 1/18/2009 0.0-1.0	CABSS04 CABSS04D 1/18/2009 0.0-1.0	CABSS05 CABSS05 1/18/2009 0.0-1.0	CABSS06 CABSS06 1/18/2009 0.0-1.0
Volatile Organic Compounds (ug/kg)								
Acetone	6,100,000 [2]	61,000,000 [2]	NE	NE	11 J	15 J	14 J	39 J
Chloroform	300	1,500	1,002 [7]	NE	0.58 U	0.62 U	0.61 U	0.84 U
Methylene Chloride	11,000	54,000	1,004 [7]	NE	1.2 U	1.2 U	1.2 U	3.8 J
Semivolatile Organic Compounds (ug/kg)								
2-Methylnaphthalene	31,000 [2]	410,000 [2]	NE	NE	2.1 U	10 U	2 U	2.6 U
Anthracene	1,700,000 [2]	17,000,000 [2]	NE	NE	2.1 U	10 U	2 U	2.6 U
Benzo[a]anthracene	150	2,100	NE	NE	2.1 U	10 U	2 U	2.6 U
Benzo[a]pyrene	15	210	NE	NE	2.1 U	10 U	2 U	2.6 U
Benzo[b]fluoranthene	150	2,100	NE	NE	2.1 U	10 U	2 U	2.6 U
Benzo[g,h,i]perylene	170,000 [2][3]	1,700,000 [2][3]	NE	NE	2.1 U	10 U	2 U	2.6 U
Benzo[k]fluoranthene	1,500	21,000	NE	NE	2.1 U	10 U	2.9 J	2.6 U
Bis(2-ethylhexyl) phthalate	35,000	120,000	6,010 [7]	NE	29 UJ	25 UJ	22 U	57 UJ
Chrysene	15,000	210,000	NE	NE	2.1 U	10 U	2 U	2.6 U
Dibenz(a,h)anthracene	15	210	NE	NE	0.7 U	3.4 U	0.68 U	0.87 U
Dimethyl phthalate	NE	NE	200,000 [11]	NE	7.8 U	38 U	7.6 U	9.8 U
Fluoranthene	230,000 [2]	2,200,000 [2]	NE	NE	0.46 U	2.3 U	2.2 J	0.75 J
Naphthalene	3,900	20,000	NE	NE	2.1 U	10 U	2 U	2.6 U
Phenanthrene	NE	NE	NE	NE	2.1 U	10 U	2 U	2.6 U
Pyrene	170,000 [2]	1,700,000 [2]	NE	NE	2.1 U	10 UJ	2 U	2.6 UJ
Low/High Moleular Weight PAHs (ug/kg)								
Low Molecular Weight PAHs	NE	NE	29,000 [5]	NE	46.4	109	40.5	78.8
High Molecular Weight PAHs	NE	NE	18,000 [6]	NE	92.7	217	81.0	158

TABLE 2-2

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Soil Screening Values	NAPR Basewide Background [1]	CABSS04 CABSS04 1/18/2009 0.0-1.0	CABSS04 CABSS04D 1/18/2009 0.0-1.0	CABSS05 CABSS05 1/18/2009 0.0-1.0	CABSS06 CABSS06 1/18/2009 0.0-1.0
PCBs (ug/kg)								
None detected (from CABSS04-00 or CABSS04-00D)								
Metals (mg/kg)								
Antimony	3.1	41	78 [9]	3.17	1.1 J	0.93 J	0.41 UJ	0.69 J
Arsenic	0.39	1.6	18 [8]	2.65	***2.7*** J	***2.5*** J	***2.9*** J	***1.9*** J
Barium	1,500 [2]	19,000 [2]	330 [9]	199	72 J	65 J	81 J	73 J
Beryllium	16 [2]	200 [2]	40 [9]	0.59	0.28	0.25	0.23	0.24
Cadmium	7 [2]	81 [2]	32 [8]	1.02	0.4	0.39	0.43	1.6
Chromium	280	1,400	57 [10]	49.8	32 J	28 J	62 J	47 J
Cobalt	2.3 [2]	30 [2]	13 [8]	46.2	**23**	**23**	**23**	**20**
Copper	310 [2]	4,100 [2]	70 [8]	168	**330** J	97 J	110 J	110 J
Lead	400 [4]	800 [4]	120 [8]	22	17	15	21	36
Mercury	2.3 [2]	31 [2]	0.1 [11]	0.109	0.04	0.038	0.034	0.043
Nickel	160 [2]	2,000 [2]	38 [8]	20.7	13 J	13 J	15 J	26 J
Selenium	39 [2]	510 [2]	0.52 [8]	1.48	0.7	0.72	1.6	0.31 U
Silver	39 [2]	510 [2]	560 [8]	NE	0.12 U	0.073 U	0.061 U	0.051 U
Thallium	0.51	6.6	1 [14]	NE	0.14 U	0.13 U	0.17 J	0.16 U
Tin	4,700	61,000	50 [14]	3.76	4.5 U	16 J	4.1 U	5.2 U
Vanadium	55 [2]	720 [2]	10 [12]	259	**150**	**140**	**230**	**130**
Zinc	2,300 [2]	31,000 [2]	120 [9]	115	77 J	69 J	120 J	550 J
TPH DRO and GRO (mg/kg)								
Diesel Range Organics	NE	NE	NE	NE	130	98	16	21
Gasoline Range Organics	NE	NE	NE	NE	0.075 U	0.078 U	0.076 UJ	0.2 J
Total TPH	100 [13]	NE	NE	NE	**130**	98	16	21.2 J

TABLE 2-2

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
R - Rejected data; data is not usable
ft bgs - feet below ground surface
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram
NE - Not Established
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

(1) NAPR basewide background surface soil screening value (upper limit of the means concentration [mean plus two standard deviations]) (Baker, 2008)

(2) Noncarcinogenic Regional Screening Levels based on a target hazard quotient of 0.1 for conservative screening purposes

(3) Pyrene used as a surrogate for screening purposes for benzo[g,h,i] perylene

(4) USEPA Action Level for lead in soils

(5) Low molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of fewer than four rings. The low molecular weight PAH compounds analyzed for in soil were 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, and phenanthrene. Maximum method detection limit was used if there were no detections.

(6) High molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of four or more rings. The high molecular weight PAH compounds analyzed for in soil were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and pyrene. Maximum method detection limits were used for non-detected PAHs.

(7) The screening value shown is an average of the target and intervention soil standards. The value is based on a default organic carbon content of 0.02 (2 percent), which represents a minimum value (adjustment range is 2 to 30 percent). [MHSPE, 2000]

(8) Plant-based ecological soil screening level (USEPA, 2005a [arsenic]; USEPA, 2005b [cadmium]; USEPA, 2005c [cobalt]; USEPA, 2005d [lead]; USEPA, 2007b [copper]; USEPA, 2007c [nickel]; USEPA, 2007e [selenium], USEPA, 2006 [silver].

(9) Invertebrate-based ecological soil screening level (USEPA, 2005h [antimony]; USEPA, 2005e [barium]; USEPA, 2005f [beryllium]; USEPA, 2007d [zinc])

(10) Reproduction-based MATC for *Eisenia andrei* (earthworm)

(11) Toxicological threshold for earthworms (Efroymson et al., 1997a)

(12) Growth-based LOAEC for *Brassica oleracea* (broccoli) with a safety factor of 10 (USEPA, 2005g)

(13) Total TPH value represents the Puerto Rico Environmental Quality Board recommended screening value for soils

(14) Toxicological threshold for plants (Efroymson et al., 1997b)

TABLE 2-2

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References:

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USEPA. 2006. Ecological Soil Screening Levels for Silver (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWEER Directive 9285.7-77

USEPA. 2007a. Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs) (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-78.

USEPA. 2007b. Ecological Soil Screening Levels for Copper (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-68.

USEPA. 2007c. Ecological Soil Screening Levels for Nickel (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-76.

USEPA. 2007d. Ecological Soil Screening Levels for Zinc (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-72.

USEPA. 2007e. Ecological Soil Screening Levels for Selenium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-72.

USEPA. 2005a. Ecological Soil Screening Levels for Arsenic (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA. 2005b. Ecological Soil Screening Levels for Cadmium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-62.

USEPA. 2005c. Ecological Soil Screening Levels for Cobalt (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-67

TABLE 2-2

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References (cont.):

USEPA. 2005d. Ecological Soil Screening Levels for Lead (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-70.

USEPA. 2005e. Ecological Soil Screening Levels for Barium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

USEPA. 2005f. Ecological Soil Screening Levels for Beryllium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

USEPA. 2005g. Ecological Soil Screening Levels for Vanadium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-75.

USEPA. 2005h. Ecological Soil Screening Levels for Antimony (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-61.

TABLE 2-3

SUMMARY OF DETECTED LABORATORY RESULTS - SUBSURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	NAPR Basewide Background [1]	CABSB01 CABSB01-03 1/21/2009 5.0-7.0	CABSB01 CABSB01-03D 1/21/2009 5.0-7.0	CABSB01 CABSB01-05 1/21/2009 9.0-11.0
Volatile Organic Compounds (ug/kg)						
Acetone	6,100,000 [2]	61,000,000 [2]	NE	120 R	13 R	23 J
Semivolatile Organic Compounds (ug/kg)						
Bis(2-ethylhexyl) phthalate	35,000	120,000	NE	170 UJ	120 UJ	230
Naphthalene	3,900	20,000	NE	2.2 U	2.2 U	2.1 J
Metals (mg/kg)						
Antimony	3.1	41	NE	2 J	0.57 J	0.47 UJ
Arsenic	0.39	1.6	1.59	120 R	13 R	**1.2** J
Barium	1,500 [2]	19,000 [2]	220	15 J	17 J	20 J
Beryllium	16 [2]	200 [2]	0.596	0.7 J	0.4 J	0.37
Cadmium	7 [2]	81 [2]	0.54	0.47 J	0.18 J	0.24
Chromium	280	1,400	114.5	2.9	3.8	4.3
Cobalt	2.3 [2]	30 [2]	26.9	**11** J	**17** J	**10**
Copper	310 [2]	4,100 [2]	246	83 J	100 J	36 J
Lead	400 [4]	800 [4]	6.3	1.7	1.2	1.2
Mercury	2.3 [2]	31 [2]	0.108	0.0043 U	0.0066 J	0.0043 U
Nickel	160 [2]	2,000 [2]	24.7	5.1	5	4.9
Selenium	39 [2]	510 [2]	5.94	0.19 J	0.16 U	0.14 U
Silver	39 [2]	510 [2]	NE	0.046 J	0.086 U	0.069 U
Vanadium	55 [2]	720 [2]	434	**200** J	**100** J	**90**
TPH DRO and GRO (mg/kg)						
None Detected						

TABLE 2-3

SUMMARY OF DETECTED LABORATORY RESULTS - SUBSURFACE SOIL - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
R - Rejected data; data is not usable
ft bgs - feet below ground surface
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram
NE - Not Established
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

(1) NAPR basewide background soil screening value (upper limit of the means concentration [mean plus two standard deviations]) for Subsurface Soil Clay Table 3-4 (Baker, 2008)

(2) Total TPH value is 100 mg/kg which represents the Puerto Rico Environmental Quality Board recommended screening value for soils the bolded value is greater thant he PREQB recommended screening value.

TABLE 2-4

SUMMARY OF DETECTED LABORATORY RESULTS - SEDIMENT - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Sediment Screening Values	NAPR Basewide Background [1]	CABSED01 CABSED01 1/19/2009 0.0-0.5	CABSED02 CABSED02 1/18/2009 0.0-0.5	CABSED02 CABSED02D 1/18/2009 0.0-0.5
Volatile Organic Compounds (ug/kg)							
Acetone	6,100,000 [2]	61,000,000 [2]	5.81 [4]	NE	120 J	120	77 J
Semivolatile Organic Compounds (ug/kg)							
Anthracene	1,700,000 [2]	17,000,000 [2]	46.9 [5]	NE	3.5 UJ	7.1 J	3.5 U
Benzo[a]anthracene	150	2,100	74.8 [5]	NE	3.5 UJ	6.2 J	7.7 J
Benzo[b]fluoranthene	150	2,100	1,800 [10]	NE	3.5 UJ	37	29
Chrysene	15,000	210,000	108 [5]	NE	5.7 J	14	21
Fluoranthene	230,000 [2]	2,200,000 [2]	113 [5]	NE	12 J	0.7 U	9.5 J
Phenanthrene	NE	NE	86.7 [5]	NE	6.7 J	3.1 U	3.5 U
Pyrene	170,000 [2]	1,700,000 [2]	153 [5]	NE	12 J	13	9.9 J
Metals (mg/kg)							
Arsenic	0.39	1.6	7.24 [5]	7.0	**1.2** J	**1** J	**1.2** J
Barium	1,500 [2]	19,000 [2]	48 [6]	24.93	26 J	31 J	46 J
Beryllium	16 [2]	200 [2]	NE	0.55	0.25 J	0.2 J	0.24 J
Cadmium	7 [2]	81 [2]	0.676 [5]	1.23	0.086 J	0.13 J	0.059 UJ
Chromium	280	1,400	52.3 [5]	50.05	22 J	17 J	23 J
Cobalt	2.3 [2]	30 [2]	10 [7]	22.35	**14** J	**11**	**12** J
Copper	310 [2]	4,100 [2]	18.7 [5]	132.44	81 J	65 J	74 J
Lead	400 [3]	800 [3]	30.2 [5]	25.4	11 J	7.7	8.8 J
Mercury	2.3 [2]	31 [2]	0.13 [5]	0.17	0.041 J	0.038	0.04 J
Nickel	160 [2]	2,000 [2]	15.9 [5]	17.31	11 J	9.7 J	12 J
Selenium	39 [2]	510 [2]	1 [6]	1.51	0.48 J	0.42 J	0.55 J
Vanadium	55 [2]	720 [2]	57 [7]	230.43	**110** J	**88** J	**110** J
Zinc	2,300 [2]	31,000 [2]	124 [5]	96.9	50 J	41 J	52 J

TABLE 2-4

SUMMARY OF DETECTED LABORATORY RESULTS - SEDIMENT - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Sediment Screening Values	NAPR Basewide Background [1]	CABSED01 CABSED01 1/19/2009 0.0-0.5	CABSED02 CABSED02 1/18/2009 0.0-0.5	CABSED02 CABSED02D 1/18/2009 0.0-0.5
TPH DRO and GRO (mg/kg)							
Diesel Range Organics	100 [8]	NE	NE	NE	17	76	79
Total Organic Carbon (mg/kg)							
Total Organic Carbon	NE	NE	NE	NE	20,000	41,000	NA

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

NA - Not Analyzed
NE - Not Established
ft bgs - feet below ground surface
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram

[1] NAPR basewide background estuarine sediment screening value (upper limit of the means concentration [mean plus two standard deviations]) (Baker, 2008)

[2] Noncarcinogenic RSLs based on a target hazard quotient of 0.1 for conservative screening purposes

[3] USEPA Action Level for lead in soils

[4] EqP-based screening value [USEPA, 1993; USEPA, 1996]

[5] Threshold Effect Level [MacDonald, 1994]

[6] Minimum Apparent Effects Threshold (amphipod) [Buchman 2008]

[7] Minimum Apparent Effects Threshold (Neanthes bioassays) [Buchman 2008]

[8] Total TPH value represents the Puerto Rico Environmental Quality Board recommended screening value for soils

References:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. National Oceanic and Atmospheric Administration, Office of Response and Restoration Division, Seattle, WA.

MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Waters: Volume 1 - Development and Evaluation of Sediment Quality Assessment Guidelines. Prepared for Florida Department of Environmental Protection, Tallahassee, Fl. November 1994.

USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/F-95/038.

USEPA. 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water, Washington, D.C. EPA-822-R-93-011.

TABLE 2-5

SUMMARY OF DETECTED LABORATORY RESULTS - CONCRETE CHIP - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID	CABCC01	CABCC02	CABCC02
Sample ID	CABCC01	CABCC02	CABCC02D
Date	1/19/2009	1/19/2009	1/19/2009
Volatile Organic Compounds (ug/kg)			
Acetone	5.7 J	6.5 J	6 J
Semivolatile Organic Compounds (ug/kg)			
Acetophenone	20 J	8.7 U	8.6 UJ
Bis(2-ethylhexyl) phthalate	99 J	35 UJ	50 UJ
Butyl benzyl phthalate	1500	290	420 J
Diethyl phthalate	130	39	75 J
Fluoranthene	0.39 U	0.56 J	0.42 J
Phenol	55	4.8 U	4.8 UJ
Metals (mg/kg)			
Arsenic	4.8 J	2.6 J	3.3 J
Barium	160 J	140 J	120 J
Beryllium	0.24	0.17	0.28
Cadmium	2.4	0.87 J	1.8 J
Chromium	100 J	8 J	20 J
Cobalt	10	8.1	9.5
Copper	72 J	49 J	57 J
Lead	440	36	38
Nickel	8.1 J	5.4 J	8.2 J
Selenium	0.14 J	0.12 U	0.1 U
Vanadium	82	53	67
Zinc	220 J	120 J	170 J

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram

TABLE 2-6

SUMMARY OF DETECTED LABORATORY RESULTS - SEPTIC TANK WATER - PHASE II ECP REPORT
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID	CABSEP01	CABSEP02	CABSEP02
Sample ID	CABSEP01	CABSEP02	CABSEP02D
Date	1/18/2009	1/18/2009	1/18/2009
Volatile Organic Compounds (ug/L)			
Acetone	5 U	12 J	11 J
Carbon disulfide	0.6 U	0.71 J	0.91 J
Chloroform	0.29 U	0.96 J	0.88 J
Semivolatile Organic Compounds (ug/L)			
2-Methylphenol	0.15 U	0.17 J	0.2 J
3 & 4 Methylphenol	0.15 U	5 J	1 J
Acenaphthylene	0.026 J	0.019 U	0.019 U
Anthracene	0.029 J	0.025 U	0.025 U
Diethyl phthalate	0.18 U	0.37 J	0.48 J
Fluoranthene	0.03 J	0.062 J	0.018 U
Fluorene	0.036 J	0.025 U	0.025 U
Naphthalene	0.029 J	0.025 UJ	0.025 UJ
Phenanthrene	0.042 J	0.03 U	0.03 U
Phenol	0.14 U	15	11
Pyrene	0.028 J	0.021 U	0.021 U
Pyridine	0.22 U	1.5 J	1.8 J
Metals (ug/L)			
Arsenic	0.68 U	3.3	3.2
Barium	17	10	6.8
Cadmium	0.12 U	0.22 J	0.12 U
Cobalt	0.21 U	0.59	0.43 U
Copper	11	21 J	12 J
Lead	0.96 J	16 R	3.6 R
Nickel	0.79 J	8.3 J	5.9 J
Selenium	0.6 U	0.88 J	0.75 J
Tin	0.9 U	4.7 J	1.8 J
Vanadium	5.9	3.3 U	2.5 U
TPH DRO and GRO (mg/L)			
Diesel Range Organics	0.35	2.4	2.4
Gasoline Range Organics	0.012 U	0.02 J	0.023 J

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
R - Rejected data; not usuable
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
ug/L- micrograms per liter
mg/L - miligrams per liter

TABLE 3-1

Revised: June 21, 2011

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Surface and Subsurface Soil Grid Samples[3]											
79SB01-00	0.0 - 1.0	X		(1)							
79SB01-01	1.0 - 3.0	X		(1)							
79SB02-00	0.0 - 1.0	X		(1)							
79SB02-01	1.0 - 3.0	X		(1)							
79SB03-00	0.0 - 1.0	X		(1)							
79SB03-01	1.0 - 3.0	X		(1)							
79SB04-00	0.0 - 1.0	X		(1)							
79SB04-01	1.0 - 3.0	X		(1)							
79SB05-00	0.0 - 1.0	X		(1)							
79SB05-01	1.0 - 3.0	X		(1)							
79SB06-00	0.0 - 1.0	X		(1)							
79SB06-01	1.0 - 3.0	X		(1)							
79SB07-00	0.0 - 1.0	X		(1)							
79SB07-01	1.0 - 3.0	X		(1)							
79SB08-00	0.0 - 1.0	X		(1)							
79SB08-01	1.0 - 3.0	X		(1)							
79SB09-00	0.0 - 1.0	X		(1)							
79SB09-01	1.0 - 3.0	X		(1)							
79SB10-00	0.0 - 1.0	X		(1)							
79SB10-01	1.0 - 3.0	X		(1)							
79SB11-00	0.0 - 1.0	X		(1)							
79SB11-01	1.0 - 3.0	X		(1)							
79SB12-00	0.0 - 1.0	X		(1)							
79SB12-01	1.0 - 3.0	X		(1)							
79SB13-00	0.0 - 1.0	X		(1)							
79SB13-01	1.0 - 3.0	X		(1)							
79SB14-00	0.0 - 1.0	X		(1)							
79SB14-01	1.0 - 3.0	X		(1)							
79SB15-00	0.0 - 1.0	X		(1)							
79SB15-01	1.0 - 3.0	X		(1)							
79SB16-00	0.0 - 1.0	X		(1)							
79SB16-01	1.0 - 3.0	X		(1)							
79SB17-00	0.0 - 1.0	X		(1)							
79SB17-01	1.0 - 3.0	X		(1)							

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Revised: June 21, 2011

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Surface and Subsurface Soil Grid Samples (Continued)[3]											
79SB18-00	0.0 - 1.0	X		(1)							
79SB18-01	1.0 - 3.0	X		(1)							
79SB19-00	0.0 - 1.0	X		(1)							
79SB19-01	1.0 - 3.0	X		(1)							
79SB20-00	0.0 - 1.0	X		(1)							
79SB20-01	1.0 - 3.0	X		(1)							
79SB21-00	0.0 - 1.0	X		(1)							
79SB21-01	1.0 - 3.0	X		(1)							
79SB22-00	0.0 - 1.0	X		(1)							
79SB22-01	1.0 - 3.0	X		(1)							
79SB23-00	0.0 - 1.0	X		(1)							
79SB23-01	1.0 - 3.0	X		(1)							
79SB24-00	0.0 - 1.0	X		(1)							
79SB24-01	1.0 - 3.0	X		(1)							
79SB25-00	0.0 - 1.0	X		(1)							
79SB25-01	1.0 - 3.0	X		(1)							
79SB26-00	0.0 - 1.0	X		(1)							
79SB26-01	1.0 - 3.0	X		(1)							
79SB27-00	0.0 - 1.0	X		(1)							
79SB27-01	1.0 - 3.0	X		(1)							
79SB28-00	0.0 - 1.0	X		(1)							
79SB28-01	1.0 - 3.0	X		(1)							
79SB29-00	0.0 - 1.0	X		(1)							
79SB29-01	1.0 - 3.0	X		(1)							
79SB30-00	0.0 - 1.0	X		(1)							
79SB30-01	1.0 - 3.0	X		(1)							
79SB31-00	0.0 - 1.0	X		(1)							
79SB31-01	1.0 - 3.0	X		(1)							
79SB32-00	0.0 - 1.0	X		(1)							
79SB32-01	1.0 - 3.0	X		(1)							
79SB33-00	0.0 - 1.0	X		(1)							
79SB33-01	1.0 - 3.0	X		(1)							
79SB34-00	0.0 - 1.0	X		(1)							
79SB34-01	1.0 - 3.0	X		(1)							

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SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Surface and Subsurface Soil Grid Samples (Continued)[3]											
79SB35-00	0.0 - 1.0	X		(1)							
79SB35-01	1.0 - 3.0	X		(1)							
79SB36-00	0.0 - 1.0	X		(1)							
79SB36-01	1.0 - 3.0	X		(1)							
79SB37-00	0.0 - 1.0	X		(1)							
79SB37-01	1.0 - 3.0	X		(1)							
79SB38-00	0.0 - 1.0	X		(1)							
79SB38-01	1.0 - 3.0	X		(1)							
79SB39-00	0.0 - 1.0	X		(1)							
79SB39-01	1.0 - 3.0	X		(1)							
79SB40-00	0.0 - 1.0	X		(1)							
79SB40-01	1.0 - 3.0	X		(1)							
79SB41-00	0.0 - 1.0	X		(1)							
79SB41-01	1.0 - 3.0	X		(1)							
79SB42-00	0.0 - 1.0	X		(1)							
79SB42-01	1.0 - 3.0	X		(1)							
79SB43-00	0.0 - 1.0	X		(1)							
79SB43-01	1.0 - 3.0	X		(1)							
79SB44-00	0.0 - 1.0	X		(1)							
79SB44-01	1.0 - 3.0	X		(1)							
79SB45-00	0.0 - 1.0	X		(1)							
79SB45-01	1.0 - 3.0	X		(1)							
79SB46-00	0.0 - 1.0	X		(1)							
79SB46-01	1.0 - 3.0	X		(1)							
79SB47-00	0.0 - 1.0	X		(1)							
79SB47-01	1.0 - 3.0	X		(1)							
79SB48-00	0.0 - 1.0	X		(1)							
79SB48-01	1.0 - 3.0	X		(1)							
79SB49-00	0.0 - 1.0	X		(1)							
79SB49-01	1.0 - 3.0	X		(1)							
79SB50-00	0.0 - 1.0	X		(1)							
79SB50-01	1.0 - 3.0	X		(1)							
79SB51-00	0.0 - 1.0	X		(1)							
79SB51-01	1.0 - 3.0	X		(1)							

TABLE 3-1

Revised: June 21, 2011

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Surface and Subsurface Soil Grid Samples (Continued)[3]											
79SB52-00	0.0 - 1.0	X		(1)							
79SB52-01	1.0 - 3.0	X		(1)							
79SB53-00	0.0 - 1.0	X		(1)							
79SB53-01	1.0 - 3.0	X		(1)							
79SB54-00	0.0 - 1.0	X		(1)							
79SB54-01	1.0 - 3.0	X		(1)							
79SB55-00	0.0 - 1.0	X		(1)							
79SB55-01	1.0 - 3.0	X		(1)							
79SB56-00	0.0 - 1.0	X		(1)							
79SB56-01	1.0 - 3.0	X		(1)							
79SB57-00	0.0 - 1.0	X		(1)							
79SB57-01	1.0 - 3.0	X		(1)							
79SB58-00	0.0 - 1.0	X		(1)							
79SB58-01	1.0 - 3.0	X		(1)							
79SB59-00	0.0 - 1.0	X		(1)							
79SB59-01	1.0 - 3.0	X		(1)							
79SB60-00	0.0 - 1.0	X		(1)							
79SB60-01	1.0 - 3.0	X		(1)							
79SB61-00	0.0 - 1.0	X		(1)							
79SB61-01	1.0 - 3.0	X		(1)							
79SB62-00	0.0 - 1.0	X		(1)							
79SB62-01	1.0 - 3.0	X		(1)							
79SB63-00	0.0 - 1.0	X		(1)							
79SB63-01	1.0 - 3.0	X		(1)							
79SB64-00	0.0 - 1.0	X		(1)							
79SB64-01	1.0 - 3.0	X		(1)							
79SB65-00	0.0 - 1.0	X		(1)							
79SB65-01	1.0 - 3.0	X		(1)							
79SB66-00	0.0 - 1.0	X		(1)							
79SB66-01	1.0 - 3.0	X		(1)							
79SB67-00	0.0 - 1.0	X		(1)							
79SB67-01	1.0 - 3.0	X		(1)							
79SB68-00	0.0 - 1.0	X		(1)							
79SB68-01	1.0 - 3.0	X		(1)							

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Revised: June 21, 2011

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Surface and Subsurface Soil Grid Samples (Continued)[3]											
79SB69-00	0.0 - 1.0	X		(1)							
79SB69-01	1.0 - 3.0	X		(1)							
79SB70-00	0.0 - 1.0	X		(1)							
79SB70-01	1.0 - 3.0	X		(1)							
79SB71-00	0.0 - 1.0	X		(1)							
79SB71-01	1.0 - 3.0	X		(1)							
79SB72-00	0.0 - 1.0	X		(1)							
79SB72-01	1.0 - 3.0	X		(1)							
79SB73-00	0.0 - 1.0	X		(1)							
79SB73-01	1.0 - 3.0	X		(1)							
79SB74-00	0.0 - 1.0	X		(1)							
79SB74-01	1.0 - 3.0	X		(1)							
79SB75-00	0.0 - 1.0	X		(1)							
79SB75-01	1.0 - 3.0	X		(1)							
79SB76-00	0.0 - 1.0	X		(1)							
79SB76-01	1.0 - 3.0	X		(1)							
79SB77-00	0.0 - 1.0	X		(1)							
79SB77-01	1.0 - 3.0	X		(1)							
79SB78-00	0.0 - 1.0	X		(1)							
79SB78-01	1.0 - 3.0	X		(1)							
79SB79-00	0.0 - 1.0	X		(1)							
79SB79-01	1.0 - 3.0	X		(1)							
79SB80-00	0.0 - 1.0	X		(1)							
79SB80-01	1.0 - 3.0	X		(1)							
79SB81-00	0.0 - 1.0	X		(1)							
79SB81-01	1.0 - 3.0	X		(1)							
79SB82-00	0.0 - 1.0	X		(1)							
79SB82-01	1.0 - 3.0	X		(1)							
79SB83-00	0.0 - 1.0	X		(1)							
79SB83-01	1.0 - 3.0	X		(1)							
79SB84-00	0.0 - 1.0	X		(1)							
79SB84-01	1.0 - 3.0	X		(1)							
79SB85-00	0.0 - 1.0	X		(1)							
79SB85-01	1.0 - 3.0	X		(1)							

TABLE 3-1 Revised: June 21, 2011

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Surface and Subsurface Soil Grid Samples (Continued)[3]											
79SB86-00	0.0 - 1.0	X		(1)							
79SB86-01	1.0 - 3.0	X		(1)							
79SB87-00	0.0 - 1.0	X		(1)							
79SB87-01	1.0 - 3.0	X		(1)							
Surface and Subsurface Soil Boring Samples[3]											
79SB88-00	0.0 - 1.0		X	X						X	Pre-determined location
79SB88-00D	0.0 - 1.0		X	X						X	Duplicate
79SB88-00MS/MSD	0.0 - 1.0		X	X						X	Matrix Spike/Matrix Spike Duplicate
79SB88-01	1.0 - 3.0		X	X						X	
79SB89-00	0.0 - 1.0		X	X						X	Pre-determined location
79SB89-01	1.0 - 3.0		X	X						X	
79SB90-00	0.0 - 1.0		X	X						X	Pre-determined location
79SB90-01	1.0 - 3.0		X	X						X	
79SB91-00	0.0 - 1.0			X		X				X	Pre-determined location
79SB91-01	1.0 - 3.0			X		X				X	
79SB92-00	0.0 - 1.0			X		X				X	Pre-determined location
79SB92-01	1.0 - 3.0			X		X				X	
79SB93-00	0.0 - 1.0			X		X				X	Pre-determined location
79SB93-00D	0.0 - 1.0			X		X				X	Duplicate
79SB93-01	1.0 - 3.0			X		X				X	
79SB94-00	0.0 - 1.0			X						X	Field-determined location
79SB94-01	1.0 - 3.0			X						X	
79SB95-00	0.0 - 1.0			X						X	Field-determined location
79SB95-01	1.0 - 3.0			X						X	
79SB96-00	0.0 - 1.0			X						X	Field-determined location
79SB96-01	1.0 - 3.0			X						X	
79SB97-00	0.0 - 1.0			X						X	Field-determined location
79SB97-01	1.0 - 3.0			X						X	
79SB98-00	0.0 - 1.0			X						X	Field-determined location
79SB98-00D	0.0 - 1.0			X						X	Duplicate
79SB98-00MS/MSD	0.0 - 1.0			X						X	Matrix Spike/Matrix Spike Duplicate
79SB98-01	1.0 - 3.0			X						X	
79SB99-00	0.0 - 1.0			X						X	Field-determined location
79SB99-01	1.0 - 3.0			X						X	

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SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Groundwater Samples											
79GWXX[4]	NA		X	X	X	(5)			X	X	
79GWXXD	NA		X	X	X	(5)			X	X	Duplicate
79GWXXMS	NA		X	X	X	(5)			X	X	Matrix Spike
79GWXXMSD	NA		X	X	X	(5)			X	X	Matrix Spike Duplicate
79GWXX[4]	NA		X	X	X	(5)			X	X	
79GWXX[4]	NA		X	X	X	(5)			X	X	
79GWXX[4]	NA		X	X	X	(5)			X	X	
79GWXX[4]	NA		X	X	X	(5)			X	X	
79GWXX[4]	NA		X	X	X	(5)			X	X	
Surface Soil Samples for Lead Screening at Buildings 104, 2004, 2037											
79SS01	0.0 - 1.0							X			
79SS01D	0.0 - 1.0							X			Duplicate
79SS01MS/MSD	0.0 - 1.0							X			Matrix Spike/Matrix Spike Duplicate
79SS02	0.0 - 1.0							X			
79SS03	0.0 - 1.0							X			
79SS04	0.0 - 1.0							X			
79SS05	0.0 - 1.0							X			
79SS06	0.0 - 1.0							X			
79SS07	0.0 - 1.0							X			
79SS08	0.0 - 1.0							X			
79SS09	0.0 - 1.0							X			
79SS10	0.0 - 1.0							X			
79SS11	0.0 - 1.0							X			
79SS12	0.0 - 1.0							X			
79SS12D	0.0 - 1.0							X			Duplicate
79SS13	0.0 - 1.0							X			
Subsurface Soil Samples Below Launch Pads											
79SB100-01	1.0 - 3.0		X	X						X	
79SB101-01	1.0 - 3.0		X	X						X	
79SB102-01	1.0 - 3.0		X	X						X	

TABLE 3-1 Revised: June 21, 2011

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAPR, CEIBA, PUERTO RICO

		XRF Field	Fixed Based Analytical Lab Analysis								
Sample ID	**Sample Depth (ft bgs)**	Metals[2]	App IX low level SVOCs	App IX Metals	App IX Metals Dissolved	TPH DRO/GRO	TOC	Lead	Salinity	Perchlorate	**Comment**
Open Water Sediment Samples											
79OWSD01	0.0 - 0.5		X	X			X			X	
79OWSD01D	0.0 - 0.5		X	X			X			X	Duplicate
79OWSD01MS/MSD	0.0 - 0.5		X	X			X			X	Matrix Spike/Matrix Spike Duplicate
79OWSD02	0.0 - 0.5		X	X			X			X	
79OWSD03	0.0 - 0.5		X	X			X			X	
79OWSD04	0.0 - 0.5		X	X			X			X	
79OWSD05	0.0 - 0.5		X	X			X			X	
79OWSD06	0.0 - 0.5		X	X			X			X	
79OWSD07	0.0 - 0.5		X	X			X			X	
79OWSD08	0.0 - 0.5		X	X			X			X	
79OWSD09	0.0 - 0.5		X	X			X			X	
79OWSD10	0.0 - 0.5		X	X			X			X	

Notes:

(1) Twenty percent of the surface and twenty percent of the subsurface soil grid samples (designated 79SB01-00 through 79SB87-00 and 79SB01-01 through 79SB87-01, respectively) analyzed by XRF will be submitted to fixed-based confirmatory analysis, as determined in the field. Duplicate samples will be collected at a frequency of ten percent and Matrrix Spike/Matrix Spike Duplicate samples will be collected at a frequency of five percent of the samples submitted for fixed-laboratory analysis.

(2) Field XRF metal analysis includes chromium, copper, lead, and zinc.

(3) Sample numbering may change based on number of grid samples collected.

(4) Groundwater Sample ID will correspond to the Soil Boring Number for that location.

(5) Groundwater Samples to be analyzed for TPH DRO /GRO only if soil borings around the generator building (Building 2037) indicate there is a potential for fuel in the soils

ft bgs - feet below ground surface.

NA - Not Applicable.

TABLE 3-2

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT REQUIRED QUANTITATION LIMITS
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Semivolatiles	Quantitation Limits		Method Description	Method Number	Preparation Methods	
	Water (µg/L)	Low Soil (µg/kg)			Water	Soil
1,2,4,5-Tetrachlorobenzene	0.1	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
1,2,4-Trichlorobenzene	0.1	4.6	GC/MS	8270D_LL	3510C	3550B/3550C
1,3,5-Trinitrobenzene	0.5	17	GC/MS	8270D_LL	3510C	3550B/3550C
1,4-Dioxane	0.31	6.7	GC/MS	8270D_LL	3510C	3550B/3550C
1,4-Naphthoquinone	0.5	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
1,4-Phenylenediamine	16	830	GC/MS	8270D_LL	3510C	3550B/3550C
1-Naphthylamine	1.3	17	GC/MS	8270D_LL	3510C	3550B/3550C
2,3,4,6-Tetrachlorophenol	0.1	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
2,4,5-Trichlorophenol	0.12	7.6	GC/MS	8270D_LL	3510C	3550B/3550C
2,4,6-Trichlorophenol	0.17	7.9	GC/MS	8270D_LL	3510C	3550B/3550C
2,4-Dichlorophenol	0.1	7.2	GC/MS	8270D_LL	3510C	3550B/3550C
2,4-Dimethylphenol	0.69	7.6	GC/MS	8270D_LL	3510C	3550B/3550C
2,4-Dinitrophenol	1.3	42	GC/MS	8270D_LL	3510C	3550B/3550C
2,4-Dinitrotoluene	0.12	7.5	GC/MS	8270D_LL	3510C	3550B/3550C
2,6-Dichlorophenol	0.1	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
2,6-Dinitrotoluene	0.13	7.9	GC/MS	8270D_LL	3510C	3550B/3550C
2-Acetylaminofluorene	0.2	42	GC/MS	8270D_LL	3510C	3550B/3550C
2-Chloronaphthalene	0.1	6	GC/MS	8270D_LL	3510C	3550B/3550C
2-Chlorophenol	0.12	5.3	GC/MS	8270D_LL	3510C	3550B/3550C
2-Methylphenol	0.74	6.3	GC/MS	8270D_LL	3510C	3550B/3550C
2-Naphthylamine	1.3	17	GC/MS	8270D_LL	3510C	3550B/3550C
2-Nitroaniline	0.2	7	GC/MS	8270D_LL	3510C	3550B/3550C
2-Nitrophenol	0.1	5.8	GC/MS	8270D_LL	3510C	3550B/3550C
2-Picolin	0.2	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
3&4 Methylphenol	0.66	7.3	GC/MS	8270D_LL	3510C	3550B/3550C
3,3'-Dichlorobenzidine	2	17	GC/MS	8270D_LL	3510C	3550B/3550C
3,3-Dimethyl benzidine	5	66	GC/MS	8270D_LL	3510C	3550B/3550C
3-Methylcholanthrene	0.5	42	GC/MS	8270D_LL	3510C	3550B/3550C
3-Nitroaniline	0.2	6.7	GC/MS	8270D_LL	3510C	3550B/3550C
4,6-Dinitro-2-methylphenol	0.13	17	GC/MS	8270D_LL	3510C	3550B/3550C
4-Aminobiphenyl	0.31	17	GC/MS	8270D_LL	3510C	3550B/3550C
4-Bromophenyl phenyl ether	0.12	6.9	GC/MS	8270D_LL	3510C	3550B/3550C
4-Chloro-3-methylphenol	0.12	7	GC/MS	8270D_LL	3510C	3550B/3550C
4-Chloroaniline	0.36	5.2	GC/MS	8270D_LL	3510C	3550B/3550C
4-Chlorophenyl phenyl ether	0.1	6.4	GC/MS	8270D_LL	3510C	3550B/3550C
4-Nitroaniline	0.5	17	GC/MS	8270D_LL	3510C	3550B/3550C
4-Nitrophenol	0.5	73	GC/MS	8270D_LL	3510C	3550B/3550C
4-Nitroquinoline-1-oxide	1.3	42	GC/MS	8270D_LL	3510C	3550B/3550C

TABLE 3-2

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT REQUIRED QUANTITATION LIMITS
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Semivolatiles (continued)	Quantitation Limits		Method Description	Method Number	Preparation Methods	
	Water (µg/L)	Low Soil (µg/kg)			Water	Soil
5-Nitro-o-toluidine	0.1	17	GC/MS	8270D_LL	3510C	3550B/3550C
7,12-Dimethyl benz(a)anthracene	0.2	17	GC/MS	8270D_LL	3510C	3550B/3550C
Acetophenone	0.1	6.8	GC/MS	8270D_LL	3510C	3550B/3550C
alpha, alpha-Dimethylphenethylamine	3.4	330	GC/MS	8270D_LL	3510C	3550B/3550C
Aniline	0.97	8.2	GC/MS	8270D_LL	3510C	3550B/3550C
Aramite	0.11	4.8	GC/MS	8270D_LL	3510C	3550B/3550C
Benzyl alcohol	0.2	6.1	GC/MS	8270D_LL	3510C	3550B/3550C
Bis(2-chloroethoxyl)methane	0.1	6.5	GC/MS	8270D_LL	3510C	3550B/3550C
Bis(2-chloroethyl)ether	0.1	6.5	GC/MS	8270D_LL	3510C	3550B/3550C
bis-(2-chloroisopropyl)ether	0.1	7.2	GC/MS	8270D_LL	3510C	3550B/3550C
Bis(2-ethylhexyl)phthalate	0.64	6	GC/MS	8270D_LL	3510C	3550B/3550C
Butylbenzylphthalate	0.12	6.7	GC/MS	8270D_LL	3510C	3550B/3550C
Diallate	0.1	5.6	GC/MS	8270D_LL	3510C	3550B/3550C
Dibenzofuran	0.1	6.7	GC/MS	8270D_LL	3510C	3550B/3550C
Diethylphthalate	0.11	7.4	GC/MS	8270D_LL	3510C	3550B/3550C
Dimethyl phthalate	0.1	7.5	GC/MS	8270D_LL	3510C	3550B/3550C
Di-n-butyl phthalate	0.39	17	GC/MS	8270D_LL	3510C	3550B/3550C
Di-n-octylphthalate	0.17	6.7	GC/MS	8270D_LL	3510C	3550B/3550C
Dinoseb	0.2	6.7	GC/MS	8270D_LL	3510C	3550B/3550C
Ethylmethanesulfonate	0.1	7.8	GC/MS	8270D_LL	3510C	3550B/3550C
Hexachlorobenzene	0.1	7.6	GC/MS	8270D_LL	3510C	3550B/3550C
Hexachlorobutadiene	0.1	6.8	GC/MS	8270D_LL	3510C	3550B/3550C
Hexachlorocyclopentadiene	0.5	3.7	GC/MS	8270D_LL	3510C	3550B/3550C
Hexachloroethane	0.5	5.8	GC/MS	8270D_LL	3510C	3550B/3550C
Hexachlorophene	25	2,400	GC/MS	8270D_LL	3510C	3550B/3550C
Hexachloropropene	0.1	5.3	GC/MS	8270D_LL	3510C	3550B/3550C
Isophorone	0.1	7	GC/MS	8270D_LL	3510C	3550B/3550C
Isosafrole	0.1	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
m-Dichlorobenzene	0.1	5.6	GC/MS	8270D_LL	3510C	3550B/3550C
m-Dinitrobenzene	0.1	17	GC/MS	8270D_LL	3510C	3550B/3550C
Methapyrilene	2.5	67	GC/MS	8270D_LL	3510C	3550B/3550C
Methyl methanesulfonate	0.1	3.8	GC/MS	8270D_LL	3510C	3550B/3550C
Nitrobenzene	0.1	6.6	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosodiethylamine	0.1	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosodimethylamine	0.25	19	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosodi-n-butylamine	0.1	17	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosodi-n-propylamine	0.13	7.4	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosodiphenylamine	0.37	6.1	GC/MS	8270D_LL	3510C	3550B/3550C

TABLE 3-2

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT REQUIRED QUANTITATION LIMITS
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Semivolatiles (continued)	Quantitation Limits		Method Description	Method Number	Preparation Methods	
	Water (µg/L)	Low Soil (µg/kg)			Water	Soil
n-Nitrosomethylethylamine	0.2	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosomorpholine	0.1	4.5	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosopiperidine	0.1	3.4	GC/MS	8270D_LL	3510C	3550B/3550C
n-Nitrosopyrrolidine	0.1	3.6	GC/MS	8270D_LL	3510C	3550B/3550C
o-Dichlorobenzene	0.1	6.6	GC/MS	8270D_LL	3510C	3550B/3550C
o-Toluidine	0.13	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
p-(Dimethylamino)azobenzene	0.1	5.2	GC/MS	8270D_LL	3510C	3550B/3550C
p-Dichlorobenzene	0.2	17	GC/MS	8270D_LL	3510C	3550B/3550C
Pentachlorobenzene	0.1	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
Pentachloronitrobenzene	0.5	17	GC/MS	8270D_LL	3510C	3550B/3550C
Pentachlorophenol	0.4	17	GC/MS	8270D_LL	3510C	3550B/3550C
Phenacetin	0.1	17	GC/MS	8270D_LL	3510C	3550B/3550C
Phenol	0.13	6.5	GC/MS	8270D_LL	3510C	3550B/3550C
Pronamide	0.12	4.2	GC/MS	8270D_LL	3510C	3550B/3550C
Pyridine	0.73	20	GC/MS	8270D_LL	3510C	3550B/3550C
Safrole	0.1	3.3	GC/MS	8270D_LL	3510C	3550B/3550C
Low Level PAHs	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (µg/L)	**Low Soil (µg/kg)**			**Water**	**Soil**
2-Methylnaphthalene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Acenaphthene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Acenaphthylene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Anthracene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Benzo(a)anthracene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Benzo(a)pyrene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Benzo(b)fluoranthene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Benzo(g,h,i)perylene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Benzo(k)fluoranthene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Chrysene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Dibenzo(a,h)anthracene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Fluoranthene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Fluorene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Indeno(1,2,3-cd)pyrene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Naphthalene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Phenanthrene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C
Pyrene	0.1	3.3	GC/MS	8270C_LL_PAH	3510C	3550B/3550C

TABLE 3-2

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT REQUIRED QUANTITATION LIMITS
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Inorganics	Quantitation Limits		Method Description	Method Number	Preparation Methods	
	Water (µg/L)	Low Soil (mg/kg)			Water	Soil
Antimony	2	1	ICP	6020A	3010A	3050B
Arsenic	1.3	0.25	ICP	6020A	3010A	3050B
Barium	1.4	0.25	ICP	6020A	3010A	3050B
Beryllium	0.25	0.05	ICP	6020A	3010A	3050B
Cadmium	0.2	0.05	ICP	6020A	3010A	3050B
Chromium	2.5	0.5	ICP	6020A	3010A	3050B
Cobalt	0.3	0.03	ICP	6020A	3010A	3050B
Copper	1.1	0.5	ICP	6020A	3010A	3050B
Lead	0.5	0.2	ICP	6020A	3010A	3050B
Mercury	0.1	0.0088	Cold Vapor AA	7470A/7471A	3010A	7471A
Nickel	2	1	ICP	6020A	3010A	3050B
Selenium	1.1	1	ICP	6020A	3010A	3050B
Silver	0.25	0.1	ICP	6020A	3010A	3050B
Thallium	0.25	0.05	ICP	6020A	3010A	3050B
Tin	1.4	5.1	ICP	6020A	3010A	3050B
Vanadium	3.2	0.55	ICP	6020A	3010A	3050B
Zinc	8.4	3	ICP	6020A	3010A	3050A
Total Petroleum Hydrocarbons	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (mg/L)	**Low Soil (mg/kg)**			**Water**	**Soil**
TPH DRO	0.05	2.1		8015C	3510C	3550B/3550C
TPH GRO	0.025	0.05		8015C	5030B	5035
Total Organic Carbon	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (mg/L)	**Low Soil (mg/kg)**			**Water**	**Soil**
TOC	500	#######	NA	9060A	NA	NA
Perchlorate	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (mg/L)	**Low Soil (mg/kg)**			**Water**	**Soil**
Perchlorate	0.2	2	HPLC/ESI/MS	6850	NA	NA
Salinity	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (ppt)	**Low Soil (mg/kg)**			**Water**	**Soil**
Salinity	2	NA	SM2520B	SM2520B	NA	NA
TCLP Volatiles	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (µg/L)	**Low Soil (µg/kg)**			**Water**	**Soil**
1,1-Dichloroethene	20	20	GC/MS	1311 / 8260B	NA	1311/3010A

TABLE 3-2

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT REQUIRED QUANTITATION LIMITS
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

TCLP Volatiles (continued)	Quantitation Limits		Method Description	Method Number	Preparation Methods	
	Water (µg/L)	Low Soil (µg/kg)			Water	Soil
1,2-Dichloroethane	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
1,4 Dichlorobenzene	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
2-Butanone (MEK)	200	200	GC/MS	1311 / 8260B	NA	1311/3010A
Benzene	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
Carbon tetrachloride	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
Chlorobenzene	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
Chloroform	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
Tetrachloroethene	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
Trichloroethene	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
Vinyl chloride	20	20	GC/MS	1311 / 8260B	NA	1311/3010A
TCLP Metals	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (µg/L)	**Low Soil (µg/kg)**			**Water**	**Soil**
Arsenic	200	200	TCLP/ICP	1311/6010C	NA	1311/3010A
Barium	1,000	1,000	TCLP/ICP	1311/6010C	NA	1311/3010A
Cadmium	100	100	TCLP/ICP	1311/6010C	NA	1311/3010A
Chromium	200	200	TCLP/ICP	1311/6010C	NA	1311/3010A
Lead	200	200	TCLP/ICP	1311/6010C	NA	1311/3010A
Mercury	20	20	Cold Vapor AA	1311/7470A	NA	1311/3010A
Selenium	500	500	TCLP/ICP	1311/6010C	NA	1311/3010A
Silver	100	100	TCLP/ICP	1311/6010C	NA	1311/3010A
Reactivity, Corrosivity, Ignitability	**Quantitation Limits**		**Method Description**	**Method Number**	**Preparation Methods**	
	Water (mg/L)	**Low Soil (mg/kg)**			**Water**	**Soil**
Reactive Cyanide	0.005	0.27	Titrimetric	9012B/9012B	9012A	9012A
Flashpoint/Ignitability	--	--	Pensky-Martens Closed Cup Tester	1010A/1030	NA	NA
pH (s.u.)	--	--	Electrometric	9040B/9045D	NA	NA
Reactive Sulfide	1	60	Titrimetric	9034/9034	NA	9030B

Notes:

µg/L - micrograms per liter
µg/kg - micrograms per kilogram
mg/kg - miligrams per kilogram
ppt - parts per thousand
AVS - Acid Volatile Sulfides
GC - Gas Chomotography
ICP - Inductively Coupled Plasma
MS - Mass Spectrometry
NA - Not Applicable
SEM - Simultaneously Extracted Metals
TCLP - Toxicity Characteristic Leach Procedure
HPLC - High Performance Liquid Chromotography
ESI - Electrospray Ionization
SM - Salinity Meter

TABLE 3-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - QA/QC AND IDW SAMPLES
SWMU 79 - NAVY OPERATIONS AREA, CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Analysis Requested										
Sample ID	VOCs	App IX Low Level SVOCs	App IX Metals	App IX Metals Dissolved	TPH GRO\DRO	TPH GRO	TCLP Metals	TCLP Volatiles	Perchlorate	RCI	**Comment**
Trip Blank Samples											
79TB01						X[1]					
79TB02						X[1]					
Equipment Rinsate Samples											
79ER01		X	X		X				X		Stainless Steel Spoon
79ER02		X	X		X				X		Macro Core Liner
79ER03		X	X	X	X				X		Polyethylene and Silicon Tubing
79ER04		X	X	X	X				X		Bladder Pump
Field Blank Samples											
79FB01		X	X		X				X		NAPR Potable Water Source
79FB02		X	X		X				X		Store Bought Distilled Water
79FB03		X	X		X				X		Lab Grade Deionized Water
IDW Samples											
79IDW01	X		X							X	Aqueous
79IDW02							X	X		X	Solid

Note:
[1] The analysis required for this sample will be dependent on which samples are being accompanied in the cooler.

TABLE 4-1

SOIL SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg):			
1,1-Biphenyl	NE	---	---
1,2,4,5-Tetrachlorobenzene	50.0	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,2,4-Trichlorobenzene	20,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
1,2-Dichlorobenzene	3,003 (1)	MHSPE 2000	Value for total chlorobenzenes (2)
1,3,5-Trinitrobenzene	40,000	---	Value for nitrobenzene used as a surrogate
1,3-Dichlorobenzene	3,003 (1)	MHSPE 2000	Value for total chlorobenzenes (2)
1,3-Dinitrobenzene	40,000	---	Value for nitrobenzene used as a surrogate
1,4-Dichlorobenzene	20,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
1,4-Dioxane	NE	---	---
1,4-Naphthoquinone	NE	---	---
2,3,4,6-Tetrachlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2,2'-Oxybis(1-chloropropane)	NE	---	---
2,4,5-Trichlorophenol	4,000	Efroymson et al. 1997b	Toxicological threshold for plants
2,4,6-Trichlorophenol	10,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
2,4-Dichlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2,4-Dimethylphenol	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
2,4-Dinitrophenol	20,000	Efroymson et al. 1997b	Toxicological threshold for plants
2,4-Dinitrotoluene	NE	---	---
2,6-Dichlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2,6-Dinitrotoluene	NE	---	---
2-Acetylaminofluorene	NE	---	---
2-Chloronaphthalene	NE	---	---
2-Chlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2-Methylphenol	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
2-Naphthylamine	NE	---	---
2-Nitroaniline	NE	---	---
2-Nitrophenol	7,000	---	Value for 4-nitrophenol used as a surrogate
2-Picoline	NE	---	---

TABLE 4-1

SOIL SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg): (cont.)			
3,3'-Dichlorobenzidine	NE	---	---
3,3'-Dimethylbenzidine	NE	---	---
3-Methylcholanthrene	NE	---	---
3-Nitroaniline	NE	---	---
4,6-Dinitro-2-methylphenol	NE	---	---
4-Aminobiphenyl	NE	---	---
4-Bromophenyl phenyl ether	NE	---	---
4-Chloro-3-methylphenol	NE	---	---
4-Chloroaniline	NE	---	---
4-Chlorophenyl phenyl ether	NE	---	---
4-Nitroaniline	NE	---	---
4-Nitrophenol	7,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
4-Nitroquinoline-1-oxide	NE	---	---
7,12-Dimethylbenz(a)anthracene	NE	---	---
Acetophenone	NE	---	---
2-Toluidine	NE	---	---
3,4-Methylphenol	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
N-Nitro-o-toluidine	NE	---	---
A,A-Dimethylphenethylamine	NE	---	---
Aniline	NE	---	---
Aramite, total	NE	---	---
Benzyl alcohol	NE	---	---
bis(2-Chloroethoxy)methane	NE	---	---
bis(2-Chloroethyl)ether	NE	---	---
bis(2-Ethylhexyl)phthalate	6,010 (1)	MHSPE 2000	Value for total phthalates (4)
Butyl benzyl phthalate	6,010 (1)	MHSPE 2000	Value for total phthalates (4)
Diallate	NE	---	---

TABLE 4-1

SOIL SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg): (cont.)			
Dibenzofuran	NE	---	---
Diethyl phthalate	100,000	Efroymson et al. 1997b	Toxicological threshold for plants
Dimethyl phthalate	200,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
Di-n-butyl phthalate	200,000	Efroymson et al 1997b	Toxicological threshold for plants
Di-n-octyl phthalate	6,010 (1)	MHSPE 2000	Value for total phthalates (4)
Dinoseb	NE	---	---
Ethyl methanesulfonate	NE	---	---
Hexachlorobutadiene	NE	---	---
Hexachlorobenzene	1,000,000	Efroymson et al. 1997a	Toxicological threshold for soil microorganisms and microbial processes
Hexachlorocyclopentadiene	10,000	Efroymson et al. 1997b	Toxicological threshold for plants
Hexachloroethane	NE	---	---
Hexachlorophene	NE	---	---
Hexachlorophene	NE	---	---
Hexachloropropene	NE	---	---
Hexachloropropene	NE	---	---
Isophorone	NE	---	---
Isosafrole	NE	---	---
Methapyrilene	NE	---	---
Methyl methanesulfonate	NE	---	---
N-Nitrosodiethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitrosodimethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitroso-di-n-butylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitroso-di-n-propylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitrosodiphenylamine	20,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
N-Nitrosomethylethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
p-Phenyl diamine	NE	---	---
p-Dimethylamino azobenzene	NE	---	---

TABLE 4-1

SOIL SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg): (cont.)			
Nitrobenzene	40,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
N-Nitrosomorpholine	NE	---	---
N-Nitrosopiperidine	NE	---	---
N-Nitrosopyrrolidine	NE	---	---
Pentachlorobenzene	1,150	USEPA 1999	Toxicological threshold for earthworms
Pentachloronitrobenzene	NE	---	---
Pentachlorophenol	2,100	USEPA 2007a	Ecological soil screening level for avian ground insectivores
Phenacetin	NE	---	---
Phenol	30,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
Pronamide	NE	---	---
Pyridine	NE	---	---
Safrole, total	NE	---	---
PAHs (ug/kg):			
Low molecular weight PAHs (5)	29,000	USEPA 2007b	Ecological soil screening level for soil invertebrates
High molecular weight PAHs (6)	18,000	USEPA 2007b	Ecological soil screening level for soil invertebrates

TABLE 4-1

SOIL SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Metals (mg/kg):			
Antimony	10.0	USEPA 2005a	Ecological soil screening level for mammalian herbivores
Arsenic	18.0	USEPA 2005b	Ecological soil screening level for plants
Barium	330	USEPA 2005c	Ecological soil screening level for soil invertebrates
Beryllium	21.0	USEPA 2005d	Ecological soil screening level for mammalian herbivores
Cadmium	0.77	USEPA 2005e	Ecological soil screening level for avian ground insectivores
Chromium, total	26.0	USEPA 2008	Ecological soil screening level for avian ground insectivores
Cobalt	13.0	USEPA 2005f	Ecological soil screening level for plants
Copper	28.0	USEPA 2007e	Ecological soil screening level for avian ground insectivores
Lead	11.0	USEPA 2005g	Ecological soil screening level for avian ground insectivores
Mercury	0.10	Efroymson et al. 1997a	Toxicological threshold for earthworms
Nickel	38.0	USEPA 2007f	Ecological soil screening level for plants
Selenium	0.52	USEPA 2007g	Ecological soil screening level for plants
Silver	4.2	USEPA 2006	Ecological soil screening level for avian ground insectivores
Thallium	1.00	Efroymson et al. 1997b	Toxicological threshold for plants
Tin	50.0	Efroymson et al. 1997b	Toxicological threshold for plants
Vanadium	7.8	USEPA 2005h	Ecological soil screening level for avian ground insectivores
Zinc	46.0	USEPA 2007h	Ecological soil screening level for avian ground insectivores

TABLE 4-1

SOIL SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes:

NE = Not Established
MHSPE = Ministry of Housing, Spatial Planning and Environment
CCME = Canadian Council of Ministers of the Environment
USEPA = United States Environmental Protection Agency
MATC = Maximum Acceptable Toxicant Concentration
LOAEC = Lowest Observed Adverse Effect Concentration
PAH = Polynuclear Aromatic Hydrocarbon
ug/kg = microgram per kilogram
mg/kg = milligram per kilogram

(1) The screening value shown is an average of the target and intervention soil standards. The value is based on a default organic carbon content of 0.02 (2 percent), which represents a minimum value (adjustment range is 2 to 30 percent).
(2) The value represents a total concentration for chlorobenzenes (mono, di, tri, tetra, penta, and hexachlorobenzene).
(3) The value represents a total concentration for all chlorophenols (mono, di, tri, tetra, and pentachlorophenol).
(4) The value represents a total concentration for all phthalates.
(5) Low molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of fewer than four rings. The low molecular weight PAH compounds analyzed for in SWMU 79 soil were 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, and phenanthrene.
(6) High molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of four or more rings. The high molecular weight PAH compounds analyzed for in SWMU 79 soil were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and pyrene.

Table References:

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Ministry of Housing, Spatial Planning and Environment (MHSPE). 2000. Circular on Target Values and Intervention Values for Soil Remediation. Directorate-General for Environmental Protection, Department of Soil Protection, The Hague, Netherlands. February 4, 2000.

United States Environmental Protection Agency (USEPA). 2008. Ecological Soil Screening Levels for Chromium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-66.

TABLE 4-1

SOIL SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References (cont.):

United States Environmental Protection Agency (USEPA). 2008. Ecological Soil Screening Levels for Chromium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-66.

USEAP. 2007a. Ecological Soil Screening Levels for Pentachlorophenol (Interim Final).Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-58.

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USEAP. 2007e. Ecological Soil Screening Levels for Copper (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-68.

USEAP. 2007f. Ecological Soil Screening Levels for Nickel (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-76.

USEAP. 2007g. Ecological Soil Screening Levels for Selenium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-72.

USEPA. 2007h. Ecological Soil Screening Levels for Zinc (Interim Final). Office of Solid Waste and Emergecny Response, Washington, D.C. OSWER Directive 9285.7-73.

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USEPA. 2005c. Ecological Soil Screening Levels for Barium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

USEPA. 2005d. Ecological Soil Screening Levels for Beryllium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-64.

USEPA. 2005e. Ecological Soil Screening Levels for Cadmium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-65.

USEPA. 2005f. Ecological Soil Screening Levels for Cobalt (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-67

USEPA. 2005g. Ecological Soil Screening Levels for Lead (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-70.

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TABLE 4-2

MARINE/ESTUARINE SURFACE WATER SCREENING VALUES USED FOR GROUNDWATER
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment [2]
Semi-Volatile Organics (ug/L):			
1,2,4,5-Tetrachlorobenzene	10.0	USEPA 2007a	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
1,2,4-Trichlorobenzene	4.50	USEPA 2001	USEPA Region 4 chronic screening value
1,3,5-Trinitrobenzene	80.0 [3]	USEPA 2007a	Minimum chronic value (71-day NOEC for *Oncorhynchus mykiss* [rainbow trout] based on reproduction)
1,1-Biphenyl	230 [3]	USEPA 2007a	Minimum chronic value (21-day MATC for *Daphnia magna* [cladoceron] based on reproduction)
1,2-Dichlorobenzene	19.7	USEPA 2001	USEPA Region 4 chronic screening value
1,3-Dichlorobenzene	28.5	USEPA 2001	USEPA Region 4 chronic screening value
1,3-Dinitrobenzene	22.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
1,4-Dichlorobenzene	19.9	USEPA 2001	USEPA Region 4 chronic screening value
1,4-Dioxane	67,000	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Menidia beryllina* [inland silverside]) with a safety factor of 100
1,4-Naphthoquinone	NA	---	---
2,3,4,6-Tetrachlorophenol	8.80	Buchman 2008	Acute LOEL with a safety factor of 50
2,4,5-Trichlorophenol	11.0	Buchman 2008	Proposed Criteria Continuous Concentration
2,4,6-Trichlorophenol	12.1	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Palaemonetes pugio* [daggerblade grass shrimp]) with a safety factor of 100
2,2'-Oxybis(1-chloropropane)	NA	---	---
2,4-Dichlorophenol	1.67	USEPA 2007a	Minimum acute value (96-hr NOEC for *Allorchestes compressa* [scud]) with a safety factor of 30
2,4-Dimethylphenol	131	USEPA 2007a	Minimum chronic value (28-day NOEC for *Menidia beryllina* [inland silverside] based on survival)
2,4-Dinitrophenol	48.5	USEPA 2001	USEPA Region 4 chronic screening value
2,4-Dinitrotoluene	44.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
2,6-Dichlorophenol	54.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Platichthys flesus* [european flounder]) with a safety factor of 100
2,6-Dinitrotoluene	81.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
2-Acetylaminofluorene	20.0 [3]	USEPA 2007a	Minimum acute value (96-hr LOEC for *Xenopus laevis* [clawed toad]) with a safety factor of 50
2-Chloronaphthalene	0.15	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50
2-Chlorophenol	53.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Crangon septemspinosa* [bay shrimp]) with a safety factor of 100
2-Methylphenol	102	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Elasmopus pectinicrus* [scud]) with a safety factor of 100
2-Naphthylamine	NA	---	---
2-Nitroaniline	48.9 [3]	USEPA 2007a	Minumum acute value (48-hr EC_{50} for *daphnia magna* [cladoceron]) with a safety factor of 100
2-Nitrophenol	10,000	USEPA 2007a	Minimum chronic value (28-day MATC for *Cyprinodon variegatus* [sheepshead minnow] based on egg hatchability)
2-Picoline	8,979 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
2-Toluidine	5.20 [3]	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Daphnia magna* [cladoceron]) with a safety factor of 100
3,4-Methylphenol	25 [3][5]	USEPA 2003	USEPA Region 5 ecological screening level (the value shown is for 4-methylphenol)
3,3'-Dichlorobenzidine	4.50 [3]	USEPA 2003	USEPA Region 5 ecological screening level
3,3'-Dimethylbenzidine	160 [3]	USEPA 2007a	Minimum chronic value (21-day NOEC for *Daphnia magna* [cladoceron] based on behavior [equilibrium])
3-Methylcholanthrene	NA	---	---
3-Nitroaniline	9.80 [3]	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Daphnia magna* [cladoceron]) with a safety factor of 100
4,6-Dinitro-2-methylphenol	23.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	1.50 [3]	USEPA 2003	USEPA Region 5 ecological screening level
4-Chloro-3-methylphenol	0.30 [3]	USEPA 2003	USEPA Region 5 ecological screening level
4-Chloroaniline	10.0 [3]	USEPA 2007a	Minimum chronic value (21-day NOEC for *Daphnia magna* [cladoceron]) based on reproduction)
4-Chlorophenyl phenyl ether	7.30 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Salvelinus fontinalis* [brook trout]) with a safety factor of 100
4-Nitroaniline	170 [3]	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Daphnia magna* [cladoceron]) with a safety factor of 100

TABLE 4-2

MARINE/ESTUARINE SURFACE WATER SCREENING VALUES USED FOR GROUNDWATER
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment [2]
Semi-Volatile Organics (ug/L):			
4-Nitrophenol	71.7	USEPA 2001	USEPA Region 4 chronic screening value
4-Nitroquinoline-1-oxide	NA	---	---
7,12-Dimethylbenz(a)anthracene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Acetophenone	1,550 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
A,A-Dimethyl phenethylamine	NA	---	---
Aniline	294	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Crangon septemspinosa* [sand shrimp]) with a safety factor of 100
Aramite, total	3.09 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Benzyl alcohol	150	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Menidia beryllina* [inland silverside]) with a safety factor of 100
bis(2-Chloroethoxy)methane	1840 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
bis(2-Chloroethyl)ether	2,380 [3]	USEPA 2001	USEPA Region 4 chronic screeing value
bis(2-Ethylhexyl)phthalate	360	Buchman 2008	Proposed Criteria Continuous Concentration
Butyl benzyl phthalate	29.4	USEPA 2001	USEPA Region 4 chronic screening value
Diallate	82.0 [3]	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Rasbora heteromorpha* [harlequinfish]) with a safety factor of 100
Dibenzofuran	33.3	USEPA 2007a	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Diethyl phthalate	75.9	USEPA 2001	USEPA Region 4 chronic screening value
Dimethyl phthalate	580	USEPA 2001	USEPA Region 4 chronic screening value
Di-n-butyl phthalate	3.40	USEPA 2001	USEPA Region 4 chronic screening value (lowest reported plant value)
Di-n-octyl phthalate	1,150	USEPA 2007a	Minimum acute value (96-hr NOEC for *Americamysis bahia* [opossum shrimp]) with a safety factor of 30
Dinoseb	1.70	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Ethyl methanesulfonate	40.0 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Clarias batrachus* [walking catfish]) with a safety factor of 100
Hexachlorobenzene	10.0	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Crassostrea virginica* [Virginia oyster]) with a safety factor of 100
Hexachlorobutadiene	0.32	USEPA 2001	USEPA Region 4 chronic screening value
Hexachlorocyclopentadiene	0.07	USEPA 2001	USEPA Region 4 chronic screening value
Hexachloroethane	9.40	USEPA 2001	USEPA Region 4 chronic screening value
Hexachlorophene	8.80 [3]	USEPA 2007a	Minimum chronic value (34-day NOEC for *Pimephales promelas* [fathead minnow] based on survival and growth)
Hexachloropropene	NA	---	---
Isophorone	129	USEPA 2001	USEPA Region 4 chronic screening value
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Nitrobenzene	66.8	USEPA 2001	USEPA Region 4 chronic screening value
N-Nitro-o-toluidine	220 [3]	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Daphnia magna* [cladoceron] based on immobilization) with a safety factor of 100
N-Nitrosodiethylamine	768 [3]	USEPA 2003	USEPA Region 5 ecological screening level
N-Nitrosodimethylamine	25.0 [3]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitroso-di-n-butylamine	25.0 [3]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitroso-di-n-propylamine	25.0 [3]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitrosodiphenylamine	25.0 [3]	USEPA 2007b	Indiana Department of Environmental Management Great Lakes Basin Tier II chronic criterion
N-Nitrosomethylethylamine	25.0 [3]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitrosomorpholine	NA	---	---
N-Nitrosopiperidine	NA	---	---
N-Nitrosopyrrolidine	NA	---	---
p-Dimethylamino azobenzene	NA	---	---
Pentachlorobenzene	129	USEPA 2001	USEPA Region 4 chronic screening value

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MARINE/ESTUARINE SURFACE WATER SCREENING VALUES USED FOR GROUNDWATER
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment [2]
Semi-Volatile Organics (ug/L):			
Pentachloronitrobenzene	0.23	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Pentachlorophenol	7.90	USEPA 2009/PREQB 2003	Criteria Continuous Concentration/Puerto Rico Water Quality Standard
Phenacetin	NA	---	---
Phenol	58.0	USEPA 2001	USEPA Region 4 chronic screening value
p-Phenylene diamine	200 [3]	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Oryzias latires* [medika, high-eyes]) with a safety factor of 100
Pronamide	35.0	USEPA 2007a	Minimum acute value (96-hr EC_{50} for *Crassostrea virginica* [Virginia oyster]) with a safety factor of 100
Pyridine	500	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Crangon septemspinosa* [sand shrimp]) with a safety factor of 100
Safrole	NA	---	---
PAHs (ug/L):			
2-Methylnaphthalene	6.00	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Penaeus aztecus* [brown shrimp]) with a safety factor of 100
Acenaphthene	9.70	USEPA 2001	USEPA Region 4 chronic screening value
Acenaphthylene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for low molecular weight PAHs)
Anthracene	5.35	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Benzo(a)anthracene	0.025 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Benzo(a)pyrene	10.0	USEPA 2004	Acute value (LC_{50}) with a safety factor of 100
Benzo(b)fluoranthene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Benzo(g,h,i)perylene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Benzo(k)fluoranthene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Chrysene	10.0	USEPA 2004	Acute value (LC_{50}) with a safety factor of 100
Dibenzo(a,h)anthracene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Fluoranthene	11.0	USEPA 1996	Final Chronic Value
Fluorene	10.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Nereis arenaceodentata* [polychaete]) with a safety factor of 100
Indeno(1,2,3-cd)pyrene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Naphthalene	23.5	USEPA 2001	USEPA Region 4 chronic screening value
Phenanthrene	8.30	USEPA 1996	Final Chronic Value
Pyrene	0.248	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100

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MARINE/ESTUARINE SURFACE WATER SCREENING VALUES USED FOR GROUNDWATER
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment [2]
Metals - Toal Recoverable Fraction (ug/L):			
Antimony	500	Buchman 2008	Proposed CCC
Arsenic	36.0	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Barium	16,667	USEPA 2007a	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Beryllium	310	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Fundulus heteroclitus* [mummichog]) with a safety factor of 100
Cadmium	8.85	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Chromium	50.4	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Cobalt	45.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Nitocra spinipes* [Harpacticoid copepod]) with a safety factor of 100
Copper	3.73	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Lead	8.52	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Mercury	1.11	USEPA 2009	Total recoverable Criteria Continuous Concentration
Nickel	8.28	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Selenium	71.1	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Silver	2.24	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Thallium	21.3	USEPA 2001	USEPA Region 4 chronic screening value
Tin	180 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Vanadium	12.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Zinc	85.6	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Metals - Dissolved Fraction (ug/L):			
Antimony	500 [6]	Buchman 2008	Proposed Criteria Continuous Concentration
Arsenic	36.0	USEPA 2009	Dissolved Criteria Continuous Concentration for trivalent arsenic
Barium	16,667 [6]	USEPA 2007	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Beryllium	310 [6]	USEPA 2007	Minimum acute value (96-hr LC_{50} for *Fundulus heteroclitus* [mummichog]) with a safety factor of 100
Cadmium	8.8	USEPA 2009	Dissolved Criteria Continuous Concentration
Chromium	50.0	USEPA 2009	Dissolved Criteria Continuous Concentration for hexavalent chromium
Cobalt	45.0 [6]	USEPA 2007	Minimum acute value (96-hr LC_{50} for *Nitocra spinipes* [Harpacticoid copepod]) with a safety factor of 100
Copper	3.1	USEPA 2009	Dissolved Criteria Continuous Concentration
Lead	8.1	USEPA 2009	Dissolved Criteria Continuous Concentration
Mercury	0.94	USEPA 2009	Dissolved Criteria Continuous Concentration
Nickel	8.2	USEPA 2009	Dissolved Criteria Continuous Concentration
Selenium	71.0	USEPA 2009	Dissolved Criteria Continuous Concentration
Silver	2.24 [6]	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SD surface waters
Thallium	21.3 [6]	USEPA 2001	USEPA Region 4 chronic screening value
Tin	180 [3][6]	USEPA 2003	USEPA Region 5 ecological screening level
Vanadium	12.0 [3][6]	USEPA 2003	USEPA Region 5 ecological screening level
Zinc	81.0	USEPA 2009	Dissolved Criteria Continuous Concentration

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MARINE/ESTUARINE SURFACE WATER SCREENING VALUES USED FOR GROUNDWATER
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes:

NA = Not Available
USEPA = United States Environmental Protection Agency
PAH = Polynuclear Aromatic Hydrocarbon
LOEL = Lowest Observed Effect Level
MATC = Maximum Acceptable Toxicant Concentration
NOEC = No Observed Effect Concentration
PREQB = Puerto Rico Environmental Quality Board
EC_{50} = Median Effective Concentration
LC_{50} = Median Lethal Concentration
µg/L = microgram per liter

(1) The values shown are marine/estuarine screening values unless otherwise noted.

(2) The safety factors applied to acute endpoints (i.e., LC_{50}, EC_{50}, NOEC, and LOEL values) and chronic endpoints (i.e., LOELs) are those recommended by Wentsel et al. (1996).

(3) The chemical lacks a marine/estuarine surface water screening value/literature-based toxicity value. The value shown is a freshwater screening value/toxicity value.

(4) The value shown is for o-xylene.

(5) The value shown is for 4-methylphenol.

(6) The chemical lacks a screening value expressed as a dissolved concentration. The value shown is expressed as a total recoverable concentration.

Table References:

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USEPA. 2001. Region 4 Ecological Risk Assessment Bulletins - Supplement to RQGS. Waste Management Division, Atlanta, GA. http://www.epa.gov/region04/waste/ots/ecolbul.htm.
USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/F-95/038.

TABLE 4-3

SEDIMENT SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Semi-Volatile Organics (ug/kg):			
1,2,4-Trichlorobenzene	4.8	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
1,3,5-Trinitrobenzene [4]	11.6	USEPA 1993 and 1996	EqP-based screening value
1,1-Biphenyl [4]	18,807	USEPA 1993 and 1996	EqP-based screening value
1,2-Dichlorobenzene	13.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
1,3-Dichlorobenzene	986	USEPA 1993 and 1996	EqP-based screening value
1,3-Dinitrobenzene	6.56	USEPA 1993 and 1996	EqP-based screening value
1,4-Dichlorobenzene	110	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts and Microtox)
1,4-Dioxane	364	USEPA 1993 and 1996	EqP-based screening value
1,4-Naphthoquinone	NA	USEPA 1993 and 1996	EqP-based screening value
2,3,4,6-Tetrachlorophenol	2,085	USEPA 1993 and 1996	EqP-based screening value
2,4,5-Trichlorophenol	3.00	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts)
2,4,6-Trichlorophenol	6.00	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts)
2,2'-Oxybis(1-chloropropane)	NA	---	---
2,4-Dichlorophenol	0.2083	Buchman 2008	Minimum Apparent Effects Threshold (basis of value not specified)
2,4-Dimethylphenol	18.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
2,4-Dinitrophenol	16.2	USEPA 1993 and 1996	EqP-based screening value
2,4-Dinitrotoluene [4]	41.6	USEPA 1993 and 1996	EqP-based screening value
2,6-Dichlorophenol	273	USEPA 1993 and 1996	EqP-based screening value
2,6-Dinitrotoluene [4]	55.8	USEPA 1993 and 1996	EqP-based screening value
2-Acetylaminofluorene [4]	233	USEPA 1993 and 1996	EqP-based screening value
2-Chloronaphthalene	3.15	USEPA 1993 and 1996	EqP-based screening value
2-Chlorophenol	0.333	Buchman 2008	Minimum Apparent Effects Threshold (basis of value not specified)
2-Methylphenol	8.00	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
2-Naphthylamine	NA	---	---
2-Nitroaniline [4]	32.2	USEPA 1993 and 1996	EqP-based screening value
2-Nitrophenol	5,752	USEPA 1993 and 1996	EqP-based screening value
2-Picoline [4]	1,108	USEPA 1993 and 1996	EqP-based screening value

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SEDIMENT SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Semi-Volatile Organics (ug/kg):			
2-Toluidine [4]	1.03	USEPA 1993 and 1996	EqP-based screening value
3,4-Methylphenol [4]	100 [5]	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
3,3'-Dichlorobenzidine [4]	127	USEPA 1993 and 1996	EqP-based screening value
3,3'-Dimethylbenzidine [4]	690	USEPA 1993 and 1996	EqP-based screening value
3-Methylcholanthrene	NA	---	---
3-Nitroaniline [4]	2.18	USEPA 1993 and 1996	EqP-based screening value
4,6-Dinitro-2-methylphenol [4]	27.9	USEPA 1993 and 1996	EqP-based screening value
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether [4]	312	Di Toro and McGrath 2000	EqP-based toxicological threshold
4-Chloro-3-methylphenol [4]	3.35	USEPA 1993 and 1996	EqP-based screening value
4-Chloroaniline [4]	7	USEPA 1993 and 1996	EqP-based screening value
4-Chlorophenyl phenyl ether [4]	287	Di Toro and McGrath 2000	EqP-based toxicological threshold
4-Nitroaniline [4]	39.5	USEPA 1993 and 1996	EqP-based screening value
4-Nitrophenol	54.1	USEPA 1993 and 1996	EqP-based screening value
4-Nitroquinoline-1-oxide	NA	---	---
7,12-Dimethylbenz(a)anthracene	193,148	USEPA 1993 and 1996	EqP-based screening value
Acetophenone [4]	635	USEPA 1993 and 1996	EqP-based screening value
A,A-Dimethylphenethylamine	NA	---	---
Aniline	27.0	USEPA 1993 and 1996	EqP-based screening value
Aramite, total [4]	1,692	USEPA 1993 and 1996	EqP-based screening value
Benzyl alcohol	52.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
bis(2-Chloroethoxy)methane [4]	101	USEPA 1993 and 1996	EqP-based screening value
bis(2-Chloroethyl)ether [4]	368	USEPA 1993 and 1996	EqP-based screening value
bis(2-Ethylhexyl)phthalate	182	MacDonald 1994	Threshold Effect Concentration
Butyl benzyl phthalate	63.0	Buchman 2008	Minimum Apparent Effects Threshold (Microtox)
Diallate [4]	21,270	USEPA 1993 and 1996	EqP-based screening value
Dibenzofuran	110	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)

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SEDIMENT SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Semi-Volatile Organics (ug/kg):			
Diethyl phthalate	630	MacDonald et al. 2003	Threshold Effect Concentration
Dimethyl phthalate	6.00	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
Di-n-butyl phthalate	58.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve and larvalmax)
Di-n-octyl phthalate	61.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve and larvalmax)
Dinoseb	72.1	USEPA 1993 and 1996	EqP-based screening value
Ethyl methanesulfonate [4]	0.45	USEPA 1993 and 1996	EqP-based screening value
Hexachlorobenzene	6.00	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
Hexachlorobutadiene	1.30	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
Hexachlorocyclopentadiene	139	USEPA 1993 and 1996	EqP-based screening value
Hexachloroethane	73.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve and larvalmax)
Hexachlorophene [4]	2,272,912	USEPA 1993 and 1996	EqP-based screening value
Hexachloropropene	NA	---	---
Isophorone	60.5	USEPA 1993 and 1996	EqP-based screening value
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
N-Nitro-o-toluidine [4]	152	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosodiethylamine [4]	22.8	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosodimethylamine [4]	0.07	USEPA 1993 and 1996	EqP-based screening value
N-Nitroso-di-n-butylamine [4]	58.5	USEPA 1993 and 1996	EqP-based screening value
N-Nitroso-di-n-propylamine [4]	5.95	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosodiphenylamine [4]	28.0	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts)
N-Nitrosomethylethylamine [4]	0.19	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosomorpholine	NA	---	---
N-Nitrosopiperidine	NA	---	---
N-Nitrosopyrrolidine	NA	---	---
Nitrobenzene	21.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
p-Dimethylamino azobenzene	NA	---	---
Pentachlorobenzene	191,183	USEPA 1993 and 1996	EqP-based screening value

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SEDIMENT SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Semi-Volatile Organics (ug/kg):			
Pentachloronitrobenzene	84	USEPA 1993 and 1996	EqP-based screening value
Pentachlorophenol	17.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
Phenacetin	NA	---	---
Phenol	130	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
p-Phenylene diamine [4]	1.02	USEPA 1993 and 1996	EqP-based screening value
Pronamide	988	USEPA 1993 and 1996	EqP-based screening value
Pyridine	22.8	USEPA 1993 and 1996	EqP-based screening value
Safrole, total	NA	---	---
PAHs (ug/kg):			
2-Methylnaphthalene	20.2	MacDonald 1994	Threshold Effect Level
Acenaphthene	6.71	MacDonald 1994	Threshold Effect Level
Acenaphthylene	5.87	MacDonald 1994	Threshold Effect Level
Anthracene	46.9	MacDonald 1994	Threshold Effect Level
Benzo(a)anthracene	74.8	MacDonald 1994	Threshold Effect Level
Benzo(a)pyrene	88.8	MacDonald 1994	Threshold Effect Level
Benzo(b)fluoranthene	1,800	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae and infaunal commuity impacts)
Benzo(g,h,i)perylene	670	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
Benzo(k)fluoranthene	1,800	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae and infaunal commuity impacts)
Chrysene	108	MacDonald 1994	Threshold Effect Level
Dibenzo(a,h)anthracene	6.22	MacDonald 1994	Threshold Effect Level
Fluoranthene	113	MacDonald 1994	Threshold Effect Level
Fluorene	21.2	MacDonald 1994	Threshold Effect Level
Indeno(1,2,3-cd)pyrene	600	Buchman 2008	Minimum Apparent Effects Threshold (Microtox)
Naphthalene	34.6	MacDonald 1994	Threshold Effect Level
Phenanthrene	86.7	MacDonald 1994	Threshold Effect Level
Pyrene	153	MacDonald 1994	Threshold Effect Level

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SEDIMENT SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Metals (mg/kg):			
Antimony	2.00	Long and Morgan 1991	Effects Range-Low
Arsenic	7.24	MacDonald 1994	Threshold Effect Level
Barium	48.0	Buchman 2008	Minimum Apparent Effects Threshold (amphipod)
Beryllium	NA	---	---
Cadmium	0.676	MacDonald 1994	Threshold Effect Level
Chromium, total	52.3	MacDonald 1994	Threshold Effect Level
Cobalt	10.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
Copper	18.7	MacDonald 1994	Threshold Effect Level
Lead	30.2	MacDonald 1994	Threshold Effect Level
Mercury	0.13	MacDonald 1994	Threshold Effect Level
Nickel	15.9	MacDonald 1994	Threshold Effect Level
Selenium	1.00	Buchman 2008	Minimum Apparent Effects Threshold (amphipod)
Silver	0.733	MacDonald 1994	Threshold Effect Level
Thallium	NA	---	---
Tin	3.40	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
Vanadium	57.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
Zinc	124	MacDonald 1994	Threshold Effect Level

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SEDIMENT SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes:

NA = Not Available
PAH = Polynuclear Aromatic Hydrocarbon
ug/kg = microgram per kilogram
mg/kg = milligram per kilogram

(1) The values shown are marine and estuarine screening values unless otherwise noted.

(2) EqP-based sediment screening values calculated using USEPA (1993 and 1996) methodology: $SV_{sed} = (K_{oc})(f_{oc})(SV_{sw})$ where K_{oc} is the organic carbon partition coefficient (L/kg), f_{oc} is the fraction of organic carbon (unitless), and SV_{sw} is the surface water screening value (ug/L). An f_{oc} of 0.01 was assumed.

(3) EqP-based sediment screening values from Di Toro and McGrath (2000) are based on an assumed f_{oc} of 0.01.

(4) The EqP-based sediment screening value was derived using a freshwater screeing value (the chemical lacks a saltwater screening value).

(5) The value shown is for 4-methylphenol.

Table References:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. National Oceanic and Atmospheric Administration, Office of Response and Restoration Division, Seattle, WA.

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TABLE 4-4
HUMAN HEALTH SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil (1)(2)	(units)	Regional Screening Levels Industrial Soil (1)(2)	(units)	Regional Screening Levels Tap Water (1)(3)	(units)	USEPA MCLs/ PRWQS (10)	(units)
Semivolatile Organic Compounds								
Acetophenone	780,000 (4)	ug/kg	10,000,000 (4)	ug/kg	370.000 (4)	ug/L	NE	
2-Acetylaminofluorene	130	ug/kg	450	ug/kg	0.018	ug/L	NE	
4-Aminobiphenyl	23	ug/kg	82	ug/kg	0.003	ug/L	NE	
Aniline	42,800 (4)	ug/kg	300,000	ug/kg	12.000	ug/L	NE	
Aramite	19,000	ug/kg	69,000	ug/kg	2.700	ug/L	NE	
Benzyl alcohol	610,000 (4)	ug/kg	6,200,000 (4)	ug/kg	370.000 (4)	ug/L	NE	
Bis(2-chloroethoxyl)methane	18,000 (4)	ug/kg	180,000 (4)	ug/kg	11.000 (4)	ug/L	NE	
Bis(2-chloroethyl)ether	210	ug/kg	1,000	ug/kg	0.012	ug/L	NE	
Bis(2-ethylhexyl)phthalate	35,000	ug/kg	120,000	ug/kg	4.800	ug/L	6	ug/L
4-Bromophenyl phenyl ether	NE	ug/kg	NE	ug/kg	NE	ug/L	NE	
Butylbenzylphthalate	260,000	ug/kg	910,000	ug/kg	35.000	ug/L	NE	
4-Chloroaniline	2,400	ug/kg	8,600	ug/kg	0.34	ug/L	NE	
4-Chloro-3-methylphenol	610,000 (4)	ug/kg	6,200,000 (4)	ug/kg	370 (4)	ug/L	NE	
2-Chloronaphthalene	630,000 (4)	ug/kg	8,200,000 (4)	ug/kg	290 (4)	ug/L	NE	
2-Chlorophenol	39,000 (4)	ug/kg	510,000 (4)	ug/kg	18 (4)	ug/L	NE	
4-Chlorophenyl phenyl ether	NE		NE		NE	ug/L	NE	
Chrysene	15,000	ug/kg	210,000	ug/kg	3	ug/L	0.038 (11)	
3&4 Methylphenol	750,000 (4)	ug/kg	9,100,000 (4)	ug/kg	93 (4)	ug/L	NE	
2-Methylphenol	310,000 (4)	ug/kg	3,100,000 (4)	ug/kg	180 (4)	ug/L	NE	
Diallate	8,000	ug/kg	28,000	ug/kg	1	ug/L	NE	
Dibenzofuran	7,800 (4)	ug/kg	100,000 (4)	ug/kg	4 (4)	ug/L	NE	
Di-n-butyl phthalate	610,000 (4)	ug/kg	6,200,000 (4)	ug/kg	370 (4)	ug/L	2,000 (11)	
Dibenzo(a,h)anthracene	15	ug/kg	210	ug/kg	0.0029	ug/L	0.038 (11)	
o-Dichlorobenzene	190,000 (4)	ug/kg	980,000 (4)	ug/kg	37 (4)	ug/L	420 (11)	ug/L
m-Dichlorobenzene	NE		NE		NE	ug/L	320 (11)	
p-Dichlorobenzene	2,400	ug/kg	12,000	ug/kg	0.43	ug/L	63 (11)	ug/L
3,3'-Dichlorobenzidine	1,100	ug/kg	3,800	ug/kg	0.15	ug/L	NE	
2,4-Dichlorophenol	18,000 (4)	ug/kg	180,000 (4)	ug/kg	11 (4)	ug/L	77 (11)	

TABLE 4-4
HUMAN HEALTH SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil (1)(2)	(units)	Regional Screening Levels Industrial Soil (1)(2)	(units)	Regional Screening Levels Tap Water (1)(3)	(units)	USEPA MCLs/ PRWQS (10)	(units)
Semivolatile Organic Compounds (Cont.)								
2,6-Dichlorophenol	NE		NE		NE	ug/L	NE	
Diethylphthalate	4,900,000 (4)	ug/kg	49,000,000 (4)	ug/kg	2,900 (4)	ug/L	17,000 (11)	
p-(Dimethylamino)azobenzene	110	ug/kg	370	ug/kg	0.015	ug/L	NE	
7,12-Dimethylbenz(a)anthracene	2	ug/kg	6	ug/kg	0.00027	ug/L	NE	
3,3'-Dimethylbenzidine	44	ug/kg	160	ug/kg	0	ug/L	NE	
2,4-Dimethylphenol	120,000 (4)	ug/kg	1,200,000 (4)	ug/kg	73 (4)	ug/L	NE	
alpha, alpha-Dimethylphenethylamine	NE		NE		NE	ug/L	NE	
Dimethyl phthalate	NE		NE		NE	ug/L	NE	
m-Dinitrobenzene	610 (4)	ug/kg	6,200 (4)	ug/kg	0.37 (4)	ug/L	NE	
4,6-Dinitro-2-methylphenol	490 (4)	ug/kg	4,900 (4)	ug/kg	0.29 (4)	ug/L	NE	
2,4-Dinitrophenol	12,000 (4)	ug/kg	120,000 (4)	ug/kg	7 (4)	ug/L	NE	
2,4-Dinitrotoluene	1,600	ug/kg	5,500	ug/kg	0.22	ug/L	1.1 (11)	
2,6-Dinitrotoluene	6,100 (4)	ug/kg	62,000 (4)	ug/kg	4 (4)	ug/L	NE	
Di-n-octylphthalate	NE		NE		NE	ug/L	NE	
1,4-Dioxane	44,000	ug/kg	160,000	ug/kg	6	ug/L	NE	
Dinoseb	6,100 (4)	ug/kg	62,000 (4)	ug/kg	4 (4)	ug/L	7	ug/L
Ethylmethanesulfonate	NE		NE		NE	ug/L	NE	
Fluoranthene	230,000 (4)	ug/kg	2,200,000 (4)	ug/kg	150 (4)	ug/L	130 (11)	ug/L
Fluorene	230,000 (4)	ug/kg	2,200,000 (4)	ug/kg	150 (4)	ug/L	1,100 (11)	ug/L
Hexachlorobenzene	300	ug/kg	1,100	ug/kg	0.042	ug/L	0.0028 (11)	ug/L
Hexachlorobutadiene	6,110 (4)	ug/kg	22,000 (4)	ug/kg	1 (4)	ug/L	4.4 (11)	ug/L
Hexachlorocyclopentadiene	37,000 (4)	ug/kg	370,000 (4)	ug/kg	22 (4)	ug/L	40 (11)	ug/L
Hexachloroethane	6,110 (4)	ug/kg	61,600 (4)	ug/kg	4 (4)	ug/L	14 (11)	ug/L
Hexachlorophene	1,800 (4)	ug/kg	18,000 (4)	ug/kg	1 (4)	ug/L	NE	
Hexachloropropene	NE		NE		NE	ug/L	NE	
Indeno(1,2,3-cd)pyrene	150	ug/kg	2,100	ug/kg	0.029	ug/L	0.038 (11)	ug/L
Isophorone	510,000	ug/kg	1,800,000	ug/kg	71	ug/L	350 (11)	ug/L

TABLE 4-4
HUMAN HEALTH SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil (1)(2)	(units)	Regional Screening Levels Industrial Soil (1)(2)	(units)	Regional Screening Levels Tap Water (1)(3)	(units)	USEPA MCLs/ PRWQS (10)	(units)
Semivolatile Organic Compounds (Cont.)								
Isosafrole	NE		NE		NE	ug/L	NE	
Methapyrilene	NE		NE		NE	ug/L	NE	
3-Methylcholanthrene	22	ug/kg	78	ug/kg	0.0031	ug/L	NE	
Methyl methanesulfonate	4,900	ug/kg	17,000	ug/kg	1	ug/L	NE	
2-Methylnaphthalene	31,000 (4)	ug/kg	410,000 (4)	ug/kg	15 (4)	ug/L	NE	
Naphthalene	3,600	ug/kg	18,000	ug/kg	0.14	ug/L	NE	
1,4-Naphthoquinone	NE		NE		NE	ug/L	NE	
1-Naphthylamine	NE		NE		NE	ug/L	NE	
2-Naphthylamine	270	ug/kg	960	ug/kg	0.037	ug/L	NE	
2-Nitroaniline	61,000 (4)	ug/kg	600,000 (4)	ug/kg	37 (4)	ug/L	NE	
3-Nitroaniline	NE		NE		NE	ug/L	NE	
4-Nitroaniline	24,000	ug/kg	86,000	ug/kg	3	ug/L	NE	
Nitrobenzene	4,800	ug/kg	24,000	ug/kg	0.12	ug/L	NE	
2-Nitrophenol	NE		NE		NE		NE	
4-Nitrophenol	NE		NE		NE		NE	
4-Nitroquinoline-1-oxide	NE		NE		NE		NE	
n-Nitrosodi-n-butylamine	87	ug/kg	400	ug/kg	0.0024	ug/L	NE	
n-Nitrosodiethylamine	1	ug/kg	11	ug/kg	0.00014	ug/L	NE	
n-Nitrosodimethylamine	2	ug/kg	34	ug/kg	0.00042	ug/L	NE	
n-Nitrosodiphenylamine	99,000	ug/kg	350,000	ug/kg	14	ug/L	NE	
n-Nitrosodi-n-propylamine	69	ug/kg	250	ug/kg	0.0096	ug/L	NE	
n-Nitrosomethylethylamine	22	ug/kg	78	ug/kg	0.0031	ug/L	NE	
n-Nitrosomorpholine	72	ug/kg	260	ug/kg	0.01	ug/L	NE	
n-Nitrosopiperidine	52	ug/kg	180	ug/kg	0.0072	ug/L	NE	
n-Nitrosopyrrolidine	230	ug/kg	820	ug/kg	0.032	ug/L	NE	
5-Nitro-o-toluidine	15,000	ug/kg	52,000	ug/kg	2	ug/L	NE	
bis(2-chloroisopropyl)ether	4,600	ug/kg	22,000	ug/kg	0.32	ug/L	NE	
Pentachlorobenzene	4,900 (4)	ug/kg	49,000 (4)	ug/kg	3 (4)	ug/L	NE	
Pentachloronitrobenzene	1,900	ug/kg	6,600	ug/kg	0.26	ug/L	NE	

TABLE 4-4
HUMAN HEALTH SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil [1][2]	(units)	Regional Screening Levels Industrial Soil [1][2]	(units)	Regional Screening Levels Tap Water [1][3]	(units)	USEPA MCLs/ PRWQS [10]	(units)
Semivolatile Organic Compounds (Cont.)								
Pentachlorophenol	3,000	ug/kg	9,000	ug/kg	1	ug/L	1	ug/L
Phenacetin	220,000	ug/kg	780,000	ug/kg	31	ug/L	NE	
Phenanthrene	170,000 [4][5]	ug/kg	1,700,000 [4][5]	ug/kg	110 [4][5]	ug/L	NE	
Phenol	1,800,000 [4]	ug/kg	18,000,000 [4]	ug/kg	1,100 [4]	ug/L	NE	
1,4-Phenylenediamine	1,200,000 [4]	ug/kg	12,000,000 [4]	ug/kg	690 [4]	ug/L	NE	
2-Picoline	NE		NE		NE		NE	
Pronamide	460,000 [4]	ug/kg	4,600,000 [4]	ug/kg	270 [4]	ug/L	NE	
Pyrene	170,000 [4]	ug/kg	1,700,000 [4]	ug/kg	110 [4]	ug/L	830 [11]	ug/L
Pyridine	7,800 [4]	ug/kg	100,000 [4]	ug/kg	4 [4]	ug/L	NE	
Safrole	2,200	ug/kg	7,800	ug/kg	0.31	ug/L	NE	
1,2,4,5-Tetrachlorobenzene	1,800 [4]	ug/kg	18,000 [4]	ug/kg	1 [4]	ug/L	NE	
2,3,4,6-Tetrachlorophenol	180,000 [4]	ug/kg	1,800,000 [4]	ug/kg	110 [4]	ug/L	NE	
o-Toluidine	NE		NE		NE	ug/L	NE	
1,2,4-Trichlorobenzene	6,190 [4]	ug/kg	27,500 [4]	ug/kg	0.412 [4]	ug/L	35 [11]	ug/L
2,4,5-Trichlorophenol	610,000 [4]	ug/kg	6,200,000 [4]	ug/kg	370 [4]	ug/L	NE	
2,4,6-Trichlorophenol	6,110 [4]	ug/kg	61,600 [4]	ug/kg	4 [4]	ug/L	14 [11]	ug/L
1,3,5-Trinitrobenzene	220,000 [4]	ug/kg	2,700,000 [4]	ug/kg	110 [4]	ug/L	NE	
PAHs								
Acenaphthene	340,000 [4]	ug/kg	3,300,000 [4]	ug/kg	220 [4]	ug/L	670 [11]	ug/L
Acenaphthylene	340,000 [4][6]	ug/kg	3,300,000 [4][6]	ug/kg	220 [4][6]	ug/L	NE	
Anthracene	1,700,000 [4]	ug/kg	17,000,000 [4]	ug/kg	1,100 [4]	ug/L	8,300 [11]	ug/L
Benzo(a)anthracene	150	ug/kg	2,100	ug/kg	0.029	ug/L	0.038 [11]	ug/L
Benzo(b)fluoranthene	150	ug/kg	2,100	ug/kg	0.029	ug/L	0.038 [11]	ug/L
Benzo(k)fluoranthene	1,500	ug/kg	21,000	ug/kg	0.29	ug/L	0.038 [11]	ug/L
Benzo(g,h,i)perylene	170,000 [4][5]	ug/kg	1,700,000 [4][5]	ug/kg	110 [4][5]	ug/L	NE	
Benzo(a)pyrene	15	ug/kg	210	ug/kg	0.0029	ug/L	0.038 [11]	ug/L

Revised: June 21, 2011

TABLE 4-4
HUMAN HEALTH SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil (1)(2)	(units)	Regional Screening Levels Industrial Soil (1)(2)	(units)	Regional Screening Levels Tap Water (1)(3)	(units)	USEPA MCLs/ PRWQS (10)	(units)
PAHs (Cont.)								
Chrysene	15,000	ug/kg	210,000	ug/kg	3	ug/L	0.038 (11)	ug/L
Dibenzo(a,h)anthracene	15	ug/kg	210	ug/kg	0.0029	ug/L	0.038 (11)	ug/L
Fluoranthene	230,000 (4)	ug/kg	2,200,000 (4)	ug/kg	150 (4)	ug/L	130 (11)	ug/L
Fluorene	230,000 (4)	ug/kg	2,200,000 (4)	ug/kg	150 (4)	ug/L	1,100 (11)	ug/L
Indeno(1,2,3-cd)pyrene	150	ug/kg	2,100	ug/kg	0.029	ug/L	0.038 (11)	ug/L
1-Methylnaphthalene	22,000	ug/kg	99,000	ug/kg	2	ug/L	NE	
2-Methylnaphthalene	31,000 (4)	ug/kg	410,000 (4)	ug/kg	15 (4)	ug/L	NE	
Naphthalene	3,600	ug/kg	18,000	ug/kg	0.14	ug/L	NE	
Phenanthrene	170,000 (4)(5)	ug/kg	1,700,000 (4)(5)	ug/kg	110 (4)(5)	ug/L	NE	
Pyrene	170,000 (4)	ug/kg	1,700,000 (4)	ug/kg	110 (4)	ug/L	NE	
Total Petroleum Hydrocarbons (TPH)								
TPH DRO	100 (12)	mg/kg	100 (12)	mg/kg	50 (12)	mg/L	50 (12)	mg/L
TPH GRO	100 (12)	mg/kg	100 (12)	mg/kg	50 (12)	mg/L	50 (12)	mg/L
Metals								
Antimony	3.1 (4)	mg/kg	41 (4)	mg/kg	1.5 (4)	ug/L	5.6 (11)	ug/L
Arsenic	0.39	mg/kg	1.6	mg/kg	0.045	ug/L	10	ug/L
Barium	1,500 (4)	mg/kg	19,000 (4)	mg/kg	730 (4)	ug/L	2,000	ug/L
Beryllium	16 (4)	mg/kg	200 (4)	mg/kg	7.3 (4)	ug/L	4.0	ug/L
Cadmium	70 (4)	mg/kg	80 (4)	mg/kg	1.8 (4)	ug/L	5.0	ug/L
Chromium	12,000 (4)(7)	mg/kg	150,000 (4)(7)	mg/kg	5,500 (4)(7)	ug/L	100	ug/L
Cobalt	2.3 (4)	mg/kg	30 (4)	mg/kg	1.1 (4)	ug/L	NE	
Copper	310 (4)	mg/kg	4,100 (4)	mg/kg	150 (4)	ug/L	1,300	ug/L
Lead	400 (4)	mg/kg	800 (4)	mg/kg	15 (8)	ug/L	15	ug/L
Mercury	0.6 (4)	mg/kg	3.4 (4)	mg/kg	0.057 (4)	ug/L	0.05 (11)	ug/L
Nickel	150 (4)	mg/kg	2,000 (4)	mg/kg	73.0 (4)	ug/L	610 (11)	ug/L

Revised: June 21, 2011

TABLE 4-4
HUMAN HEALTH SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil [1][2]	(units)	Regional Screening Levels Industrial Soil [1][2]	(units)	Regional Screening Levels Tap Water [1][3]	(units)	USEPA MCLs/ PRWQS [10]	(units)
Metals (Cont.)								
Selenium	39 [4]	mg/kg	510 [4]	mg/kg	18 [4]	ug/L	50	ug/L
Silver	39 [4]	mg/kg	510 [4]	mg/kg	18 [4]	ug/L	NE	
Thallium	NE		NE		2.0 [9]	ug/L	0.24 [11]	ug/L
Tin	4,700 [4]	mg/kg	61,000 [4]	mg/kg	2,200 [4]	ug/L	NE	
Vanadium	0.6 [4]	mg/kg	7.2 [4]	mg/kg	0.26 [4]	ug/L	NE	
Zinc	2,300 [4]	mg/kg	31,000 [4]	mg/kg	1,100 [4]	ug/L	NE	
Perchlorate								
Perchlorate	5.5 [4]	mg/kg	72 [4]	mg/kg	2.6 [4]	ug/L	NE	

Notes:

ug/L - microgram per liter
ug/kg - microgram per kilogram
mg/L - milligram per liter
mg/kg - milligram per kilogram

USEPA - United States Environmental Protection Agency
PAH - Polynuclear Aromatic Hydrocarbon
MCL - Maximum Contaminant Level
NE - Not established
PR WQS - Puerto Rico Water Quality Standards Regulation. Regulation No. 7837. March 31, 2010.

[1] USEPA Regional Screening Levels (May 2010)
[2] USEPA Regional Screening Levels for Soil also used for sediment in absence of sediment-specific screening values.
[3] USEPA Regional Screening Levels for Tap Water also used for surface water in absence of surface water-specific screening values.
[4] Noncarcinogenic Regional Screening Levels based on a target hazard quotient of 0.1 for conservative screening purposes.
[5] Value for total 1,3-dichloropropene used as a surrogate.
[5] Value for pyrene used as a surrogate.
[6] Value for acenaphthene used as a surrogate.
[8] Value for technical-BHC used as a surrogate.
[9] Value for chlordane used as a surrogate.
[10] Value for endosulfan used as a surrogate.
[11] Value for endrin used as a surrogate.
[7] Value for chromium III used as a surrogate.

[8] USEPA Action Level for lead in soil.
[9] Value for MCL used as surrogate.
[10] The more stringent of the USEPA MCL or PRWQS is listed.
[11] Value designated by PRWQS for protection of water body for reasons of human health (Class SG).
[12] Total TPH values represents the Puerto Rico Environmental Quality Board recommended screening values for soil and groundwater.

TABLE 4-5
NAPR BACKGROUND SCREENING VALUES
SWMU 79 - NAVY OPERATIONS AREA CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Surface Soil (mg/kg)	Subsurface Clay (mg/kg)	Groundwater Metals (Total) ug/L	Groundwater Metals (Dissolved) ug/L
Metals	**Upper Limit of Means (x+2s)**	**Upper Limit of Means (x+2s)**	**Upper Limit of Means (x+2s)**	**Upper Limit of Means (x+2s)**
Antimony	3.17	--	12.24	11.19
Arsenic	2.65	1.59	18.89	14.03
Barium	199	220	686	260
Beryllium	0.59	0.596	2.21	5.400
Cadmium	1.02	0.54	16.62	36.42
Chromium	49.8	114.5	162.41	6.5
Cobalt	46.2	26.9	633.21	580.5
Copper	168	246	324	29
Lead	22	6.3	26.25	1.3
Mercury	0.109	0.108	0.15	0.157
Nickel	20.7	24.7	95.74	84.1
Selenium	1.48	5.94	29.88	23.92
Silver	--	--	18.31	3.67
Thallium	--	0.92	--	--
Tin	3.76	4	9.35	--
Vanadium	259	434	484.66	20.96
Zinc	115	88	547.53	360.64

Notes:
(--) - Could not be calculated (insufficient number of detections)

Reference: Baker, 2008, *Revised Final II Summary Report for Environmental Background Concentrations of* Inorganic Compounds, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. February 29, 2008.

FIGURES

111626_cabras_01.DWG

4 0 2 4 8

1 inch = 4 miles

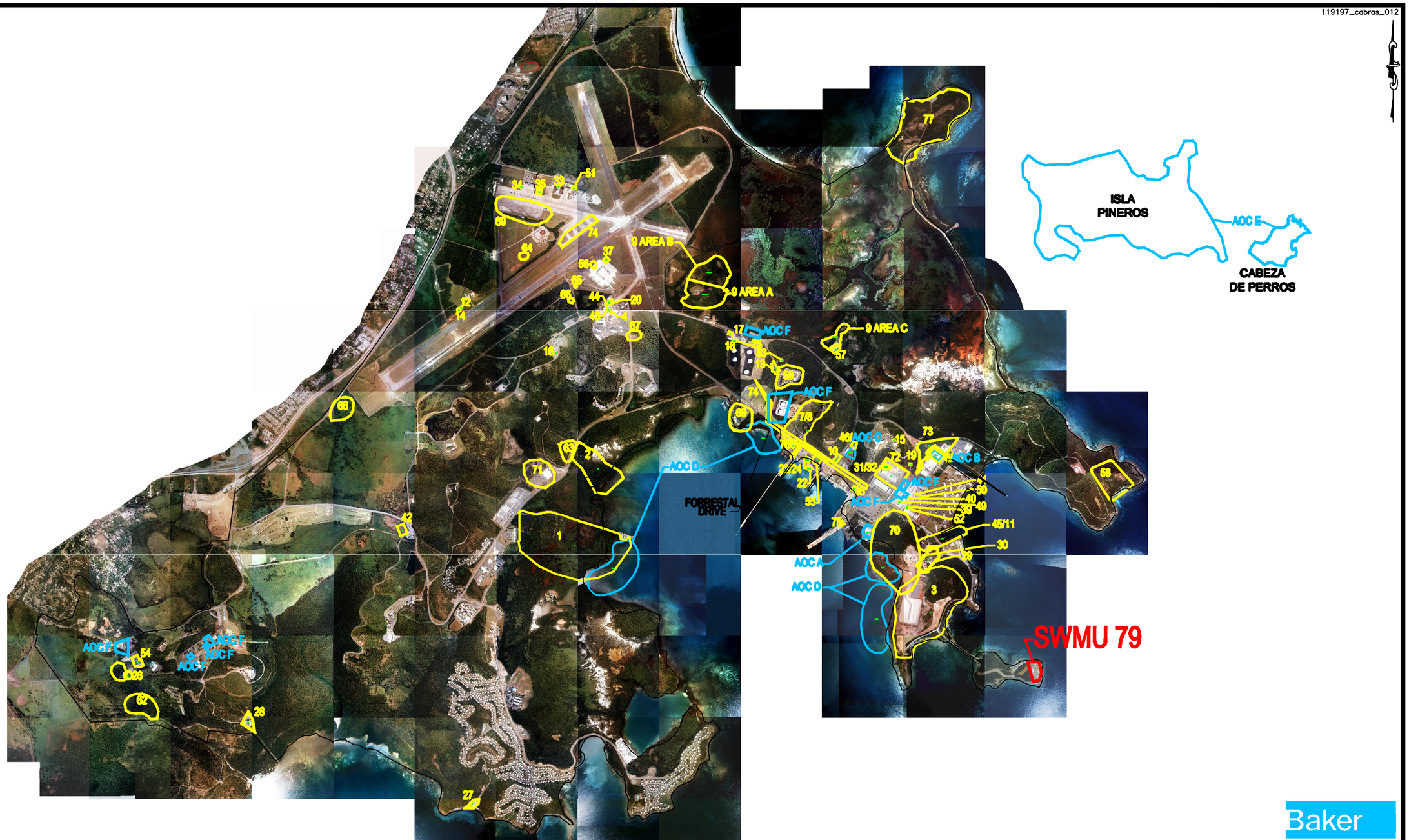
Baker

FIGURE 1-1
REGIONAL LOCATION MAP
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND
PHASE I RFI WORK PLAN

SOURCE: METRODATA, INC., 1999.

NAVAL ACTIVITY PUERTO RICO

119197_cabras_012



LEGEND

1 – SWMUs

79 – AREA TO WHICH THIS INVESTIGATION PERTAINS

AOC D – AOCs

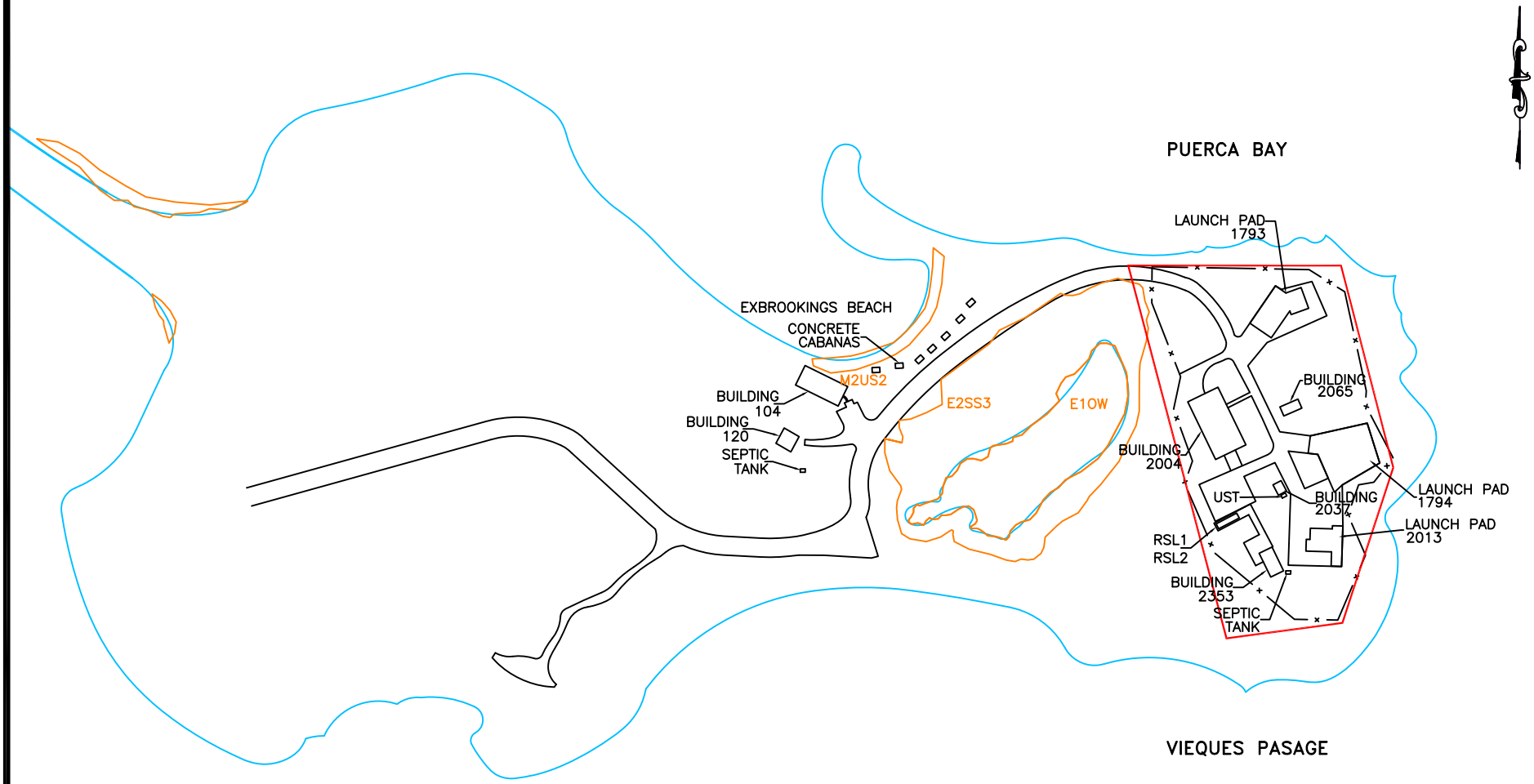
SOURCE: GEO–MARINE, INC., SEPTEMBER 6, 2000.

3000 0 1500 3000

1 inch = 3000 ft.

FIGURE 1–2
SWMU/AOC LOCATION MAP
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

119197_CABRAS_12



NOTE: APPROXIMATE SIZE AND LOCATION OF TANKS SHOWN.

250 0 125 250

1 inch = 250 ft.

Baker

LEGEND

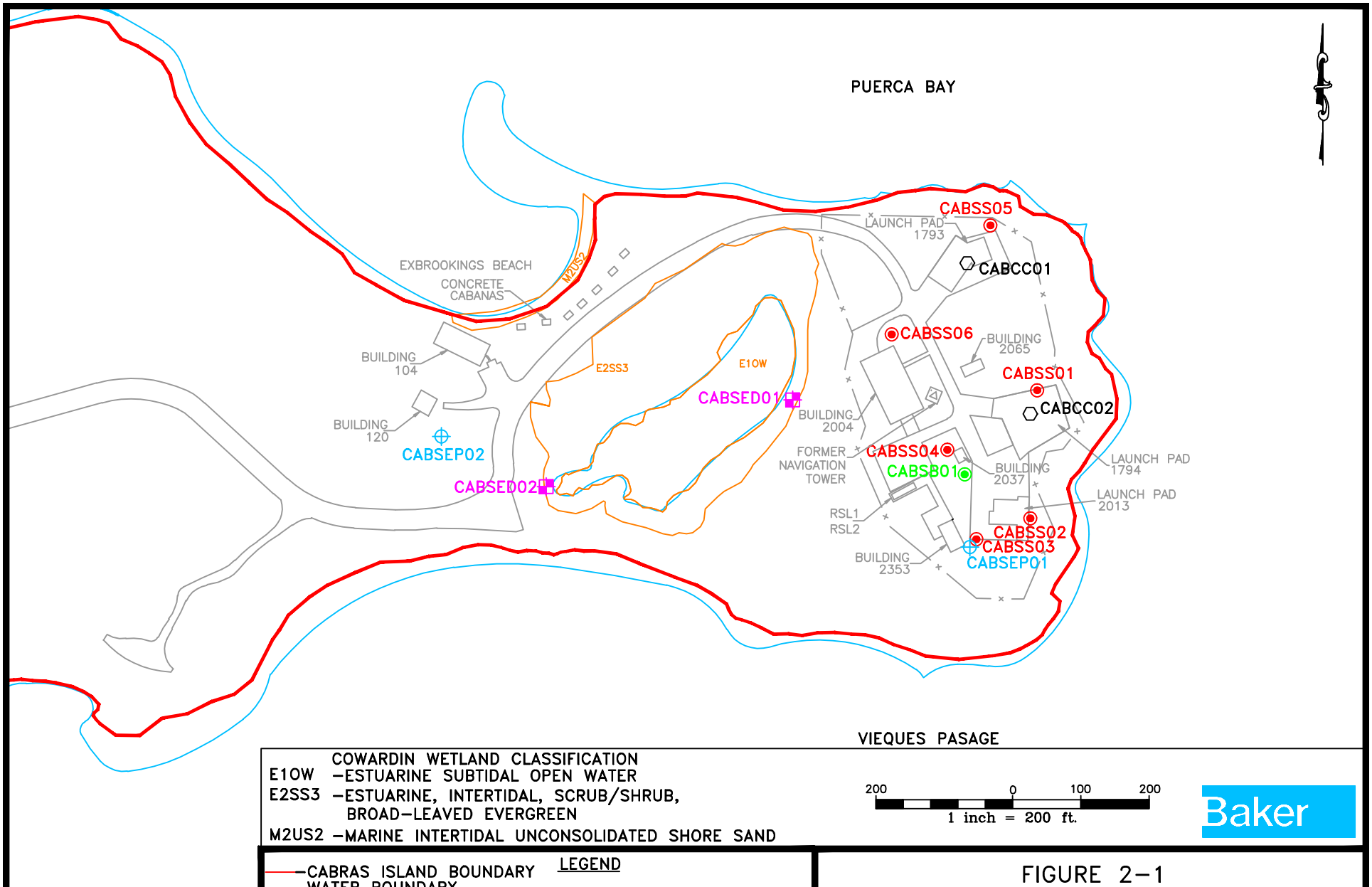
—SWMU 79 BOUNDARY
—WATER BOUNDARY
E2SS3 —WETLAND CLASSIFICATION
—WETLAND BOUNDARY
—·—FENCE
RSL1 —READY SERVICE LOCKER

COWARDIN WETLAND CLASSIFICATION

E10W – ESTUARINE SUBTIDAL OPEN WATER
E2SS3 – ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD-LEAVED EVERGREEN
M2US2 – MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

FIGURE 1-3
SWMU 79 SITE LAYOUT
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO



COWARDIN WETLAND CLASSIFICATION
E1OW –ESTUARINE SUBTIDAL OPEN WATER
E2SS3 –ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD–LEAVED EVERGREEN
M2US2 –MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

200 0 100 200
1 inch = 200 ft.

Baker

LEGEND
–CABRAS ISLAND BOUNDARY
–WATER BOUNDARY
E2SS3–WETLAND CLASSIFICATION INDENTATION
–WETLAND BOUNDARY
–SURFACE SOIL SAMPLE LOCATION
–SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
–SEPTIC WATER SAMPLE LOCATION
–SEDIMENT SAMPLE LOCATION
–CONCRETE CHIP SAMPLE LOCATION

FIGURE 2–1
PHASE I/II ECP SAMPLE LOCATIONS
SWMU 79 – NAVY OPERATIONS AND MWR AREAS – CABRAS ISLAND
PHASE I/II ECP REPORT
NAVAL ACTIVITY PUERTO RICO

119197_CABRAS_04

80 0 40 80
1 inch = 80 ft.

119197_CABRAS_2.2

LEGEND

—SWMU 79 BOUNDARY
—WATER BOUNDARY
E2SS3 —WETLAND CLASSIFICATION
—WETLAND BOUNDARY
RSL1 —READY SERVICE LOCKER

COWARDIN WETLAND CLASSIFICATION
E1OW – ESTUARINE SUBTIDAL OPEN WATER
E2SS3 – ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD-LEAVED EVERGREEN
M2US2 – MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

FIGURE 2-2
WETLAND LOCATION MAP
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

M - MARINE

SYSTEM	M - MARINE																						
SUBSYSTEM	1 - SUBTIDAL					2 - INTERTIDAL																	
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	RF - Reef	OW - Open Water (unknown bottom)	AB - Aquatic Bed	RF - Reef	RS - Rocky Shore	US - Unconsolidated Shore	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	RF - Reef	OW - Open Water (unknown bottom)	AB - Aquatic Bed	RF - Reef	SB - Streambed	RS - Rocky Shore	US - Unconsolidated Shore	EM - Emergent	SS - Scrub-Shrub	FO - Forested
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm		1 Algal 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	2 Mollusk 3 Worm		1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	2 Mollusk 3 Worm	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Dead	1 Persistent 2 Nonpersistent	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*

E - ESTUARINE

R - RIVERINE

SYSTEM	R - RIVERINE										
SUBSYSTEM	1 - TIDAL	2 - LOWER PERENNIAL		3 - UPPER PERENNIAL		4 INTERMITTENT		5 - UNKNOWN PERENNIAL			
CLASS	RB - Rock	UB - Unconsolidated Bottom	SB - Streambed	AB - Aquatic Bed	RS - Rocky Shore	UB - Unconsolidated Shore	OW - Open Water (unknown bottom)	**EM - Emergent	RB - Rock Bottom	UB - Unconsolidated Bottom	
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble 3 Cobble - Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic		2 Nonpersistent	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	

L - LACUSTRINE

SYSTEM	L - LACUSTRINE									
SUBSYSTEM	1 - LIMNETIC			2 - LITTORAL						
CLASS	AB - Aquatic Bed	OW - Open Water (unknown bottom)	RB - Rock Bottom	RS - Rocky Shore	UB - Unconsolidated Bottom	AB - Aquatic Bed	US - Unconsolidated Shore	EM - Emergent	OW - Open Water (unknown bottom)	
Subclass	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*		1 Bedrock 2 Rubble	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent		

P - PALUSTRINE

SYSTEM	P - PALUSTRINE								
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	US - Unconsolidated Shore	ML - Moss-Lichen	EM - Emergent	SS - Scrub-Shrub	FO - Forested	OW - Open Water (unknown bottom)
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	

MODIFIERS

WATER REGIME					WATER CHEMISTRY			SOIL	SPECIAL
	Non-Tidal		**Tidal**		**Coastal Halinity**	**Inland Salinity**	**pH (fresh water)**		
A Temp. Flooded	H Permanently Flooded	K Artificially Flooded	*S Temporary-Tidal		1 Hyperhaline	7 Hypersaline	a Acid	g Organic	b Beaver
B Saturated	J Intermittently Flooded	L Subtidal	*R Seasonal-Tidal		2 Euhaline	8 Eusaline	t circumneutral	n Mineral	d partially drained/ditched
C Seasonally Flooded	K Artificially Flooded	M Irregularly Flooded	*T Semipermanent- Tidal		3 Mixohaline	9 Mixosaline	i Alkaline		f Farmed
D Seasonally Flooded/ Well Drained	W Intermittently Flooded/ Temporary	N Regularly Flooded	*V Permanent-Tidal		4 Polyhaline	0 Fresh			h Diked/Impounded
E Seasonally Flooded/ Saturated	Y Saturated/Semipermanent/ Seasonal	P Irregularly Flooded	U Unknown		5 Mesohaline				r Artificial Substrate
F Semipermanently Flooded	Z Intermittently Exposed Permanent		* These water regimes are only used in tidally influenced, freshwater systems.		6 Oligohaline				s Spoil
G Intermittently Exposed	U Unknown				0 Fresh				x Excavated

SOURCE: UNITED STATES, FISH AND WILDLIFE SERVICE. CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES, 1985

Baker

FIGURE 2–3
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
SWMU 79–NAVY OPERATION AREA
CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

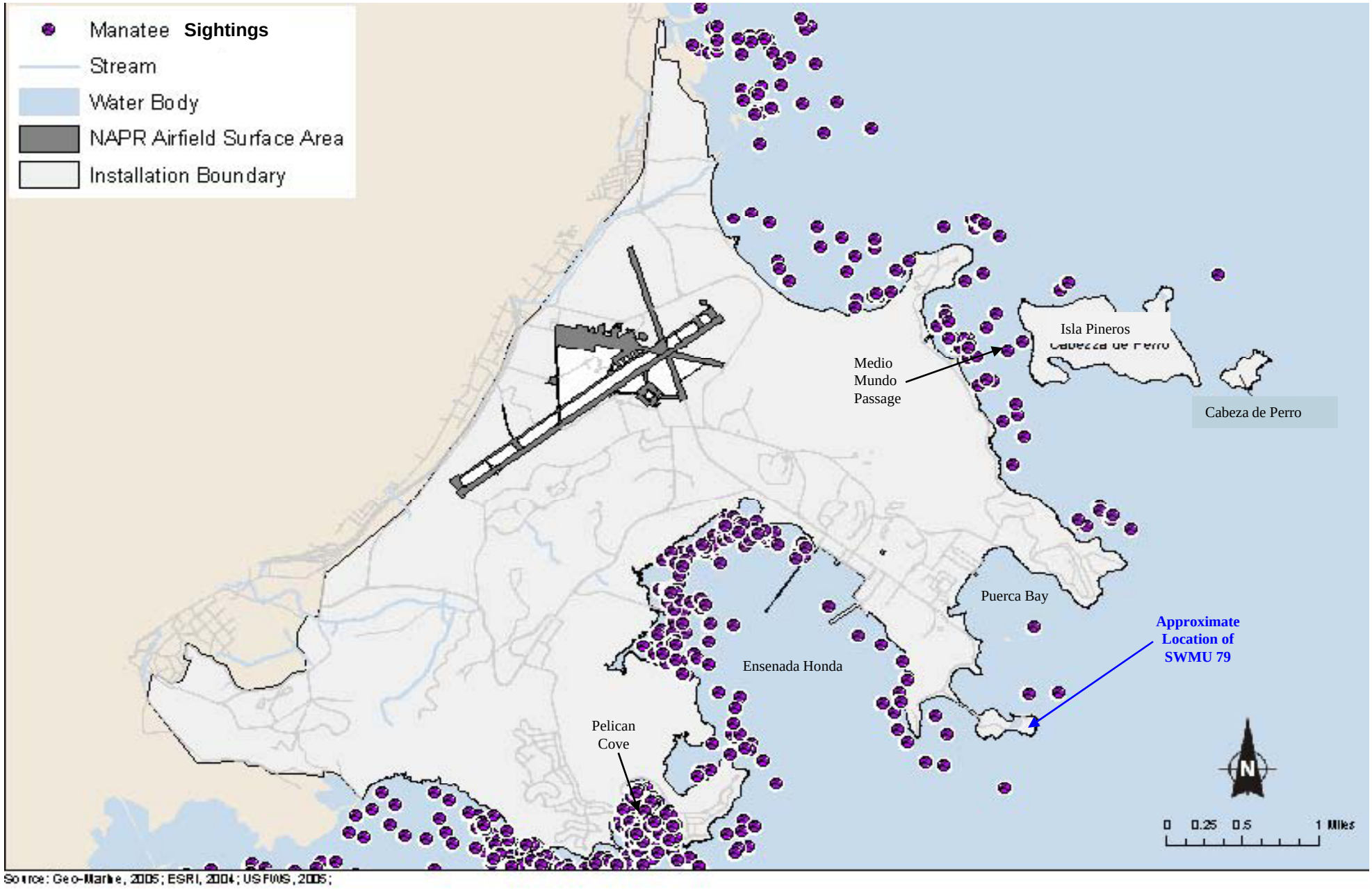
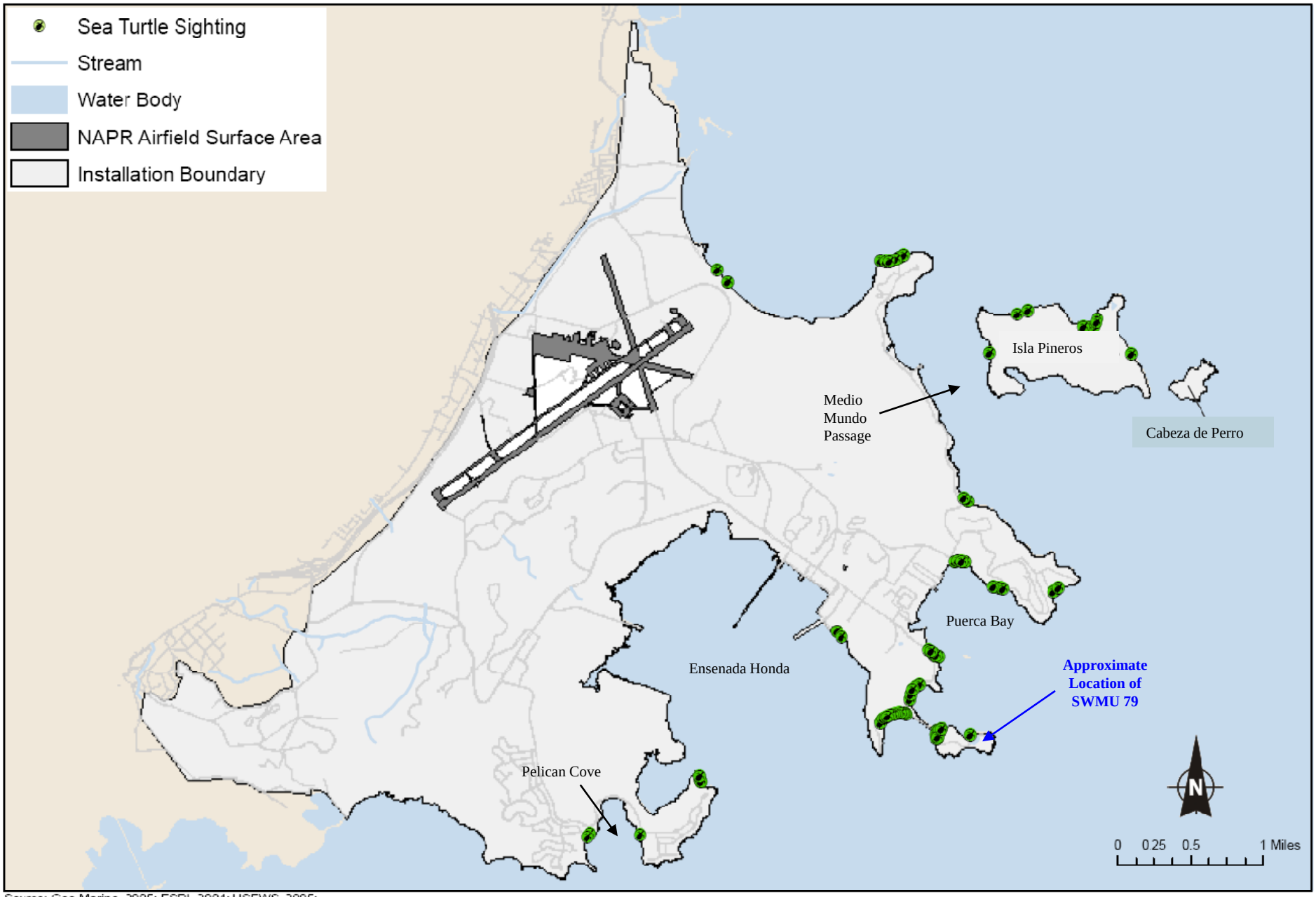


Figure from: Department of the Navy (DoN). 2007. *Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* April 2007.

FIGURE 2-4
HISTORICAL MANATEE SIGHTINGS IN EASTERN PUERTO RICO
SWMU 79 – CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

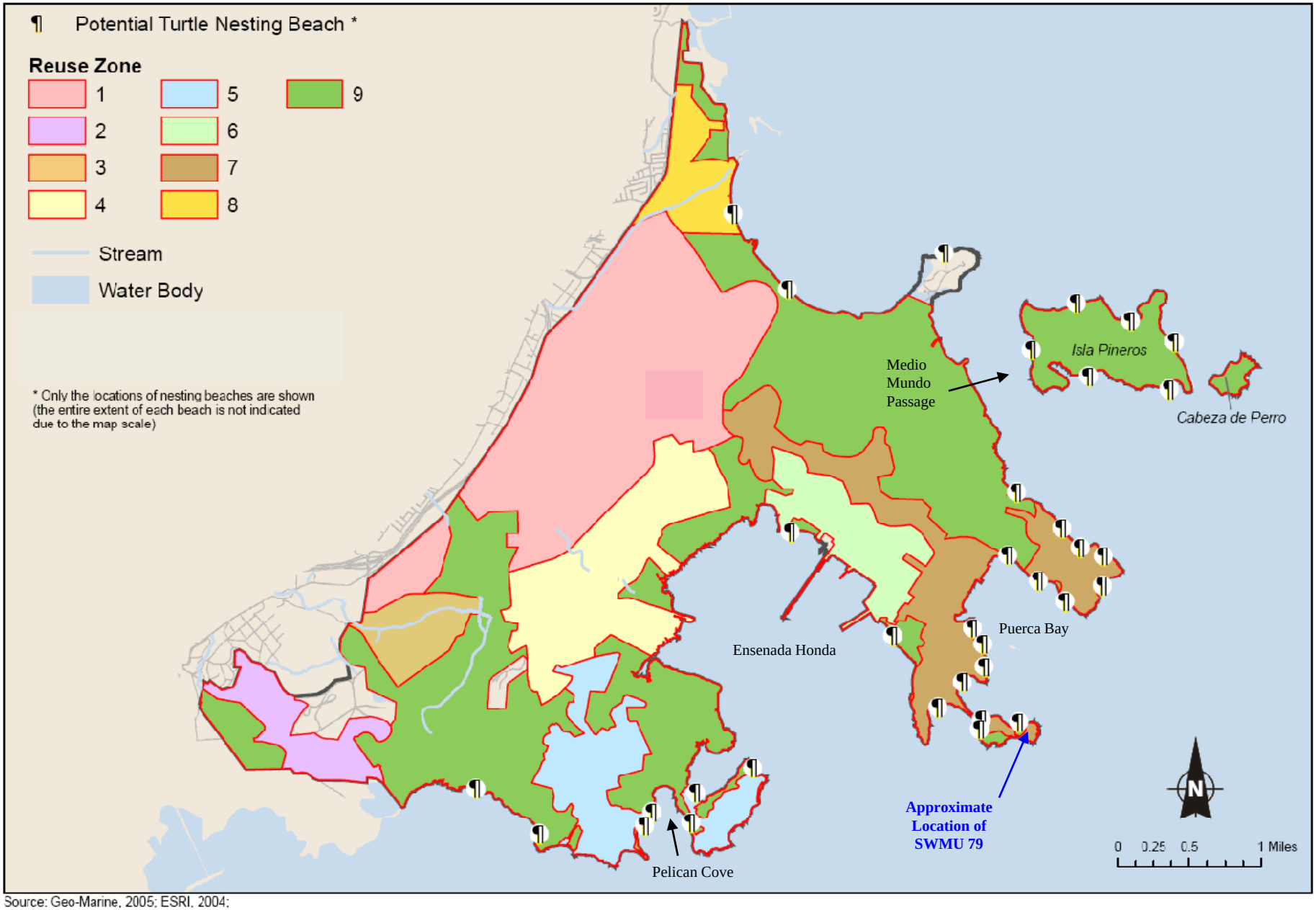


Source: Geo-Marine, 2005; ESRI, 2004; USFWS, 2005;

Cumulative sea turtle sightings from March 1984 through March 1995 obtained from weekly aerial surveys of the Former Naval station Roosevelt Roads.

Figure from: Department of the Navy (DoN). 2007. *Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* April 2007.

FIGURE 2-5
SEA TURTLE SIGHTINGS AT NAVAL ACTIVITY PUERTO RICO
SWMU 79 – CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

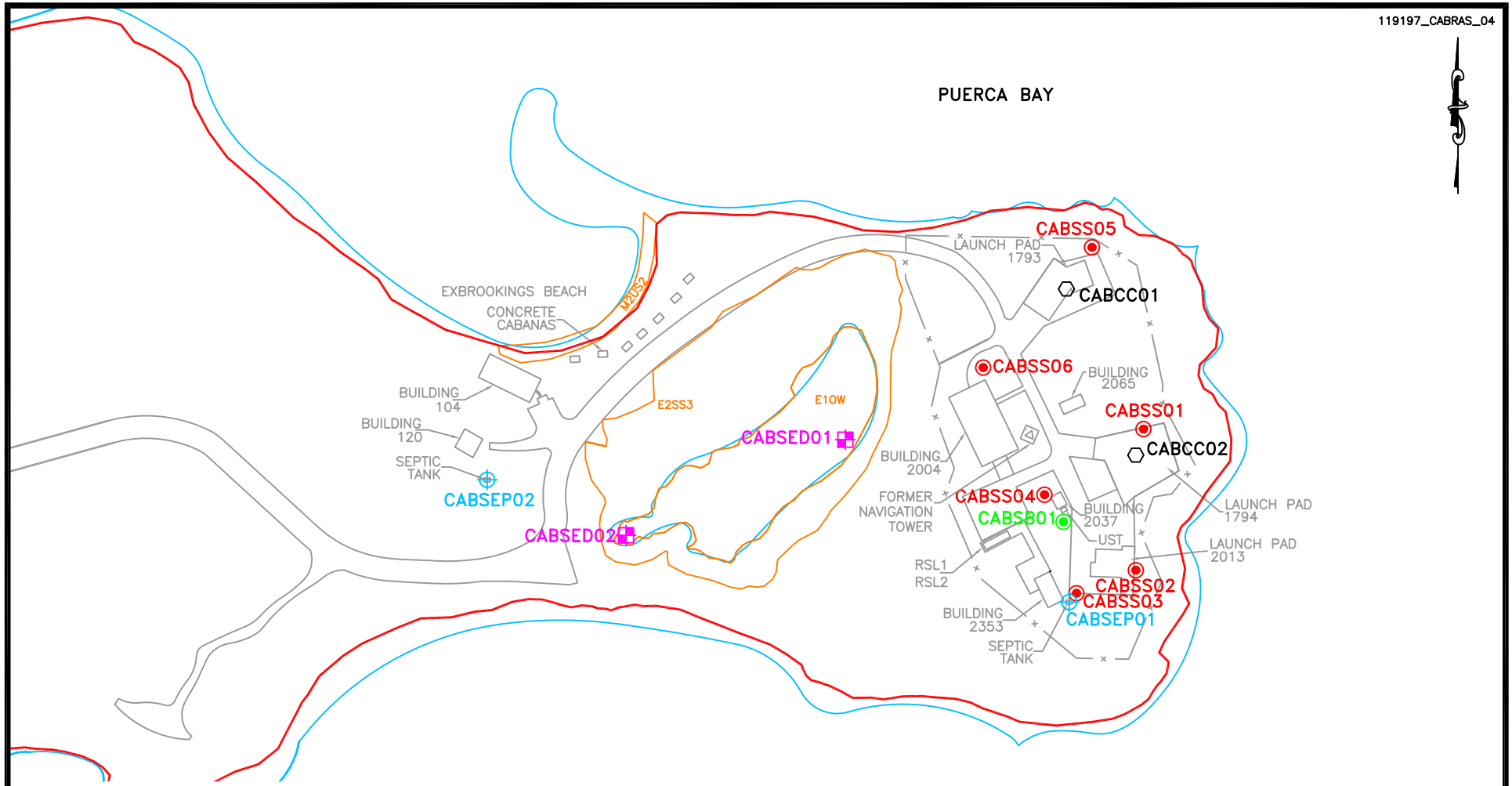


Source: Geo-Marine, 2005; ESRI, 2004;

Figure from: Department of Navy (DoN). 2007. *Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* April 2007

FIGURE 2-6
POTENTIAL TURTLE NESTING SITES
SWMU 79 – CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

119197_CABRAS_04



NOTE: SAMPLING RESULTS ARE LOCATED IN TABLES 2-2 TO 2-7.

APPROXIMATE SIZE AND LOCATION OF TANKS SHOWN.

COWARDIN WETLAND CLASSIFICATION

E1OW –ESTUARINE SUBTIDAL OPEN WATER

E2SS3 –ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD-LEAVED EVERGREEN

M2US2 –MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

200 0 100 200

1 inch = 200 ft.

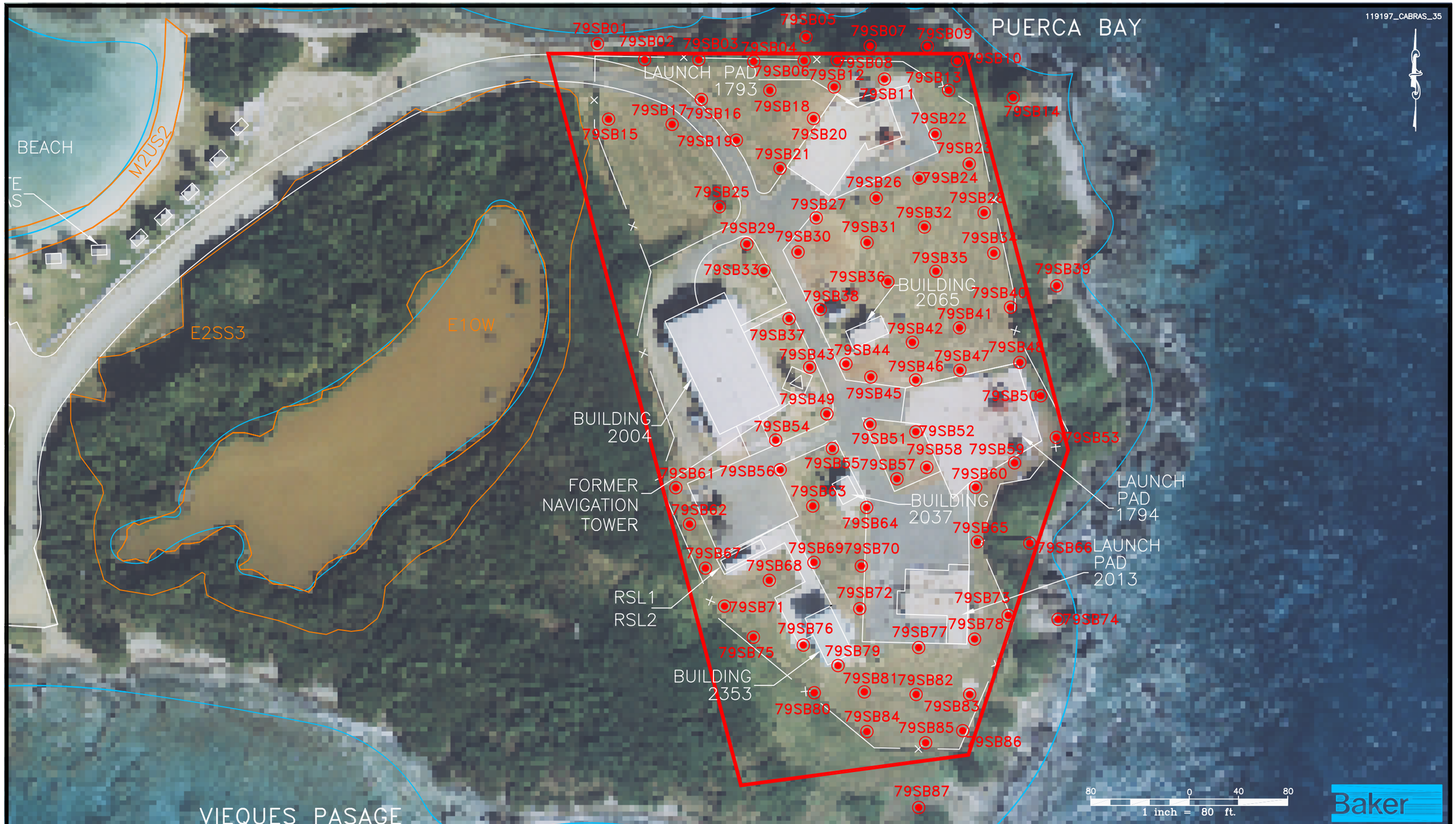
Baker

LEGEND

- –CABRAS ISLAND BOUNDARY
- –WATER BOUNDARY
- E2SS3 –WETLAND CLASSIFICATION
- –WETLAND BOUNDARY
- –SURFACE SOIL SAMPLE LOCATION
- –SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- –SEPTIC WATER SAMPLE LOCATION
- –SEDIMENT SAMPLE LOCATION
- –CONCRETE CHIP SAMPLE LOCATION
- RSL1 –READY SERVICE LOCKER

FIGURE 2-7
PHASE II ECP SAMPLE LOCATIONS
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO



LEGEND

- —SWMU 79 BOUNDARY
- —WATER BOUNDARY
- E2SS3 —WETLAND CLASSIFICATION
- —WETLAND BOUNDARY
- RSL1 —READY SERVICE LOCKER
- 79SB40 —PROPOSED XRF SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION

COWARDIN WETLAND CLASSIFICATION

- E1OW – ESTUARINE SUBTIDAL OPEN WATER
- E2SS3 – ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD-LEAVED EVERGREEN
- M2US2 – MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

NOTE: THE FIXED-BASED LABORATORY CONFIRMATORY SAMPLES WILL INCLUDE A RANGE OF LOW LEVEL, MEDIUM LEVEL, AND HIGH LEVEL DETECTIONS FOR CONFIRMATORY ANALYSIS. THIS RANGE WILL ASSIST TO DETERMINE THE ACCURACY OF THE XRF ANALYSIS COMPARED TO THE FIXED-BASE RESULTS.

FIGURE 3-1
XRF SOIL SAMPLE LOCATIONS
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

LEGEND

- —SWMU 79 BOUNDARY
- —WATER BOUNDARY
- E2SS3 —WETLAND CLASSIFICATION
- —WETLAND BOUNDARY
- RSL1 —READY SERVICE LOCKER
- —PHASE II ECP SURFACE SOIL SAMPLE LOCATION (2009)
- —PHASE II ECP SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (2009)
- —PROPOSED SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- 79SB90

COWARDIN WETLAND CLASSIFICATION

- E10W – ESTUARINE SUBTIDAL OPEN WATER
- E2SS3 – ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD-LEAVED EVERGREEN
- M2US2 – MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

NOTE: SOIL BORING LOCATIONS 79SB94 THROUGH 79SB99 (NOT SHOWN) TO BE FIELD-DETERMINED.

FIGURE 3-2
PRE-DETERMINED SOIL BORING LOCATIONS
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

LEGEND

- —SWMU 79 BOUNDARY
- —WATER BOUNDARY
- E2SS3 —WETLAND CLASSIFICATION
- —WETLAND BOUNDARY
- —ASSUMED PREFERENTIAL SURFACE WATER RUNOFF FLOW PATHWAY
- RSL1 —READY SERVICE LOCKER
- 790WSD06 —PROPOSED SEDIMENT SAMPLE LOCATION

COWARDIN WETLAND CLASSIFICATION

E10W – ESTUARINE SUBTIDAL OPEN WATER

E2SS3 – ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD–LEAVED EVERGREEN

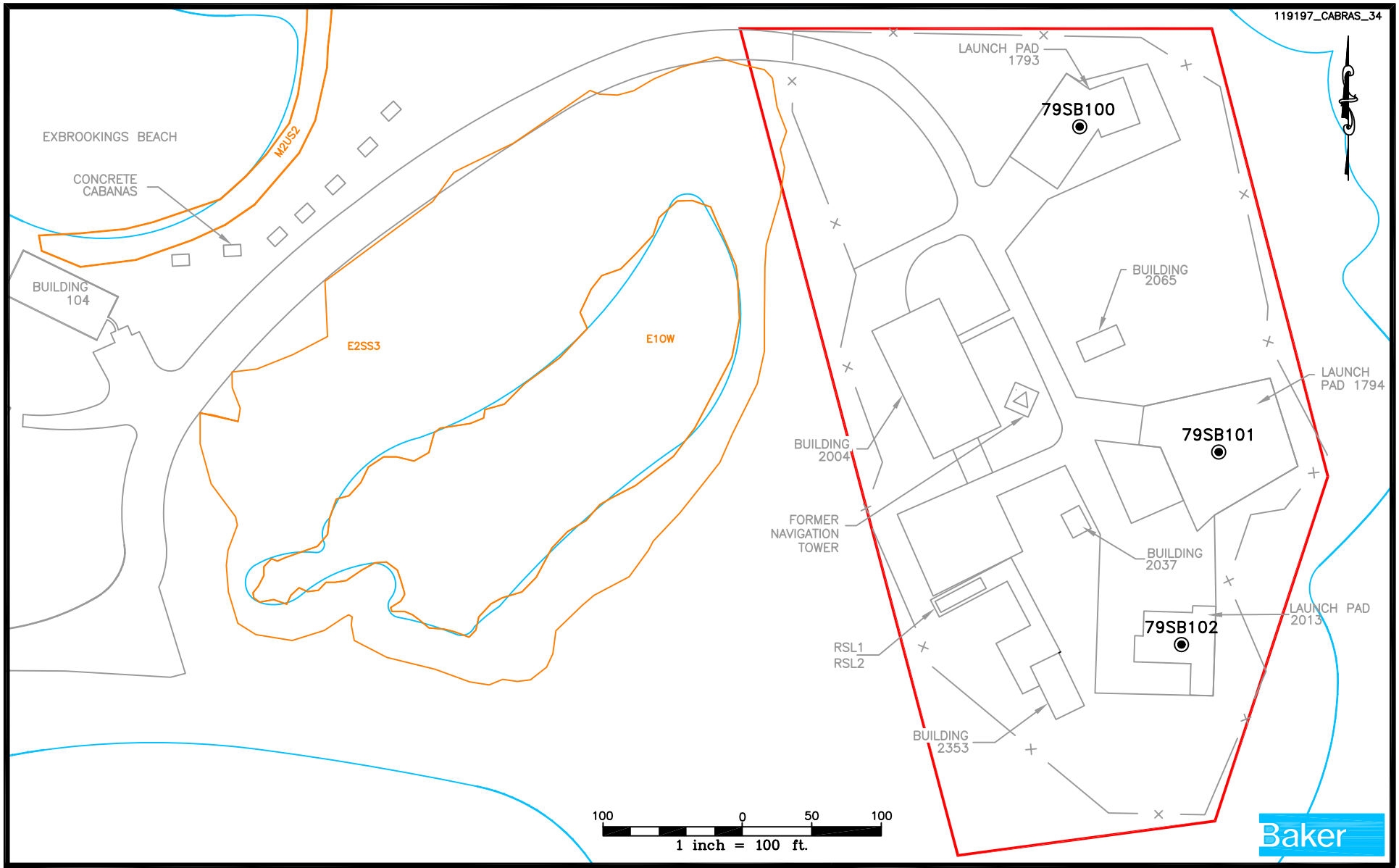
M2US2 – MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

NOTE: SAMPLE LOCATIONS TO BE FIELD–DETERMINED BASED ON EVIDENCE OF MIGRATION.

FIGURE 3–3

OPEN WATER SEDIMENT SAMPLE LOCATIONS
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO



LEGEND

- —SWMU 79 BOUNDARY
- —WATER BOUNDARY
- E2SS3 —WETLAND CLASSIFICATION
- —WETLAND BOUNDARY
- RSL1 —READY SERVICE LOCKER
- 79SB100 —PROPOSED SUBSURFACE SOIL SAMPLE LOCATION

COWARDIN WETLAND CLASSIFICATION

E1OW – ESTUARINE SUBTIDAL OPEN WATER
E2SS3 – ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD-LEAVED EVERGREEN
M2US2 – MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

FIGURE 3-4
LAUNCH PAD SUBSURFACE SOIL SAMPLE LOCATIONS

SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

80 0 40 80
1 inch = 80 ft.

119197_CABRAS_33

LEGEND

—SWMU 79 BOUNDARY
—WATER BOUNDARY
E2SS3 —WETLAND CLASSIFICATION
—WETLAND BOUNDARY
RSL1 —READY SERVICE LOCKER
—PROPOSED SURFACE SOIL LEAD SCREENIING
79SS08 SAMPLE LOCATION

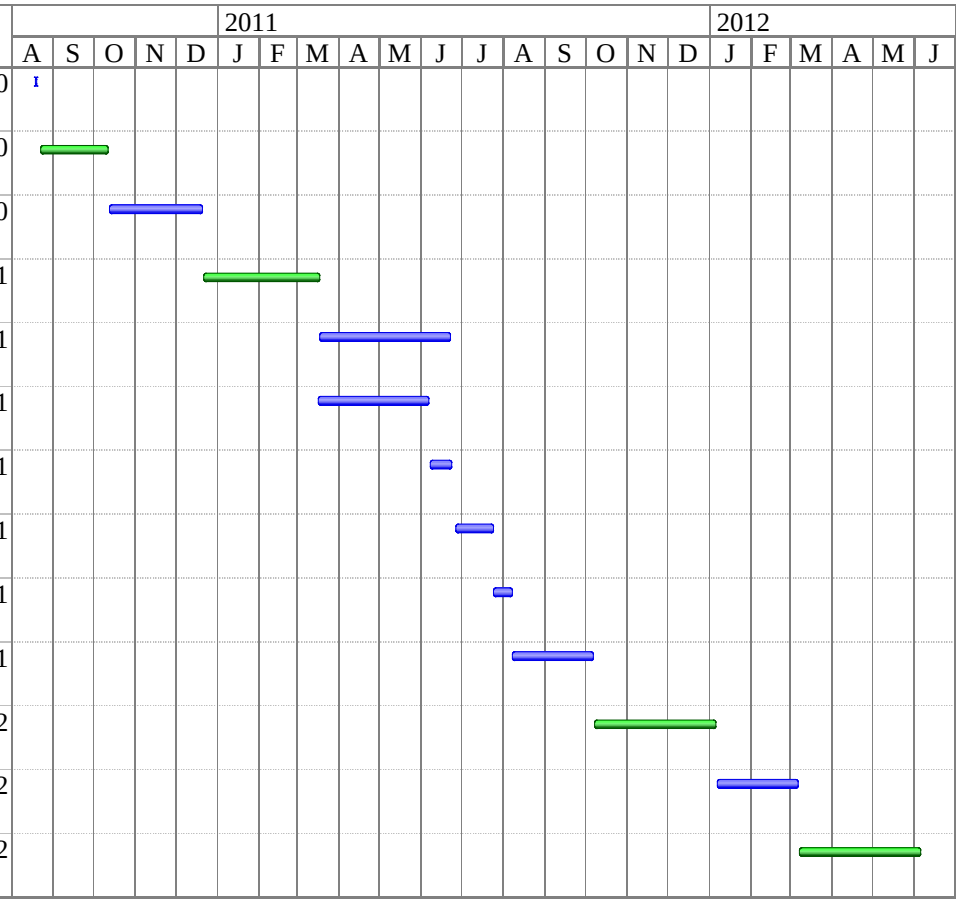
COWARDIN WETLAND CLASSIFICATION
E10W – ESTUARINE SUBTIDAL OPEN WATER
E2SS3 – ESTUARINE, INTERTIDAL, SCRUB/SHRUB, BROAD-LEAVED EVERGREEN
M2US2 – MARINE INTERTIDAL UNCONSOLIDATED SHORE SAND

FIGURE 3-5
SURFACE SOIL LEAD SAMPLE LOCATIONS
SWMU 79 – NAVY OPERATIONS AREA
CABRAS ISLAND

PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

FIGURE 5-1
PROJECT SCHEDULE
SWMU 79 CABRAS ISLAND
PHASE I RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Task Name	Duration	Start	Finish
Draft Phase I RFI Work Plan to the EPA	1 eday	8/19/10	8/20/10
EPA Review	50 edays	8/23/10	10/12/10
Final RFI Work Plan to the EPA	69 edays	10/12/10	12/20/10
EPA Review and Approval	86 edays	12/21/10	3/17/11
Revised Final RFI Work Plan	97 edays	3/17/11	6/22/11
Initiate Field Work	82 edays	3/17/11	6/7/11
Field Investigation	16 edays	6/8/11	6/24/11
Laboratory Analysis	28 edays	6/27/11	7/25/11
Data Validation	14 edays	7/25/11	8/8/11
Draft Phase I RFI Report for SWMU 79 to EPA	60 edays	8/8/11	10/7/11
EPA Review	90 edays	10/7/11	1/5/12
Final Phase I RFI Report to EPA	60 edays	1/6/12	3/6/12
EPA Review and Approval	90 edays	3/7/12	6/5/12

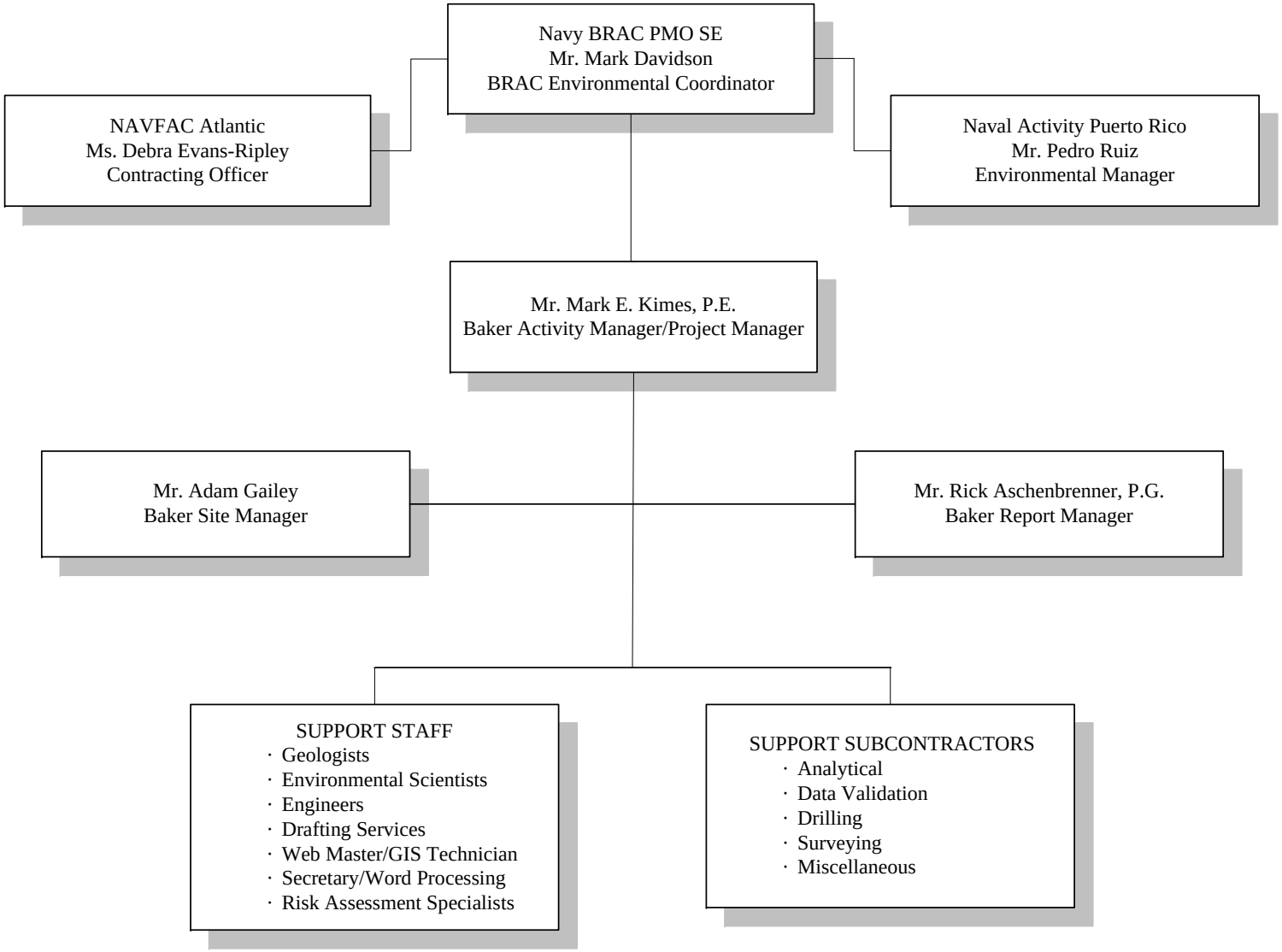


Project: Full RFI Work Plan
Date: June 21, 2011

Task

\\mooncl1fs\vol4_projects_SOUTHNAVFAC\119197 JM01\SWMU 79\Work Plan\Phase I RFI\Revised Final\Figure 5-1 pHASE I RFI WP Schedule.mpp

FIGURE 6-1
PROJECT ORGANIZATION
PHASE I RFI WORK PLAN – SWMU 79
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO



APPENDIX A
JATO BOTTLE STUDY RESULTS

INDIAN HEAD

MK117 JATO Carrier Ejection Trajectory

David R. González
Code E33DG
06/17/10

Summary

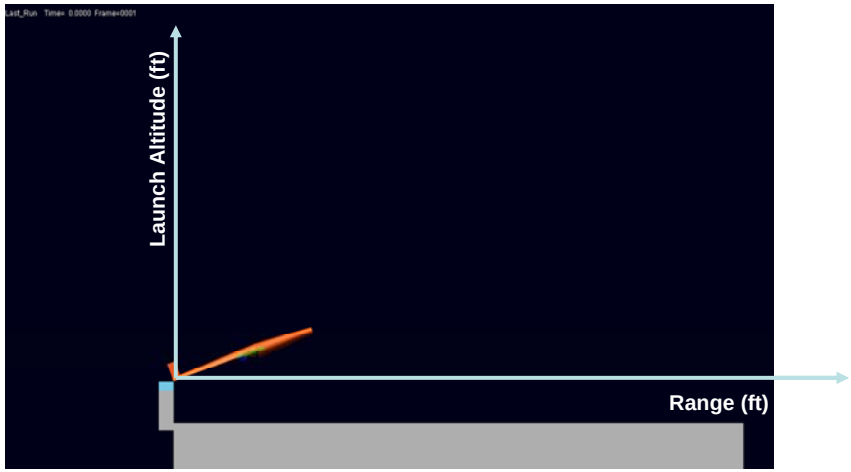
- Presented herein are the results of a six-degree-of-freedom dynamic analysis to predict the trajectory of the MK117 JATO bottles after their release from a BQM-74 drone.

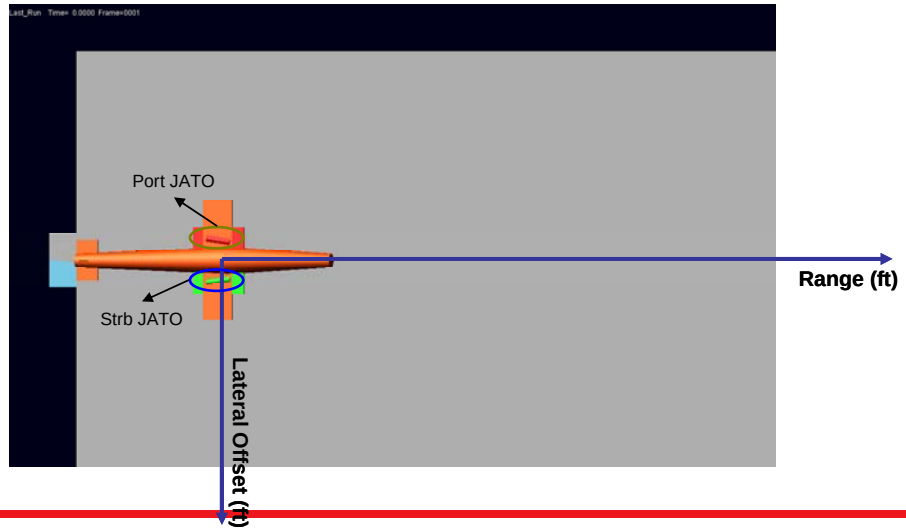
- The following were assumptions made in the analysis:
  1. ***Identical*** thrust profiles were used on both sides of the target drone
  2. ***No wind*** was taken into account throughout the flight
  3. Aerodynamic forces on the JATO bottle were based upon approximate drag coefficient due to the JATO carrier's unconventional shape

- Results consist of the range and lateral offset of the JATO carriers.
  - Range is relative to the launch point and down-range
  - Lateral offset is relative to the launch *heading*

Results Reference Frame

- Simulation Views





X = Range

Y = Altitude

Z = Lateral Offset

DOD Energetics Center
Excellence for the Warfighter

Tabulated Results

- Below is a table consisting of the ***water entry*** predicted locations for various launch altitudes
  - Only one value for lateral offset is reported as the carriers were spread by less than two feet in all of the simulations
  - Therefore, this is an average of the two locations

Launch Altitude ft	Range ft	Lat Offset ft
0	3381	-16
25	3434	-16.2
50	3484	-16.4
75	3532	-16.6
100	3580	-16.9
200	3755	-17.8

- NOTES:
  1. A ***negative*** value for lateral offset corresponds to a drone deviating to *port* (left when facing the direction of flight)
  2. This deviation occurs due to the inertia of the jet engine even though the JATO thrust is perfectly matched

Disclaimers

- Water impact locations for the carriers are *expected* to differ from the results presented due to:
  1. JATO-pair thrust profiles are *never* matched perfectly and the slightest mismatch induces a flight direction change of the drone (and JATO carriers once ejected), greatly affecting the water entry location. For example, for a *known* small thrust differential and a ground level launch, the lateral offset was predicted to be approximately 960 feet, as opposed to 16 feet.
  2. Wind conditions can have some effect on the trajectory of both the target drone and ejected JATOs
- Results correspond *only to water impact* locations
  1. No conclusions can be made as to the carriers' locations on the sea bed

Restoration Advisory Board (RAB) Meeting

Former Naval Station Roosevelt Roads

Ceiba, Puerto Rico

Meeting #18

July 28, 2010

Use of Jet Assisted Take Off (JATO) Bottles at Cabras Island

Mark Kimes

July 28, 2010

Questions Raised Regarding Underwater Objects

- Objects found off shoreline of Cabras Island
- Identified by Navy personnel as JATO bottles used to propel target drones
- Engineers from Michael Baker Jr. met with NAVSEA personnel who provided product formulation information, environmental data , and simulation modeling results

JATO Bottles

- Used to propel BQM 74E target drones during Navy exercises at Cabras Island.
- Two JATOs were used to launch each drone, one under each wing.
- After drones were remotely activated, the JATO bottles would propel the drones for about 1.3 seconds and then the bottles would drop off into the ocean.
- After ignition, temperatures within the JATO bottle reach 4,404°F, according to manufacturer's test data.

Components of JATO Bottles

- Majority (49%) of JATO propellant composed of Nitrocellulose which explodes at 165°F
- Other components of JATO bottle propellant include nitroglycerine (39%) and the ballistic modifier (12%) – used to increase the burning rate of the propellant.
- Navy tests indicate that at 4,403°F, all propellant material within bottle is annihilated.

Propellant Composition

Mk 117 MoD 0 JATO Rocket Motor
Propellant Description Sheet

PROPELLANT DESCRIPTION SHEET

REPORTS CONTROL SYMBOL
EXEMPT-PARA-7-2a
AR 335-15

COMPOSITION PROPELLANT, NOSIH AA-6 CARPET ROLL	DA LOT NUMBER RAD06D0098003
SPECIFICATION AS-3028C dated November 3, 2004 and RFD RAD04-03D	PACKED AMOUNT 20 Pounds
MFG. AT RADFORD ARMY AMMUNITION PLANT, RADFORD, VA	CONTRACT NUMBER N00174-05-C-0025

ACCEPTED BLEND NUMBERS

BG60022, 60023, 60024, 60025, 60026

PRODUCED WITH A BLEND OF HIGH/LOW VISCOSITY GLUCKSTADT LINTERS.

NITROCELLULOSE

NITROGEN CONTENT			KI STARCH (65.5 °C)		STABILITY (134.5 °C)	
MAX	12.45	%	45	MINS	30	MINS.
MIN	12.38	%	40	MINS	30	MINS.
AVG.	12.42	%	44	MINS	30	MINS.

TEMPERATURES °F FROM	TO	MANUFACTURE OF SOLVENTLESS PROPELLANT	SECONDS FROM	TO
206°F	210°F	PREROLLING	180 SEC	
148°F	152°F	EVENSPEED ROLLING	5 MIN	

Propellant mfg. by slurry mix process.

PROPELLANT COMPOSITION* CONSTITUENT	TESTS OF FINISHED PROPELLANT PERCENT FORMULA	PERCENT TOLERANCE	PERCENT MEASURED
NITROCELLULOSE **	49.00	NOM.	47.5
NITROGLYCERIN	38.80	NOM.	39.17
TRIACETIN	3.25	NOM.	3.45
DI-N-PROPYL-ADIPATE	2.00	NOM.	2.33
2-NITRODIPHENYLAMINE	2.00	1.60 MIN	1.86
LC-12-15	3.30	NOM.	3.71
CANDELILLA WAX	0.1	NOM.	0.07
CARBON BLACK	0.05	NOM.	0.08
ALUMINUM	1.50	NOM.	1.84
TOTAL	100.00		100.00
MOISTURE	0.60	MAX	0.31

*MOISTURE FREE BASIS
**NITROCELLULOSE DETERMINED BY DIFFERENCE

STABILITY AND PHYSICAL TESTS

TALIANI SLOPE 0.3665 (mmHg/min) at 100 MIN.
Taliani requirement 1.1 mm Hg/min max at 100 minutes

TEMP. °F	AVG. CROSSWISE MAX STRESS psi	STRAIN	AVG. LENGTHWISE MAX STRESS psi	STRAIN
-65°F	5245.02	0.07	4947.4	0.095
77°F	586.85	0.360	783.7	0.254
165°F	157.5	0.416	242.6	0.265

SPEC FOR TENSILES AT 77°F- LENGTHWISE ONLY
STRESS 630 lbs/sq in MINIMUM
STRAIN 0.180 MINIMUM

TENSILE INFORMATION AT -65°F AND 165°F IS FOR INFORMATION ONLY

STRAND BURNING RATE AND HEAT OF EXPLOSION

TEMP °F	700psi	900psi	1200psi	1600 psi	2000 psi	2400 psi	2800 psi
-65°F (MINIMUM)	—	—	0.560	0.520	0.420	0.440	0.490
-65°F	0.465	0.530	0.573	0.584	0.541	0.433	0.532
165°F(MAXIMUM)	—	—	0.700	0.700	0.760	0.800	0.900
165°F	0.640	0.637	0.703	0.694	0.771	0.788	0.861

Average range = 0.079 in/sec fails requirement of 0.050 in/sec max
Strand burn rates at 700 and 900 psi are for information only

HEAT OF EXPLOSION (cal/gm.): AVG.: 1037 STD. DEVIATION: 2.69

PROPELLANT DIMENSIONS (inches)

N/A

DATES
PACKED 6/10/2006
SAMPLED 6/10/2006
TEST FINISHED 7/11/2006
OFFERED 7/21/2006
DESCRIPTION SHEETS FORWARDED

TYPE OF PACKING CONTAINER LEVER PACK DRUM

REMARKS

MODIFER	LOT
LC-12-15	1035967
ALUMINUM POWDER	5-6017 and 04-511

This shipment is LAT samples weighing 20 pounds net and 30 pounds gross weight.
Eight of the ten pressures @ -65°F and +165°F exeed the 0.50 in/sec strand burning rate maximum limit
DESCRIPTION SHEET FOR NOSIH-AA-6 SAMPLES ONLY

THIS MATERIAL MEETS ALL REQUIREMENTS OF AS-3028C dated November 3, 2004, with RFD RAD-04-03D WITH THE EXCEPTION OF SBRs and SBR RANGE

SIGNATURE OF CONTRACTOR'S REPRESENTATIVE

SIGNATURE OF AAE LLC QUALITY ASSURANCE REPRESENTATIVE

Mike Kirkner Quality Assurance Engineer

ARRCOM FORM 214R 10 AUG 77

JATO Bottle Propellant

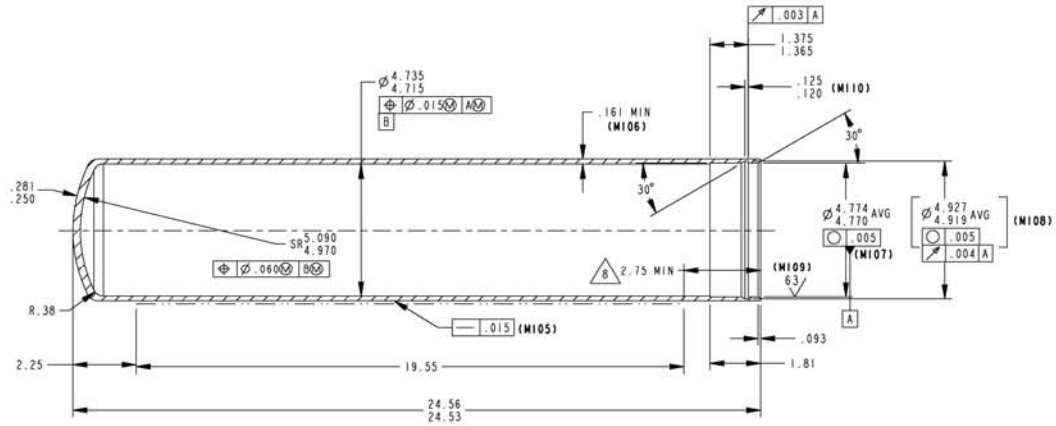
- **Depicts solid fuel propellant prior to placement in JATO bottle**

JATO Bottle Casing

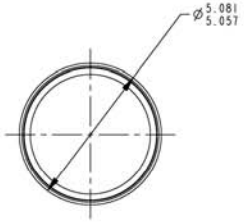
- **Composed of painted 4130 carbon steel**

REVISIONS			
REV	DESCRIPTION	DATE	APPROVAL
A	SEE ECP 1H87071.1	8/24/87	MEY
C	SEE ECP 1H90094	4/22/91	MEY
E	SEE ECP 1H93009	18JUN93	JCN
F	SEE ECP 1H95023	7JUN95	D.J.S.
G	REDRAWN WITH CHANGE SEE ECP 1H02003, 1H02003.1 R1	6/10/02	REK
H	SEE ECP 1H08007	11/28/07	[illegible]

CAD MAINTAINED. CHANGES SHALL BE INCORPORATED BY THE DESIGN ACTIVITY.



SECTION A-A

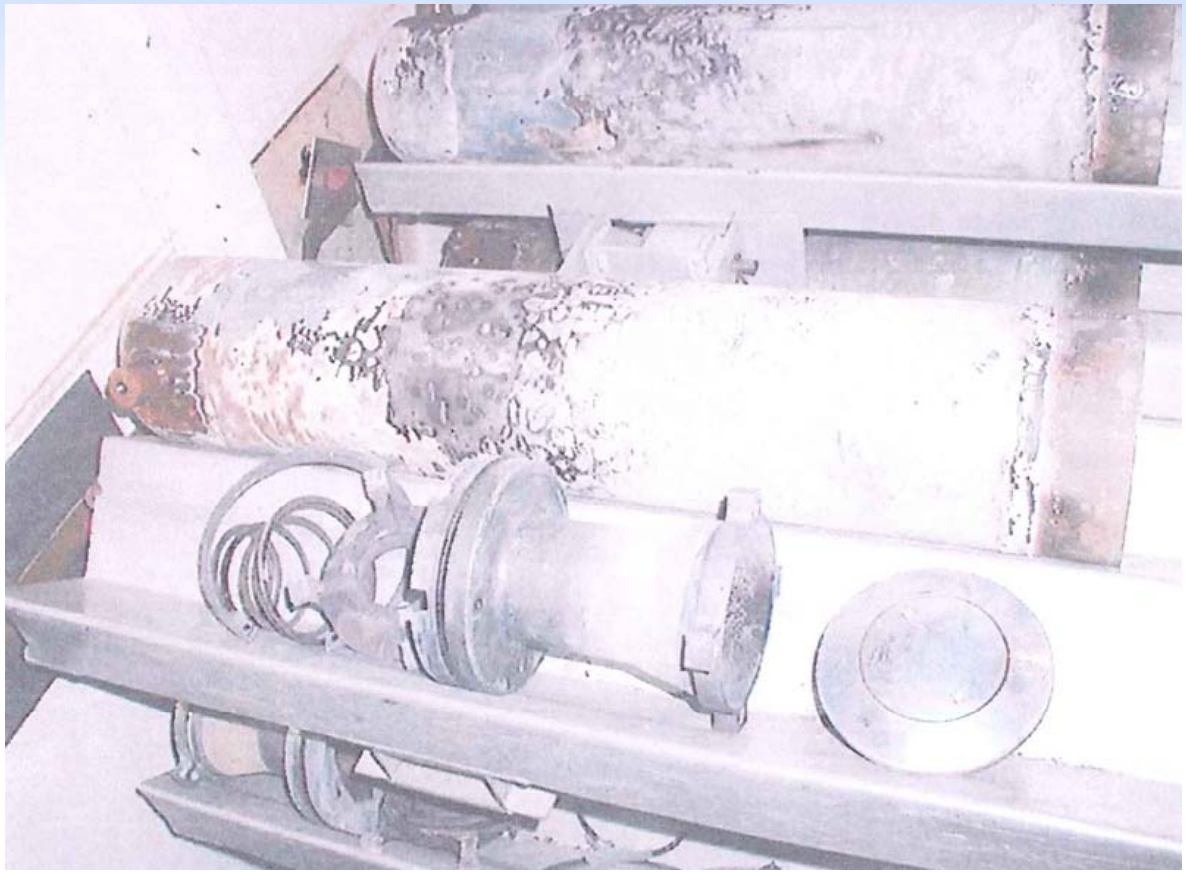


SIZE	CAGE CODE	DRAWING NUMBER
D	30003	1506AS106
SCALE: 0.500		SHEET 2 OF 2

Used JATO Bottle Casing

Recovered JATO bottle casing

- **Tubes recovered and tested for explosives and hazardous constituents indicate "items are completely decontaminated and entirely safe and may be released for general use AND the item was never exposed to hazardous contaminants and may be released for general use."**



Source: Explosives Decontamination Tag for Used JATO tube

Modeling of JATO Bottle Location

- **Engineers at NAVSEA (DOD Energetics) provided analysis of where JATO bottles should be located.**
- **Results are shown in table below:**

Launch Altitude ft	Range ft	Lat Offset ft
0	3381	-16
25	3434	-16.2
50	3484	-16.4
75	3532	-16.6
100	3580	-16.9
200	3755	-17.8

Approximate distances from launch pads of JATO Bottle Locations

Conclusions

- JATO bottle propellant reaches temperatures of 4,403°F during propulsion.
- No material remains after burn within steel chamber.
- Recovered tubes tested by Navy explosives experts indicate used tubes are completely decontaminated.
- Steel casing drops after 1.3 seconds at horizontal distances ranging from 3,400 feet to 3,800 feet from take-off location.

ENCLOSURE(3)

NOSIH-AA-6

DOT-ICC Classification	Class B	Manufacturer	Radford AAP and Badger AAP
Military Storage Classification	Class 2	Type	NC-NG/Al
Established temperature range	-65 to 165°F	Density at 77°F	0.0581 lbm/in.^{3}
Pressure range at 77°F	1200 to 2800 psia	Flame temperature at 1000 psia	4403°F
Related burning rate range	0.42 to 0.88 in./sec	I^o_{sps}	234.4 lbf-sec/lbm
r at 1500 psia and 77°F	0.58 in./sec	Storage life at 77°F	years
Tensile modulus at 77°F	10,124 psi	Usage	Zuni Mk 71 Mod 1
Ultimate elongation at 77°F	23.7%		

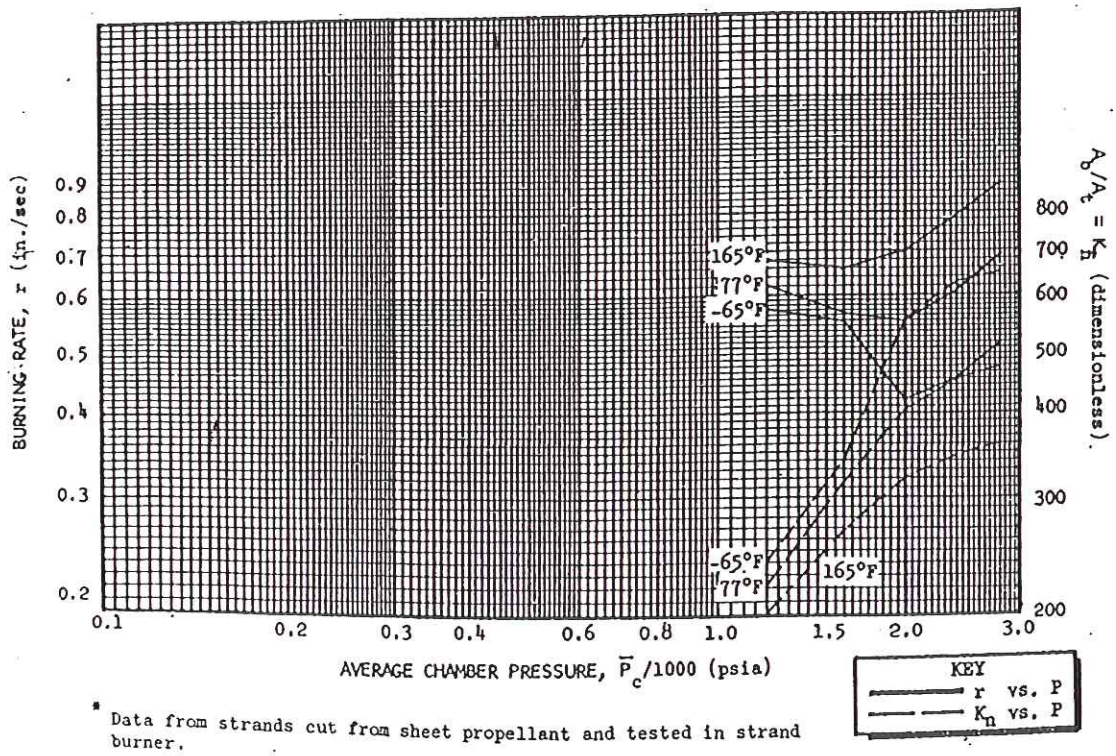
Everything Burns

PROPELLANT COMPOSITION

CONSTITUENT	TRADE NAME, ETC.	SOURCE	FUNCTION	NOMINAL WT%
Nitrocellulose (12.2%N)	MIL-N-244 Grade A, Type 1	--	binder-fuel	24.50
Nitrocellulose (12.6%N)	MIL-N-244 Grade D	--	binder-fuel	24.50
Nitroglycerine	MIL-N-246	--	oxidizer-plasticizer	38.80
Aluminum	Alcoa 123	Aluminum Company of America	resonance suppressant-fuel	1.50
Triacetin	MIL-T-301	--	plasticizer	3.25
2-Nitrodiphenylamine	2-NDPA; MIL-N-3399	--	stabilizer	2.00
Di-n-propyl adipate	MIL-D-22346	--	plasticizer	2.00
Lead salicylate	MIL-L-17700	--	b.r. modifier	1.50
Monobasic cupric salicylate	AS 3236	National Lead	b.r. modifier	1.50
Lead β-resorcylate	AS 2853, Type II	National Lead	b.r. modifier	0.30
Carbon black	Raven 15, MIL-C-306	--	opacifier	0.05
Candelilla wax	JAN-W-181	--	extrusion aid	0.10

Decompose quickly

BURNING CHARACTERISTICS*



* Data from strands cut from sheet propellant and tested in strand burner.

NOSIH-AA-6

BALLISTIC PROPERTIES

Equation of propellant burning rate as a function of pressure: $r = aP^n$

a	n				
1.472	-0.13	for propellant at	77°F from P =	1600 psia to	2000 psia
0.018	0.45	for propellant at	77°F from P =	2000 psia to	2400 psia
0.0013	0.79	for propellant at	77°F from P =	2400 psia to	2800 psia

π_K = 0.09%/°F at K_n = 300 for $\bar{P}$ = 1500 psia from -65°F to 165°F
= 0.16%/°F at K_n = 350 for $\bar{P}$ = 1700 psia from -65°F to 165°F

σ_P = 0.09%/°F at P = 1500 psia for $\bar{r}$ = 0.575in./sec from -65°F to 165°F
= 0.10%/°F at P = 1700 psia for $\bar{r}$ = 0.557in./sec from -65°F to 165°F

	$\bar{P}_c$	P_{amb}	ε	α	Assumptions	Value
I^o_{sp}	1000	14.7	optimum	0°	frozen composition	231.7 lbf-sec/lbm
I^o_{sps}	1000	14.7	optimum	0°	equilibrium composition	234.4 lbf-sec/lbm
I_{spd}	1430	14.7	3.44	7°16'	Zuni Mx 71 Mod 1; m_p = 44.81 lbm	215.5 lbf-sec/lbm
I_{sps}						lbf-sec/lbm
c^*	1000	14.7	optimum	0°		4755 ft/sec

THERMODYNAMIC PROPERTIES

	Calculated	Experimental
Propellant heat of explosion, ΔH_{ex} (cal/gm)	-1030	-1045
Propellant heat of formation, $\Delta H_{f(298)}$ (cal/gm)	-551.9	NA

Empirical formula (gm-atoms/100 gm): $C_{2.0621}H_{2.8337}O_{3.5074}N_{0.9648}Al_{0.0556}Cu_{0.0069}Pb_{0.0039}$

Exhaust gas composition; equilibrium expansion from 1000 to 14.7 psia; units of *moles/100 gm:*

COMPONENT	CHAMBER	EXIT EQUIL. COMPN.	COMPONENT	CHAMBER	EXIT EQUIL. COMPN.
CO_2	0.4464	0.7200	Al_2O_3	0.0278	0.0278
CO	1.6157	1.3420	Cu	0.0069	0.0069
H_2O	0.9098	0.6419	HO	0.0047	
H	0.0097		NO	0.0004	
H_2	0.4998	0.7750	Pb	0.0034	0.0039
N_2	0.4822	0.4824	PbO	0.0005	

	CHAMBER	FROZEN EXIT COMPN.	EQUILIBRIUM EXIT COMPN.
Pressure, P (psia)	1000	14.70	14.70
Temperature, T (°K)	2701		1247
Temperature, T (°F)	4403		1786
Mean heat capacity of products, $\bar{c}_p$ (cal/gm-°K)	0.425	0.425	0.382
Mean heat capacity of gases, $\bar{c}_p$ (cal/gm-°K)			
Mean molecular wt of products, $\bar{M}_p$ (gm/gm-mole)	24.95	24.95	25.04
Mean molecular wt of gases, $\bar{M}_g$ (gm/gm-mole)	25.126	25.126	25.221
Combustion gas specific heat ratio, γ	1.2284	1.2284	1.2599

NOSIH-AA-6

MECHANICAL AND PHYSICAL PROPERTIES

Uniaxial tensile properties; procedure reference:

Specimen fabrication process: die cut from 0.080-in. sheet.
Specimen shape and retention technique: ASTM D412 Die A, 3.2-in. gage length; ASTM D638 retention
Propellant cured for hrs at °F; conditioned for 2 hrs at %RH and test temp ± 2°F
Elongation rate 3.2 in./min; effective gage length 3.2 in.; tester type: Instron

T, °F	E, psi	σ_m, psi	ε_m, %	σ_b, psi	ε_b, %
165	1,503	194	28.0	194	28.0
140	3,715	199	30.2	199	30.2
100	6,019	554	29.8	554	29.8
77	10,124	832	23.7	832	23.7
0	60,231	2936	7.7	2936	7.7
-20	73,871	3862	6.0	3862	6.0
-40	110,864	4941	4.6	4941	4.6
-65	171,580	3732	2.2	3732	2.2

Propellant density, ρ_p, at 77°F	0.0581 lbm/in.^{3}
*Coefficient of linear thermal expansion, α, from -40 to 77°F	6.6×10^{-5} in./in.-°F
*Coefficient of linear thermal expansion, α, from 77 to 140°F	7.4×10^{-5} in./in.-°F
**Coefficient of linear thermal expansion, α, from -40 to 77°F	12.0×10^{-5} in./in.-°F
**Coefficient of linear thermal expansion, α, from 77 to 140°F	11.5×10^{-5} in./in.-°F
Glass transition temperature, T_g	°F
Poisson's ratio, ν	

* parallel to extrusion direction
** perpendicular to extrusion direction

SENSITIVITY AND STABILITY

DOT-ICC Shipping Classification	Class B
Military Storage Hazard Classification	Class 2
Impact sensitivity with 5 kg weight; no fire	17.5 cm
with kg weight; 50% fire	cm
tester type: ABL-type tooling; metal-to-metal flat surfaces	
Autoignition temperature for a 2.0 gm sample ignited in 38.5 minutes	284 °F
for a gm sample ignited in seconds	°F
test equipment and heating method: DTA	
NOL card gap; no fire at 77°F	50 cards
50% fire	cards

Taliani test at 110°C: 0.66 to 0.69 mm Hg/minute at 100 mm Hg pressure

No. 8 blasting cap test: negative in 5 trials

Ignition and unconfined burning test: negative; sample burned 20 sec

Friction: 960 lbf at 77 and 140°F in ABL sliding friction

Electrostatic discharge: 12.5 joules at 77°F and 5000 volts dc

NOSIH-AA-6

MANUFACTURING

Sequence of operations: Nitrocellulose, nitroglycerine, and part of the inert plasticizer are slurried in water as a pre-mix. All other ingredients except water-reactive ingredients are added to pre-mix; centrifuging and air drying reduce moisture content to about 10 percent, at which time the water-reactive ingredients are blended. Standard solventless propellant procedures are used in rolling and extrusion.

Cost of raw mix-ready ingredients (no processing). . . . . .$0.32 per lbm propellant
Approximate total production to date . . . . . .2,000,000 lbm propellant

Mixer type		End-of-mix viscosity		N-sec/m^2
Mix temperature	°F	Pot life		hours
Mix pressure	psia	Optimum cure temperature		°F
Deaeration method		Cure time		hours
Casting method		Cure atmosphere	at	psia

STATUS AND REFERENCES

This propellant is/was used in: Zuni, 5.0-Inch Rocket Motor Mark 71 Mod 1

1. CPIA/M2 Questionnaire from U.S. Naval Ordnance Station, Indian Head, Maryland, completed by Mr. Anthony Mycka, Jr., January 1973.

2. AS 3028, Purchase Description, Propellant, Double-Base, NOSIH-AA-6, 17 Apr 1972.

3. Telecon Anthony Mycka, Jr., U. S. Naval Ordnance Station, Indian Head, Maryland, 31 May 1973.

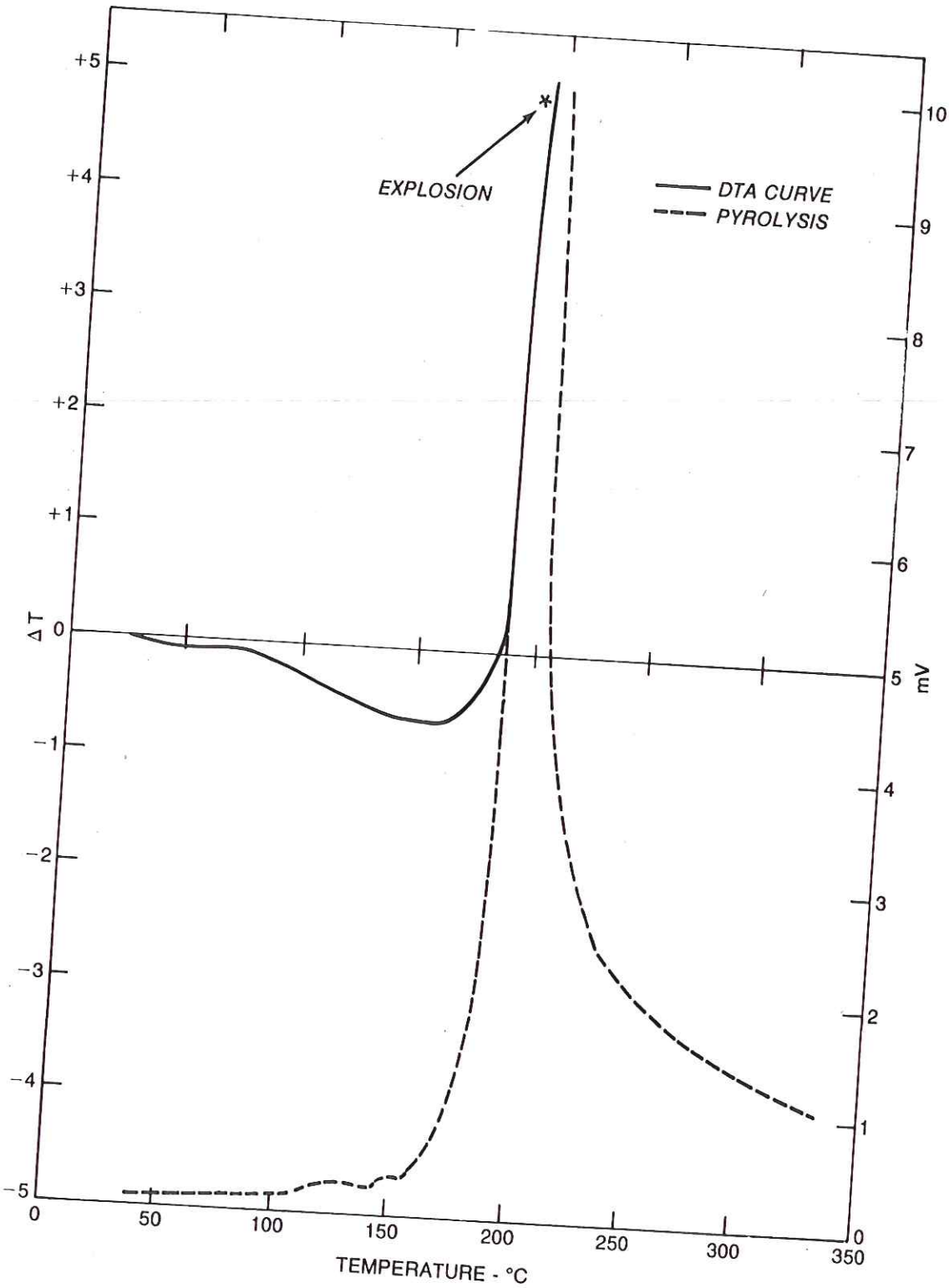


Figure 8-5. DTA curve for nitrocellulose.

Mk 117 MoD 0 JATO Rocket Motor
Propellant Description Sheet

PROPELLANT DESCRIPTION SHEET

REPORTS CONTROL SYMBOL
EXEMPT-PARA-7-2a
AR 335-15

COMPOSITION PROPELLANT, NOSIH AA-6 CARPET ROLL	DA LOT NUMBER RAD06D009S003
SPECIFICATION AS-3028C dated November 3, 2004 and RFD RAD04-03D	PACKED AMOUNT 20 Pounds
MFG. AT RADFORD ARMY AMMUNITION PLANT, RADFORD, VA	CONTRACT NUMBER N00174-05-C-0025

ACCEPTED BLEND NUMBERS

BG60022, 60023, 60024, 60025, 60026

PRODUCED WITH A BLEND OF HIGH/LOW VISCOSITY GLUCKSTADT LINTERS.

NITROCELLULOSE

	NITROGEN CONTENT		KI STARCH (65.5°C)	STABILITY (134.5°C)
MAX	12.45	%	45 MINS	30 MINS.
MIN	12.38	%	40 MINS	30 MINS.
AVG.	12.42	%	44 MINS	30 MINS.

TEMPERATURES °F FROM	TO	MANUFACTURE OF SOLVENTLESS PROPELLANT	SECONDS FROM	TO
206°F	210°F	PREROLLING	180 SEC	
148°F	152°F	EVENSPEED ROLLING	5 MIN	

Propellant mfg. by slurry mix process.

PROPELLANT COMPOSITION* CONSTITUENT	TESTS OF FINISHED PROPELLANT PERCENT FORMULA	PERCENT TOLERANCE	PERCENT MEASURED
NITROCELLULOSE **	49.00	NOM.	47.5
NITROGLYCERIN	38.80	NOM.	39.17
TRIACETIN	3.25	NOM.	3.45
DI-N-PROPYL-ADIPATE	2.00	NOM.	2.33
2-NITRODIPHENYLAMINE	2.00	1.80 MIN	1.86
LC-12-15	3.30	NOM.	3.71
CANDELILLA WAX	0.1	NOM.	0.07
CARBON BLACK	0.05	NOM.	0.03
ALUMINUM	1.50	NOM.	1.84
TOTAL	100.00		100.00
MOISTURE	0.60	MAX	0.31

*MOISTURE FREE BASIS
**NITROCELLULOSE DETERMINED BY DIFFERENCE

STABILITY AND PHYSICAL TESTS

TALIANI SLOPE 0.3665 (mmHg/min) at 100 MIN.
Taliani requirement 1.1 mm Hg/min max at 100 minutes

TEMP. °F	AVG. CROSSWISE MAX STRESS psi	STRAIN	AVG. LENGTHWISE MAX STRESS psi	STRAIN
-65°F	5245.02	0.07	4547.4	0.095
77°F	586.85	0.360	783.7	0.254
165°F	157.5	0.416	242.6	0.265

SPEC FOR TENSILES AT 77°F- LENGTHWISE ONLY
STRESS 630 lbs/sq in MINIMUM
STRAIN 0.180 MINIMUM

TENSILE INFORMATION AT -65°F AND 165°F IS FOR INFORMATION ONLY

STRAND BURNING RATE AND HEAT OF EXPLOSION

TEMP °F	700psi	900psi	1200psi	1600 psi	2000 psi	2400 psi	2800 psi
-65°F (MINIMUM)	—	—	0.660	0.620	0.420	0.440	0.490
-65°F	0.465	0.630	0.673	0.684	0.641	0.433	0.632
165°F(MAXIMUM)	—	—	0.700	0.700	0.760	0.800	0.900
165°F	0.640	0.637	0.703	0.694	0.771	0.788	0.861

Average range = 0.079 in/sec falls requirement of 0.050 in/sec max
Strand burn rates at 700 and 900 psi are for information only

HEAT OF EXPLOSION (cal/gm.): AVG.: 1037 STD. DEVIATION: 2.69

PROPELLANT DIMENSIONS (inches)
N/A

DATES
PACKED 6/10/2006
SAMPLED 6/10/2006
TEST FINISHED 7/11/2006
OFFERED 7/21/2006
DESCRIPTION SHEETS FORWARDED

TYPE OF PACKING CONTAINER LEVER PACK DRUM

REMARKS

MODIFER	LOT
LC-12-15	1035967
ALUMINUM POWDER	5-6017 and 04-511

This shipment is LAT samples weighing 20 pounds net and 30 pounds gross weight.
Eight of the ten pressures @ -65°F and +165°F exeed the 0.50 in/sec strand burning rate maximum limit
DESCRIPTION SHEET FOR NOSIH-AA-6 SAMPLES ONLY

THIS MATERIAL MEETS ALL REQUIREMENTS OF AS-3028C dated November 3, 2004, with RFD RAD-04-03D WITH THE EXCEPTION OF SBRs anf SBR RANGE

SIGNATURE OF CONTRACTOR'S REPRESENTATIVE

SIGNATURE OF AAE LLC QUALITY ASSURANCE REPRESENTATIVE
Mike Kirkner Quality Assurance Engineer

ARRCOM FORM 214R 10 AUG 77

nitroCELLULOSE
a clear market leader

Product Safety Data Sheet Revision (Nov 2000)

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY

PRODUCT: **Industrial Nitrocellulose wetted with alcohol (UN2556) or water (UN2555)**

MANUFACTURER: Nobel Enterprises
ADDRESS: Ardeer Site
Stevenston
Ayrshire
Scotland KA20 3LN
Telephone: +44 (0)1294 487000
Facsimile: +44 (0)1294 487111

Emergency Telephone Number (24Hour):+44 (0)1294 461000

2. COMPOSITION/INFORMATION ON INGREDIENTS

	%	CAS No	Index No
Nitrocellulose (cellulose nitrate) (<12.3 % N)	65-75	9004-70-0	603-037-01-3
With **Ethyl alcohol**	25-35	64-17- 5	603-002-00-5
or **Isopropyl alcohol**	25-35	67-63-0	603-117-00-0
or **Water**	25-35	7732 -18 - 5	-

	Hazard Symbol	R Phases	S Phases
Nitrocellulose (cellulose nitrate) (<12.3 % N)	F	R11	S 16, 33, 37/39
Ethyl alcohol	F	R11	S 7, 16
Isopropyl alcohol	F, Xi	R11, 36, 67	S 7, 16, 24/25, 26

3. HAZARDS IDENTIFICATION

Nitrocellulose can be ignited by flame, heat, shock, impact, friction, sparks or static electricity.

The wetting agent may cause eye, skin and respiratory tract irritation; overexposure to vapour may produce dizziness, drowsiness or even unconsciousness.

Burning nitrocellulose will produce toxic fumes.

4. FIRST-AID MEASURES

Inhalation of Vapour & Materials of Combustion:	Remove to fresh air. If not breathing, give artificial respiration.

	If breathing is difficult, give oxygen. Call a physician.
Skin Contact:	Immediately flush skin with plenty of water. Remove contaminated clothing. Call a physician if irritation persists. Wash clothing before reuse.
Eye Contact:	Immediately flush eyes with an eye-wash-solution or plenty of water, holding the eyelids apart, for at least 10 minutes. Call a physician.
Ingestions:	Do not induce vomiting. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.

5. FIRE-FIGHTING MEASURES

Burning nitrocellulose can **only** be extinguished by large quantities of water applied as mist or spray.

Drum lids can be blown off.

Fumes emitted from burning nitrocellulose may contain toxic nitrous gases.

Fire-fighters must work from the windward side and should be equipped with self-contained breathing apparatus to protect against potentially toxic and irritating fumes.

After the fire is extinguished material may be unstable and could re-ignite by itself. Therefore ensure residual material is thoroughly wetted.

6. ACCIDENTAL RELEASE MEASURES (SPILLAGES)

Remove sources of ignition. No smoking!

Ensure sufficient ventilation or fresh air.

Avoid contact with eyes or skin.

Avoid inhalation of vapours.

Wear suitable protective equipment/clothing. Check with the PPE manufacturer.

Tools used with nitrocellulose should be non-ferrous materials such as copper or brass or wood i.e. non-sparking.

Spilled nitrocellulose must be thoroughly wetted with plenty of water, swept up carefully and kept in tightly closed watertight container.

Prevent spilled nitrocellulose from contaminating water courses, sewers, soil or vegetation.

7. HANDLING & STORAGE

Handling

Do not drop, slide, roll or bang the drums.

Keep away from flame, heat, shock, impact, friction, sparks or static electricity.

Do not allow wetted nitrocellulose to dry out.

Ensure adequate ventilation.

Pull polyethylene liner, if present, carefully down over the outside of the container. Ensure package is completely grounded/earthed during emptying.

Tools used with nitrocellulose should be of non-ferrous materials such as copper, brass or wood. Tools made of plastic material must not be used because of their tendency to produce static electricity.

Avoid contact with strong alkaline and acidic materials, amines or oxidising agents.

Keep quantity of product in the processing area to a minimum. This would not be expected to exceed the amount necessary for one shift.

Storage

Store in a cool and well ventilated place appropriate to the packaging material. Keep in original containers. Maximum recommended continuous storage temperature is 40° C.

Keep away from heat including direct sunlight, flame or any source of ignition.

Pallet loads should be stacked no more than **two** high.

Nitrocellulose is not to be stored together with incompatible materials for instance strong alkaline and acidic materials, amines or oxidising agents.

Rotate inventory on a "First in/first out" basis.

The recommended shelf life of two years from month of manufacture, for unopened packages, should not be exceeded.

Once a package has been opened, the entire contents should be used as quickly as possible.

Do not open or empty containers within the storage area.

The storage should be in accordance with national state and local environmental regulations.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Limits:

	Long Term Exposure Limit (8 hour TWA) mgm $^{-3}$	Short Term Exposure Limit (15 min ref) mgm $^{-3}$
Ethyl alcohol	1920	-
Isopropyl alcohol	999	1250

Concentration of solvent in the workplace atmosphere should be monitored. Ensure good ventilation or use local exhaust to maintain ambient vapour concentrations below the exposure limits.

Employee Protection Recommendations:

Respiratory protection: - Where suitable engineering controls are not fitted or are inadequate wear suitable respiration equipment e.g. an approved organic vapour respirator.

Hand protection: - Wear antistatic/solvent resistant gloves.

Eye protection: - Protective goggles and/or full face shield.

Skin protection: - Non-flammable, antistatic protective clothing antistatic protective shoes.

Check with PPE manufacture

9. PHYSICAL AND CHEMICAL PROPERTIES

Form:	granular/chip
Colour:	white
Odour:	of wetting alcohols

Bulk density:	500-600 Kg/m^3
Specific Gravity	1.4 (Solvent Damped) 1.66 (Dried Chip)
Vapour pressure of the wetting alcohol at 20°C	ethanol = 58.1 mbar isopropanol = 41.6 mbar
Viscosity:	not applicable
Solubility in water:	NC is soluble in esters, ketones and glycol ethers. Alcohols are completely miscible with water.
Flash point of the wetting agent (Abel-Pensky)	ethanol = 12°C isopropanol = 12° C

Explosion limits (of wetting alcohol):

	lower limit	upper limit
ethanol	3.5 % -vol	15.0 %-vol
isopropanol	2.0 % -vol	12.0 %-vol

Decomposition temperature:	higher than 180°C

10. STABILITY AND REACTIVITY

Stability:	Stable under recommended storage and handling conditions.
Conditions to Avoid:	Avoid exposure to heat, shock and friction. Stability decreases and deterioration starts with increasing temperatures. Observe recommended storage conditions.
Materials to Avoid:	Nitrocellulose decomposes when in contact with strong alkaline and acidic materials, amines or oxidising agents.
Hazardous Decomposition Products	CO, CO_2, oxides of nitrogen and other potentially toxic fumes.

11. TOXICITY DATA

Nitrocellulose has been in use for many years with no evidence of adverse effects. The toxicity is dependant on the wetting agent.

	Ethanol	Isopropanol	Nitrocellulose
Oral LD50, Rat	6200	5045	> 5000 mg/kg
Inhalation LD50, Rat	> 8000 mg/l	16,000 ppm 8hr	-
Dermal Rabbit	> 20000	12800 mg/kg	-
Eye Contact	Irritant	Irritant	Not Irritating
Skin Contact	Not Irritating	Irritant	Not Irritating

12. ECOLOGY DATA

There is no evidence to suggest that nitrocellulose has any detrimental effect on the environment.
See data below for details of wetting agent environmental toxicity.

		Ethanol	Isopropanol	Nitrocellulose
1.	Fish toxicity LC50 96 hr (Fathead minnow)	13480	10400 mg/l	>10,000 mg/l

2.	Bacteria toxicity EC50	6500	1,050 mg/l	>1000 mg/l
3.	Chemical oxygen demand (COD)	2.0	2.22 mg/mg	-
4.	Biochemical oxygen demand (BOD_5)	1.46	1.72 mg/l	-
5.	Degradability	94%	99.0%	Resistant to degradation
6.	Water pollution class (WGK)	1	1	Not Hazardous
7.	Bioaccumulation	Low	Low	Nil
8.	Log (Pow)	-0.32	0.05	-

13. DISPOSAL CONSIDERATIONS

Product disposal

It is recommended that small quantities of nitrocellulose should be dissolved prior to destruction as waste NC-lacquer.

Alternatively destroy by burning small quantities outside at a safe place in an open fire under competent control. Ignite remotely.

Waste disposal should be in accordance with national, state and local environmental regulations.

Container disposal

Empty container retains hazardous residue. Observe all label precautions. Keep away from heat, sparks and flames. Do not weld or use cutting torch on or near container.

Do not distribute, make available, furnish or reuse empty container except for storage and shipment of original product.

Remove all hazardous residue from container eg. Wiping with damp rag: cleaning should include inside of lid and closure ring. (Dispose of rag as for spilled nitrocellulose).

Remove or erase all labels. Then offer container for recycling/reconditioning or puncture or otherwise destroy empty container and dispose of in facility permitted for non hazardous waste.

14. TRANSPORTATION

Proper Shipping Name	UN No	Packing Groups	Hazard Class
Nitrocellulose with alcohol	2556	II	4.1
Nitrocellulose with water	2555	II	4.1

ADR

Proper Shipping Name	Substance Identification No	Hazzard Class	Item No
Nitrocellulose with alcohol	2556	4.1	24°(b)
Nitrocellulose with water	2555	4.1	24°(b)

IATA/IMDG

Proper Shipping Name	UN No	Packing Groups	Hazard Class	Marine Pollutant
Nitrocellulose with alcohol	2556	II	4.1	No

Nitrocellulose with water	2555	II	4.1	No

15. REGULATORY INFORMATION

ETHANOL AND WATER WET

EEC Classification:	Flammable
Hazard Symbol:	F
Risk Phrases:	R11 Highly Flammable
Safety Phrases:	S7 Keep Container tightly closed S16 Keep Away from Sources of Ignition - No Smoking. S33 Take Precautionary Measures Against Static Discharge. S37/39 Wear Suitable Gloves and Eye/Face Protection.

ISOPROPANOL WET

EEC Classification:	Flammable, irritant
Hazard Symbol:	F, Xi
Risk Phrases:	R11 Highly Flammable R36 Irritating to eyes R67 Vapours may cause drowsiness and dizziness
Safety Phrases:	S7 Keep Container tightly closed S16 Keep Away from Sources of Ignition - No Smoking. S24/25 Avoid contact with skin and eyes S26 In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice S33 Take Precautionary Measures Against Static Discharge. S37/39 Wear Suitable Gloves and Eye/Face Protection.

16. OTHER INFORMATION

This datasheet was last revised in November 2000.

This Data Sheet was prepared in accordance with the Chemicals (Hazard Information and Packaging for Supply) Regulations (Chip 2 as amended).

The technical information provided in this safety data sheet should only be used for the purposes of assessing hazards with respect to safety or the environment. It should not be used as a technical specification or for engineering calculations.

Information in this document is believed to be accurate and is given in good faith but it is for the customer to satisfy itself of the suitability for its own particular purpose. The information provided is intended to describe the product for the purposes of health, safety and environmental requirements only. It is not intended, and should not be construed as a warranty. ICI Nobel Enterprises should be consulted for further information.

Return to Brochure.

IHD Form 2271 (Rev. 09/25/09) Do not use previous editions

EXPLOSIVES DECONTAMINATION TAG

THIS TAG IS VOID IF ALTERED, MODIFIED IN ANY WAY, OR ATTACHMENT SEAL IS BROKEN. REMOVE TAG AND KEEP FOR YOUR RECORD BEFORE USING ITEM. FILL OUT STUB AND SEND TO INSTALLATION/ACTIVITY SAFETY OFFICE.

COMPLETE INSTRUCTIONS FOR THE USE OF THIS FORM ARE LOCATED IN STANDARD OPERATING PROCEDURE #500-005.

NAME OF INSTALLATION/ ACTIVITY	DECONTAMINATION TAG SERIAL NUMBER	REPLACES TAG SERIAL NO.
Indian Head Division Naval Surface Warfare Center Indian Head, MD 20640		ARE SEALED CAVITIES PRESENT? Yes ☐ No ☐
DEGREE OF DECONTAMINATION *(Letter(s) not crossed out indicate degree)* X X X X X O		DATE DECONTAMINATED (YYMMDD)

DESCRIPTION OF ITEM:

ITEM USED FOR	NAME OF CONTAMINANT	NET EXPLOSIVE WEIGHT PRESENT

ITEM SERIAL/MODEL NUMBER: BUILDING NUMBER OR AREA:	ITEM TAGGED AT Indian Head Division, Naval Surface Warfare Center 101 Strauss Avenue, Indian Head, MD 20640

REASON FOR DECONTAMINATION

☐ REPAIR IN PLACE ☐ TRANSFER TO_____ FOR _____

If item is being transferred to the invasive or waste processor (IWP) for processing, treatment, clearance, indicate [illegible] initials at the "safe for IWP" certification statement.

☐OTHER (explain)

DECONTAMINATION PROCEDURE USED	DECONTAMINATION PROCEDURE USED SPECIFIED IN STANDARD OPERATING PROCEDURE (SOP):
☐ HOT WATER ☐ FLAME: TEMP: _____ ☐ STEAM ☐ OVEN: HOURS: _____ ☐ SOLVENT: TYPE: _____ ☐ Other _____	

SPECIFIC INSTRUCTIONS/ADDITIONAL INFORMATION: The degree of decontamination specified on this form pertains only to explosive hazard as defined by NAVSEA OP-5. Other hazards or hazardous materials may remain.

SIGNATURE(S) (authorized personnel sign above their printed name, code and phone number)

CERTIFIER (Approved by Command)	DATE (*YYMMDD*)
VERIFIER (Approved by Command)	DATE (*YYMMDD*)

Certification Statements: Authorized personnel will initial appropriate statement box to certify and / or verify the decontamination level.

☐ This certifies and verifies that the ammunition, explosives, and dangerous articles (AEDA) residue, range residue and/or explosively contaminated property listed has been 100 percent properly inspected by us and to the best of our knowledge and belief, are inert and/or free of explosives or related materials. (5X and 0)	☐ This certifies that the material potentially presenting an explosive hazard listed has been 100 percent [illegible] and to the best of our knowledge [illegible] (1X and 3X)

☐ SAFE FOR IWP [illegible]

NAME OF INSTALLATION/ACTIVITY	SERIAL NO.
Indian Head Division, Naval Surface Warfare Center 101 Strauss Ave Indian Head, MD 20640	
NAME OF PERSON REMOVING TAG (Last, First, MI)	DATE (*YYMMDD*)

REASON TAG REMOVED

☐ ITEM BEING USED

☐ OTHER (explain)

☐ TAG REPLACED BY TAG NO. _____

DD Form 2271

EXPLANATION OF DEGREE OF CONTAMINATION CODES

X	- ITEM PARTIALLY DECONTAMINATED. MARKING TEMPORARY, TO BE FOLLOWED BY FURTHER DECONTAMINATION PROCESS.
XXX	- ITEM EXAMINED AND CLEANED BY APPROVED PROCEDURES AND NO CONTAMINATION VISIBLE. DO NOT USE OPEN FLAME, HIGH TEMPERATURE HEATING DEVICES, CUTTING DEVICES, OR HAMMERING DEVICES ON THIS ITEM.
XXXXX	- ITEM COMPLETELY DECONTAMINATED AND IS ENTIRELY SAFE AND MAY BE RELEASED OR GENERAL USE.
O	- ITEM NEVER EXPOSED TO HAZARDOUS CONTAMINANTS AND MAY BE RELEASED FOR GENERAL USE.

MOVEMENT OF ITEM

X	- MOVEMENT NOT AUTHORIZED, EXCEPT BY APPROVED SOP.
XXX	- TRANSPORT ONLY IN APPROVED GOVERNMENT VEHICLES.
XXXXX OR O	- NO MOVEMENT RESTRICTION.

REPAIR, SERVICING, MODIFICATION OF ITEM

X	- REPAIR, SERVICING, OR MODIFICATION OF ITEM NOT AUTHORIZED.
XXX	- MAY BE WORKED ON IN ACCORDANCE WITH REQUIREMENTS OF A SAFETY PERMIT OR APPROVED SOP.
XXXXX OR O	- NO RESTRICTION ON REPAIR, SERVICING, OR MODIFICATION OF ITEM.

XXX, XXXXX, OR O - ITEMS SHALL NOT LEAVE CONTAMINANT AREA UNLESS YELLOW MARKINGS CORRESPONDING TO X'S OR O ARE PAINTED ON ITEM. HOWEVER, MARKINGS MAY BE OMITTED FROM ITEMS BEING REPAIRED, SERVICED, OR MODIFIED.

8000
Ser 5/ac
01 May 07

MEMORANDUM

From: Joseph D. Anderson, Code T27
To: Peter C. Henderson, Code T27PH

Subj: Designation as a Certifier and Verifier for Material Potentially Presenting an Explosive Hazard

Ref: (a) Memorandum Ser 4/ac dated 01 May 2007
(b) NAVSEA OP 5 paragraph 13-15.7
(c) DOD 4160.21-M, Defense Materiel Disposition Manual
(d) Memorandum Ser T27/38/ac dated 21 JUL 06

1. Peter C. Henderson is technically qualified to sign as a certifier and verifier for the explosive safety status of material potentially presenting an explosive hazard; reference (a) provides supporting documentation for this designation. As required by reference (b), you are hereby designated in writing as authorized to certify and verify the explosive safety status of material potentially presenting an explosive hazard.

2. In accordance with Chapter 4, paragraph B3.a (8)(a), reference (c) you are also authorized to certify and verify Ammunition, Explosives and Dangerous Articles (AEDA) items as inert prior to turn-in to the Defense Reutilization Marketing Office. To ensure authenticity of turn in documents the signature of Peter C. Henderson is provided below.

Name	Signature	Rank and Position
Peter C. Henderson	Peter C. Henderson	Team Leader, explosive decontamination group

3. In performance of this duty, this employee will attach a signed statement as part of the turn in document. The statement shall read as follows:

> "We certify and verify that the property listed hereon has been 100% inspected by us and, to the best of our knowledge and belief, is inert and free of explosives or other dangerous materials."

4. The authorization to designate Peter C. Henderson is provided in reference (d).

Joseph D. Anderson
JOSEPH D. ANDERSON

Copy to: T23C (Amy Sexton), SA1 (Kris Bigej), FISCN (Tom Prien), T27AC (Anne Caris)

5090
Ser T27/38/ac
21 Jul 06

MEMORANDUM

From: Commander, Indian Head Division-NSWC
To: Joseph D. Anderson, Code T27

Subj: DELEGATION OF AUTHORITY TO APPOINT CERTIFIERS AND VERIFIERS

Ref: (a) NAVSEA OP 5, Volume 1, Seventh Revision, Change 4

1. Reference (a) requires that personnel who are qualified and authorized to sign a certification of material potentially presenting an explosive hazard as safe or hazardous, will be so appointed in writing by the direction of the Commander. This memorandum delegates the Command Authority to appoint certifiers and verifiers to Joseph D. Anderson (Code T27).

2. Joseph D. Anderson serves as the Board Chairperson for the certification area that includes this discipline. He is the Engineering Manager for the decontamination specialty including the decontamination of facilities, equipment, vehicles and ordnance items in the Explosives Safety and Security Technical Authority pyramid established by the Navy Energetics Enterprise in support of the Naval Ordnance Safety and Security Activity. Mr. Anderson is highly qualified to perform the appointment of certifiers and verifiers and is designated to do so by direction of the Commander.

NEIL C. STUBITS

A LOT 009
12-2-02
#1
A LOT 009
12-2-02
#6
12-02-02
A1 LOT 009

APPENDIX B
USEPA REGION II GROUNDWATER SAMPLING PROCEDURE
LOW STRESS (Low Flow) PURGING AND SAMPLING

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II

GROUND WATER SAMPLING PROCEDURE
LOW STRESS (Low Flow) PURGING AND SAMPLING

I. SCOPE & APPLICATION

This Low Stress (or Low-Flow) Purging and Sampling Procedure is the EPA Region II standard method for collecting low stress (low flow) ground water samples from monitoring wells. Low stress Purging and Sampling results in collection of ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by minimizing stress on the geological formation and minimizing disturbance of sediment that has collected in the well. The procedure applies to monitoring wells that have an inner casing with a diameter of 2.0 inches or greater, and maximum screened intervals of ten feet unless multiple intervals are sampled. The procedure is appropriate for collection of ground water samples that will be analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and microbiological and other contaminants in association with all EPA programs.

This procedure does not address the collection of light or dense non-aqueous phase liquids (LNAPL or DNAPL) samples, and should be used for aqueous samples only. For sampling NAPLs, the reader is referred to the following EPA publications: DNAPL Site Evaluation (Cohen & Mercer, 1993) and the RCRA Ground-Water Monitoring: Draft Technical Guidance (EPA/530-R-93-001), and references therein.

II. METHOD SUMMARY

The purpose of the low stress purging and sampling procedure is to collect ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by setting the intake velocity of the sampling pump to a flow rate that limits drawdown inside the well casing.

Sampling at the prescribed (low) flow rate has three primary benefits. First, it minimizes disturbance of sediment in the bottom of the well, thereby producing a sample with low turbidity (i.e., low concentration of suspended particles). Typically, this saves time and analytical costs by eliminating the need for collecting and analyzing an additional filtered sample from the same well. Second, this procedure

minimizes aeration of the ground water during sample collection, which improves the sample quality for VOC analysis. Third, in most cases the procedure significantly reduces the volume of ground water purged from a well and the costs associated with its proper treatment and disposal.

III. ADDRESSING POTENTIAL PROBLEMS

Problems that may be encountered using this technique include a) difficulty in sampling wells with insufficient yield; b) failure of one or more key indicator parameters to stabilize; c) cascading of water and/or formation of air bubbles in the tubing; and d) cross-contamination between wells.

Insufficient Yield

Wells with insufficient yield (i.e., low recharge rate of the well) may dewater during purging. Care should be taken to avoid loss of pressure in the tubing line due to dewatering of the well below the level of the pump's intake. Purging should be interrupted before the water level in the well drops below the top of the pump, as this may induce cascading of the sand pack. Pumping the well dry should therefore be avoided to the extent possible in all cases. Sampling should commence as soon as the volume in the well has recovered sufficiently to allow collection of samples. Alternatively, ground water samples may be obtained with techniques designed for the unsaturated zone, such as lysimeters.

Failure to Stabilize Key Indicator Parameters

If one or more key indicator parameters fails to stabilize after 4 hours, one of three options should be considered: a) continue purging in an attempt to achieve stabilization; b) discontinue purging, do not collect samples, and document attempts to reach stabilization in the log book; c) discontinue purging, collect samples, and document attempts to reach stabilization in the log book; or d) Secure the well, purge and collect samples the next day (preferred). The key indicator parameter for samples to be analyzed for VOCs is dissolved oxygen. The key indicator parameter for all other samples is turbidity.

Cascading

To prevent cascading and/or air bubble formation in the tubing, care should be taken to ensure that the flow rate is sufficient to maintain pump suction. Minimize the length and diameter of tubing (i.e., 1/4

or 3/8 inch ID) to ensure that the tubing remains filled with ground water during sampling.

Cross-Contamination

To prevent cross-contamination between wells, it is strongly recommended that dedicated, in-place pumps be used. As an alternative, the potential for cross-contamination can be reduced by performing the more thorough "daily" decontamination procedures between sampling of each well in addition to the start of each sampling day (see Section VII, below).

Equipment Failure

Adequate equipment should be on-hand so that equipment failures do not adversely impact sampling activities.

IV. PLANNING DOCUMENTATION AND EQUIPMENT

- Approved site-specific Field Sampling Plan/Quality Assurance Project Plan (QAPP). This plan must specify the type of pump and other equipment to be used. The QAPP must also specify the depth to which the pump intake should be lowered in each well. Generally, the target depth will correspond to the mid-point of the most permeable zone in the screened interval. Borehole geologic and geophysical logs can be used to help select the most permeable zone. However, in some cases, other criteria may be used to select the target depth for the pump intake. In all cases, the target depth must be approved by the EPA hydrogeologist or EPA project scientist.

- Well construction data, location map, field data from last sampling event.

- Polyethylene sheeting.

- Flame Ionization Detector (FID) and Photo Ionization Detector (PID).

- Adjustable rate, positive displacement ground water sampling pump (e.g., centrifugal or bladder pumps constructed of stainless steel or Teflon). A peristaltic pump may only be used for inorganic sample collection.

- Interface probe or equivalent device for determining the presence or absence of NAPL.

- Teflon or Teflon-lined polyethylene tubing to collect samples for organic analysis. Teflon or Teflon-lined polyethylene, PVC, Tygon or polyethylene tubing to collect samples for inorganic analysis. Sufficient tubing of the appropriate material must be available so that each well has dedicated tubing.

- Water level measuring device, minimum 0.01 foot accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).

- Flow measurement supplies (e.g., graduated cylinder and stop watch or in-line flow meter).

- Power source (generator, nitrogen tank, etc.).
- Monitoring instruments for indicator parameters. Eh and dissolved oxygen must be monitored in-line using an instrument with a continuous readout display. Specific conductance, pH, and temperature may be monitored either in-line or using separate probes. A nephalometer is used to measure turbidity.

- Decontamination supplies (see Section VII, below).

- Logbook (see Section VIII, below).

- Sample bottles.

- Sample preservation supplies (as required by the analytical methods).

- Sample tags or labels, chain of custody.

V. SAMPLING PROCEDURES

Pre-Sampling Activities

1. Start at the well known or believed to have the least contaminated ground water and proceed systematically to the well with the most contaminated ground water. Check the well, the lock, and the locking cap for damage or evidence of tampering. Record observations.

2. Lay out sheet of polyethylene for placement of monitoring and sampling equipment.

3. Measure VOCs at the rim of the unopened well with a PID and FID instrument and record the reading in the field log book.

4. Remove well cap.

5. Measure VOCs at the rim of the opened well with a PID and an FID instrument and record the reading in the field log book.

6. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Note that the reference point should be surveyed for correction of ground water elevations to the mean geodesic datum (MSL).

7. Measure and record the depth to water (to 0.01 ft) in all wells to be sampled prior to purging. Care should be taken to minimize disturbance in the water column and dislodging of any particulate matter attached to the sides or settled at the bottom of the well.

8. If desired, measure and record the depth of any NAPLs using an interface probe. Care should be taken to minimize disturbance of any sediment that has accumulated at the bottom of the well. Record the observations in the log book. If LNAPLs and/or DNAPLs are detected, install the pump at this time, as described in step 9, below. Allow the well to sit for several days between the measurement or sampling of any DNAPLs and the low-stress purging and sampling of the ground water.

Sampling Procedures

9. Install Pump: Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified for that well in the EPA-approved QAPP or a depth otherwise approved by the EPA hydrogeologist or EPA project scientist. The pump intake must be kept at least two (2) feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Record the depth to which the pump is lowered.

10. Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

11. Purge Well: Start pumping the well at 200 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every five minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water

level (drawdown of 0.3 ft or less). Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. As noted above, care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

12. Monitor Indicator Parameters: During purging of the well, monitor and record the field indicator parameters (turbidity, temperature, specific conductance, pH, Eh, and DO) approximately every five minutes. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows (Puls and Barcelona, 1996):

    ±0.1 for pH
    ±3% for specific conductance (conductivity)
    ±10 mv for redox potential
    ±10% for DO and turbidity

    Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. The pump must not be removed from the well between purging and sampling.

13. Collect Samples: Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft. VOC samples must be collected first and directly into sample containers. All sample containers should be filled with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the container.

    Ground water samples to be analyzed for volatile organic compounds (VOCs) require pH adjustment. The appropriate EPA Program Guidance should be consulted to determine whether pH adjustment is necessary. If pH adjustment is necessary for VOC sample preservation, the amount of acid to be added to each sample vial prior to sampling should be determined, drop by drop, on a separate and equal volume of water (e.g., 40 ml). Ground water purged from the well prior to sampling can be used for this purpose.

14. Remove Pump and Tubing: After collection of the samples, the tubing, unless permanently installed, must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

15. Measure and record well depth.

16. Close and lock the well.

VI. FIELD QUALITY CONTROL SAMPLES

Quality control samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the ground water samples. The appropriate EPA Program Guidance should be consulted in preparing the field QC sample requirements of the site-specific QAPP.

All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples should be collected during the sampling event:

- Field duplicates
- Trip blanks for VOCs only
- Equipment blank (not necessary if equipment is dedicated to the well)

As noted above, ground water samples should be collected systematically from wells with the lowest level of contamination through to wells with highest level of contamination. The equipment blank should be collected after sampling from the most contaminated well.

VII. DECONTAMINATION

Non-disposable sampling equipment, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use ("daily decon") and after each well is sampled ("between-well decon"). Dedicated, in-place pumps and tubing must be thoroughly decontaminated using "daily decon" procedures (see #17, below) prior to their initial use. For centrifugal pumps, it is strongly recommended that non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with the sample, be decontaminated thoroughly each day before use ("daily decon").

EPA's field experience indicates that the life of centrifugal pumps may be extended by removing entrained grit. This also permits inspection and replacement of the cooling water in centrifugal pumps. All non-dedicated sampling equipment (pumps, tubing, etc.) must be

decontaminated after each well is sampled ("between-well decon," see #18 below).

17. **Daily Decon**

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Disassemble pump.

E) Wash pump parts: Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush.

F) Rinse pump parts with potable water.

G) Rinse the following pump parts with distilled/ deionized water: inlet screen, the shaft, the suction interconnector, the motor lead assembly, and the stator housing.

H) Place impeller assembly in a large glass beaker and rinse with 1% nitric acid (HNO_3).

I) Rinse impeller assembly with potable water.

J) Place impeller assembly in a large glass bleaker and rinse with isopropanol.

K) Rinse impeller assembly with distilled/deionized water.

18. **Between-Well Decon**

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.
B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5

minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Final Rinse: Operate pump in a deep basin of distilled/deionized water to pump out 1 to 2 gallons of this final rinse water.

VIII. FIELD LOG BOOK

A field log book must be kept each time ground water monitoring activities are conducted in the field. The field log book should document the following:

- Well identification number and physical condition.
- Well depth, and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid layers and detection method.
- Collection method for immiscible liquid layers.
- Pumping rate, drawdown, indicator parameters values, and clock time, at three to five minute intervals; calculate or measure total volume pumped.
- Well sampling sequence and time of sample collection.
- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

IX. REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation, C.K. Smoley Press, Boca Raton, Florida.

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures, EPA/540/S-95/504.

U.S. EPA, 1993, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001.

U.S. EPA Region II, 1989, CERCLA Quality Assurance Manual.

APPENDIX C
EQUILIBRIUM PARTITIONING APPROACH

APPENDIX C

EQUILIBRIUM PARTITIONING APPROACH

The United States Environmental Protection Agency (USEPA, 1993) has chosen the equilibrium partitioning (EqP) approach for developing sediment quality criteria for nonionic organic chemicals. This approach was used to derive sediment screening values for organic chemicals lacking literature-based, bulk sediment screening values.

There are three underlying assumptions to the derivation of sediment quality criteria using EqP. First, it is assumed that sediment toxicity correlates with the concentration of the chemical in the sediment pore water and not the bulk sediment concentration (i.e., the pore water concentration represents the bioavailable fraction). Second, partitioning between sediment pore water and bulk sediment is assumed to be dependent on the organic content of the sediment with little dependence upon other chemical or physical properties. Third, the EqP approach assumes that equilibrium has been attained between the sediment pore water concentration and the bulk sediment concentration.

The relationship between the concentration of a nonionic organic chemical in sediment pore water and bulk sediment is described by the partitioning coefficient, K_p (USEPA, 1993):

$$K_p = (C_s)/(C_{pw}) \quad \text{(Equation C-1)}$$

Where C_s is the concentration in bulk sediment and C_{pw} is the concentration in sediment pore water. For a given organic chemical, the partition coefficient can be derived by multiplying the fraction of organic carbon (f_{oc}) present in the sediment by the chemical's organic carbon partition coefficient (K_{oc}) (USEPA, 1993):

$$K_p = (f_{oc})(K_{oc}) \quad \text{(Equation C-2)}$$

Combining Equations C-1 and C-2 yields the following:

$$C_s = (K_{oc})(f_{oc})(C_{PW}) \quad \text{(Equation C-3)}$$

If the organic carbon content of the sediment is known, a site-specific sediment screening value (SSV) can be calculated for a given organic chemical by setting C_{pw} equivalent to a conservative surface water screening value for that chemical (SWSV):

$$SSV = (K_{oc})(f_{oc})(SWSV) \quad \text{(Equation C-4)}$$

In this equation, SSV represents the concentration of the chemical in bulk sediment that, at equilibrium, will result in a sediment pore water concentration equal to the surface water screening value. Sediment concentrations less than SSV would be protective of sediment-associated biota. The use of surface water screening values (i.e., criteria and toxicological benchmarks) in Equation C-4 assumes that the sensitivities of sediment-associated biota and the species typically tested to derive surface water screening values such as USEPA NAWQC (predominantly water column species) are similar. Furthermore, it assumes that levels of protection afforded by the surface water screening values are appropriate for sediment-associated biota. It is noted that the EqP approach can only be used if the total organic carbon (TOC) content in sediment is greater than 0.2 percent (i.e., 2,000 mg/kg). At TOC concentrations less than 0.2 percent, other factors (e.g., particle size, sorption to nonorganic mineral fractions) become relatively more important (USEPA, 1993).

Although the EqP approach was developed by the USEPA for nonionic organic chemicals (e.g. semi-volatile organic chemicals [SVOCs]), this method was used to derive sediment screening values for all organic chemicals lacking literature-based, bulk sediment screening values, including ionic organic chemicals (e.g., volatile organic chemicals [VOCs]). Application of the EqP approach to ionic organic chemicals likely overestimates their pore water concentrations since adsorption mechanisms other than hydrophobicity may significantly increase the fraction of the chemical sorbed to sediment particles (Jones et al., 1997). The overly conservative nature of sediment quality benchmarks derived using EqP is documented in the literature (Fuschman, 2003). Regardless, application of the EqP approach to the development of sediment screening values for ionic chemicals is recognized in the literature (USEPA, 1996 and Jones et al., 1997).

Sediment screening values derived using EqP (see Table 4-3) are conservatively based on a default f_{oc} of 0.01 (USEPA, 1996). K_{oc} values used in the derivation of EqP-based sediment screening values are those listed in Table C-1. The K_{oc} values listed in Table C-1 were estimated from the following equation (USEPA, 1993 and 1996):

$$Log\ K_{oc} = 0.00028 + (0.983)(Log\ K_{ow}) \quad \text{(Equation C-5)}$$

In this equation, log K_{ow} represented the log octanol-water partition coefficient. The surface water screening values used to derive EqP-based sediment screening values for organic chemicals lacking bulk sediment screening values are included within Table 4-2 of the work plan. They were identified from the literature using the sources and procedures presented in Section 4.4.1.3. It is noted that EqP-based sediment screening values could not be calculated for those organic chemicals lacking a surface water screening value.

References

Fuchsman, P.C. 2003. Modification of the Equilibrium Partitioning Approach for Volatile Organic Compounds in Sediment. Environ. Toxicol. Chem. 22(7):1532-1534.

U.S. Environmental Protection Agency (USEPA). 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water, Washington, D.C. EPA-822-R-93-011.

USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA 540/F-95/038.

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APPENDIX D
GROUNDWATER SAMPLING FORMS

WELL DETAIL AND SAMPLING LOG

Well ID #: _____ **DATE:** _____

PROJECT: _____ **WEATHER:** _____

WELL DATA

(CONDITIONS): (G = Good, F = Fair, P = Poor)

Pad _____ Well Cap _____ PVC Locking Cap/Plug _____

Cap Lock _____ Cover Bolts _____ Water over PVC? Y / N

Casing (outer) _____ Casing (inner) _____ SWL Reference Mark _____ Reference Mark Location? _____

Casing Dia.: _____ Casing Material: _____ Flushmount / Stickup

Comments: _____

(OTHER): Static Water Level (ft.): _____ Time: _____ (**Pre-Pump** Installation)

Depth to Product (ft.): _____

Water Level (ft.): _____ Time: _____ (Post-Pump Installation, **Pre-Purge**)

Total Well Depth (ft.) - Post Sampling: _____ Time: _____

PID Reading (PPM) - Unopened: _____ Opened: _____

PURGE DATA

Pump Type: _____

From Boring Log: Total Depth (ft.): _____ Screened Interval (ft.): _____

Pump Intake Set @ (ft.): _____ Controller Settings / Pressure: _____

Comments: _____

SAMPLE DATA

Sample ID #: _____ Dup.: Y / N - (ID#: _____)

Sample Time: _____ MS / MSD: Y / N Field Filtered: Y / N

Sampled By: _____ Signature: _____

Sample Description: _____

SAMPLE CONTAINERS

Bottle Type	Qty.	Preservative	Analysis

GENERAL COMMENTS

LOW FLOW PURGE DATA SHEET

WELL ID: _____

DATE: _____ **SAMPLER (s):** _____

PROJECT: _____ **SAMPLE ID:** _____

TIME [3-5 min.]	DEPTH TO WATER (ft) [<0.3 ft.]	VOL. (ml)	PURGE RATE (ml/min) [250-500 ml/min]	TEMP. (°C)	SP. COND. (mS/cm) [+/- 3%]	D.O. (mg/l) [+/- 10%]	pH (S.U.) [+/- 0.1]	ORP (mV) [+/- 10]	TURBIDITY (NTU) [+/- 10%]	COMMENTS (Sample descrip.: color, clarity, odor - issues and adjustments, etc.)
		- (Water Level : Post-Pump Installation, Pre-Start)								
	- (Start of Purging)									
	- **Sample Time** (Note: Flow rate to be btwn. 100 - 250 ml/min.)									**Sampler Signature:**

Note: Stability achieved when 3 consecutive readings fall within specific parameter ranges shown in the above header.

DAILY METER CALIBRATION RECORD

Date: _____ Time: _____

Model: YSI 556 MPS
Serial #:

		Initial	Adjusted
pH (Std. Units)			
Buffer:	4		
Buffer:	7		
Buffer:	10		
ORP (mV's)			
Std.:			
Sp.Cond. (mS/cm)			
Std.:			
D.O. (mg/l)			
Baro. Pressure (mm/Hg):			
Temp. (Celsius)			N/A

Model: RAE 2000
Serial #:

	Initial	Adjusted
Isobutylene (100ppm)		

Model:
Serial #:

		Initial	Adjusted
Turbidity (NTU's)			
Std.:	10		

APPENDIX E
XRF USER MANUAL

User Manual

Delta™ Family: Handheld XRF Analyzers

PN_103201
Rev_A: June/2010

General

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Innov-X Systems, Inc. reserves the right to make changes in the product design without reservation and without notification to its users.

Revision History

Release Date for this document and its individual sections is June, 2010. This enters the Innov-X document control system as Revision A

The material is available as Adobe PDF-type files. Distribution of the files or hard-copy representations is at the discretion of Innov-X Systems, Inc.

GO TO

See "*A7. Legal Information*" for information concerning Innov-X Systems, Inc.'s warranties, licenses, and liabilities.

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Delta Family End User Documentation Resources

During Delta's development and initial product shipments several End User documents have been created. They are listed in the table below.

Delta Documentation Resources		
Innovx Part #	*Release Date*	*----------Title----------*
103202_RevA	July/2010	Delta User Interface Guide (UI version 2.5))
103201_RevR	June/2010	Delta Family User Manual (This document)
103076_RevA	3/2010	Delta Family Quick Start
101593_RevA	11/2007	Window Replacement: Hinged Plate HandHeld Analyzers
102922_RevA	2/2010	Delta Family User Manual (Canadian Edition)
103158_RevA	3/2010	HOW TO: Setup and Configure A-020-D Teststand/Workstation for Delta Analyzer
TBA	6/2010	HOW TO: Convert A-020-A or A-020-O Teststand/Workstation to Support a Delta Analyzer

Preface

This *Preface* provides the following information:

- "Manual Structure"
- "Document Conventions"

Manual Structure

This *User Manual* consists of eight chapters, ten appendices, this Preface, Table of Contents, and a Cover. Individual chapter material is summarized below:

C1. Introduction describes the basics of the system:

- The Innov-X Delta™ Family
- Visual tour of the instrument noting all the major components

C2. Safety Information describes general safety information:

- Priority Information
- General Precautions
- Electrical Precautions
- X-ray Safety
  - Safety Interlock Structure
  - Safe and Unsafe Usage Scenarios
  - Radiation Doses for Several Scenarios
  - Comparative Analysis of Typical Exposure
  - Common Questions and Answers
- Delta Radiation Profile
- Required Certification
- Analyzer Shut-down Procedures

C3. Safety Administration describes safety program information:

- Radiation Safety Training Recommendations
- Dosimeter badges
- A typical dosimeter monitoring program
- Dosimeter service contractors
- Registration requirements

C4. Operations describes operations and testing procedures:

- Configure and Use Delta Docking Station (DDS)
- Start-up Procedure
- Cal Check Issues
- Battery Issues
- Conducting and Ending Test Operations

NOTE

Information concerning the Delta Family's user interface is supplied in the companion document ***"Delta User Interface Guide"*** (PN103202_Rev2.5 June/2010).
The goal is to provide revised Delta UI Guides when a substantial software change is released.

C5. Alloy Analysis Modes describes five specific modes and calibrations including:

— Alloy
— Alloy Plus
— FastID
— Pass/Fail
— Precious Metal Additions

C6. Mining Analysis Modes describes three specific modes and calibrations including:

— Mining
— Two Beam Mining
— Car Catalyst

C7. Soil Analysis Modes describes two specific modes and two calibrations including:

— Soil	— Environmental
— Three Beam Soil	— Exploration

- LEAP issues for Classic Delta (PiN detector)
- Check Standards
- Sample Preparation

C8. Consumer Goods Modes describes two specific modes including:

— RoHS	— Consumer Products

- *RoHS Mode* provides a details from EU regulation directives which list the limits for RoHS elements and information for qualitative measurements.
- *Consumer Products Mode* is dedicated to testing for Lead (Pb)

A1. Overview: X-Ray Fluorescence (XRF) Spectrometry presents background information and general knowledge, including:

- Basic Theory and X-ray History
- Elemental Analysis
- EDXRF Spectrometers

A2. Soil Testing presents information on using the analyzer for soil analysis within certain accepted guidelines, including:

- Status for Field Portable XRF and Overview of Field Usage
- Quality Assurance
- Calibration for Innov-X Portable XRF
- Effects of Moisture on XRF Results
- Comparing XRF Results to Laboratory Results
- Common Interferences
- Sample Prep Procedures and Testing Protocols

A3. Specifications presents analyzer hardware and software specifications.

A4. Typical Delta Test Sequence

- Prerequisites noted by Mode
  - Grade Libraries
  - Check Standards
  - Sample Presentations
- Typical Test Sequence

A5. User Maintenance provides a key procedure/technique:

- Using the AC Power Adapter kit to replace a Li-ion battery
- Using the stand-alone battery charger
- Replacing a Prolene, Mylar, or Kapton Window

A6. Packing and Shipping gives the procedure for returning a unit to Innov-x.

- Warning Label for shipping products with Li-ion batteries

A7. Legal Information presents material, including:

- Analyzer Limited Warranty including:
- Limitation of Liability
- Warranty Period, Returns, and Repairs
- Instructions for Contacting Innov-X
- End User Software License Agreement including:
  - Use, Restrictions, and Termination of Software
  - Liability Limitations

A8. Alloy Grade Libraries including the Alloy Factory Grade library for each Model, and a “Tramp” Library with seven base alloys.

Document Conventions

Messages

There are four messages used in this Manual:

WARNING, CAUTION, NOTE, and **GOTO.**

They are characterized by an icon and a message box topped with a colored banner. The message text is on a gray background. An example of each message is below:

WARNING

DEMANDS that you observe the actions given in the text.
The **WARNING** message has a **bold** type style.

Remember:
The WARNING icon signifies information that denotes a potentially hazardous situation, which if not avoided, may result in serious injury or death.

CAUTION

SUGGESTS that you review the referenced details and heed the instructions offered.
The CAUTION message has a regular type style with *emphasized keywords*.

NOTE

REQUESTS that you pay particular attention to a specified procedure or piece of information. Adds details that make it easier to use the system and this manual.
The NOTE message has a regular type style.

GO TO

DIRECTS the user to another portion of this manual, or to other reference materials containing relevant data.
The **GOTO** (or Pointer) message has a regular type style.

Type Styles

These conventions are used to present information:

Convention (Type Style)	Description
Bold	Indicates an action taken on a button or other item.
Italic	Menu commands, names of keys, buttons, tabs, or items from picklists. User-entered text. It is used for references to other documents, C(hapter) titles, and A(ppendix) titles (for example, "… see *"C2. Safety Information"*). Labels on unit's I/O panels; panel or window names of the UI (User Interface).
`Courier` type-face	Computer displayed text or filename.

Pagination

Page numbering in this Manual is consecutive with the Front Cover being assigned Page Number 1. This enables the PDF document file and any hard-copy print to map to the Page field information in the Adobe Reader.

C1. Introduction

C1 includes a:

- Description of the Innov-X *Delta*™ family of handheld XRF analyzers.
- Visual tour of the instrument(s) noting all the major features, and accessories.

Description of *Delta* System

What Is It?

The *Delta* is a handheld energy dispersive X-Ray fluorescence spectrometer, generally referred to as an XRF analyzer.A complete **Delta** package consists of:

- Handheld analyzer using an integrated group of instrument components that are sealed in an ergonomically designed, light-weight body. They include --
  - Controller
  - Color touchscreen (ergonomically mounted interactive display)
  - Membrane navigation keys
  - Choice of detectors (**PiN or SDD**) to meet wide-ranging application goals

Coordinated with these robust characteristics, the instrument's *key feature* is Innov-X's proprietary control, data acquisition, and analysis software with customer configured options.

Additional accessories (standard and optional) include:

- Li-Ion batteries (2) - {Standard}
- Delta Docking Station (DDS) Dedicated charging and calibration unit - {Standard}
- Rugged waterproof carry case - {Standard}
- Portable test stand to create a Delta workstation (A-020-D) {Optional}
- Soil foot (A-035) (Optional)
- Soil extension pole (990055) (Optional)
- Trimble Xplorer Package (Optional)

What Does It Do?

The expanded *Delta* family of handheld XRF instruments delivers fast and precise identification and analysis for elements from magnesium to uranium (Mg to U) depending on the selected model. A weatherproof/dustproof ultra rugged design including an **integral heat sink** permits users to conduct diverse analysis testing under severe operating conditions. An added convenience feature for field use is battery **"Hot Swapping."**

Applications

The analyzer gives accurate chemical analysis for commercial or industrial areas, such as:

- Positive Material Identification
- Mining and Exploration
- Consumer Safety
- Scrap Processing
- Environmental Testing
- Light Element & Aluminum Analysis

Delta Family: Types, Models, Modes and Calibrations

Delta Types and Models

Type	Modes	Models
Premium	Alloy	DP-2000
	Environmental	DP-4000
	Mining	DP-6000
	RoHS	DP-6500
Standard	Alloy	DS-2000
	Environmental	DS-4000
	Mining	DS-6000
	RoHS	DS-6500
Classic	Alloy	DC-2000
	Environmental	DC-4000
	Mining	DC-6000
	RoHS	DC-6500

Modes and Calibrations

ALLOY Analysis	Alloy	**MINING**	Mining Mode	**LEAD PAINT**	Lead in Paint (HUD)
	Alloy Plus		2 Beam Mining		Lead in Paint (Industrial)
	FastID & Pass/Fail		Car Catalyst		
	Precious Metals			**THIN**	Filter Analysis
		CONSUMER GOODS	RoHS		Dust Wipe
SOIL Analysis	Environmental		Consumer Products		
	Exploration				

Inspection

Inspection

Use this procedure:

1. Remove the carry case from the shipping cartons; save cartons.
2. Open the carry case
   Remove the shipping documentation
3. Verify that all the parts and accessories are included.
   Remember that the case has **TWO FOAM LAYERS**.
4. Verify that no visible damage occurred during shipping.

WARNING

If there is damage to any of the components, DO NOT attempt to use the instrument.
Immediately contact Innov-X Customer Support at:

- **United States: 1-781-938-5005**
- **Europe: +31 (0)73 62 72 590**
- **Canada: 1-778-960-6279**
- **Australia: 02-9577-9500**

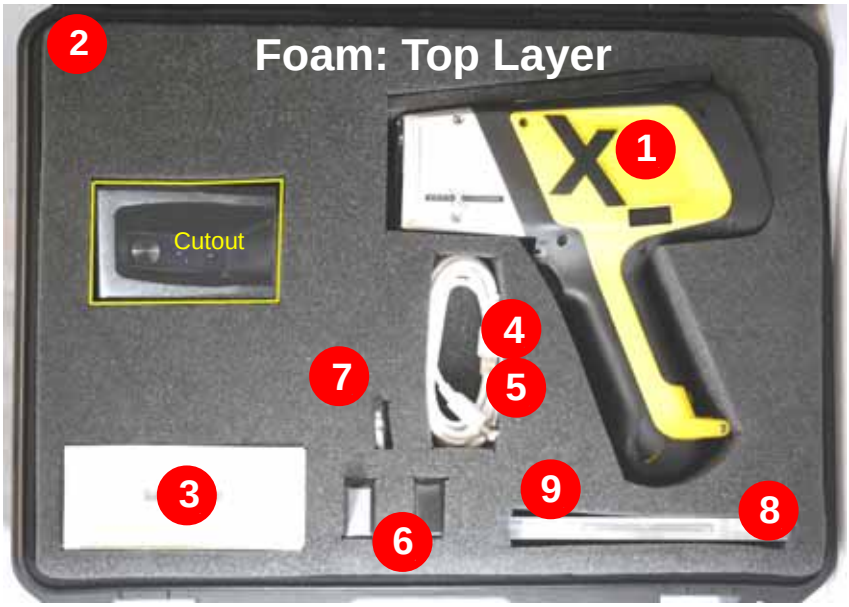
Or call your local distributor.

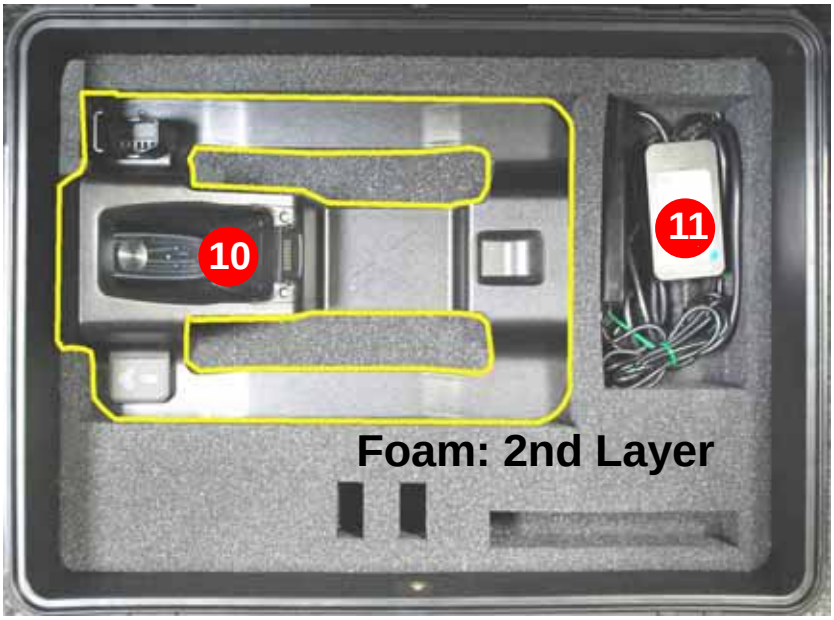
GO TO

- See *C4. Operations, Page 45 & 50 Battery Issues* for battery charging information.
- See **"***Delta User Interface Guide"* (PN 103202) for a complete description of the *Innov-X* application's User Interface.
- See *A7. Legal Information* for warranty, liability, and software licensing information.

Tour of the *Delta* Package

The figure below depicts *Delta's* major components as initially shipped to a customer. Note that the protective foam in the Carry Case has **TWO LAYERS**.





Component Key

	—Foam: Top Layer—
1	Delta Analyzer
2	Carry Case
3	Docking Station Charger
4	USB Cable #1
5	USB Cable #2
6	Li-ion Batteries (2)
7	Cal Check Coupon
8	Extra Windows (Bag of 10)
9	End/User Documentation
	—Foam: 2nd Layer—
10	Docking Station
11	AC Power Adapter (Optional)

Tour of Instrument

1. Handheld Analyzer

Component Key

	Delta - All Models
1	Delta Analyzer (Premium Model Shown)
2	Probe
3	Measurement Window (Prolene Film)
4	Hinged Window Plate
5	Docking Station Connector
6	Trigger
7	Handle - Non-Slip Rubber Grip
8	Battery Boot
9	Data Port w/ Rubber Cover
10	Heat Sink
11	I/O (Power) Switch w/ LED Indicator
12	X-ray Warning Light Array
13	Touchscreen for User Interface
14	Navigation Buttons

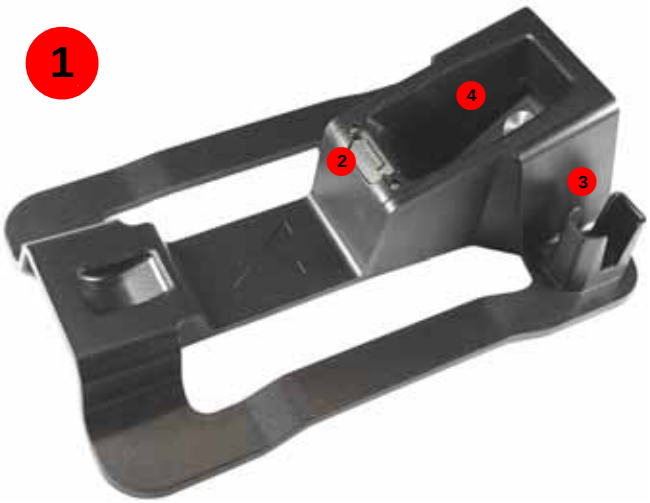
10 Heat Sink

14 Navigation Buttons

11 I/O Power Switch w/LED Indicator

12 X-ray Warning Light Array

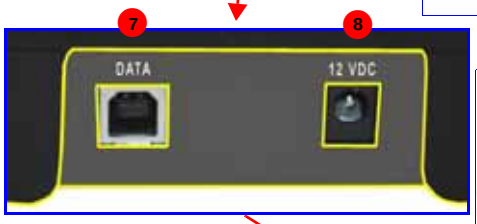
2. Delta Docking Station (DDS)

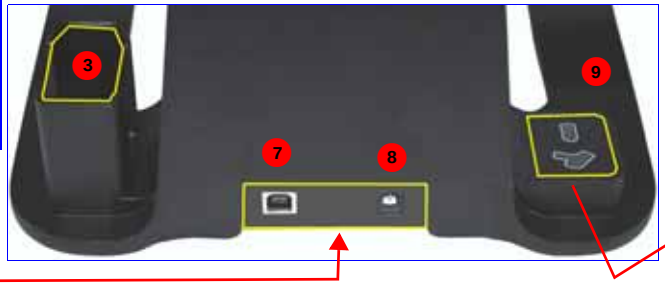


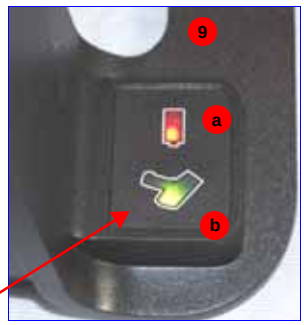
Component Key

	Delta - All Model
1	Delta Docking Station (Empty)
2	Analyzer Signal/Control Connector
3	Spare Battery Charge Socket
4	CalCheck Test Cup (316 stainless steel coupon)
5	Docking Station (Loaded)
6	Second Battery in Socket
7	Data Port(s): — Docking Station ->Rear
	— Analyzer -> Left Side
8	Input Power (12 VDC)
9	Indicator Lights
a	Second Battery Charging
b	Analyzer Engaged

See C4/Pages 44-45 for more information







3. Accessories- List the Standard and Optional Accessories

Standard

- Batteries
- Delta Docking Station (DDS)
- DDS Power Adapter
- USB Cables 1 - USB mini to USB A
- USB Cable 2 - two part powered data cable
- Windows- Bags of Kapton and Prolene films
- Cal Check (Standardization) Coupon

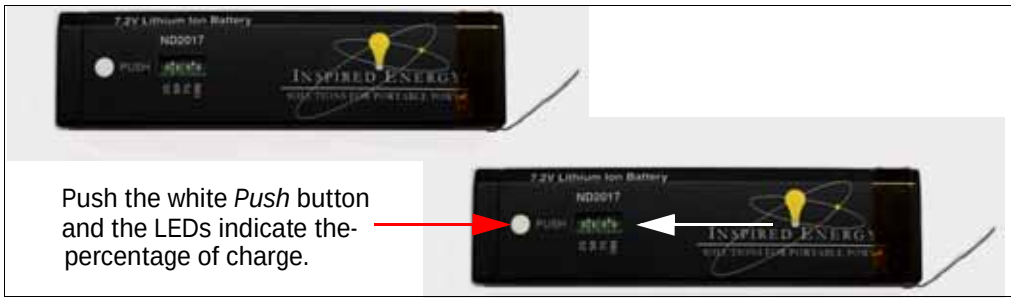
Optional

- AC Power Adapter (Battery Replacement)
- A-020-D TestStand/Workstation for Delta

STANDARD Accessories

Batteries

Two removable Li-ion batteries are standard accessories for the Delta.

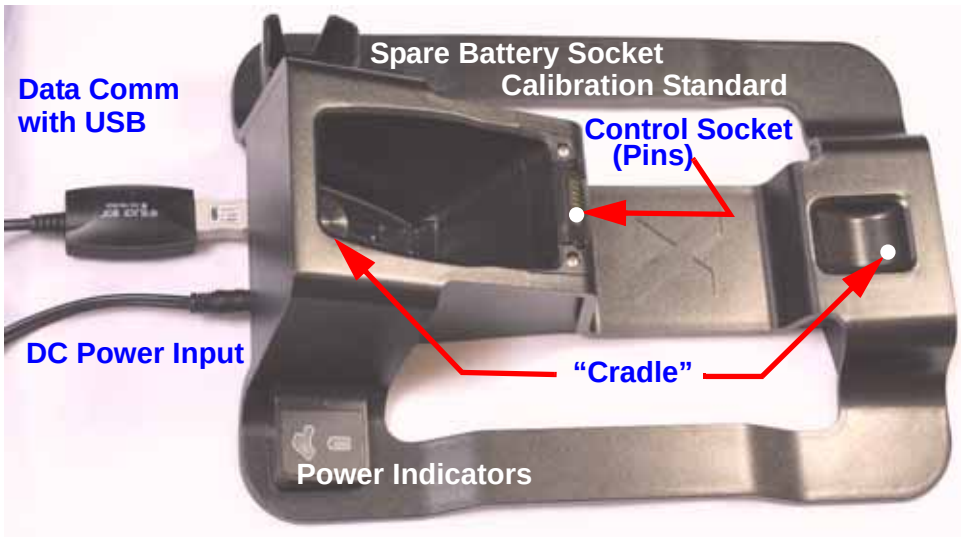


See Chapter 4, Page 50
"Battery Issues"

Delta Docking Station (DDS)

This is key accessory. It provides **three** functions:

- Cal Check by one of two means - "On Demand" or Automatically
- Charge internal battery in handle
- Charge additional battery in auxiliary socket



See Chapter 4, Page 46
"Use DDS for Start Up & Initial Cal Check"

Power Adapter for DDS

See Chapter 4, Page 44
"Configure DDS"

I/O Cables

PN 101310: This *standard accessory* provides a means to transfer information into or out of the sealed analyzer. It is good practice to export the current day's testing results to your PC.

PN 101310
USB Data Cable
- Mini USB B Connector
- USB A Connector

PN 103209 and 103210: This is a two part assembly that supports communication between the Delta Docking Station and a PC.

.

Data Cable Assembly

Part One
PN 103209
USB Repeater Cable
- USB A Female Connector
- USB A Male Connector

Part Two
PN 103210
USB Adaptor
Male to Male
- USB A Connector
- USB B Connector

Cal Check (Standardization) Coupon

This part is used as a reference sample to provide a test standard for a Cal Check procedure if the Docking Stations is not available. The instrument indicates when a Cal_Check is necessary.

See Chapter 4, Page 51
"Cal Check Information"

Measurement Window Films

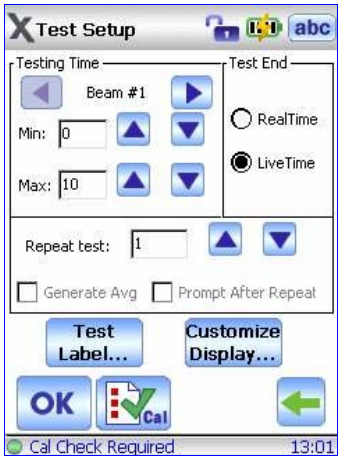
A bag of 10 window films are a standard accessory. The composition of the film is model and application dependent

PN 103115 REV A
Kapton Windows
for Classic

PN 102999
Prolene windows for
Standard and Premium

Application Software

The *Delta* instrument is shipped with proprietary InnovX data acquisition and processing software and Windows Embedded CE® operating system. The User Interface employs an icon-based home page graphic style. Factory calibration has been completed on all purchased modes.



Sedately *User Interface Guide"* (PN 103202) for a complete description of the Innov-X application's User Interface.

OPTIONAL Accessories

AC Power Adapter

PN 100043: This accessory enables the user to operate the instrument without the limitation of battery charge status. The unit comes with approximately ten feet of power cord that defines the effective range of use.

PC Software

This application package permits an operator to execute Innovx S/W functions from a PC. With cable PN 101310, a user can connect from the Delta's mini-USB data port to a PC's USB port.

This package is optional for a handheld instrument and standard for A-020-D TestStand/Workstation.

When used with the A-020-D the proper configuration cable is the powered USB assembly (PN 103209 - PN 103210)

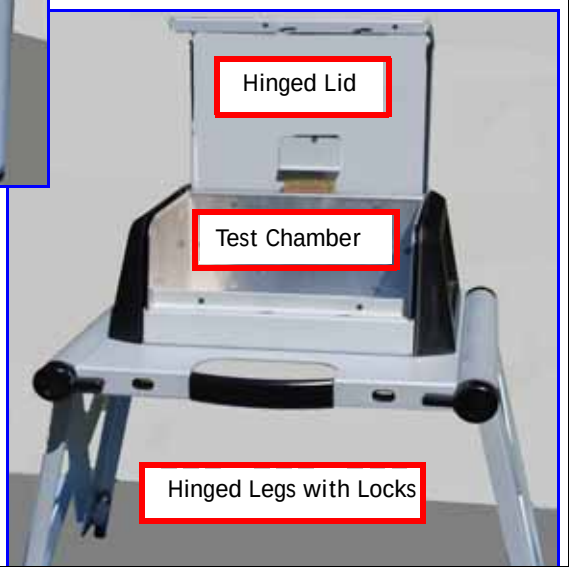
XRF Workstation

The Delta XRF Workstation is comprised of two major components:

- A-020-D Test Stand, and
- Any Delta analyzer

In this configuration, the Delta is controlled by Innovx Delta PC Software. The open-beam handheld instrument is converted to a closed-beam workstation.

See PN 103158 document: *"HowTo-Setup & Configure Delta XRF Workstation"* for complete instructions.



Tour of XRF Workstation

The **XRF Workstation** offers the following features:

- Portable, light-weight, shielded enclosure
- A rugged and repeatable testing environment
- Easily erected in laboratory or at remote field site

In this configuration the Delta (an open-beam handheld instrument) is converted to a safe closed-beam system

C2. Safety Information

C2 presents the following information:

- Radiation Safety Information
- General Precautions
- Electrical Precautions
- X-Ray Safety
- Compliance
- Instrument Usage Scenarios
- Radiation Dosage for Several Scenarios
- Radiation Safety: Common Questions and Answers
- Analyzer Shut Down Procedure

Radiation Safety Information

Always make Operational Safety your HIGHEST PRIORITY.

The *Delta* Handheld XRF Analyzer is a secure and dependable instrument when used according to Innov-X's recommended testing techniques and safety procedures. However, this instrument produces ionizing radiation; only individuals trained in correct operating techniques and authorized to use X-ray producing devices should be permitted to use it. The radiation detected at any outside surface (excluding the Prolene, Mylar, or Kapton window area) is below that required for an unrestricted area.

- Heed all warning labels and messages
- Observe the safety interlock features

WARNING

X-ray tubes in Delta instruments can emit dangerous levels of ionizing radiation.

Prolonged exposure can cause serious illness, injury, or death.

It is the responsibility of Innov-X Systems' customers to follow the operating instructions and safety recommendations of this guide and good radiation control practices.

Radiation Safety Program

Innov-X strongly recommends that organizations using *Delta* analyzers implement a formal *Radiation Safety Program* that includes:

- Dose monitoring of critical personnel.
- Monitoring of area radiation levels.
- Information specific to the site and application of the XRF system.
- An annual review (and update, if necessary).

"C3. Safety Administration" provides a more comprehensive safety discussion for operators and managers.

X-Ray Safety

X-ray safety is a priority at any time and in any testing situation.

WARNING

- **Innov-X analyzers must be used by trained and authorized operators, according to proper safety procedures. Improper usage may circumvent safety protections and could potentially cause harm to the user.**
- **Heed all warning labels and messages.**
- **DO NOT USE the instrument if there is any chance that it is damaged or might leak radiation. In such a case, arrange for qualified personnel to perform a radiation safety test and repair any analyzer damage.**

General Precautions

Apply these general safety guidelines when managing or operating the *Delta* instrument:

- Retain and follow all product safety and operating instructions.
- Comply with all warnings on the product and in the operating instructions.

Comply with the precautions listed in this section to reduce the risk to:

- Users
  - Physical injury
  - Electric shock
  - Radiation exposure
- Equipment damage
  - Measurement window
  - Overheated electronics and other internal components

Service Considerations

Except as expressly noted here, do not service any Innov-X product yourself. Opening or removing the external housings may expose you to electric shock and the instrument to mechanical damage. It also voids the warranty.

CAUTION

If service is required, it must be performed by Innov-X or its authorized service representatives. Failure to observe this can result in loss of warranty. The **ONLY EXCEPTION** is replacing a damaged measurement window (see ***"A5. Window Replacement"***).

Damage Requiring Service

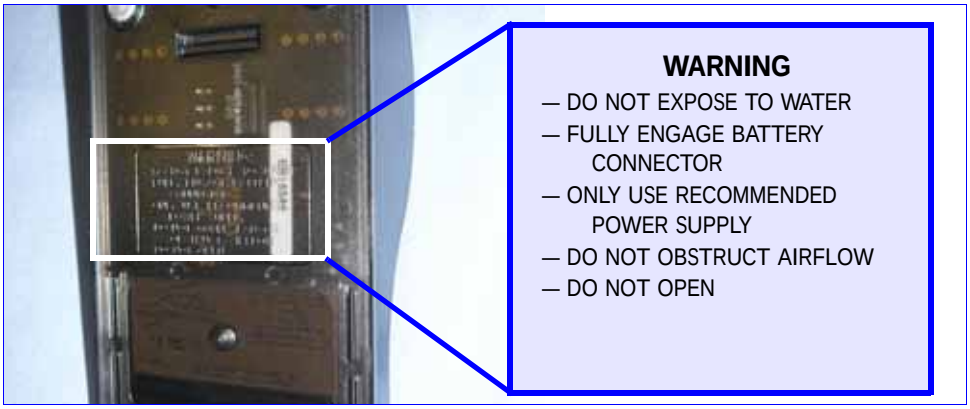
Types of problems or conditions that require service are (*but not limited to*):

- Power cords are damaged.
- Excessive or corrosive liquids spilled on the instrument or accessories.
- Instrument impacted, dropped, or physically damaged.
- Noticeable signs of overheating.
- Instrument or docking station does not perform normally when you follow the usual operating instructions.

Electrical Precautions

Guidelines for safe electrical operation of a *Delta instrument*:

- Use the correct battery or AC power adapter.
  - Install the battery or AC power adapter carefully, don't damage connections.
- Use the correct external AC power sources for the Delta Docking Station (DDS) (battery charging and Cal Checking) and the AC power adapter:
  - Ensure that the voltage is appropriate (100V-240 V/ 50-60 Hz) for operating either accessory.
    See *"A3. Specifications"* for electrical specifications.
- Do not overload an electrical outlet, power strip, or convenience receptacle.
- Do not exceed 80% of the branch circuit rating.
- Comply with the warning messages on the under side of the Battery Charger.
  - Similar precautions should be observed for the Delta Docking Station (DDS).



Cables and Cords

The *Delta* instrument and docking station is delivered with:

- AC power adapter (1) for Docking Station (standard)
- AC power adapter (2) as battery replacement for instrument (optional)

Each device has a standard IEC 3 conductor power cord which includes a safety grounding plug.

- If necessary, have an authorized individual replace these plugs to conform to local conventions.

Two data cables are supplied:

- Data cable (1) with connectors — USB A to USB B
- Data cable (2) with connectors — USB A to mini USB B

Cable Guidelines

Use these guidelines to ensure safety and proper equipment performance:

- The power cords MUST be connected to a properly grounded and easily accessible power outlet.
- Use a surge protector device, if possible.
- Do not defeat or bypass the ground conductor.
- Do not pull on cords or cables. Grasp the plug housing when removing the cord from the electrical outlet.
- Install all cords in accordance with applicable regulations.
- If you substitute a USB cable, ensure that the length doesn't exceed 10 feet.

Delta Docking Station (DDS) and Li ion Battery Packs

Plug the Delta Docking Station (and optional battery charger, if utilized) into a grounded electrical outlet that is easily accessible at all times.

- To handle battery packs properly do not:
  - Disassemble
  - Crush
  - Puncture
  - Short external contacts
  - Dispose of in fire or water
  - Expose to temperatures higher than 60 ^{o}C (140 ^{o}F).

GO TO

See ***"C4. Battery Issues"*** for instructions concerning Batteries, the Battery Charger, and the AC Power Adapter.

WARNING

Danger of explosion if battery is incorrectly substituted.
Replace only with Innov-X specified batteries.

Used batteries may be returned to Innov-X Systems for disposal.
If returning batteries, or equipment with batteries installed, the shipping container must display a special caution label.
See "*A6. Packing and Shipping*" for label details.

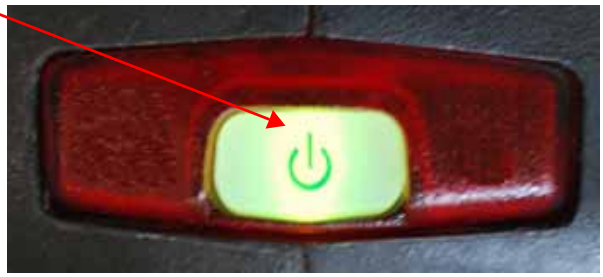
Indicator and Warning Lights

Power Switch w/ Integral Indicator Light

The Delta power switch is located at the upper rear of the unit.

POWER ON

- Press the I/O switch to turn on the power.
  - A green LED indicator comes on.
- This switch *DOES NOT* turn on the x-ray tube.
  - No tube power supplied until the Innov-X software is launched and a test is initiated.



POWER OFF

- Press and hold switch for >3 seconds.
  - Unit powers off. (See page 36 for more Exit options)

X-Ray Indicator Light Array

An indicator light array (six red LEDs) alerts the operator when the tube is receiving power, and when x-rays are emitted from the analyzer through the measurement window.

- When the unit is initially powered ON, the Indicator array remains Off.
- As test is conducted, array is in a **flashing** state.
- At the test's conclusion, the array stays **on continuously** until the beginning of the next test.

X-Ray Indicator ON (*Blinking*)

When the indicator array is flashing, this signifies:

- X-ray tube is powered to full operational level
- Internal filter wheel is in operational position
- Analyzer is emitting x-ray radiation through the analysis window.

In this condition, the analyzer must be pointed at a test sample.

X-Ray Indicator ON Continuously (*Not Blinking*)

When the indicator array is on continuously, this signifies:

- X-ray tube's current is set to 0.0
- X-ray tube is producing a minimum level of x-rays
- Internal filter wheel is closed so there is no radiation exposure to you or bystanders.

The instrument is *safe* to be carried or set down in this condition.

Back of Analyzer

In addition to the I/O switch and the X-Ray indicator array, the back of the Delta analyzer has:

- **Touch screen** which displays and controls the Delta User Interface.
- **Three Navigation Buttons** below the screen. They permit the user to conveniently step through the Test Results Spectrum screens.

Navigation Buttons

X-Ray Label

The Delta has a warning label affixed to the lower surface of the probe.

The analyzer has a label on the lower surface of analyzer's probe/nose.

- This label is ***required*** by most regulatory agencies. Do not remove it.
- The label term "*WHEN ENERGIZED*" refers to the condition where the tube is fully energized and the filter wheel is open.
  - This condition corresponds with the blinking red LEDs that comprise the X-ray indicator array.

Other Safety Features

Proximity Sensor

The Delta automatically detects when it is engaged with a test sample.
It immediately shuts off the X-ray tube if:

(a) Initially there is no sample in front of the window,

— or —

(b) Instrument is pulled away from the sample before the test time has expired.

Safety Interlock Structure

For controlling the Delta's X-ray emissions and therefore minimizing the possibility of accidental exposure, there is a standard safety interlock structure consisting of the three features listed below.

Software Trigger Lock

- If five minutes elapse between tests (default time), the trigger locks automatically and you must tap on the lock icon to unlock it. See Safety Software instructions in "*Delta User Interface Guide*".

Software Proximity Sensor

- Within two seconds of a test start, the analyzer detects a sample in front of the measurement window. If not, the test aborts, the filter wheel closes, and the x-rays shut off. The tube is placed in standby and the red light stops blinking.

Safeguards

As an owner of an Delta handheld XRF instrument, your safeguards are:

A. Limited Access
B. Trained Operators
C. Shielding Issues

A. Limited Access

Keep the instrument in a controlled location, where only trained and authorized users are likely to have access.

B. Trained Operators

Keep a sign with the analyzer indicating that in order to use it an operator must have completed a training class provided by your company, or must have attended an Innov-X training course and completed any other requirements as dictated by the local regulating authority. When the Innov-X system is turned on, the controller screen displays a message indicating that the system should only be used by authorized personnel.

C. Shielding Issues

Background

The Delta emits a tightly collimated beam of X-ray radiation. The beam projects many meters when only air attenuates it.

	NOTE
	Refer to governing regulations on compliance in the jurisdiction installed, dose limits, etc. Requirements differ from state to state, region to region, country to country. *DO NOT* rely solely on this manual for instruction.

Action

Adequate shielding is achieved by:

- Establishing a *no-admittance zone* sufficiently distant from the instrument's measurement window that allows air to attenuate the beam.
- Enclosing the beam working area with *protective panels* (for example, 1/8" stainless steel can attenuate the beam to background levels)

Contact your Innov-X Systems representative for assistance and suggestions on interlocks and applications for limiting radiation exposure.

Instrument Usage Scenarios

The Delta is used in several testing configurations. Obey the guidelines listed below.

Practical Safety Guidelines for Handheld Analyzers

WARNING

- DO NOT POINT the unit at yourself or any other person during operation.
- Never perform a test by holding the sample with your fingers or in the palm of your hand.
- Always wear both a ring-style and a badge-style dosimeter.

Correct Usage

Test in Place

Test targets can include pipes, valves, large pieces of scrap metal, soil, or any sample large enough to be tested in place.

In this configuration the proper procedure is as follows:

1. Always observe the relevant parts of the *Practical Safety Guidelines* shown above.
2. Point the instrument at the sample such that *no part* of your body (including hands and/or fingers) is near the measurement window.
3. Ensure that the Delta's nose (with window) is firmly placed on the target.
4. Perform the test using one of these methods:
   - Tap **Start** on the UI

   — or —
   - Pull the trigger (this toggles the instrument to ON state)

   — or —
   - Pull-and-hold the trigger with the "deadman trigger" active.

Employing Steps 3 & 4 assures that no operator's body part is exposed to an excess radiation dose. The radiation detected at user interface areas is < 5 µSv/h.

Take care that during testing, personnel are not located within three feet (one meter) of the Delta's probe head, in the direction of the x-ray beam. Provided the window is completely covered, there is minimal radiation being emitted around the area of the sample.

Small Component Testing

Examples of small component targets include metal turnings, weld rod, wires, fasteners, nuts and/or bolts.

For analysis of these types of components, use this procedure:

1. Always observe the relevant parts of the *Practical Safety Guidelines* shown above.
2. Place the sample on a flat surface.
3. Carefully place the nose/window over the sample.
4. Perform the test using one of these techniques:
   - Tap **Start** on the UI

   — or —
   - Pull the trigger (this toggles the instrument to ON state)

   — or —
   - Pull-and-hold the trigger with the "deadman trigger" active.

1. Sample lying on a flat surface

SAFETY PRECAUTIONS

WARNING

Do not test samples while sitting at a desk or table If the desk is made of wood or another non-metallic material, some radiation will penetrate the desk and may provide exposure to legs or feet.

ANALYTICAL PRECAUTIONS

NOTE

If the sample does not completely cover the window, ensure that your *background surface* does not contain metals or even trace levels of metals, as this may affect the accuracy of the XRF result. The XRF may report the presence of additional metals in the surface material.

2. Clamp-held sample

NOTE

A handheld plastic locking clamp can be an effective and safe tool when analyzing small, irregular shaped samples.

Incorrect (Unsafe) Usage

WARNING

Never hold a sample in your hand such that any part of your body or appendages are exposed to the x-ray beam. Testing samples in this way may generate significant radiation exposure to your fingers.

Unsafe Testing Technique

The sample is held up to the measurement window with fingers. The sample does not completely cover the window.
Even though the analyst is wearing a ring dosimeter, this is an unsafe testing technique.
Here, the only value that the ring provides is to validate the level of unnecessary radiation exposure that has been experienced.

Unsafe Testing Technique

The sample is held up to the measurement window with fingers. The sample does not completely cover the window.
To compound the danger, the analyst is not wearing a ring dosimeter.
There is no measure of the radiation exposure endured.

Summary

InnovX repeats the Warning ---

NEVER hold a sample in your hand.

Testing samples in this way generates significant radiation exposure to your fingers.

Compliance

Complying Agency Statements

United States of America: FCC

Changes or modifications not expressly approved by Innov-X Systems, Inc. could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Radiation Doses for Several Scenarios

In this section we provide data, concrete examples of use and misuse of the analyzer and common questions and answers we encounter when training personnel on the safe use of the Innov-X analyzer. The goal is to explain scenarios of safe versus improper usage.

WARNING

For the x-ray energy emitted by portable XRF analyzers (8-60 keV region), the bone in the fingers will absorb radiation about 3-5 times more than soft tissue, so the bone would be at an elevated radiation risk compared to soft tissue.
For this reason, no person shall hold a test specimen in front of the window with the fingers in the direct beam, or direct the beam at any part of the human body.

Reference: *Health Physics 66(4):463-471;1994*.

The table below presents radiation doses for normal operating conditions and also for examples of misuse of the analyzer and even extreme misuse. Innov-X provides installation training that includes detailed radiation safety training and documentation designed to prevent misuse of the analyzer.

Although the doses shown below are derived from experiments with TLD (thermo-luminescent dosimeters) and may or may not represent actual absorbed dose in human tissue and bone in each scenario, they are examples of the level of x-ray radiation being emitted from the device.

The message is simple:

USE CAUTION AND PROPER TECHNIQUE when operating the device.

Example: Instrument Usage	Radiation Exposure and Comments
Normal Operation- Dose to Hand User analyzes samples according to standard operating procedures described in this manual. Assumption: Operator using system with x-ray tube ON for eight hours/day, five days/week, 50 weeks/year. (Alloy sample).	Maximum exposure is to operator's hand, at the trigger is < 1μSv/h. Annual exposure to hand is then < 2mSv. Maximum exposure under ICRP regulations is 500 mSv for radiation workers and 50 mSv for the general public. Thus continuous operation provides a dosage 250 times lower for a radiation worker and and 25 times lower for the general public.
Normal Operation- Dose to Torso Analyzer is used under the same operating conditions described above.	Exposure to Torso is so low it cannot be measured (essentially background). To be conservative we use 1/2 the value as the trigger, < 0.5μSv/h. Annual exposure using operating conditions above is then estimated at less than 1 mSv. Maximum allowed is 20 mSv under ICRP for radiation workers (1 mSv for general public).
Misuse Example 1: Operator holds samples in front of window with fingers, such that fingers are directly in the primary beam. Presumption is sample does not block any radiation. **Do not do this!**	At the window, in the primary beam, the maximum dose to the fingers is 20,000 mSv/hr. Assume an operator performs a 10 sec. test (typical). The dose to the operator's fingers or hand is 20,000 x (10/3600) = 55 mSv. If the operator did this just ten times per year he would exceed the allowable annual dose of 500 mSv to an extremity. Take the extra time to test a sample on a surface or use a testing stand. **Note: If the operator takes a shortcut and places his/her fingers within the primary x-ray beam at the window, they will exceed the annual dose rate.**
Misuse Example 2: Operator places analyzer against body and pulls the trigger to start a test. Analyzer tests to preset testing time (usually ten seconds) unless operator pulls trigger again to stop test. This applies to analyzer being in contact with operator or with bystander. **Do not do this!**	Dose at exit of sampling window is 20,000 mSv/h. Dose for a ten second exposure with analyzer in contact with Torso: 55 mSv. If an operator did this act just once, he would exceed the annual safe dosage to the torso of 20 mSv/year by a significant amount! **PLEASE NOTE:** The maximum dose of 20 mSv/year is a whole body limit, which does not truly apply in this case because the x-ray beam size is small (about 25 mm^2 area at the port). Applying correction factors for the beam size is complex and beyond the scope of this manual. The important point is that for proper operation there is no reason to ever expose any part of the human body directly to the x-ray source. This example serves to provide estimated exposure in the event this occurs.

Misuse Example 3: Operator manages to initiate a test for ten seconds running normal soil mode and exposes a bystander that is standing ten cm away from analyzer port. What is exposure to bystander? **Note:** The **proximity sensor** would automatically shut down the x-ray tube immediately, so this is an extremely improbable occurrence. It would require a malfunction of the instrument - this safety feature in NOT modifiable. **Note 2:** Equations to scale these to other scenarios involving longer or shorter tests, and bystander being at distances other than ten cm are provided at right.	Dose to bystander at ten cm is 215 mSv/hr. For a ten second exposure the dose is 0.6 mSv. This is 33 times lower than the allowable dose to a nuclear worker in a year. This would have to happen 33 times to for that worker or bystander to obtain the maximum allowable dose. Formula for calculating other scenarios: DOSE (in mSv) = $6T/D^2$ D = distance from port in inches T = testing time Example: Bystander is 30 cm away from port for a 30 second test. In this case the dose is calculated as: DOSE = $6(30)/30^2$ = 0.2 mSv

Comparative Analysis:
Radiation Doses from Typical Exposures to Ionizing Radiation

Activity	Typical Dose
Smoking	*2.8 mSv per year*
Dental x-ray	*100 μSv per x-ray*
Chest x-ray	*80 μSv per x-ray*
Drinking water	*50 μSv per year*
Cross country round-trip by air	*50 μSv per trip*
Mammogram	*1-2 mSv per examination*
Yearly exposure from background* radiation * depends on geographic location	*3.6 mSv*

Radiation Safety: Common Questions & Answers

Question: When I'm shooting a piece of pipe or valve on a rack or on a table top, is there any exposure to people standing several feet away from the analyzer?

Answer: Even a thin amount of a dense metal sample (three to four mm thickness, not Al alloy) is enough to completely attenuate the emitted x-ray beam. Shooting a piece of material that covers the sampling window on the analyzer completely shields any bystanders from radiation exposure.

However, use good practice: Keep the area clear of people for at least four to five feet in front of the analyzer.

Question: If I forget to lock the trigger, I pick up the analyzer and accidentally pull the trigger, is that dangerous to nearby personnel?

Answer: No, this example of misuse is not dangerous, but it may produce a non-negligible radiation exposure to nearby personnel. For an exposure to occur, the following things must happen.

First, you must be holding the analyzer so that a bystander is actually standing in the x-ray beam being emitted. Just being near the analyzer is totally safe otherwise.

Second, the bystander must be within one meter from the nose of the analyzer to receive any appreciable dose. If all of these conditions are true, the dose received by a bystander is still extremely low. Please see Misuse Example 3 in the table above.

Third, it would require failure of the proximity hardware and software.

Question: Do I need to create restricted areas where I am using the analyzer?

Answer: No, provided you are following normal operating procedures there is no reason to restrict access to an area where the analyzer is in use. However, the operator should take precautions to keep any personnel more than three feet away from the sampling window of the analyzer in the event of accidental misuse as detailed above. Should operators also elect to test small samples as shown on pages 34 and 35, they should also be sure that no personnel are standing within about four to five feet of the sampling window.

Question: How does the x-ray tube in the Innov-X system compare to a radiography system used for taking images of metal parts?

Answer: The x-ray tube used in the Innov-X system produces between 1,000 and 10,000 times less power than most radiography systems (0.5-1 watt versus multiple-kW). A portable XRF is designed to perform surface analysis of alloys and other samples, whereas a radiography system is designed to shoot x-rays entirely through metal components in order to obtain an image on the other side of the test object. For example, many tube-based radiography systems use a 300-400 kV tube and currents in the tens or hundreds of milliamperes (mA). The Delta uses a tube operating at a maximum of 40kV and typically 6 -10 μA.

The radiation levels produced by an Delta are thousands, or tens of thousands, times lower than a radiography unit.

Question: Should we use dosimeter badges with the Innov-X analyzer?

Answer: Dosimeter badges are required by some provincial regulatory agencies, and optional with others. Innov-X recommends that operators wear badges, at least for the first year of operation, as a general precaution to flag any misuse of the analyzer. Dosimeter badges are available for the torso (generally worn in a shirt pocket) and also as "ring" badges.

The best practice is to wear a ring badge on a finger on the opposite hand used to hold the analyzer. This records accidental exposure for the most likely case – an operator grabbing a small sample and holding it in one hand while analyzing it.

Note: These badges generally have a threshold of 100 µSv and are renewed monthly. So it takes several cases of misuse even to obtain a reading on a typical badge. When purchasing a badge, obtain the type used for x-ray and low energy gamma ray radiation.

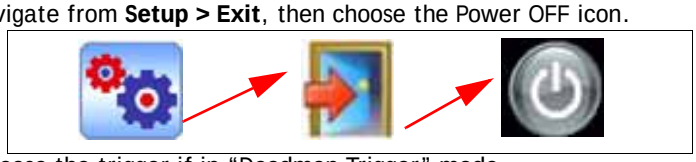
Analyzer Shut Down

There are several techniques for shutting off the Delta. They can be categorized by whether the action is taken under normal or emergency conditions. *Shut down* or *turned off* is defined as: *The analyzer cannot provide X-ray emissions*.

Under normal conditions

Use one of following actions:

- Press the trigger.
- Tap **STOP** icon on the UI touchscreen.
- Navigate from **Setup > Exit**, then choose the Power OFF icon.



- Release the trigger if in "Deadman Trigger" mode.
- Press the I/O power switch; ensure that the On/Off LED goes off.

In an emergency

Because the Innov-X system is a battery-operated, x-ray tube-based analyzer, the Emergency Response plan is simple. If you believe that the analyzer is locked up in an *OPEN* position, the red X-ray indicator array remains illuminated or blinking:

1. Press the I/O power switch as noted above. If the power does not turn off, continue to Step 2.
2. Open the battery cover and immediately remove the battery.

If you are using the AC Power Adapter:

- Remove the Battery Eliminator from the Delta's handle

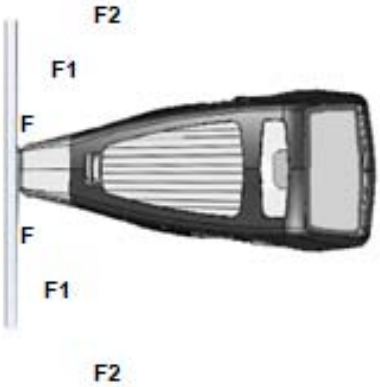
— or —

- Pull the AC cord from the AC Power Adapter or pull the plug from the receptacle.

Delta Radiation Profile

This is the current Delta Radiation Profile.

RADIATION PROFILE – Hand Held Instruments



Measured Shallow Dose Rate in mR/h - Secondary Radiation (Scatter)

Mode(s)	Substrate	Voltage kV	Amperage µA	Filter	Trigger R	Close F	10 cm F1	30 cm F2
Alloy Plus Mining 2-Beam Mining	316 Stainless	40	100	1	0.1	1	0.5	0.1
	Al (319 AA)				0.2	6	3	0.6
	Soil (SiO_2)				3	50	25	9
Alloy Plus 2	316 Stainless	13	200	7	BK	0.1	BK	BK
	Al (319 AA)				BK	BK	BK	BK
2-Beam Mining 2	Soil (SiO_2)	10	200	7	BK	0.1	BK	BK
3-Beam Soil 1		40	100	3	1	16	7	2
3-Beam Soil 2		40	100	2	3	100	25	45
3-Beam Soil 3		15	200	5	BK	0.1	BK	BK

BK – No higher than background

TEST CONDITION: Instrument run at normal setting for mode and represents typical production unit.

NOTES

C3. Safety Administration

C3 provides information regarding:

- Radiation safety training recommendations
- Dosimeter badges
- A typical dosimeter monitoring program
- Dosimeter service contractors
- Typical registration requirements for operating XRF equipment (in the USA)

Radiation Safety Training Recommendations

Individual companies and states have specific regulations and guidelines for using ionizing radiation generated by an X-ray tube.

NOTES

For the convenience of clients, Innov-X has compiled a list of recommendations that:

- Provide generic guidance for an ALARA (*as low as reasonably achievable)* approach to radiation safety.
- Do not replace the requirement to understand and comply with specific policies of any state or organization.

Personal Monitoring

Radiation control regulations may require implementation of a radiation monitoring program, where each instrument operator wears a film badge or TLD detector for an initial period of one year to establish a baseline exposure record. Continuing radiation monitoring after this period is recommended, but may be discontinued if accepted by radiation control regulators. See *Dosimeter Suppliers* for a list of film badges providers.

Proper Usage

Never point the instrument at a person. Never point the instrument into the air and perform a test. Never hold a sample in your hand during a test.

Establish Controlled Areas

Restrict access to the location of instrument storage and use to limit potential exposure to ionizing radiation. In use, the target should not be hand held and the area at least three paces beyond the target should be unoccupied.

Specific Controls

When not in use, store the instrument in a locked case or locked cabinet.
When in use, keep it in the direct control of a factory trained, certified operator.

Time - Distance - Shielding Policies

Operators should minimize the time around the energized instrument, maximize the distance from the instrument window, and shoot into high density materials whenever possible.

Prevent Exposure to Ionizing Radiation

All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, & shielding, should be implemented to limit radiation exposure to *as low as reasonably achievable* (ALARA).

Dosimeter Badges

A dosimeter badge consists of a radiation-sensitive material, generally an aluminum oxide crystalline layer, which is worn in a small container. It is most often attached to a person's clothing, on a belt loop, or shirt pocket. It is worn on the body in location(s) that most closely simulate the pattern of potentially absorbed dose.

The protection can also be provided in a plastic ring format. Here the detection material is lithium fluoride crystal.

Dosimeter
Clip-on Style

Dosimeter
Ring Style

These devices record a person's accumulated radiation exposure over a period of time. They monitor individuals working with, or near someone working with devices which emit ionizing radiation.

Dosimeter badges are required by some regulatory agencies, and are optional with others.

Innov-X recommends that (at a minimum) all *Delta* operators wear badges (both clip-on and ring styles) for the first year that their system is in use.

NOTE

- When purchasing a badge or ring, always select the type used for *X-ray* and *low energy gamma* radiation.
- Innov-X suggests that the ring badge be worn on a finger of the *opposite hand* used to hold the analyzer. This records accidental exposure for the most likely case: An operator grabbing a small sample and holding it in a hand while analyzing it.

Every country (including every region, state, or province within a country) can have differing regulations. Always consult your local radiation protection authority or Innov-X Systems for information and recommendations.

Dosimeter Safety Program

A typical dosimeter-based safety program uses the following steps:

1. The company develops a dosimeter program with an independent service contractor.
   - They establish the quantity of badges needed and the frequency of analysis (a monthly or quarterly interval)
2. The company receives the first lot of badges and provides them to their analyst/operators.
3. At the end of the interval:
   - The company collects the badges and returns them to the service contractor for analysis.
   - Simultaneously, the service contractor delivers another lot.
4. The company provides the new set of badges to maintain a continuous protection /monitoring program for their employees.
5. The service contractor prepares a report for the company that tabulates any X-ray dose received and identifies any personnel with readings higher than typical background radiation.
6. The safety monitoring cycle repeats with Steps 1 through 5.

NOTE

The service contractor's written records are very important to a company's overall safety documentation plan.

Dosimeter Suppliers

Some dosimeter service companies are:

Company	Location	Telephone
AEIL	Houston, TX	713-790-9719
Global Dosimetry Solutions	Irvine, CA	800-251-3331
Landauer	Glenwood, Il	708-755-7000
• Landauer, Inc.	Oxford, England	+44-1 86-537-3008
• Nagase Landauer, ltd.	Japan	+81-3-36 66-4300
• LCIE Landauer	Paris, France	+33-(0)1-40 95 62 90
• Landauer	Beijing, China	+86-10-62 21 56 35

Registration Requirements

Contact Innov-X for assistance with locating registration requirements information.

- Most states require some form of registration. Generally they require the registration to be received within 30 days of receipt of the system.
- Some states require no registration.
- Some states require notification in advance.

Customers are advised to consult their local radiation protection authority for specific regulatory information.

Typical Device Registration Information

The following information is usually requested by a licensing agency:

Purpose of device:

Response is *Analytical or Industrial.*

Be sure to inform the government registration office that the system will NOT be used for radiography or for medical uses.

Radiation Safety Officer:

List person who monitors training, safe use, and controls access to the system.

Authorized Users:

List the analyst/operators who have been trained and authorized by the instrument owner and/or regulating agency to operate the XRF equipment.

Operating parameters of the Delta XRF analyzer:

8— 40 kV, 5 - 200 uA max.

Type of system:

Response is: *Handheld/Portable*

User Training Specified:

Indicate that only individuals receiving manufacturer training, *documented by a manufacturer's training certificate*, will operate the system. Additional training may be required. Verify with the local regulating agencies the level and type of training required.

Personal Monitoring

Many government agency registration forms require that you indicate whether or not you intend to perform dosimeter monitoring.

See "Dosimeter Safety Program" on previous page for information regarding typical personal radiation monitoring.

CAUTION

Always keep the following documentation at the job site:

- Copy of *License Registration*
- Other pertinent *government agency* documentation
- Copies of any *dosimeter analysis* reports
- Copy of this equipment's *User Manual*.

C4. Operations

This chapter provides information regarding:

- Configure the Delta Docking Station (DDS)
- Use DDS for Initial Cal Check
- Operation - General
- Start Up Procedure
- Snapshot of Delta User Interface
- Typical Test Procedure
- Ending Test Operations
- Battery Issues
- Additional Cal Check Information
- TIPS - Things You Should Know About the Delta

Safety First !

As emphasized in *"C2.Safety Information,"* it is a priority to keep the analyzer operator's safety in mind at all times.

- Operators, *before turning on the analyzer or using the Delta Docking Station,* should review the safety procedures (*"C2.Safety Information"*).

Set Up and Use the Delta Docking Station

Background

The Delta Docking Station (DDS) provides several key functions:

- Supports an automatic or on-demand Cal_Check procedure
- Charges the "Main" battery located in the instrument's handle
- Simultaneously charges a "Spare" battery in an auxiliary socket
- Provides control information so that both batterys' status can be monitored
- Allows data communication from the Delta to a PC via a powered USB cable

The first phase for preparing to operate a Delta involves:

1. Configuring the DDS with its power and communication cables
2. Using the DDS to support the Delta's initial:
   a. Start up sequence, and
   b. Cal Check procedure.

NOTE

A new instrument is shipped with two fully charged Li Ion batteries. Therefore, prior to **initially** using the analyzer, it is not necessary to charge a battery.

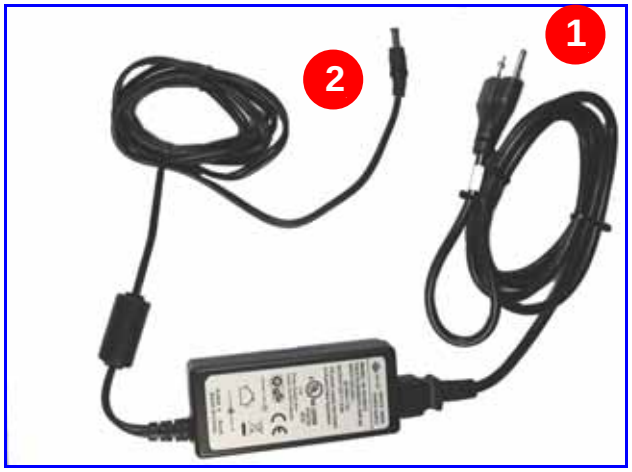
GO TO

- See *Pages 45 and 50* for battery information, including charging, changing, determining status, and Hot Swap techniques.
- See *Page 51* for Cal Check background information.

Configure Delta Docking Station

Rear View - DDS

PN 103209 & PN 103210
Powered Hub USB Cable Assembly



Power Adapter for DDS

Configure DDS with this procedure:

1. Plug the AC power adapter's line cord (1) into suitable AC outlet.
2. Plug the AC power adapter's DC jack (2) into the 12 Vdc socket on the rear of DDS
3. {Option at this point: Powered USB cable assembly}
   — Insert connector B (3) into DATA port
   — Insert connector A (4) into USB port of PC

Use the Delta Docking Station for Charging Batteries

The Delta analyzer has a multi-purpose standard accessory:
the **Delta Docking Station** or **DDS**.

In addition to providing an automatic Calibration Check, the DDS delivers **two** charging functions:

1. It charges the installed "Main" battery in the instrument's **handle**.
2. Simultaneously, it charges a spare or "Dock" battery when its inserted into the special auxiliary charging **socket**.

Charge status is shown in real-time on the Delta's display screen.

The second docked battery's status is also shown by the battery icon located on the rear left side of the DDS.

(either "charging = red" or "full = green")

Battery Status Screen
(Delta inserted in DDS)

Cradle

Delta Docking Station Procedure for
Battery Charging Functions:

1. Ensure that the DDS has DC power cable installed
   See *page 44*
   The Icon lights are Off **{1}**
2. With Delta Off, place instrument in cradle.
   Take care that Analyzer Icon comes On (Green) **{2}**
   The main battery in the handle is charging although there is no indicator.
3. If Delta On, the Battery Status Screen appears
4. Place a spare battery in the auxiliary socket
   Battery Icon is On (Red - unless fully charged) **{3}**
5. Both batteries will charge; their real-time charge status is displayed.
6. When both batteries are fully charged, the Icons display Green. **{4}**

Delta Docking Station Procedure for
Automatic Cal_Check

1. Ensure that the DDS has DC power cable installed
   See *page 44*
   The all Icon lights are Off **{1}**
2. With Delta On, place instrument in cradle.
   Take care that Analyzer Icon comes On (Green) **{2}**
   Battery Status screen is displayed.
3. Ensure that the Battery Status screen stays On.

NOTE: Do not exit this screen -->> the automatic Cal_Check function will not work.

Use the Delta Docking Station for Startup - Initial Cal Check

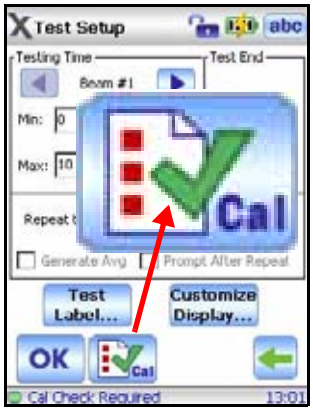
DDS w/Empty Cradle

DDS w/Premium Delta in Cradle

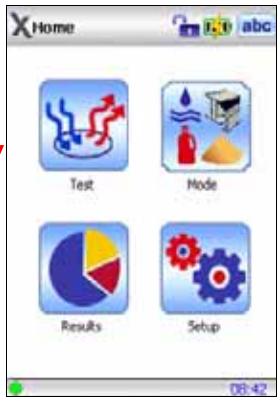
DDS - Indicator Light
Delta is engaged in cradle

1. Place analyzer into the Delta Docking Station cradle.
   Ensure that the Delta indicator light is ON.
   This signifies that the instrument is properly seated in the cradle.
2. Press analyzer's I/O switch (>1 second to turn it ON.)

Radiation Safety **NOTICE** appears after a few seconds.



3. Read and respond to notice
   Tap **START** to acknowledge that you are a certified user.
   The UI begins its launch with the following messages:
   Initializing System
   Starting System
   Loading Files

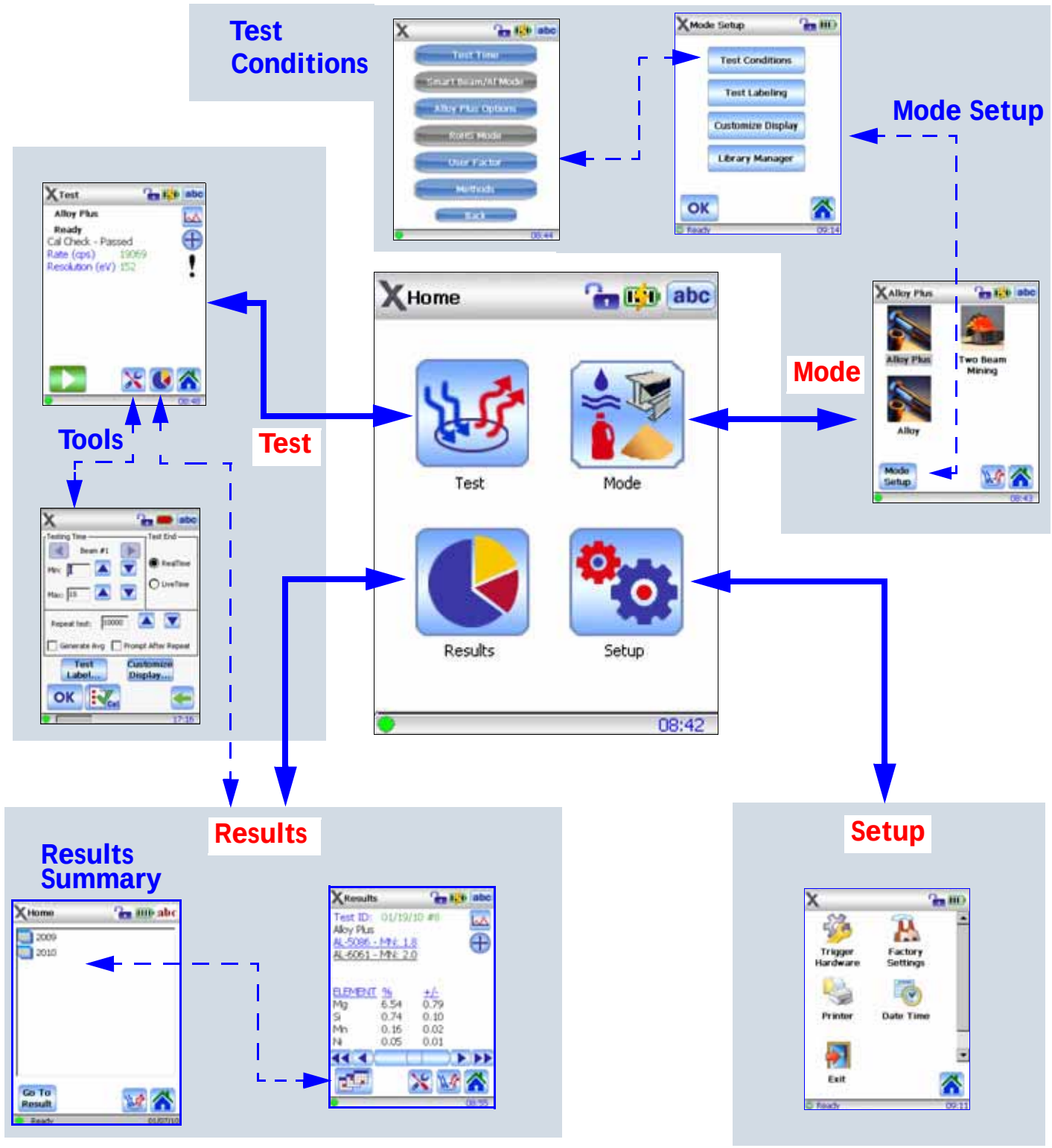


4. Unit displays a **Test** screen using the Mode last selected.
   4a. If the mode should be changed, go to **Home** screen.
   4b. Select the Mode button
   4c. Choose the desired Mode

5. Return to **Test** {now with your selected Mode)
   Note that message *Cal Check Required* is present.
6. Choose **Tools** icon:
   This launches **Test Setup** screen with Cal_Check button
7. Tap **Cal_Check**
   If necessary, unlock the **Trigger** with the icon at top of screen.
   Procedure begins immediately; it concludes in about 15 seconds.
8. Message *Cal Check - Passed* means you may begin testing.
   Message *Cal Check - Failed* will give error message, such as"! Wrong Count Rate"
   Re-try the procedure
   If unit fails repeatedly, contact InnovX service or your local distributor.

SNAPSHOT of Delta's User Interface

The Delta's user interface is introduced by the startup **Radiation Safety** and **Initialization** screens. Main operations then revolve around the **Home** screen.



Typical Test Procedure

Background

Details of routine testing operations vary depending on the selected analysis mode. Some relevant modes for Delta XRF users are:

• Alloy Modes —Alloy Plus —Fast ID & Pass/Fail —Precious Metals	• Mining Modes —Two-Beam Mining —Mining —Car Catalyst	• Soil Modes —Environmental —Exploration	• Consumer Goods —RoHS —Consumer Products

For the test sequence (below) the instrument has:

- Mode selected (Soil 3 Beam), and
- Cal Check procedure successfully completed.

To conduct a typical test:

1. Remove the instrument from the Delta Docking Station. Place the the measurement window flush against the sampling area. Ensure the sampling area is covered by the window.

WARNING

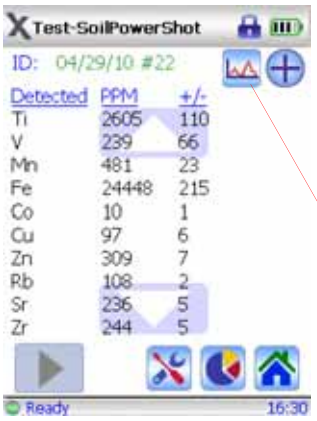
Do not point the unit at yourself or any other person during operation. Do not test small samples in your hand. Place them on a surface for testing.
See *C2, Safety Information, Pages 29-31* for examples of safe and unsafe testing techniques.

2. Use one of these techniques to initiate the X-ray beam:
   a. Tap **Start Test (Green Arrow Icon)**, or
   b. Pull the trigger (toggles unit ON); can release the trigger during the test, or
   c. Pull-and-hold the trigger (deadman trigger function is enabled)
   This is a mandatory technique in Canada.

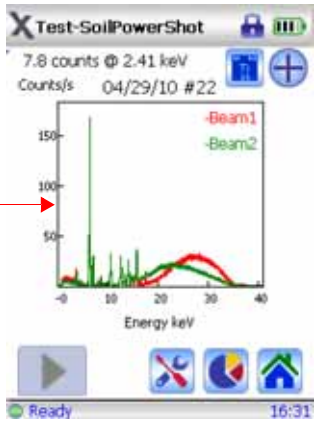
   Trigger options are configurable from:
   Setup > **Trigger Hardware** > **Trigger Settings**

The Test screens are as follow:

Test results with progress status bar



Test result complete; Elements are listed



Spectrum screen for this result (ID: 4/29/10 #22)

End of Day Operations

Save Results

When finishing testing for the day (or shift, or current session} InnovX recommends that test results be saved (e.g. exported) to a PC.

A necessary prerequisite is a DATA connection between the analyzer and PC.

This connection is made in one of two ways:

- Analyzer in DDS cradle — use the powered hub USB cable assembly (PN 103209 and PN 103210) from the DDS' rear Data port to a USB port of the PC
- Analyzer NOT in DDS cradle — use the mini USB B to USB A (PN 101310) cable from the analyzer's Data port to a USB port on the PC

The UI operational sequence is:

1. Navigate from **Home** > **Results** > **Calendar**
2. Select Year, Month, Day listing; it lists the total number of tests for the day
3. Select **Tools**, then **Results Setup**
4. Select the **Export** icon (button)
5. Choose the results to be exported
6. Name the export file (or accept default name)
7. Select Destination to save to
8. Tap the **Export** button

The file is exported.

GO TO

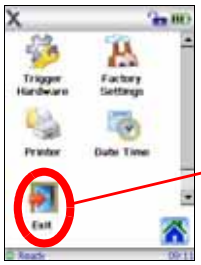
- See "*Delta SW User Interface Guide*" for the details (including options) of this sequence.

Ending Test Operations

When testing and exporting are complete, the user has the following options:

- Turn off Delta with I/O switch or UI (see Exit Options procedure below); store unit in a secure location
- Place Delta in Docking Station and use the "Automatic" option:
  - Leave Delta powered ON;
  - Ensure that DDS is On (Delta ICON is lit);
  - Unit initiates Cal_Check after being idle for five minutes, then every ten hours thereafter.

Exit Option Procedure from UI



Setup Screen

Exit Icon

User has **three** options:

Soft Reboot
Restart OS and restart IX app.

Power OFF
Turn analyzer off after confirmation.

Relaunch
Restart IX app.

Battery Issues

1 — Changing a Battery

To CHANGE the battery:

1. Hold the instrument by the handle, upside down, so the bottom of the instrument base is pointing upward with the nose pointing away from the operator.
2. Pull the rubber latch and lift cover.
3. Remove the existing battery using the tab. A new instrument will **not** have an installed battery.
4. Insert the charged battery into the analyzer with the battery connectors facing to the left. The battery slot is keyed so that the battery can be inserted only one way.

2 — Battery Status

To TEST a Li-ion battery's charge status:

EXTERNAL battery test —

1. Push the white button on the battery.
   The green lamps indicate the percent of charge, from less than 25% to 100%.
2. If a battery has a charge of less than 25%, use the Delta Docking Station to establish a full charge. See *Page 45*.

INTERNAL MAIN battery test —

1. The battery icon from any UI screen (upper right side) shows an approximate value of charge.
2. Tap the battery icon and a more precise charge percentage is displayed as a number.

3 — HOT SWAP for Delta Battery

A battery HOT SWAP capability is a **standard feature** with the Delta analyzer. An operator can remove and replace a battery without having to shut down, restart, or Cal Check.

When the battery is removed:

- A "Shutdown" status display gives the percentage of internal charge remaining.
- If the internal charge reaches 0, you have to re-start the unit with the I/O switch, after inserting a fresh battery.
- If red X-ray indicator lights flash, the battery voltage is too low.

Cal_Check Information

Cal_Check Facts

Question: What is involved with the Cal_Check procedure?

Answer: The analyzer:

- Collects a spectrum on a known standard (Alloy 316 Stainless Steel)
- Compares a variety of parameters to values stored when the instrument was calibrated at the factory.
- When comparisons are within pre-set tolerances, the unit determines that it remains properly calibrated.

GENERAL FACTS INCLUDE:

- Cal_Check must be performed when the analyzer requests the procedure.
- The *Start* button and trigger are disabled until a successful Cal_Check is achieved.
- You can run a Cal_Check at any time during *InnovX* software operation, except during a test.
- When Cal_Check is in progress, the x-ray indicator light assembly blinks.This indicates that the X-ray tube is energized and the filter wheel is operational. In addition, a status bar appears on the UI display, showing the percentage completion for the measurement.
- The Cal_Check procedure takes about 15 seconds.

Cal_Check Procedures

There are two separate techniques:

- **In the test laboratory** - Use the DDS to initiate "on-demand" procedure. Described above in *"Use the DDS for Startup - Initial Cal Check"*:

  Also have the "Automatic" option, as follows:

  Leave Delta powered On and InnovX software running;

  Ensure that DDS is On (Delta ICON is lit);

  Unit initiates Cal_Check after being idle for five minutes, then every 10 hours thereafter.

- **In the field** - Use the Coupon {the procedure is described below)

1. Place the 316 stainless steel Cal_Check coupon on a flat surface.

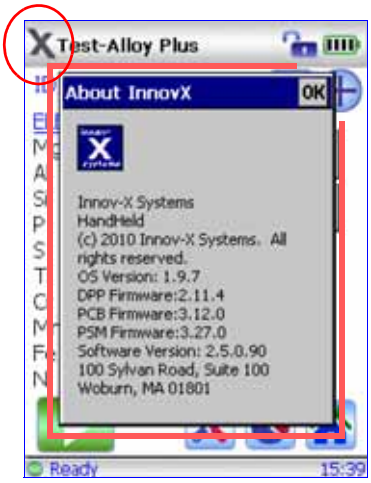
   See *C2. Safety Information, Page 29* for safety measures that must be observed.
2. Position the analyzer's measurement window flush over the coupon.
3. With the Test Setup screen invoked, tap the Cal Check icon. There are now two techniques to choose from:
   - Tap the "Start Test" icon, or
   - Pull the trigger (or pull-and-hold if using "Deadman Trigger")
4. The procedure takes about fifteen seconds.

> **NOTE**
>
> Improperly positioning the window over the coupon can result in a failure.

5. When Cal_Check completes successfully, you may begin testing.
6. If Cal_Check fails, ensure that:
   - Coupon is positioned correctly.
   - X-ray indicator assembly is blinking during the procedure.
   - You have waited several seconds before starting the procedure.
7. If Cal_Check fails again,
   - Shut down the Delta software.
   - Shutdown and restart the analyzer.
   - Launch another attempt to Cal Check.

If Cal_Check fails repeatedly, contact Innov-X Systems Customer Service or your local distributor. Contact information is available at appendix *A6. Packing and Shipping*

TIPS - or - things you should know about the Delta



System Information
To call information "About InnovX" tap the **X** (InnovX icon) in upper left of UI screen. This provides various firmware and software versions that are installed on the analyzer.

UI Screen Note
All User Interface screens have a time-out (power saving) feature that causes the screen to go blank after 45 seconds if the UI is not accessed or the unit is not moved.
However, the analyzer is still running.
Restore the screen by tapping it or by moving the instrument.

Battery Status Info #1
When you turn on the instrument and you may not be aware that the battery is low, the X-ray indicator (Red LEDs) flashes dimly and briefly. The unit will not turn ON. Swap out the battery.

Battery Status Info #2
The on-screen battery icon (in upper right corner of UI) shows "real-time" battery charge status in a **graphical** way.
Tap this icon to receive a **numeric** value for battery charge level.

Delta Docking Station to Delta Analyzer: Contact Status
Keep the rubber boot attached to instrument when inserting it into the DDS. This helps ensure that the DDS contact pins are engaged.

The DDS analyzer icon (rear left corner) should be ON.

If the rubber boot is not available, and the analyzer icon remains OFF, use a small piece of padding under the handle to ensure contact.

C5. Alloy Analysis Modes

Alloy analysis for the Delta family includes:

- Wide range of modes and calibrations
- Outstanding performance for a variety of materials

There are five Alloy modes/calibrations:

ALLOY

Use with: **ALL Models**

ALLOY

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb

Fundamental Parameters Analysis for metal alloys.
Alloy library including 300+ grade specifications, common tramp limits, including full editing capabilities.

ALLOY Plus

Use with: **Premier** and **Standard Only**

ALLOY PLUS

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb
PLUS Mg, Al, Si, P

Fundamental Parameters Analysis for metal alloys.
Optimized beam condition for extended light element performance.
Alloy library including 300+ grade specifications, common tramp limits, including full editing capabilities.

FastID

Use with: **All** Models

Spectral signature matching for alloy grade & chemistry calculation.
Full library editing & alloy matching capabilities included.

Pass/Fail

Use with: **All** Models

Spectral signature or **chemistry matching** for alloy grades.
Customer created library with min/max grade specifications.
Full library editing & alloy matching capabilities included.

Precious Metals Additions

Use with: **All** Models

ADDS Ir, Pt, Au, Rh, and **Pd** to Analytical Analysis calibration suite.

Introduction to Alloy Analysis Modes

ALLOY

ALLOY PLUS

The Delta family of instruments currently presents six unique modes for alloy analysis. The core analytical analyzer modes/types are:

Alloy mode - **Classic** (PiN detector based) type

Alloy Plus mode - **Standard** (SDD detector based) type

- **Premium** (SDD detector based) type

All three analyzer types can support additional alloy-oriented modes, such as

FastID

Pass/Fail

Precious Metals (No added details)

Alloy analysis utilizes a Fundamental Parameters (FP) algorithm to determine elemental chemistry. This method calculates chemistry from the spectral data, without the requirement of stored fingerprints. The Analytical FP calibration is done at the factory, and requires no user set-up or recalibration. The software also searches an alloy grade library to produce a grade match based on the calculated chemistry. Analytical mode can provide a **grade ID** and **chemistry** in as little as one second, with increased precision for longer test times.

Alloy mode/Classic type supports Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb.

Alloy Plus mode /Standard type and Premium type supports light elements Mg, Al, Si, and P in addition to the core list of elements from the Alloy mode.

Standard and Premium units expand the Limits of Detection range permitting operators to analyze these light elements without a vacuum or helium purge requirement.

Both modes have a feature, Altitude Compensation, which automatically corrects calibrations based on barometric pressure.

Determination of Grade Identification:

Analytical modes utilize a Factory Grade Library consisting of a set of minimum and maximum values for each element in an alloy.

There is a SPECIFIC Alloy Factory Grade Library for EACH Delta model.

See appendix *A8. Alloy Grade Libraries* for a listing of the alloys that are contained in each Factory Grade Library.

Additionally, every analyzer is shipped with a "**Tramp**" library comprised of seven base alloys. These seven items with their min/max element values are increasingly valuable to fast and accurate sorting in Pass/Fail and FastID modes.

The libraries can be searched individually or together. All libraries, including each Factory Grade Library, can be edited by the user. However, InnovX strongly suggests that users NOT edit the Factory Grade Library. Instead, copy the Factory Grade Library to a USER library, then make any edits on it.

Match Number Concept

After calculating chemistry with the Fundamental Parameters algorithm, *Innov-X* compares the chemical composition values to grade tables stored in a grade library. The application calculates the value for a parameter called *Match Number*. This provides an indication of how close the measured alloy's chemistry is to library values.

- The *lower* the Match Number, the *better* the match.
- A Match Number of 0 is an *exact match*, meaning that the calculated chemistry for all elements falls within the grade table specifications.

GO TO

- See **"***Delta User Interface Guide"* (PN 103202) for a complete description of the *Innov-X* application's User Interface.
- See *A8. Alloy Grade Libraries* for listing of each model's "Factory Grade Library"
  - A "Spectral Fingerprint" library that would be used for "FastID" and "Pass/Fail" analysis is created by the customer.

Match Issues

There are three Match determination possibilities provided within the Analytical modes:

EXACT MATCH

An unknown alloy is matched to one of the grades contained in the Grade Libraries, and a *Grade ID* appears on the *Results* screen. Often other grades are listed with their accompanying Match Numbers. The analyst has the opportunity to view their elemental chemistries and see how they differ from an exact match.

MULTIPLE MATCHES

In some cases, several grades are shown as possible matches. This can signify one of two conditions:

- There was not enough statistical information to definitively separate two or more alloys. The actual identification of the unknown alloy is one of the grades listed. Often increasing the testing time makes it possible to separate the alloys.
- There was sufficient statistical information, but the test sample did not meet any of the existing specifications with enough precision to cause an exact match identification.

NO MATCH

If no matches are found within the libraries, the words *NO MATCH* appear.

There are several causes for a NO MATCH result:

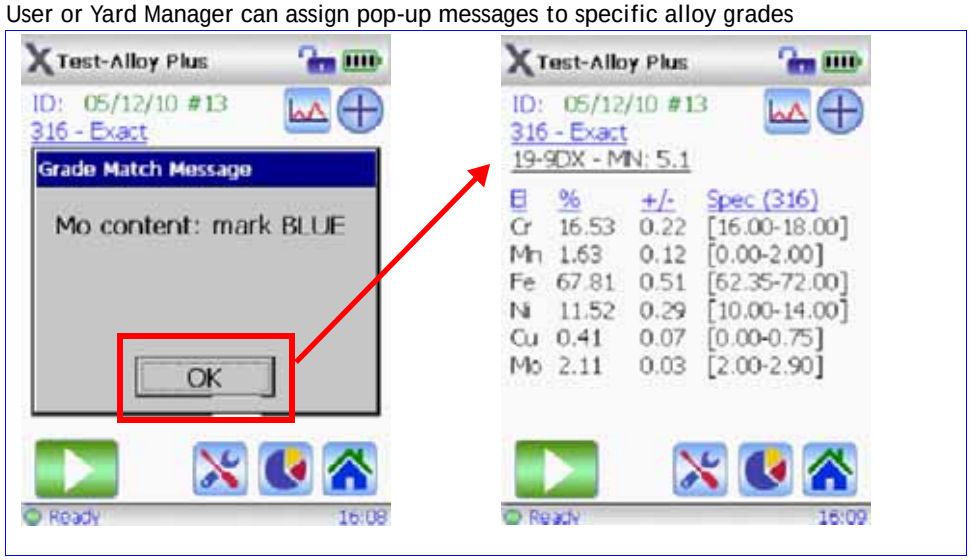
- The test sample does not meet any of the specifications in the Grade Library.
- The test sample is coated; Remove the coating by grinding, filing, or sanding and repeat the test.
- The testing time was too short.
  - Increase the testing time and measure the sample again.
- The Match Number is too low.
  - If possible, increase the Match Number

Scrap and Recycling Features

Delta analyzers in Alloy or Alloy Plus modes support many new features to specifically enhance scrap processing by maximizing speed and accuracy.

Grade Match Messaging (GMM)

User or Yard Manager can assign pop-up messages to specific alloy grades



- Quick start for next test, or
  view the chemistry details with one click

Grade Match Messaging offers:

- Immediate sorting instructions
- Less operator training
- More efficiency and higher throughput

SmartSort

Automated sorting decisions that allow users to maximize speed and sorting accuracy. Some features include:

- Specific grades set up to automatically extend testing time.
- Maximize efficiency for speed testing by automatically extending test time for light elements (Mg, Al, Si, P, S)
  - Eliminate unnecessary long tests

Nominal Chemistry

Nominal Chemistry looks for 'invisible' elements, based on grade ID, including:

- Elements not tested under active beam, (like Al in Beam 1)

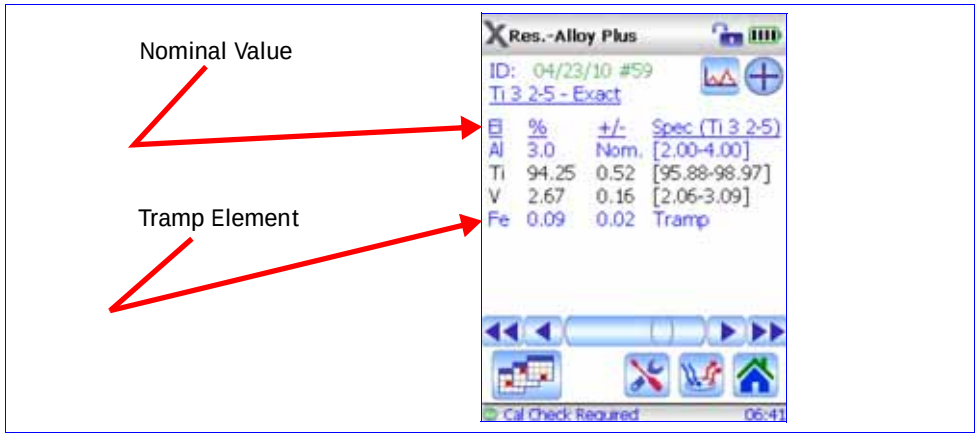
  — or —

- XRF invisible elements (like B or C)

Tramp Library

Analyzers with Alloy or Alloy Plus mode come pre-loaded with a tramp library based on industry standards.

- Operators may assign other "Tramp" elements with max tolerated concentration for individual elements in seven unique graded families.
- Analyzers can report tramp material (optionally) and simplify grade match by not counting small, expected amounts of tramp elements against the grade match.



See appendix *A8. Alloy Grade Libraries* for a discussion of the Tramp Library concept, including:

- How the InnovX Tramp Library works
- Practical advantages of the Tramp element approach
- List of seven Tramp Base Alloys

Test Sample Considerations

Coated or Painted Samples

XRF is a surface analysis technique, where X-rays penetrate a very short distance into most alloy samples. Therefore, the analyzer detects what is on the surface of an alloy, rather than what comprises the bulk of the material. If a material has been coated, plated, painted, or has had some sort of surface treatment, such as heat treating, it may be misidentified.

For example, a steel piece painted grey may show high concentrations of titanium from the paint, and may be misidentified as a titanium alloy. In another example, large amounts of metal dust or turnings on a surface may be detected by the analyzer.

To ensure proper identification of coated materials, grind an area slightly larger than the analyzing window to remove the coating. It is important to select the correct grinding material so as to not interfere with the analysis.

Do not use Silica for a Silicon analysis.

It may not be necessary to completely clean and polish all materials, however, remove obvious metal dust.

Mixed Samples, Heterogeneous Materials

Often finished metal pieces may consist of more than one type of metal. In addition, you may wish to measure mixed turnings, or an assortment of small pieces. In these cases, remember that the analyzer measures the entire area covered by the analyzing window and reports an average chemistry. For turnings, this is useful, as the analyzer provides an average composition. However, if two or more pieces of metal cover the window, the results is just an average reading, and may tell very little about the composition of one piece or the other.

When shooting metal pieces, or welds, ensure that **only** the metal of interest is covering the analyzing window.

Small and Irregularly Shaped Samples

To measure samples smaller than the analyzing window:

- Increase the testing time.

— and —

- Maximize the material in contact with the window.

The precision of analysis for small parts measurements is reduced, as the signal from smaller samples is less than for samples that completely cover the window. If possible, analyze the largest, flattest side of an irregularly shaped object.

GO TO

- See *A4. Typical Test Procedure* for description of a Test sequence.
- See **"***Delta User Interface Guide"* (PN 103202) for a complete description of the *Innov-X* application's User Interface.

Introduction to FastID Mode (All Models)

FastID mode is designed to quickly identify an alloy. It uses an empirical calibration method known as a "type" calibration. It is most useful where the number of alloys to test is small and well known.

FastID is best suited for Positive Material Identification (PMI) and QA/QC applications.

For example, where alloy producers or fabricators handle materials that may be very similar or where maximum user simplicity is a primary concern.

This mode offers:

- Simplified results (grade name only or less information on tramp elements).
- A narrow, customized grade library base upon stored spectral fingerprint reference standards.
- **Full chemical analysis based on reference standard assays.**
- Results which are the best combination of SPEED and ACCURACY.
  - A Grade and Chemistry result in as little as one to two seconds.
- User selectable match criteria settings.
- Expansion of up to 500 additional alloy grades and assays (alloy chemistries) — password protected.
- Multiple independent grade libraries. You choose to search one or more libraries.
- All libraries are editable

How FastID works:

Prerequisite: The operator creates a "custom FastID fingerprint' library by testing an array of reference standards. This list spans the number of alloys for which he is interested.

1. Delta's XRF process allows a test sample to create a spectral fingerprint.
2. Analyzer compares this spectral fingerprint to entries from library of many certified spectra, the "custom FastID fingerprint" library.
3. Analyzer finds the best spectral match to the sample spectra: thus identifying and reporting the matching alloy grade.
4. If concentration data has been entered for the standards, the instrument then calculates the sample's **chemistry**.

   The reported chemistry data are an extrapolation from standard intensity data stored in the customer -generated fingerprint library.

   The user gets a real time grade match and a precise report of the chemical composition of the sample.

NOTE

— Because FastID mode performs a spectral match to a library of reference standards, it is important that before testing, a "likely" stored reference standard be in the customer-created FastID fingerprint library.

Introduction to Pass/Fail Mode (All Models)

Pass/Fail mode is designed for high-throughput alloy sorting and quality control.

Mode Features

- All test samples are sorted by comparison to an operator-selected reference standard.
- Results are displayed as a *PASS* or a *FAIL*, depending on whether they match the reference standard.
- Pass/Fail criteria may be based on:
  - "quality of fit" to the selected spectral fingerprint

    — or —
  - elemental chemistry.
- Pass/Fail ranges may be implemented for one or more elements.
- This mode offers a full range of options from the simple sorting of mixed loads in a recycling facility to QC on specific element(s) of the most complex superalloys.

Pass/Fail mode has two options: *Fingerprint and Chemistry*:

1. Fingerprint Option

Select this method when the goal is to determine whether or not test samples are a **specific grade**.

Fingerprint Pass/Fail and FastID use the same method to determine a match.

Data from analyzed samples are compared to the reference standard fingerprint.

If the differences between the fingerprints are small enough, the sample is judged to be of the same grade as the reference sample.

This method requires:

Only that the library contains a valid fingerprint for the reference standard.

2. Chemistry Option

Select this method to determine whether the chemistries for specific elements fall **within specified min/max grade** specifications.

Chemistry pass/fail process is:

1. Analyzer uses the fingerprint method to determine whether the sample matches the reference sample.
   If it does not, it automatically fails.
2. If Step 1 has a match, the alloy chemistry is calculated from assays stored for the standard fingerprint.
3. The calculated chemistry for each element is compared to the values stored in a *Grade Table*.

   In order for a sample to pass, all the chemistries must be within "n" standard deviations of the min and max values specified in the grade table.
   Number "n" is specified by the user.

This method requires three items:

(1) a valid fingerprint, (2) assays for that fingerprint, and (3) Min/Max values saved in the library.

C6. Mining Modes

There are three Mining modes

MINING Use with: **ALL models**

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb, Bi, Zr, Mo, Ag, Cd, Sn, Sb
(elements may be customized on request)
Fundamental Parameter based calibration for **ore grading and percent-level** analysis of **process bulk** samples.
Suitable for measurement of percentage level analyte concentrations, 0.5% and greater.

2 BEAM MINING Use with: **Premier** and **Standard** Only

Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb, Bi, Zr, Mo, Ag, Cd, Sn, Sb
(elements may be customized on request)
Mining mode optimized for **SDD based systems to enhance SPEED and LOD for light elements**

CAR Catalyst Use with: **All** Models

Mode ICON
T.B.A.

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb
PLUS Rh, Pt, Pd
Accurate analysis of **bulk recycled catalyst** materials

The Mining modes/types are:

Mining mode - **Classic** (PiN detector based) type
2 Beam Mining mode - **Standard** (SDD detector based) type
Beam Mining mode - **Premium** (SDD detector based) type
Car Catalyst mode - **All** types

These modes utilize a Fundamental Parameters algorithm which automatically corrects for inter-element results.

The units can analyze:

- *in situ* (directly on the ground),
- prepared soil samples (in sample cups)
- bagged samples

Best Practices

Check Standards

Measure a check standard after each Cal Check, and periodically throughout the day. This confirms that data continues to be as accurate as possible.

The standards provided with Delta instruments are contained in special XRF sample cups. These cups have film windows (through which the soil can be viewed and analyzed) on one side, and solid caps on the other side.

Sample Presentation

in situ testing

In situ testing is performed by pointing the analyzer at the ground. Clear any grass or large rocks away and hold the analyzer with the probe head front flush to the ground. Since dirt can accumulate on the analyzer window, wipe the window clean after each analysis. Ensure the window is not ripped or punctured.

Bagged or prepared sample testing

Analyze prepared samples in a sample cup, through its Mylar window. Place the instrument's measurement window directly over the sample cup with the Mylar side up.

Preparation considerations include:

- Avoid measuring very thin samples, as this can affect results. Prepare samples cups to contain at least 15 mm of packed samples.
- When analyzing bagged samples, ensure that sufficient sample material exists in the bag to completely cover the window with a sample thickness of a minimum of 15 mm.
- When using bags, cheaper bags (having thinner plastic walls) are better than more expensive ones (which have thicker plastic walls).

Optional Accessories

Accessories that can assist in Mining mode testing are:

- A-035: Soil Foot
- 990055: Soil Extension Pole
- A-020-D: Workstation - portable, fully shielded, closed beam test stand for bench-top or remote controlled testing.
- Trimble Xplorer Package

Typical Test Procedure

GO TO

See *"A4. Typical Test Procedure"* for description of a Delta Test sequence..

Mining Mode Options

Test length in Mining Mode is **user defined**.

GO TO

Refer to *"Delta User Interface Guide, User Factors"* for procedure to modify User Factors..

Factors

Mining modes allow you to create your own set of **factors**, focusing on particular elements of interest or correcting for matrix effects.

You can make several different *Factor* tables, allowing analysis of a variety of samples.

Setting Mining User Factors

Example:

A group of samples covering the full concentration range for each element of interest are identified. Each sample is homogenized and split. A portion of each sample is sent to an outside lab for analysis. The other portion is analyzed with the analyzer. For best results ensure that the samples are very well homogenized, and characterized, so the correlation is quite good.

Procedure:

Plot the data. Innov-X data must be on the X-axis, lab values on the y-axis.

CAUTION

ENSURE that you use this order: Innov-X data on X-axis and lab data on the Y-axis.

Determine the linear best fit with both the slope and intercept for each element.

The slope and intercepts for these graphs are entered directly into the analyzer. In many cases it is sufficient to enter just a correction for the slope as the intercept is almost zero. In others, enter the slope and intercept.

You can enter multiple sets of user factors for different applications, or different ore bodies. A group of factors is given a name, and then the factors are entered. The factor set can then be selected by name.

NOTES

C7. Soil Modes

The Delta family currently supports two soil modes, **Soil** and **3 Beam Soil**. Each mode has a possibility of two default element suites, **Environmental** and **Exploration**.
Note that both calibration packages cannot reside on one instrument.:

SOIL Environmental Use with: **All** Models

K, Ca, S, P, Cl, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Hg, As, Pb, Se, Rb, Sr, Zr, Mo, Ag, Cd, Sn, Sb, Ba
(elements may be customize on request)
Compton Normalization algorithm designed for achieving lowest Limit of Detection (LOD) possible for **SOIL** and **BULK** samples.
PowerShot and SmartShot 3-beam modes included.

SOIL Exploration Use with: **All** Models

K, Ca, S, P, Cl, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hg, As, Pb, Bi, Se, Th, Rb, U, Sr, Zr, Mo, Ag, Cd, Sn, Sb

(elements may be customized on request)
Compton Normalization algorithm designed for achieving lowest Limit of Detection (LOD) possible for exploration samples. PowerShot and SmartShot 3-beam modes included.

Soil Mode Beam Selection

SmartShot Beam Mode:

Uses a single incident bean setting (Transition Metals) otimized to deliver ultra fast results with solid LOD performance across the periodic table. SmartShot offers excellent sensitivity in the fastest testing time possible.

PowerShot Beam Mode:

Offers a fully optimized, multi-beam analysis method that provides exceptional LODs for all elements analyzed - heavy metals, transition metals, and light elements. PowerShot can be used to analyze the full element range, or to focus in on a particular element of interest, such as Cr, Cd, Ni, or Cu. Any or all of the following beams conditions may be selected:

- Heavy Elements
- Transition Metals
- LEAP (Light Elements)

Use this procedure to configure beam selections:

From the Mode Setup screen select **Test Conditions**.

Select the **LEAP** option

Configure one or more **Powershot(s)**. Note that multiple beams may be chosen.
Press **Save** to return to soil testing.

Best Practices

Check Standards

Measure a check standard after each standardization, and periodically throughout the day, for a minimum of one minute. Elemental concentrations for elements of interest, in the range expected at the site, plus or minus the error on the reading, should be within 20 percent of the standard value. *A2.Soil Testing* describes recommended quality assurance considerations in detail.

The standards provided with the analyzer are contained in XRF sample cups. These containers have a film window (through which the soil can be viewed) on one side, and a solid cap on the other side. Always measure samples through the film window.

Sample Preparation

Preparation considerations include:

- Avoid measuring very thin samples, as this can affect results. Prepare samples cups to contain at least 0.5”(usually 4-8 grams) of packed samples.
- When analyzing bagged samples, ensure that sufficient sample material exists in the bag to create a a sample thickness of a minimum of 15 mm for a spot size that is larger than the analyzer’s measurement window.
- When using bags, cheaper bags (having thinner plastic walls) are better than more expensive ones (which have thicker plastic walls).

C8. Consumer Goods Analysis Modes

There are two consumer goods modes:

RoHS

RoHS regulated elements- **Cr, Hg, As, Pb, Br, Cd**,
PLUS Cl, Ti, Fe, Co, Ni, Cu, Zn, Sn, Sb, Ba

Analysis software for measurement of restricted elements in electronics and consumer goods. Auto-compensations built in for metal, polymer, and mixed matrices.

Consumer Products

Analysis software designed for CPSIA & Prop 65 testing. **Pb** content displayed as **Pass/Fail** based on regulated limits.

Additional elements Cl, Ti, Cr, Fe, Co, Ni, Cu, Zn, Hg, As, Br, Cd, Sn, Sb, Ba also reported.

Introduction to RoHS Mode

Toxic metals in consumer electronics are the focus of EU regulations that have worldwide ramifications. These new directives currently include:

- *Restriction of Hazardous Substances* (**RoHS**)
  - Designates maximum allowable levels of Pb, Cd, Cr^{6+}, Hg and certain Br-containing flame retardants (PBB and PBDE) in new electrical and electronic equipment sold into the EU.

The limits for RoHS elements are:

- <0. 1% Pb, Cr6+, Hg, Br (as flame retardants, PBB and PBDE)
- <0.01% Cd

The Innov-X analyzer is a screening tool for RoHS Compliance. It is used to:

- Directly analyze the amount of toxic metals in electronics,
- Identify quickly whether a plastic is made of or contains:
  - PVC
  - A brominated flame retardant.

XRF measures *total elemental composition*, regardless of speciation of the element. Therefore, it reports

- Total chromium including the concentration of hexavalent chromium plus any other forms of Cr.
- Total bromine, however cannot distinguish the type of brominated flame retardant present in analyzed materials.

In order for XRF to be quantitative, samples must be:

- Homogeneous
- Have a certain minimum sample thickness
  - Five (5) mm for polymers and light alloys
  - Fifteen (15) mm for liquid samples
  - One (1) mm for other alloys

If samples are heterogeneous, too thin, or too small, only qualitative screening is possible.

The IEC-ACEA (International Electro-technical Commission – Advisory Committee on Environmental Aspects) recommends XRF screening.

Test Overview

The Delta analyzer controlled by *InnovXPC* application software (in RoHS mode) automatically executes a test sequence to determine:

- Whether a sample is an **alloy**, **polymer**, or **mixed**.
  - "Mixed" indicates heterogeneous samples consisting of both polymer and alloy, such as wires or circuit boards.
- Whether each RoHS element **passes**, **fails**, or is **inconclusive** when compared to a set of stored criteria.
  - These criteria are either those recommended by the IEC, or ones added by the user.

The sequence begins with the instrument utilizing tube settings appropriate for analyzing a polymer sample. The following logic applies:

- If the sample is determined to be a polymer or mixed, the test continues, and a calibration based on a polymer matrix is used.
- If the sample is found to be a metal alloy, the analyzer switches to a secondary test, using an alloy matrix calibration, in order to determine correct alloy concentrations.

Check Standards

Innov-X Systems recommends that a check standard be measured after each Cal Check procedure, and periodically throughout the day.

Two certified standards are provided for verification.

- At least one standard should be measured for a minimum of two minutes.
- Concentrations for target elements (plus or minus the error on the reading) should be within 20% of the standard value.
- Standards provided are contained in XRF sample cups with a Mylar window (through which the plastic pellets can be viewed) on one side, and a solid cap on the other side.
- Samples should be measured in the sample cup, through the Mylar window.

Sample Presentation

Since many pieces of plastic analyzed for ROHS compliance are very small, take care to measure them in a safe and accurate manner. See the IEC-ACEA recommendations for minimum thickness of test samples.

IEC Quantitative Screening Requirements

RoHS requirements are derived from the *"Directive 2002/95/EC of the European Parliament and of the Council of the European Union on the restriction of the use of certain hazardous substances in electrical and electronic equipment."*

Dated 27 January 2003.

Important Current Issues

- At this User Manual's release date (May, 2010), the IEC requirements (including limits and exemptions) have **not been formally accepted.**
  A timetable for acceptance has not been established.
- Users must be aware that the information in Figure 1 concerning RoHS screening limits has been extracted from **proposed/draft** IEC-ACEA documentation**.**
- **Innov-X strongly advises users to have their own compliance departments determine the current status of the requirements that they must meet.**

Elemental Range/Limits for RoHS Compliance

—RoHS— Elements	PASS	Lower Limit	Incon-clusive	Upper Limit	FAIL
	Polymer Materials				
Cd	P	≤(70-3s)	< X <	(130 +3s)≤	F
Pb	P	≤(700-3s)	< X <	(1300+3s)≤	F
Hg	P	≤(700-3s)	< X <	(1300+3s)≤	F
Br	P	≤(300-3s)<	X		
Cr	P	≤(700-3s)<	X		
	Metallic Materials				
Cd	P	≤(70-3s)	< X <	(130 +3s)≤	F
Pb	P	≤(700-3s)	< X <	(1300+3s)≤	F
Hg	P	≤(700-3s)	< X <	(1300+3s)≤	F
Br			N/A		
Cr	P	≤(700-3s)<	X		
	Electronics				
Cd	P	LOD	< X <	(150 +3s)≤	F
Pb	P	≤(500-3s)	< X <	(1500+3s)≤	F
Hg	P	≤(500-3s)	< X <	(1500+3s)≤	F
Br	P	≤(250-3s)<	X		
Cr	P	≤(500-3s)<	X		

Figure 1: Proposed Screening Limits for RoHS Elements

Grade Definitions for Screening

Grade	Proposed Screening Criteria
PASS	Results for ALL elements are lower than the lower limits shown in Figure 1.
FAIL	Result for ANY element higher than the higher limits shown in Figure 1.
INCONCLUSIVE	Result of the quantitative analysis, for any of the elements Hg, Pb, or Cd, is in the region defined as intermediate, OR if the result of the elements BR and Cr is higher than the higher limits shown in Figure 1, the analysis is inconclusive. Additional investigation must be performed.

GO TO

- See *A4. Typical Test Procedure* for description of a Test sequence.
- See **"***Delta User Interface Guide"* (PN 103202) for a complete description of the *Innov-X* application's User Interface.

Introduction to Consumer Products Mode

Background

This mode is dedicated to testing items for Lead (**Pb**) content.

The result output is **Pass/Fail** based on the regulated limits that are specified in:

- **CPSIA** (the Consumer Products Safety Improvement Act of 2008)
- **Prop 65** - refers to California Proposition 65 enacted in 1986

Additional elements that may be reported are:
Cl, Ti, Cr, Fe, Co, Ni, Cu, Zn, Hg, As, Br, Cd, Sn, Sb, Ba

Regulatory limits vary with the governing body, state-to-state, and country-to-country. European Union nations generally use the RoHS limits and testing practices.

The regulatory limits for Pb are:

- CSPIA: 300ppm currently, but going to 100ppm
- RoHS: see Table 1.0 on Page 70

GO TO

- See *A4. Typical Test Procedure* for description of a Test sequence.
- See **"***Delta User Interface Guide"* (PN 103202) for a complete description of the *Innov-X* application's User Interface.

A1. Overview: X-Ray Fluorescence (XRF) Spectrometry

Basic Theory

Although most commonly known for diagnostic applications in the medical field, x-rays are the basis of many powerful analytical measurement techniques, including X-ray Fluorescence (XRF) Spectrometry.

XRF Spectrometry determines the elemental composition of a material. This method identifies elements in a substance and quantifies the amount present of those elements. An element is defined by its characteristic X-ray emission wavelength (λ) or energy (E). The amount of an element present is determined by measuring the intensity of its characteristic line.

All atoms have a fixed number of electrons (negatively charged particles) arranged in orbitals around their nucleus. The number of electrons in a given atom is equal to the number of protons (positively charged particles) in the nucleus. In the classical Periodic Table of Elements, the Atomic Number is specified by the number of protons. Each Atomic Number is assigned an elemental name, such as Iron (Fe), with Atomic Number 26.

XRF Spectrometry typically utilizes activity in the first three electron orbitals, the K, L, and M lines, where K is closest to the nucleus. Each electron orbital corresponds to a specific and different energy level for a given element.

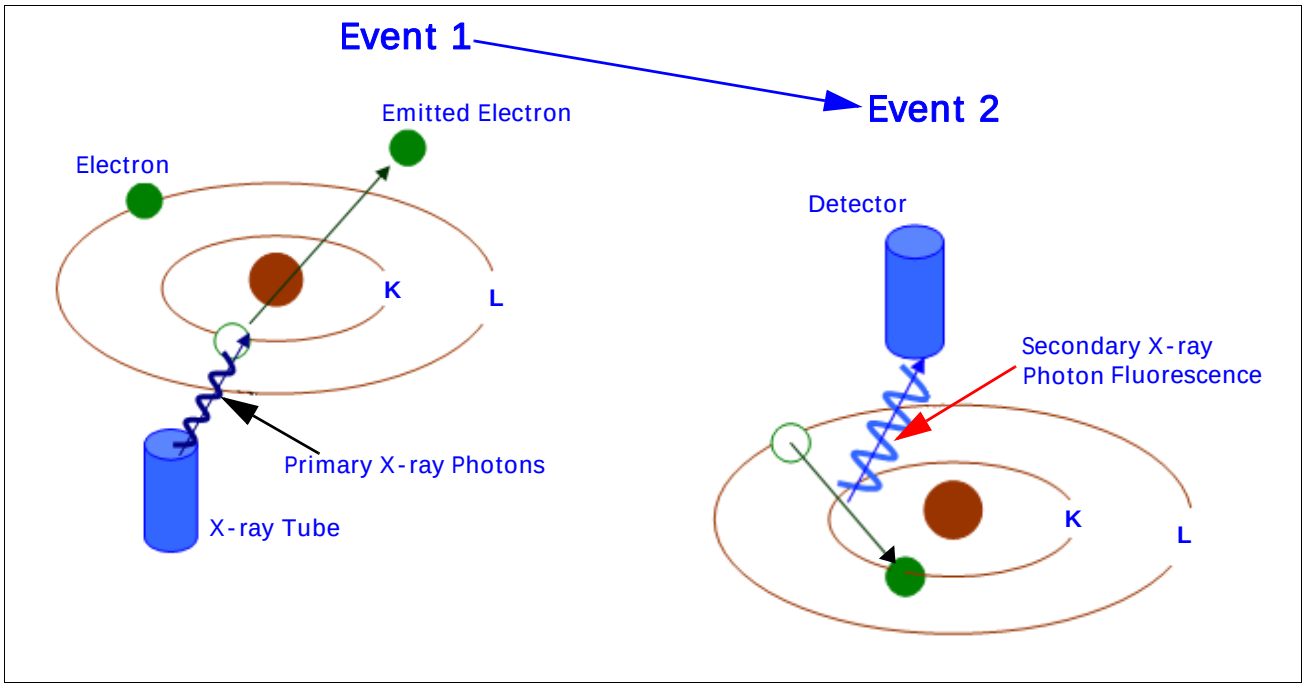
In XRF Spectrometry, high-energy primary X-ray photons are emitted from a source (X-ray tube or *radioisotope*) and strike the sample. The primary photons from the X-ray source have enough energy to knock electrons out of the innermost, K or L, orbitals. When this occurs, the atoms become unstable ions. Electrons seek stability; therefore, an electron from an outer orbital, L or M, moves into the newly vacant space at the inner orbital. As the electron from the outer orbital moves into the inner orbital space, it emits an energy known as a secondary X-ray photon.

This phenomenon is called **fluorescence**.

The secondary X-ray produced is characteristic of a specific element.

The energy (**E**) of the emitted fluorescent X-ray photon is determined by the difference in energies between the initial and final orbitals of the individual transitions.

This is described by the formula $\mathbf{E=hc/\lambda}$ where **h** is Planck's constant; **c** is the velocity of light; and λ is the characteristic wavelength of the photon.

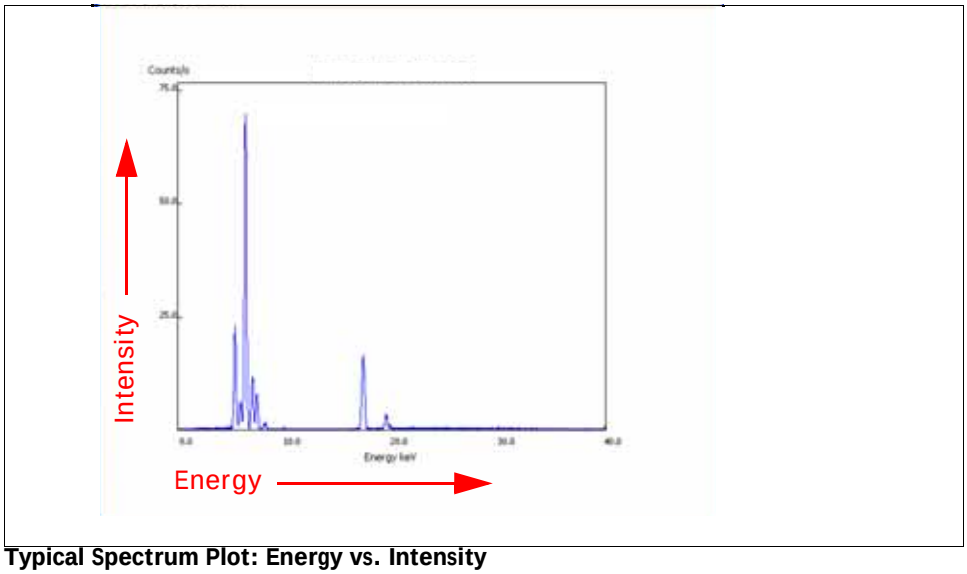


Creating a Secondary X-ray - Photon Fluorescence

Wavelengths are inversely proportional to the energies; they are characteristic for each element.

For example, the Ka energy for Iron (Fe) is about 6.4keV. The number of element-specific characteristic X-rays produced in a sample over a given period of time, or the intensity, is measured. This determines the quantity of a given element in that sample.

Typical spectra for EDXRF Spectrometry appear as a plot of **Energy (E)** versus the **Intensity (I)**.



Typical Spectrum Plot: Energy vs. Intensity

History

Timeline for XRF Spectrometry

- Wilhelm Roentgen discovered X-rays in 1895.
- Henry Moseley first published methods for identifying and quantifying elements using XRF in 1913.
- XRF research and development continued, especially during WWII.
  - Critical developments in the aircraft, automotive, steel, and other metals industries increased the need to identify alloys *quickly* and *reliably*.
- The first commercial XRF Spectrometers became available in the early 1950's. These systems were based on **Wavelength Dispersive (WD) XRF** technology.
  - The characteristic **wavelength** of an element was measured **one element at a time**.
  - WDXRF systems were useful for elemental analyses, however, the equipment had the following properties:
    - Large size
    - High initial cost
    - Required highly skilled operators to use and maintain them.
- In the late 1960's, **Energy Dispersive (ED) XRF** technology emerged as a viable commercial choice:
  - EDXRF measured the characteristic **energy** of an element.
  - Improvements in solid state detectors offered better energy resolution of the signal.
  - Had potential to collect and display information on **all** of the elements in a sample at the **same time**.
- Many of the early EDXRF systems used radioisotopes for excitation. They had the following properties:
  - Required changing sources to determine all the elements of interest.
  - Did not easily resolve multiple elements in a single analytical run.
- The current state-of-the-art in EDXRF is the result of
  - Advancements in technology (particularly X-ray tubes, solid-state components, electronics, computers, software)
  - Application of the technology by instrument manufacturers, research scientists, engineers, and industrial users.
- Now a mature technology, XRF Spectrometry is routinely used for R&D, QC, production support, and regulatory compliance.

Elemental Analysis

Investigators involved with elemental analysis generally have two working instrument techniques — *Wet Chemistry* and *XRF Spectrometry*. They are compared operationally as follows.

Wet Chemistry

Important considerations are:

- Instrument techniques are *time-consuming*.
  - Often takes twenty minutes to several hours for specimen preparation and analysis.
- Specimen is *destroyed*.
- Often necessary to employ *concentrated acids* or other *hazardous materials*.
- Requires *disposal* of waste streams generated during the analytical process.
- Relatively *high cost* per sample.

However, wet chemistry instrument techniques are necessary if the primary measurement requirement involves elemental concentrations in the PPB (or lower) range

XRF Spectrometry

Important considerations are:

- Easily and quickly identifies and quantifies elements over a wide dynamic concentration range, from PPM levels up to virtually 100% by weight.
- Does *not destroy* the sample.
- Overall sample turnaround time is *fast*.
  - Requires little, if any, specimen preparation.
  - Often results are available within seconds, minutes for some details.
- Relatively *low cost* per sample

Interferences

All elemental analysis techniques experience chemical and physical interferences. They must be corrected or compensated for in order to achieve adequate analytical results.

WET CHEMISTRY ISSUES

Most suffer from interferences that are corrected only by extensive and complex specimen preparation techniques.

XRF SPECTROMETRY ISSUES

The primary interference is from other specific elements in a substance that can influence (matrix effects) the analysis of the target element(s) of interest.

However, this interference style is well known and documented.

Both types of analyzer techniques benefit from (a) instrumentation advancements, and (b) mathematical corrections in the system's software.

In certain cases, the *geometry* of the sample can effect XRF analysis.

- This is compensated for by:
  - Grinding or polishing the sample
  - Pressing a pellet
  - Making glass beads

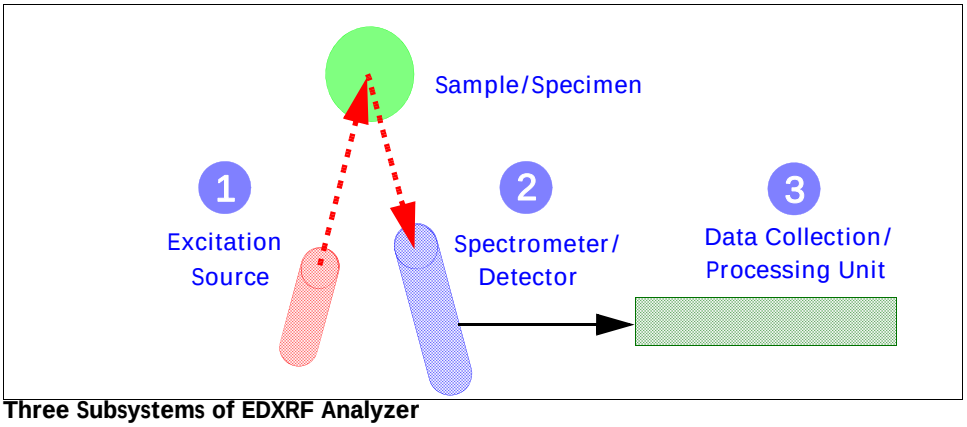
Quantitative analysis

XRF Spectrometry supporting quantitative analysis typically employs one of two software applications:

- **Empirical Methods**
  Uses calibration curves derived from standards similar in property to the target unknown sample.
- **Fundamental Parameters (FP)**
  FP is frequently preferred because it allows elemental analysis to be performed *without* standards or calibration curves.
  The analyst can use the system immediately.
  Modern computers support this *no-standard* mathematical analysis, FP, accompanied by stored libraries of known materials. These systems quickly determine not only the elemental composition of an unknown material, but even identify the unknown material itself.

EDXRF Spectrometers

An EDXRF instrument typically has three major subsystems:



Three Subsystems of EDXRF Analyzer

EDXRF analyzers are mechanically very simple; there are *no moving parts* in the excitation and detection subsystems. However, a bench-top analyzer can have moving parts.

When compared to WDXRF systems, EDXRF systems exhibit the following attributes:

- Ease of use
- Rapid analysis time
- Lower initial purchase price
- Substantially lower long-term maintenance costs

EDXRF analysis equipment is useful for many applications, including:

- Environmental analysis
- RoHS/WEEE compliance
- Scrap alloy sorting
- Forensic science
- Archaeometry

NOTES

A2. Soil Testing

This appendix explains usage of all of the company's hand-held portable analyzers with the *Soil* or *3 Beam Soil* mode option installed.

This document offers instructions/procedures and regulations, as well as useful reference material, regarding:

- Portable XRF equipment usage in accordance with accepted methods.
- Basic overview of the technique of x-ray fluorescence (XRF).
- Appropriate data quality assurance protocols.
- Sample preparation steps for operators analyzing prepared soil samples.
- Tables of certified values for selected standards.

If LEAP mode is enabled, refer to configuration help in *PN 103202*.

Section 1: Commonly Accepted Methods for Field Portable XRF

A commonly accepted method is shown: *Field Portable XRF Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment*.

Features of this method are:

- It is a field screening method, for analysis of *in-situ* or bagged samples.
- The method provides basic quality assurance methods, including calibration verification, determination of instrument precision, accuracy and limit of detection.
- The method recognizes that some XRF instruments do not require site-specific calibrations by the operator, that is, the factory calibration provides appropriate data quality.
- The method recommends that a minimum of 5-10% of samples tested by XRF be confirmed by an outside laboratory, using a total-digestion EPA analytical reference method.

The purpose of this method is *NOT* to replace laboratory analysis.

There are two primary sources of error in assessing a site for metal concentration: *Analytical error* and *Sampling error*.

Analytical Error

The error in the analysis of any one sample by whatever technique is used, for example XRF, ICP, or AA.

Sampling Error

This arises when **too few** samples are collected and tested.

In this case an incomplete picture of the extent of metals contamination may be obtained. Although any one sample may be analyzed with very high analytical accuracy, measuring too few samples may result in contamination plumes being mis-judged in size, or depth into the soil. In extreme cases contamination can be missed entirely.

Methods have been developed to reduce Sampling Errors by **increasing** the number of samples measured. In general, a large number of screening-level measurements provide a better characterization of contamination than a small number of measurements produced by sample removal and analytical analysis. A large number of in-situ samples provide detailed data on contamination profiles, depth (provided surface soil is moved aside), and approximate contamination levels. Portable XRF can provide results with a high degree of analytical accuracy on any given sample.

Section 2: Overview of Field Usage:

Field portable XRF is generally used in three ways to test for metals in soil:

IN-SITU SOIL TESTING:

The XRF is placed directly onto the ground for soil testing. Operators remove any plant growth and foreign objects so that the analyzer probe is flush to the soil.

BAGGED SOIL SAMPLE TESTING:

A soil sample is collected in a thin plastic bag (i.e. a *Baggie*) and testing occurs directly through the Baggie. Except for a few elements – namely Cr, V and Ba – testing through the thin plastic bag has little effect on the test result. However, results for Cr, V and Ba will be lower by 20-30%.

PREPARED SOIL SAMPLE TESTING:

Prepared sample testing assures the operator of the maximum possible accuracy. Prepared sample tests require a sample to be collected, dried if necessary, sieved and ground into a powder. The prepared sample is then placed into a baggie or XRF cup for analysis.

Sample prep procedures are provided on Section 8: Sample Prep Procedures and Testing Protocols on page 130.

ALL analytical methods require a *uniform, homogenous* sample for the best results. **XRF is no different!**

The methods generally used, namely In-situ and bagged sample testing, are considered *field-screening methods*. Although a field-screening method, in-situ testing is a valuable technique because it generates a great deal of data very quickly. Prepared soil samples generally offer the best accuracy, albeit with several minutes of sample preparation required per sample.

Subsection 2-A: Data Quality Objectives

The objective of testing is generally to determine the mixture of in-situ versus prepared sample testing. It is important to understand your data quality objectives (DQO) in order to determine the appropriate mix of field screening and prepared sample testing.

In-situ testing usually provides only *screening-level data quality.*

This is because analytical testing always requires a uniform, homogeneous sample matrix. A laboratory achieves this by digesting the sample into a hot acid before analysis. Testing directly on the ground does not ensure that uniformity is met. Preparing a sample provides a uniform sample and likely better analytical data quality, although several minutes of testing time is required.

Most portable XRF operators use a mixture of in-situ and prepared sample testing. The exact mixture of in-situ and prepared sample testing depends upon the goals of the soil testing. The examples below serve as guidelines.

Example 1: Initial site investigation to provide detailed contamination data with efficient use of laboratory analysis costs.

PROBLEM:

The site needs to be assessed for metals contamination. Little information is available about what metals are present, likely contamination levels or geographic profile of contamination.

The goal of testing is to determine what metals are present at what levels, both in area and in depth into soil. Additionally, testing will locate possible contamination plumes and/or possible sources of contamination.

RECOMMENDED TESTING PLAN:

This example uses predominately in-situ testing. The analyst will perform in-situ testing, and gather samples into plastic bags for XRF analysis. A testing grid should be established in two or three dimensions, every several feet. XRF tests can be taken at each location or bagged samples can be collected from each location for later analysis. The in-situ data for each element analyzed may be plotted in a 2-dimensional grid (X, Y coordinates versus elemental concentration) to profile a site. These concentration profiles are ideal for showing contamination patterns, boundaries and plumes. Combining this data with historical use data from the site often allows the operator to deduce sources of contamination. Obtaining this level of geographic data with purely laboratory analysis would produce excessive analytical costs.

Prepared sample analysis should also be done to confirm the regions where in-situ data indicates low or non-detected levels of metal contaminant. There is little need to prepare areas where in-situ testing indicates high concentration levels.

Innov-X recommends this procedure:

For locations where in-situ tests indicate low or non-detected concentrations, calculate the total number of in-situ tests, collect 5% of this number of tests from the various locations. Prepare these samples according to instructions on "Section 8: Sample Prep Procedures and Testing Protocols on page 130." Use these prepared samples to confirm the findings of the in-situ testing. Send a subset of these prepared samples to a laboratory for confirmatory results.

COST JUSTIFICATION:

To adequately characterize a site may require 100-200 samples/acre to be sure the contaminated areas are firmly established. This work may be done with in-situ testing to generate laboratory savings of $5,000 - $10,000/acre depending upon the number of elements being analyzed. The cost reduction in off-site analysis often justifies the price of the XRF.

Example 2: Monitor remediation efforts and assure site meets clearance levels before contractors leave the site.

GOAL:

Minimize remediation costs by only treating contaminated soil, and obtain immediate verification that various site locations meet clearance objectives.

RECOMMENDED TESTING PLAN:

This type of project uses a lot of both in-situ and prepared sample testing. Use in-situ testing to thoroughly delineate contamination regions in both area and depth. To determine depth profiles, test surface soil, remove at least 1-2', and retest. Repeat this step as necessary to profile contamination depth to guide remediation activities (XRF is a surface technique and only analyzes the first few mm of soil sample). As part of clearance, collect several samples from *cleared* area. Prepare samples according to *"Section 8: Sample Prep Procedures and Testing Protocols"* on page 92. Test with portable XRF.

If XRF indicates that concentration levels are:

- In excess of clearance requirements, then continue remediation efforts.
- Below clearance requirements, then discontinue remediation efforts, and send a subset of the samples to an analytical laboratory to confirm results. Most operators safely assume that the cleanup requirements have been met for the elements in question, but await final analysis from the laboratory.

If XRF lists concentration levels as non-detected, but the detection level reported exceeds clearance requirements, send samples to a laboratory for final results.

Cost Justification: In-situ results are used to guide remediation efforts, in order to obtain maximum efficiency. Efficiency is produced because contamination boundaries are firmly established, thus avoiding remediation efforts with *clean* soil. Prepared sample testing is used to assure that clearance requirements are met on-site in near real-time (pending laboratory confirmation). Costs savings are generated by avoiding clearance failures. The contractors can leave the site earlier and will not be called back to the site for additional cleanup.

IMPORTANT NOTE:

Never clear a site based solely on in-situ testing. Always use well-prepared samples to make a clearance decision.

Example 3: Minimize volume of hazardous waste for treatment or disposal.

GOAL:

For some cleanup projects, the cost of soil disposal in a hazardous waste landfill is much greater than disposal in a standard landfill. Testing soil samples with XRF may minimize the amount of *clean* soil that is inadvertently shipped to a hazardous-waste landfill.

RECOMMENDED TESTING PLAN:

This example is almost entirely based on prepared sample testing. Representative samples are removed from the soil being hauled to landfill. Obtaining an accurate analysis of the samples is crucial for making a hazardous versus non-hazardous determination. For this reason, prepared sample testing is strongly recommended.

IMPORTANT NOTE:

These types of samples are subject to Toxicity Characteristic Leaching Procedures (TCLP) for the landfill determination. In general, 20 times the XRF result should be less than the allowable limit for the metal in question. Please contact Innov-X Systems for more details on testing samples versus TCLP regulatory requirements.

Section 3: Quality Assurance

Quality assurance is detailed for both the proper use of the analyzer and for verifying the data quality of in-situ testing. All operators should perform the QC procedure, regardless of their data quality objectives. There must be strict requirements about quality assurance. Additionally, Innov-X recommends that operators verify the data quality of in-situ test results, if they are using in-situ data to guide their reporting or remediation decisions. Procedures are listed below:

Proper verification of instrument operation

Quality assurance here consists of testing known standards to verify calibration, as well as testing blank standards to determine limits of detection and to check for sample cross-contamination or instrument contamination. We recommend a detailed procedure, which is provided here in abbreviated form.

Components of instrument QC:

- An energy calibration check sample at least twice daily
- An instrument blank for every 20 environmental samples
- A method blank for every 20 *prepared* samples
- A calibration verification check sample for every 20 samples
- A precision sample at least one per day
- A confirmatory sample for every 10 environmental samples

Energy Calibration Check: The Innov-X analyzer performs this automatically; this is the purpose of the standardization check when the analyzer is started. The software does not allow the analyzer to be used if the standardization is not completed.

Instrument Blank: The operator should use the SiO_2 (silicon dioxide) blank provided with the analyzer. The purpose of this test is to verify there is no contamination on the analyzer window or other component that is *seen* by the x-rays. We recommend an instrument blank at least once per day, preferably every 20 samples. For either in-situ or prepared-sample testing, the operator should just test the SiO_2 blank to be sure there are no reported contaminant metals.

Method Blank: The purpose of the method blank is to verify that cross-contamination is not introduced into samples during sample preparation. We recommend following the sample preparation procedures with clean SiO_2 once very 20 prepared samples. This QC step is not required if the operator is not preparing samples.

Calibration Verification: Innov-X provides standard reference samples for calibration check by operator. The operator should perform a two minute test on a standard. The difference between the XRF result for an element and the value of the standard should be 20% or less. Calibration Verification should be performed upon instrument startup and periodically during testing.

NOTE

Innov-X recommends a calibration check every 4 hours. Some users make a calibration check every 20 samples. Reference standards are generally applicable for Pb, As, Cr, Cu, Zn. Innov-X provides additional reference standards for Priority Pollutant metals including Cd, Se, Ag, Hg, Ag, Ba, Sn, Sb, and Ni.

Precision Verification: It is good practice to make a minimum of one precision sample run per day by conducting from 7 to 10 replicate measurements of the sample. The precision is assessed by calculating a relative standard deviation (RSD) of the replicate measurements for the analyte. The RSD values should be less than 20 percent for most analytes, except chromium, for which the value should be less than 30 percent.

Confirmatory Sample: It is recommended that one confirmatory sample is run for every 10 samples collected. It is good practice to have confirmatory samples collected from the same sample material that is analyzed on site, but are sent to an off-site laboratory for formal analysis. The purpose of a confirmatory sample is to judge the accuracy of the data obtained by analysis on site and to allow corrections, if necessary."

Important Notes about confirmatory samples:

Innov-X always recommends that customers compare prepared-sample results to laboratory results. To do this, collect and prepare a sample following the protocols shown on *"Section 8: Sample Prep Procedures and Testing Protocols"* on page 92. Take a subsample and submit to the laboratory for analysis. The single largest error in XRF analysis is lack of sample preparation. For the best comparison, always use prepared samples.

Determining data quality of in-situ testing:

For operators relying extensively on in-situ testing, it is important to determine the data quality of this testing at a given site. *This protocol is not intended for every sample, but rather for a small percentage of samples considered representative of the site.* If the operator can demonstrate that quantitative data is achieved with little or no sample preparation, then the site characterization will be completed much more quickly but correctly.

For example, an operator may be able to demonstrate that the XRF result changes considerably when samples are passed through a 2 mm sieve, but that XRF results do NOT change appreciably upon finer sieving. In this case, the operator can conclude that good XRF data is achievable with only 2 mm sieving. Sieving only to this level requires far less time than a more robust sample preparation.

A protocol to determine the *appropriate level of sample preparation* is the following:

1. Delineate a region of soil approximately 4" x 4".
2. Perform several in-situ tests in this area, or collect the top (approximately) quarter inch of soil from this region, bag the soil, test through the bag. In either case, average the results.
3. If you did not bag the in-situ test sample, collect the top (approximately) quarter inch of soil from this region and sieve through the 2 mm sieve provided. Otherwise sieve the bagged sample used for the in-situ test. Thoroughly mix the sieved sample, and place some of the sieved material into an XRF cup, and perform a test of this sample.
4. If the results of this prepared sample differ by:
   - Less than 20% with the average in-situ result, this indicates the soil in this region is reasonably homogeneous. The data quality in this case is probably at the semi-quantitative level, rather than just screening data.
   - More than 20%, this indicates the soil is not very homogeneous, and there are serious particle size effects affecting your in-situ measurements.
     In this case, sieve the sample through the ~250 m sieve. Mix this sample and place a sub-sample into an XRF cup for testing. If this result differs from the previous by less than 20% then this indicates that at a minimum the 2 mm sieving is necessary to achieve higher data quality.
     If this result differs by more than 20% from the sample sieved through 2 mm, then particle size effects are still affecting the XRF result. In this case samples should be sieved through 125 µm to assure data quality at the quantitative level.

Section 4: Calibration for Innov-X Portable XRF

The Innov-X analyzer can run *three* different calibration methods, described below.

COMPTON NORMALIZATION:

In nearly all cases, customers use the Compton Normalization method. This method (recognized in EPA 6200) offers speed, ease of use, and generally good accuracy for concentration ranges from the ppm level up to 2-3% concentrations. As most field-testing is seeking to remediate or locate environmental contaminants, the upper limit of the calibration (2-3%) is generally not a limitation.

FUNDAMENTAL PARAMETERS (FP):

If customers do require a calibration up to 100% concentration (i.e. a pure element), then Innov-X recommends they also include the Fundamental Parameters (FP) software module with the analyzer. The FP module may be added at time of purchase or as an upgrade at any later date.

NOTE

In general, customers do not need to calibrate Innov-X analyzers for soil testing. The analyzer is delivered with a factory calibration, generally based upon the Compton Normalization (CN) method. The CN method has been proven over the past several years to provide a robust calibration generally independent of site-specific soil matrix chemistry.
All customers should follow the QC procedure described in Section 3, which includes a check of the calibration.

EMPIRICAL CALIBRATION:

In this case, customers run standards to generate calibration curves for various elements in specific soil matrices. With a well-prepared sample, the empirical method generally yields the most accurate result. In our experience, the accuracy gains going *from* Compton Normalization *to* Empirical Mode are small and not worth the extra effort in setting up calibration curves.
The empirical calibration module is an optional software package, available for an upgrade fee at the time of purchase, or as an upgrade at any later date.

CAUTION

The *greatest source of error* for in-field XRF analysis of soil is *lack of adequate sample preparation*, thus there is little gained in developing a sophisticated empirical calibration if the operator does not grind and homogenize the all measured samples.

Calibration Requirements:

The concentration of an element in a soil sample is well-described by the formula:

$$w_i = \frac{k_i}{M(Z,i)} I_i$$

where:

k_i = calibration constant for element *i*

ω_i = concentration of element *i* – the quantity being measured

I_i = measured x-ray intensity from element *i*

M(Z,I) = Soil matrix value

The factory calibration determines the value of the calibration constants k_i for each element, and a typical value M(Z,I). The calibration method – either CN, fundamental parameters, or empirical – performs the necessary corrections to the value M(Z,I) that are important for the site-specific soil chemistry. The XRF analyzer uses the measured intensity of each element's fluorescence from the sample, and the calibration data, to produce elemental concentrations.

COMPTON NORMALIZATION CALIBRATION:

The Compton Normalization method calibration consists of the analysis of a single, well-characterized standard, such as an SRM or SSCS. The standard data are normalized to the Compton peak. The Compton peak is produced from incoherent backscattering of X-ray radiation from the excitation source and is present in the spectrum of every sample. The matrix affects the way in which source radiation is scattered off the samples. This scatter is directly related to the intensity of the Compton peak. For that reason, normalizing to the Compton peak can reduce problems with matrix effects that vary among samples. Compton normalization is similar to the use of internal standards in analysis for organic analytes.

FUNDAMENTAL PARAMETERS CALIBRATION:

The fundamental parameters (FP) calibration is a *standardless* calibration. Rather than establishing a unit's calibration curve by measuring its response to standards that contain analytes of known concentrations, FP calibration relies on the known physics of the spectrometer's response to pure elements to set the calibration. Built-in mathematical algorithms are used to adjust the calibration for analysis of soil samples and to compensate for the effects of the soil matrix. The FP calibration is performed by the manufacturer, but the analyst can adjust the calibration curves (slope and y-intercept) on the bases of results of analyses of check samples, such as SRMs which are analyzed in the field.

EMPIRICAL CALIBRATION:

The empirical calibration method requires that a number of site-specific calibration standards (SSCS) are used to establish calibration parameters. The instrument response to known analytes is measured and used to create calibration curves. Empirical calibration is effective because the samples used closely match the sample matrix. SSCSs are well-prepared samples collected from the site of interest in which the concentrations of analytes have been determined by inductively coupled plasma (ICP), atomic absorption (AA), or other methods.

The standards should contain all the analytes of interest and interfering analytes. Manufacturers recommend that 10 to 20 calibration samples be used to generate a calibration curve. The empirical method is the least desirable calibration method as it requires that new standards and curves are generated for each site that is analyzed.

Section 5: Effects of Moisture on XRF Results

Sample moisture has two effects on XRF results:

- It alters the soil chemistry, since water is another chemical compound that comprises the soil matrix.
- Moisture impedes the ability to properly prepare samples.

There is a further testing consideration:

- Laboratory results are provided on a *dry weight* basis.

EFFECT ON SOIL CHEMISTRY:

While the presence of significant moisture does impact the soil chemistry, modern XRF analyzers all perform automatic corrections for variations in soil chemistry from site to site. Indeed, such variations are expected, and that is the reason analyzers use Compton Normalization or fundamental parameters, in order to correct for moisture content changes as well as other differences in soil geochemistry.

It is known that moisture content above 20 percent may cause problems, since moisture alters the soil matrix for which the FPXRF has been calibrated. However, the Compton Normalization or fundamental parameters methods are implemented in order to automatically correct results for changes to the soil matrix. Thus, we believe that soil moisture is not a significant effect on accuracy due to effects of soil matrix, except for the *dilution* effect that can cause discrepancies with laboratory results which is described below.

SAMPLE PREPARATION ISSUES:

The inability to adequately prepare a wet sample is, we believe, the single biggest contributor to errors when testing wet samples. It is very difficult to grind or sieve a wet sample. The highest quality XRF results are generally obtained from prepared samples.

CAUTION

If the operator is unwilling to dry the sample to prepare it, comparisons to the laboratory may yield poorer correlation since the samples are not homogeneous.

Laboratory Tests on Dry-Weigh Basis:

Laboratories always dry samples prior to analysis. They report percent weight content based upon a dry sample basis. Portable XRF may often be used to analyze wet samples in the field, and results are thus reported that include the moisture content. Thus, with all other factors the same, the laboratory will report results higher than portable XRF. The results are higher by the amount of moisture content in the sample. For example, laboratory results will be 10% higher compared to XRF results, if the sample contained 10% by weight water when it was tested with XRF. Recall, this applies to samples where other possible sources of error are the same or negligible.

Section 6: Comparing XRF Results to Laboratory Results

Innov-X strongly recommends that operators compare prepared sample results to laboratory results. This is because prepared-sample results yield the best possible accuracy with portable XRF. Moreover, the most common source of error is due to non-uniform samples. No analytical technique, including the XRF technique, can properly account for non-uniform sample types.

To perform a comparison between XRF results and laboratory:

1. Collect a sample and prepare it according to the sample preparation guide given in *"Section 8: Sample Prep Procedures and Testing Protocols"* on *page 90*.
2. Take a sub-sample (5-10 grams) of the fully-prepared sample, place it into an XRF cup and perform at least a one-minute test on that sample.
3. Send the same sample to the laboratory for wet chemistry analysis.
4. Require the laboratory to use a *total-digestion method*. If the laboratory does not, they may not extract all of the elemental metal from the sample. In this case, the lab result will be lower than the XRF result. Incomplete sample digestion is one of the *most common* sources of laboratory error, thus it is very important to request a total digestion method.

Example of Error: The operator collects a bag of sample, performs XRF analysis on one part of the bag, and sends the bag, or part of the bag of sample to a laboratory for analysis. The laboratory reports a very different value than the operator obtained with the XRF.

Problem:

Since the sample is very non-homogeneous, the operator did not obtain a result that was representative of the entire bag of sample. The lab analyzed a different part of the sample and obtained a very different result due to the non-uniformity of the sample. The solution to this problem is, at a minimum, to test several locations in the bag of sample and report the average value. Also note the differences between the tests, as this is indicative of the non-uniformity of the sample. The operator should send entire bag of sample to the lab, and instruct the lab to prepare the sample before removing the sub-sample for lab analysis.

Best Practice:

The operator should homogenize and prepare the entire bag of sample, and then collect a sub-sample for XRF testing. After testing, the *same sample* should be sent to the lab.

Section 7: Common Interferences

Interference occurs when the spectral peak from one element overlaps either partially or completely with the spectral peak of another.

Case 1 Conditions

If the instrument is calibrated for both elements, one causing the interference and one being interfered with, it is generally capable of correctly handling the interference. In this instance, the element being interfered with may be measured with a poorer detection limit or poorer precision, but the analytical results should still be acceptable for field-portable XRF.

Case 2 Conditions

If the XRF is not calibrated for the element causing the interference, then the instrument may report the presence of elements not in the sample, or greatly elevated concentrations of elements in or not in the sample.

Example CASE 1: Lead and arsenic

Lead and arsenic. Most XRFs are calibrated for lead and arsenic. Lead interferes with arsenic (not vice-versa though). The net effect is a worsened detection limit for arsenic, and poorer precision. The XRF handles the correction automatically, but the precision is affected. The loss of precision is also reported by the XRF.

(Refer to Innov-X Applications Sheet: *In-field Analysis of Lead and Arsenic in Soil Using Portable XRF* which is now available as *Arsenic and Lead in Soil.PDF* for more detail).

Example CASE 2: Bromine

Bromine in the sample, but the XRF is not calibrated for bromine. Bromine, as a fire retardant, is being seen more and more in soil and other sample types. For this reason, Innov-X analyzers include Br in the calibration data. If Br is not calibrated, but is present in the sample, the analyzer will report highly elevated levels of Pb, Hg and As. The levels will depend upon the concentration of Br in the sample.

Interferences between elements can be broadly categorized into two types:

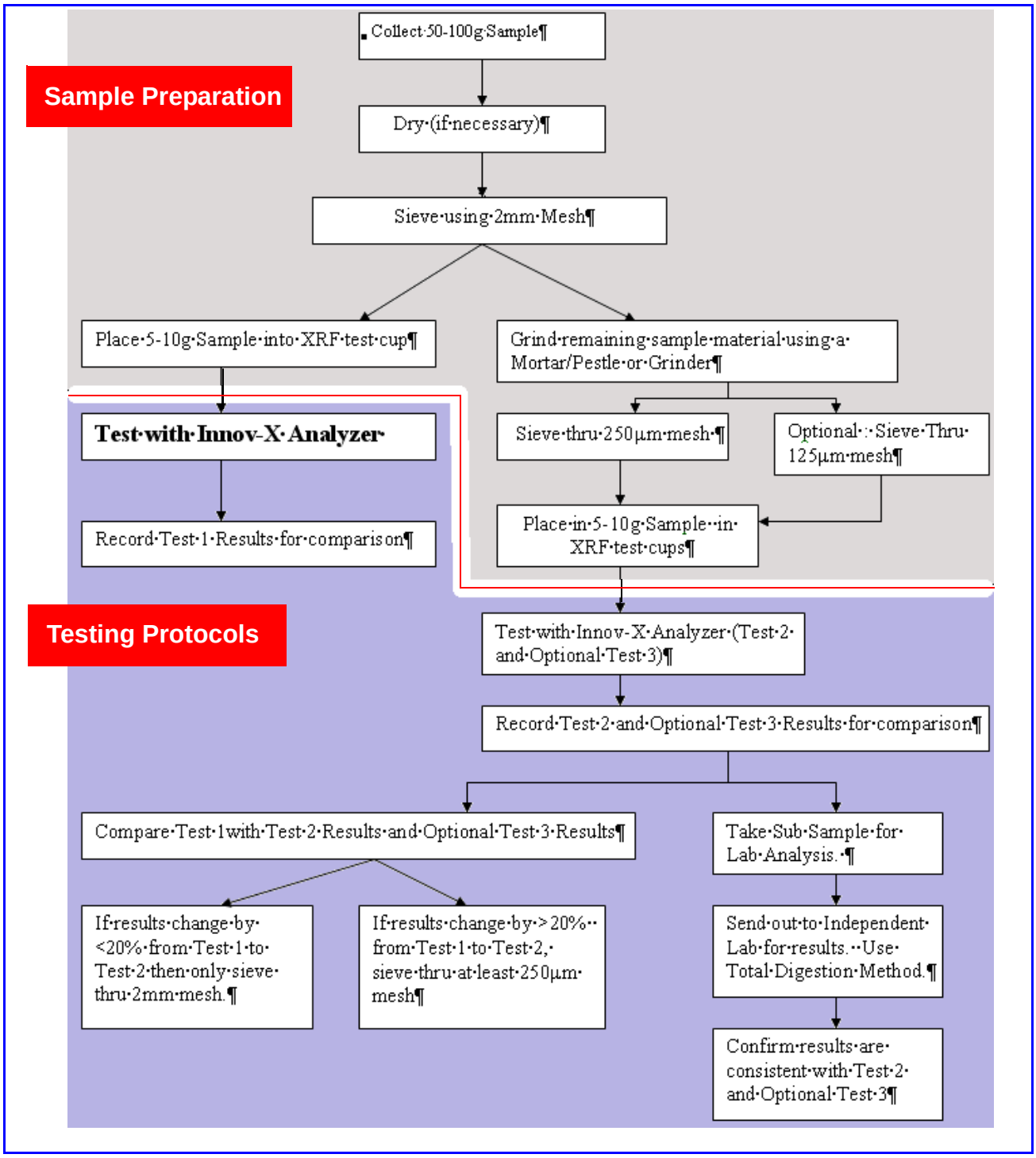
Z, Z-1, Z+1 interferences

Occurs when high levels of an element of atomic number Z are present. This can cause elevated levels of elements with atomic number Z-1 or Z+1. Generally, portable XRFs have good correction methods, so this interference only causes problems with very high levels of the element in question. Example: High concentrations of Fe (Z=26) in excess of 10% may cause elevated levels of Mn or Co (Z=25 or Z=27 respectively).

K/L interferences

Occurs when the L-shell line of one element overlaps with the K-shell spectral line of another element. The most common example is the lead/arsenic interference where the L-alpha line of lead is in nearly the exact same location as the K-alpha line of arsenic.

Section 8: Sample Prep Procedures and Testing Protocols



Section 9: NIST Certificates of Analysis

Innov-X systems provides three NIST standards (subject to change with availability). Each standard's certified values are given in Table 1 and Non-certified values are in Table 2 in the graphics below.

- ☑ SRM2709
- SRM2710
- SRM2711

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2709

San Joaquin Soil

Baseline Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. SRM 2709 is an agricultural soil that was oven-dried, sieved, radiation sterilized, and blended to achieve a high degree of homogeneity. A unit of SRM 2709 consists of 50 g of the dried material.

The certified elements for SRM 2709 are given in Table 1. The values are based on measurements using one definitive method or two or more independent and reliable analytical methods. Noncertified values for a number of elements are given in Table 2 as additional information on the composition. The noncertified values should **NOT** be used for calibration or quality control. Analytical methods used for the characterization of this SRM are given in Table 3 along with analysts and cooperating laboratories. All values (except for carbon) are based on measurements using a sample weight of at least 250 mg. Carbon measurements are based on 100 mg samples.

Noncertified Values: Noncertified values, shown below, are provided for information only. An element concentration value may not be certified if a bias is suspected in one or more of the methods used for certification or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Carbon	1.2	Cerium	42
		Cesium	5.3
		Dysprosium	3.5
		Europium	0.9
		Gallium	14
		Gold	0.3
		Hafnium	3.7
		Holmium	0.54
		Iodine	5
		Lanthanum	23
		Molybdenum	2.0
		Neodymium	19
		Rubidium	96
		Samarium	3.8
		Scandium	12
		Thorium	11
		Tungsten	2
		Uranium	3
		Ytterbium	1.6
		Yttrium	18
		Zirconium	160

Table 1. Certified Values

Element	Mass Fraction (%)			Element	Mass Fraction (µg/g)		
Aluminum	7.50	±	0.06	Antimony	7.9	±	0.6
Calcium	1.89	±	0.05	Arsenic	17.7	±	0.8
Iron	3.50	±	0.11	Barium	968	±	40
Magnesium	1.51	±	0.05	Cadmium	0.38	±	0.01
Phosphorus	0.062	±	0.005	Chromium	130	±	4
Potassium	2.03	±	0.06	Cobalt	13.4	±	0.7
Silicon	29.66	±	0.23	Copper	34.6	±	0.7
Sodium	1.16	±	0.03	Lead	18.9	±	0.5
Sulfur	0.089	±	0.002	Manganese	538	±	17
Titanium	0.342	±	0.024	Mercury	1.40	±	0.08
				Nickel	88	±	5
				Selenium	1.57	±	0.08
				Silver	0.41	±	0.03
				Strontium	231	±	2
				Thallium	0.74	±	0.05
				Vanadium	112	±	5
				Zinc	106	±	3

SRM2709

☑ SRM2710

SRM2711

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2710

Montana Soil

Highly Elevated Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. SRM 2710 is a highly contaminated soil that was oven-dried, sieved, radiation sterilized, and blended to achieve a high degree of homogeneity. A unit of SRM 2710 consists of 50 g of the dried material.

The certified elements for SRM 2710 are given in Table 1. The values are based on measurements using one definitive method or two or more independent and reliable analytical methods. Noncertified values for a number of elements are given in Table 2 as additional information on the composition. The noncertified values should **NOT** be used for calibration or quality control. Analytical methods used for the characterization of this SRM are given in Table 3 along with analysts and cooperating laboratories. All values (except for carbon) are based on measurements using a sample weight of at least 250 mg. Carbon measurements are based on 100 mg samples.

Noncertified Values: Noncertified values shown below are provided for information only. An element concentration value is not certified if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (mg/kg)
Carbon	3	Bromine	6
		Cerium	57
		Cesium	107
		Chromium	39
		Cobalt	10
		Dysprosium	5.4
		Europium	1
		Gallium	34
		Gold	0.6
		Hafnium	3.2
		Holmium	0.6
		Indium	5.1
		Lanthanum	34
		Molybdenum	19
		Neodymium	23
		Rubidium	120
		Samarium	7.8
		Scandium	8.7
		Strontium	330
		Thallium	1.3
		Thorium	13
		Tungsten	93
		Uranium	25
		Ytterbium	1.3
		Yttrium	23

Table 1. Certified Values

Element	Mass Fraction (%)			Element	Mass Fraction (mg/kg)		
Aluminum	6.44	±	0.08	Antimony	38.4	±	3
Calcium	1.25	±	0.03	Arsenic	626	±	38
Iron	3.38	±	0.10	Barium	707	±	51
Magnesium	0.853	±	0.042	Cadmium	21.8	±	0.2
Manganese	1.01	±	0.04	Copper	2950	±	130
Phosphorus	0.106	±	0.015	Lead	5532	±	80
Potassium	2.11	±	0.11	Mercury	32.6	±	1.8
Silicon	28.97	±	0.18	Nickel	14.3	±	1.0
Sodium	1.14	±	0.06	Silver	35.3	±	1.5
Sulfur	0.240	±	0.006	Vanadium	76.6	±	2.3
Titanium	0.283	±	0.010	Zinc	6952	±	91

SRM2709

SRM2710

☑ SRM2711

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2711

Montana Soil

Moderately Elevated Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. SRM 2711 is a moderately contaminated soil that was oven-dried, sieved, radiation sterilized, and blended to achieve a high degree of homogeneity. A unit of SRM 2711 consists of 50 g of the dried material.

The certified elements for SRM 2711 are given in Table 1. The values are based on measurements using one definitive method or two or more independent and reliable analytical methods. Noncertified values for a number of elements are given in Table 2 as additional information on the composition. The noncertified values should **NOT** be used for calibration or quality control. Analytical methods used for the characterization of this SRM are given in Table 3 along with analysts and cooperating laboratories. All values (except for carbon) are based on measurements using a sample weight of at least 250 mg. Carbon measurements are based on 100 mg samples.

Noncertified Values: Noncertified values, shown below, are provided for information only. An element concentration value may not be certified, if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Carbon	2	Bromine	5
		Cerium	69
		Cesium	6.1
		Chromium	47
		Cobalt	10
		Dysprosium	5.6
		Europium	1.1
		Gallium	15
		Gold	.03
		Hafnium	7.3
		Holmium	1
		Indium	1.1
		Iodine	3
		Lanthanum	40
		Molybdenum	1.6
		Neodymium	31
		Rubidium	110
		Samarium	5.9
		Scandium	9
		Thorium	14
		Tungsten	3
		Uranium	2.6
		Ytterbium	2.7
		Yttrium	25
		Zirconium	230

Table 1. Certified Values

Element	Mass Fraction (%)			Element	Mass Fraction (µg/g)		
Aluminum	6.53	±	0.09	Antimony	19.4	±	1.8
Calcium	2.88	±	0.08	Arsenic	105	±	8
Iron	2.89	±	0.06	Barium	726	±	38
Magnesium	1.05	±	0.03	Cadmium	41.70	±	0.25
Phosphorus	0.086	±	0.007	Copper	114	±	2
Potassium	2.45	±	0.08	Lead	1162	±	31
Silicon	30.44	±	0.19	Manganese	638	±	28
Sodium	1.14	±	0.03	Mercury	6.25	±	0.19
Sulfur	0.042	±	0.001	Nickel	20.6	±	1.1
Titanium	0.306	±	0.023	Selenium	1.52	±	0.14
				Silver	4.63	±	0.39
				Strontium	245.3	±	0.7
				Thallium	2.47	±	0.15
				Vanadium	81.6	±	2.9
				Zinc	350.4	±	4.8

NOTES

A3. Specifications

Handheld Analyzer	Description
Weight	3.35 lbs. (Base wt.), 3.70 lbs. (1.6 kg) with battery
Excitation Source	4 Watt X-ray tube - Au, Ag, Rh, or Ta anode (application optimized), 8-40 keV, 5 - 200 µA, eight filter positions
Detector	Various: Si PIN diode or Si Drift detector, thermo-electrically cooled, high resolution
Power	Removable Li-ion batteries, or AC power unit
Battery Life	Battery life varies depending on usage patterns
Display	Color "transflective" touchscreen (800 x 600) with 16-bit LCD interface)
Cal Check Coupon	316 Stainless Steel Alloy -- see also Docking Station
Power Requirements for AC Adapter	110-220 VAC, 50-60 Hz, 600 W max (P/N 100043)
Pressure Correction	Built-in barometer for automatic altitude correction
Operating Environment	Temperature: -10°C to 45°C Humidity: 10 to 90% Relative Humidity, non-condensing Altitude Rating: 2000 meters
Operating System	Windows Embedded CE®
Application Software	Innov-X Systems' proprietary Data Acquisition and Processing package.
USB Interface	USB 2.0

Operating specifications ar posted as **nominal**.

Docking Station	Description
Dimensions	L=14.0 in x W=8.75 in x H=4.75 in (H w/ spare battery = 6.5 in); Wt = 3.25 lbs.
Power Requirement	AC adapter standard: 110-220 VAC, 50-60 Hz, 600 W max
Cal Check Cup	Automatically performs Cal Check on inserted instrument
Battery Charging	Charges battery in unit; can simultaneously charge spare battery in separate socket

Accessories	Description
AC Battery Charger	P/N 120253
TestStand/Workstation	A-020-D - portable equipment stand making a fully shielded closed beam system. Uses Delta PC Software.
Soil Foot	A-035
Soil Extension Pole	P/N 990055
Trimble Xploration Package (P6000FDC)	**XPLORER FIELD DATA COLLECTION BUNDLE** **Trimble Nomad 800G-LC** - Ruggedized 800Mhz Field Computer with integrated GPS, Wi-Fi, Bluetooth, Camera, 16Gb Memory, SD Card Slot Options: Barcode Scanner, Cell Phone Interface, Fully DGPS compatible running Windows Mobile 6.0 OS.

Trimble Xploration Package (P6000TFG)	**XPLORER TOTAL FIELD GEOCHEM BUNDLE** Includes all features supplied with **Field Data Collection Package** and: **Soil Extension Pole** - Ergonomic extension pole facilitating soil analysis by a standing (and walking) operator. **Soil Foot** - Attaches to nose of DELTA analyzer balancing analyzer on ground for hands-free, extended in-situ testing. **ioGAS** - ioAnalytics GeoChemical Analysis Software Suite, an advanced spatial data analysis package for visualization, interrogation & validation of geochemical data for mineral exploration, mining, & environmental industries.

A4. Typical Delta Test Sequence

Innov-X Delta User Interface

Operators manage their measurement, analysis, and results activities from the *Innov-X* UI when in ANY of the Alloy modes/calibrations. This Appendix presents:

- Typical Sample Test Procedure, and
- Prerequisites for testing necessary for various modes

GO TO

The operational features of the *Home, Mode, Setup, Test, and Results* screens are explained in *"Delta User Interface Guide" (PN 103202)*
In this document, "*Delta User Manual*," see *C4, Operations, Page 47* for a SNAP-SHOT of the UI.

Typical Sample Test Procedure

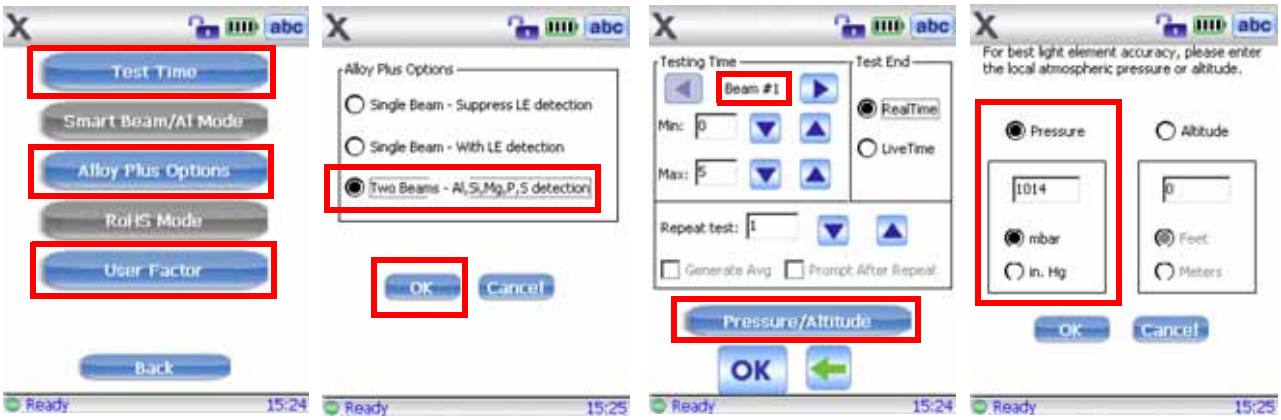
This sample procedure features the **Alloy Plus** mode.

Other modes follow a similar sequence, however, the **Test Condition** screens are generally unique to each testing situation.

Use these steps:

1. From the **Home** screen, tap **Mode** icon
2. From **Mode** screen, tap the **Alloy Plus** icon
3. Select **Mode Setup** button

4. Select **Test Conditions**, then **Test Time**
5. Ensure that the **Testing Time** and other parameters are properly selected



6. Press OK button, the Back, then OK again
7. Return to Home screen, select **Test** to call the *Test-Alloy Plus* screen

Testing Tips for Certain Modes

Alloy:

- Place the analyzer's window on/over the test specimen, cover the window completely.
- Remember the Safety information (*C2, Pages 29-31*) to ensure your own personal safety.
- Take care not to damage the window film, such as when testing "metal turnings" or hot surfaces.

Soil or Mining:

- Place the analyzer's measurement window directly over the sample cup with the film side up.
- Specify the altitude or atmospheric pressure to gain increased accuracy for light elements.
- Confirm that the Testing Time and other parameters are properly selected
- Take care not to damage the window film, such as when testing uneven surfaces

RoHS:

- In order for XRF testing to be *quantitative*, samples must be:
  - Homogeneous
  - Have a certain minimum sample thickness
    - Five (5) mm for polymers and light alloys
    - Fifteen (15) mm for liquid samples
    - One (1) mm for other alloys
- If samples are heterogeneous, too thin, or too small, only *qualitative* screening is possible.

8. Start a new test by using one of these methods:
   a. Tap **Start** button on the UI (toggles Delta to X-ray ON state)
   — or —
   b. Pull the trigger (toggles instrument to X-ray ON state)
   — or —
   c. Pull-and-hold the trigger when the "Deadman Trigger" is active.

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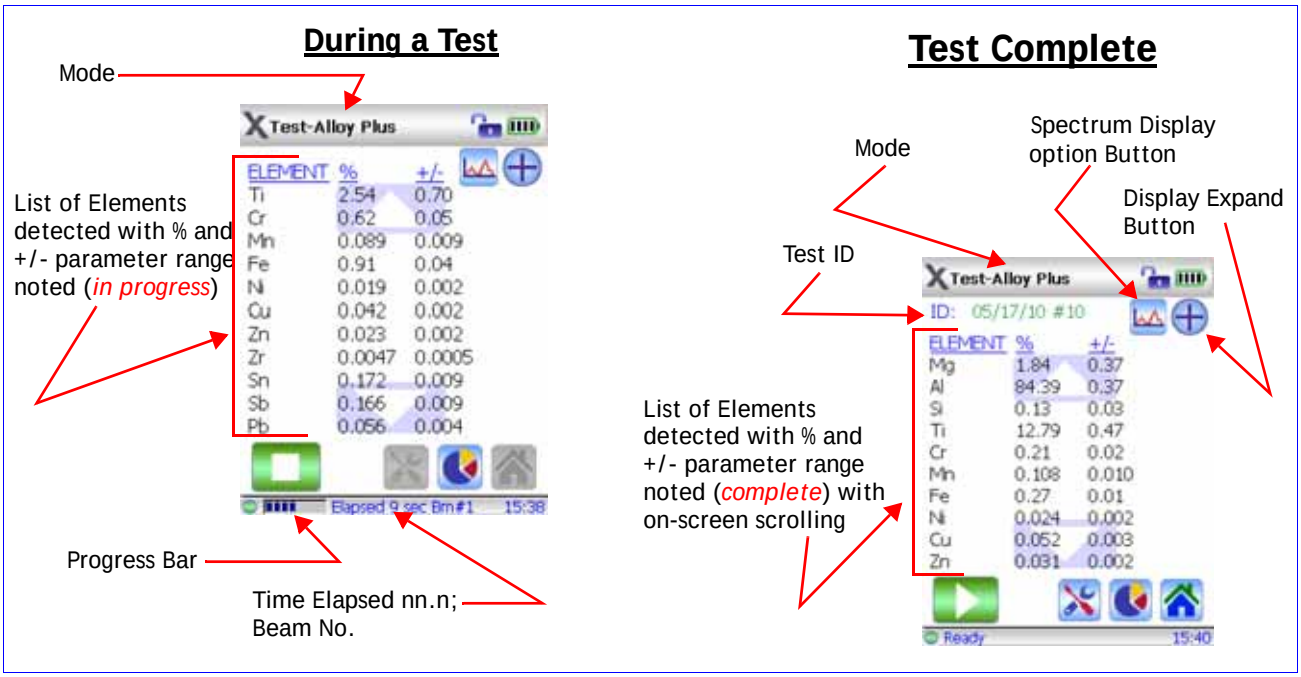


Best Practices for Testing

Alloy Mode

Prior to a test session, analysts should have an understanding of *Innov-X*'s implementation of:

- **Grade Libraries** -> populated by alloy Grades -> their chemistry characterized by Grade Tables.
  See *Grade Libraries* for library management procedures.
- **Match Issues** including the concept and use of Match Numbers.
  See *Match Issues*

Prior to initiating testing with the analyzer software, **ensure** that the following tasks are complete:

1. Analyzer does not require a Cal Check procedure.
2. The analyzer's measurement window is properly positioned in front of or over the test sample.
3. The *Match Cutoff* and *nSigma* parameters are configured.

Mining and Soil Modes

Check Standards

- Measure a **check standard** after each Cal Check, and periodically throughout the day. Test for a recommended minimum of one minute.
- Concentrations for elements of interest, in the range expected, plus or minus the error on the reading, should be within 20 percent of the standard value.
- *A2.Soil Testing* describes recommended quality assurance details.

- The standards provided with the analyzer are contained in XRF sample cups. These containers have a window (through which the soil can be viewed) on one side, and a solid cap on the other side.

Always measure samples through the window.

Sample Presentation

IN SITU TESTING

In situ testing is performed by pointing the analyzer at the ground. Clear any grass or large rocks away and hold the analyzer with the probe head front flush to the ground. Since dirt can accumulate on the analyzer window, gently wipe the window clean after each analysis. Ensure the window is not ripped or punctured.

BAGGED OR PREPARED SAMPLE TESTING

Analyze prepared samples in a sample cup, through its window. Place the instrument's measurement window directly over the sample cup with the film side up.

Preparation considerations include:

- Avoid measuring very thin samples, as this can affect results. Prepare samples cups to contain at least 15 (usually 4-8 grams) mm of packed samples.
- When analyzing bagged samples, ensure that sufficient sample material exists in the bag to create a a sample thickness of a minimum of 15 mm for a spot size that is larger than the analyzer's measurement window.
- When using bags, cheaper bags (having thinner plastic walls) are better than more expensive ones (which have thicker plastic walls).

Consumer Mode

RoHS Best Practices

Check Standards

Innov-X Systems recommends that a check standard be measured after each Cal Check procedure, and periodically throughout the day.

Two certified standards are provided for verification.

- At least one standard should be measured for a minimum of two minutes.
- Concentrations for target elements (plus or minus the error on the reading) should be within 20% of the standard value.
- Standards provided are contained in XRF sample cups with a window (through which the plastic pellets can be viewed) on one side, and a solid cap on the other side.
- Samples should be measured in the sample cup, through the window.

Sample Presentation

Since many pieces of plastic analyzed for ROHS compliance are very small, take care to measure them in a safe and accurate manner.

See the IEC-ACEA recommendation for minimum thickness of test samples as shown in Chapter *C.8*.

A5. User Maintenance

5.1 Alternative Techniques for Powering or Charging the Delta

5.1.1. AC Power Adapter Kit

The kit is an **optional** accessory.

It is supplied with a 10 foot AC power cord, a switching AC adapter, and a Battery Module. This kit eliminates the Li-ion battery requirement, however the user is constrained by the length of the AC power cord.

The procedure for using the AC adapter is shown below.

WARNING

Ensure that each AC supply circuit has adequate power load capability and is provided from a grounded AC receptacle.

TO SETUP THE ADAPTER:

1. Plug the three-prong male plug into the receptacle.

2. Insert the three-prong female plug into the male receptacle on the *Switching AC Adaptor* brick.

3. Slide the Battery Eliminator unit into the analyzer with the contacts to the left. It is keyed to only go in oriented this way.

4. The user now has no limit to instrument power; not restricted by battery charge level. The range of action is constrained by the length of the power cord.

5.1.2. Li ion Battery Charger Assembly

This section describes the procedure for charging the Li-ion batteries when the Delta Docking Station is NOT available. It features a single socket standalone battery charger (P/N 120253) The unit takes about two hours to completely charge a battery. Status of the battery's charge is shown by two lights on the power adaptor.

TO CHARGE THE BATTERY:

1. Plug the three-prong male plug into the Modes receptacle.

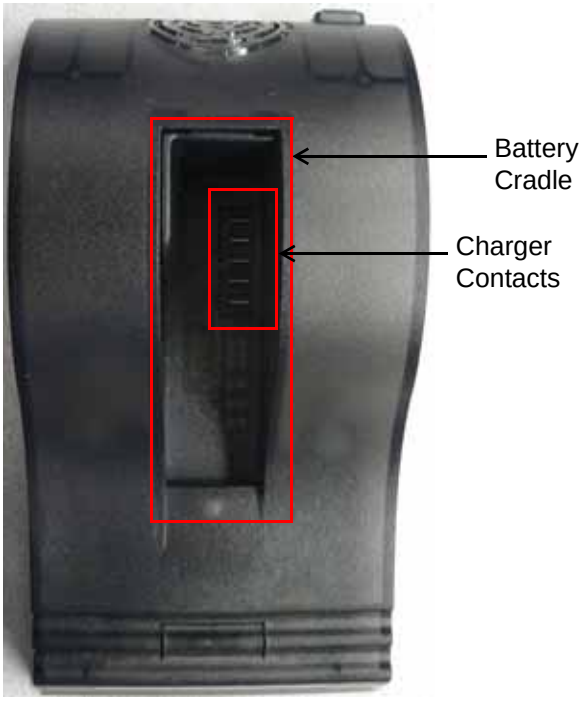
2. Plug the three-prong female plug into the male receptacle on the *AC Adaptor* brick.

3. Plug the connector labeled *CH4500 24 VDC* into the connector labeled *SWC* on the back of the charger.

4. Insert the Li-ion battery into the charger with the contacts facing right.

CAUTION

Forcing the battery in with the contacts oriented improperly will injure the contacts and destroy the battery.



Battery Charger Status Lights

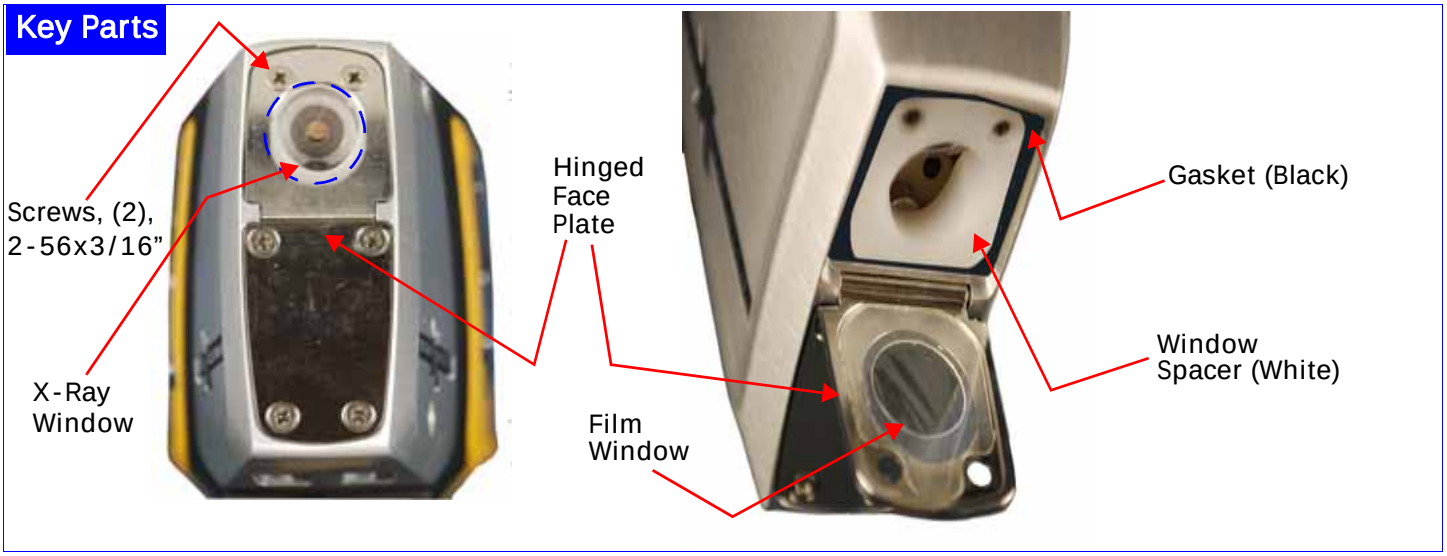
Left Light (Green only)	Right Light (Red only)	Status
On - Flashing	Off	Battery is charging
On - Solid	Off	Battery is charged
Off	On - Solid	Error. Remove battery and replace on charger. If the error persists, call Innov-X Systems Technical support.
Off	Off	No battery is on charger

5.2 — Window Replacement for “Hinged Plate” Analyzers

How to Replace the Window on a Delta Analyzer (All Models)

Tools: *Required -* Small Phillips Head Screwdriver
Recommended - Tweezers or Needle nose pliers; Can of compressed air
As needed: - Lint-free wipes or swabs

Key Parts



Remove Old Window

Use these guidelines:

- During this entire removal process, keep dust or foreign material out of the instrument.
- Ensure that the instrument is powered off.
- Take care to have clean hands.
- Orient the instrument with the nose pointing up.
- Review the **TIPS** section on next page **before** opening the hinged plate.
- Use Phillips head screwdriver to remove the two screws.
  - Carefully set aside the screws.
- Swing the hinged face plate out to expose the film window.
- Remove the old window.
- Observe the white plastic window spacer and the black rubber gasket
- Remove any dirt or foreign material from the gasket with compressed air
- Take EXTREME CARE to not harm any internal components

CAUTION Avoid expensive internal damage, DO NOT INSERT anything (fingers or tools) into the instrument.

Replacement Window Details

- Windows assemblies are made from either **Prolene, Mylar,** or **Kapton** film.
  - Users must specify the proper material to match their original application and calibration.
- The selected film is adhered to **one** side of a polyester backing plate; this creates a "front" and "back" surface
  - "Back" surface is completely covered with film.
  - "Front" surface shows a circular ridge where the film only is present, showing through the center hole of backing plate. This front surface also has a part type designator.
- Ensure that the "back" surface faces up when installing a new window (See below).

PRO 6
Prolene

MYL 25
Mylar

KAP 8
Kapton

P/N: -->> 102999 103000 103173 (Hi-Temp)
103115 (Classic Standard)

Install Replacement

Follow these steps:

- Remove new window assembly from shipping envelope.
- Handle it by edges or use tweezers.
- Apply canned compressed air to clear any contaminants from the surfaces.
- Place window assembly on the hinged plate with **film back surface facing up**.
  - Center it to avoid the screw holes.
- Carefully rotate the hinged plate up to secure the window assembly.
- Insert the two screws; tighten only to "snug".
  - Don't over-tighten them or strip the threads.

TIPS

- Do not touch the film in the center opening (on either side).
- When using the screwdriver, keep a finger or thumb between the tool and the X-ray window. This prevents accidentally sticking the tool through the film and causing internal damage.
- The cost for replacement windows is quite low. Users are encouraged to change them frequently in order to obtain optimum test results.
- When not operating an instrument, experienced users routinely keep it the Delta Docking Station cradle.
  - This keeps the window clean, and
  - Prevents accidental damage to the window film, and
  - Takes advantage of the battery charging and Cal Checking procedure that the DDS offers.

NOTES

A6. Packing and Shipping

If the instrument is not returned in the protective case, it can be damaged during shipping. Innov-X Systems reserves the right to void the warranty on instruments that are damaged during return shipping that are sent without the protective case.

Prior to returning a unit, contact Customer Service at the appropriate depot:

— United States —

- Phone: 1-781-938-5005
- Fax: 1-781-938-0128
- Email: Service@Innov-Xsys.com

- Mail & Shipping Address:
  Innov-X Systems, Inc.
  100 Sylvan Road
  Woburn, MA 01801

— Canada —

- Phone: 1-778-960-6279
- Fax: 1-604-568-2474
- Toll Free Fax: 1-888-873-6598
- Email: service@innovx.ca

- Mail & Shipping Address:
  Innov-X Canada
  1201 West Georgia, Ste. 2
  Vancouver BC
  Canada V6E 3J5

— Europe —

- Phone: +31 (0)73 62 72 590
- Fax: +31 (0)73 62 72 599
- Email: info@innovx-europe.com

- Mail & Shipping Address:
  Innov-X Systems, Inc.
  Kasteleinenkampweg 9R
  5222 AX 's-Hertogenbosch
  The Netherlands

— Australia —

- Phone: 02 9577 9500
- Fax: 02 9519 1850
- Email: service@innovx.com

- Mail & Shipping Address:
  Innov-X Systems Australia PTY LTD
  Suite 6, Level 3
  215 Euston Road
  Alexandria NSW 2015
  Australia

Or call your local distributor.

Ensure that you receive the required RMA number.

Follow these instructions to return your XRF Analyzer:

1. Pack the analyzer in the black protective case in which it arrived, using the original packing materials.
2. Include the RMA in the case and reference the RMA number in your shipping documents.
3. Close the protective case and either:
   - Secure it with plastic zip ties,
     — or —
   - Pack the protective case within another box.

Regulations for Shipping Products with Lithium Ion Batteries

The United States and many other countries have instituted regulations that require shippers to use a special Caution label referring to a Lithium Ion Battery.

- Label must be prominently displayed on the outer shipping container of any product that contains a Lithium Ion battery.
- Shipper may copy the label shown below to facilitate making the warning label. Use a color copier if possible.

A7. Legal Information

This section provides copies of the following:

- Delta Analyzer Limited Warranty including:
  - Limitation of Liability
  - Warranty Period, Returns, and Repairs
  - Instructions for Contacting Innov-X
- End User Software License Agreement including:
  - Use, Restrictions, and Termination of Software
  - Governmental End User Conditions
  - Limited Warranty and Limitation of Liability

Innov-X Delta Analyzer Limited Warranty

General Terms

EXCEPT AS EXPRESSLY SET FORTH IN THIS LIMITED WARRANTY, INNOV-X SYSTEMS, INC. (INNOV-X) MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. INNOV-X EXPRESSLY DISCLAIMS ALL WARRANTIES AND CONDITIONS NOT STATED IN THIS LIMITED WARRANTY. ANY IMPLIED WARRANTIES THAT MAY BE IMPOSED BY LAW ARE LIMITED IN DURATION TO THE LIMITED WARRANTY PERIOD.

This Limited Warranty applies to Innov-X analyzers sold or leased from Innov-X, its affiliates, authorized resellers, or country distributors (collectively referred to in this Limited Warranty as “Innov-X.”

Innov-X warrants that the analyzer and all its internal and external components that you have purchased are free from defects in materials or workmanship under normal use during the Limited Warranty Period. The Limited Warranty Period starts on the date of shipment by Innov-X. You may be required to provide proof of purchase or lease as a condition of receiving warranty service. You are entitled to warranty service according to the terms and conditions of this document if a repair to your Innov-X analyzer is required within the Limited Warranty Period.

During the Limited Warranty Period, Innov-X will repair or replace the defective component parts. All component parts removed under this Limited Warranty become the property of Innov-X. In the unlikely event that your Innov-X analyzer has a recurring failure, Innov-X, at its discretion, may elect to provide you with a replacement unit of Innov-X’s choosing that is at least equivalent to your Innov-X analyzer. This is your exclusive remedy for defective products. The repaired or replacement analyzer is warranted for the remainder of the limited Warranty Period.

YOU SHOULD MAKE PERIODIC BACKUP COPIES OF THE DATA STORED ON THE ANALYZER’S SYSTEM COMPUTER AS A PRECAUTION AGAINST POSSIBLE FAILURES, ALTERATION, OR LOSS OF THE DATA. BEFORE RETURNING ANY UNIT FOR SERVICE, BE SURE TO BACK UP DATA AND REMOVE ANY CONFIDENTIAL, PROPRIETARY, OR PERSONAL INFORMATION. INNOV-X IS NOT RESPONSIBLE FOR DAMAGE TO OR LOSS OF ANY PROGRAMS, OR DATA. INNOV-X IS NOT RESPONSIBLE FOR THE RESTORATION OR REINSTALLATION OF ANY PROGRAMS OR DATA OTHER THAN SOFTWARE INSTALLED BY INNOV-X WHEN THE ANALYZER IS MANUFACTURED.

Innov-X does not warrant that the operation of this analyzer will be uninterrupted or error-free. Innov-X is not responsible for damage that occurs as a result of your failure to follow the instructions that came with the Innov-X analyzer.

This Limited Warranty does not apply to expendable parts. This Limited Warranty does not extend to any analyzer from which the serial number has been removed or that has

been damaged or rendered defective (a) as a result of accident, misuse, abuse, or other external causes; (b) by operation outside the usage parameters stated in user documentation that shipped with the product; (c) by modification or service by anyone other than (i) Innov-X, or (ii) an Innov-X authorized service provider; (d) installation of software not approved by Innov-X.

These terms and conditions constitute the complete and exclusive warranty agreement between you and Innov-X regarding the Innov-X analyzer you have purchased or leased. These terms and conditions supersede any prior agreements or representations --- including representations made in Innov-X sales literature or advice given to you by Innov-X or any agent or employee of Innov-X --- that may have been made in connection with your purchase or lease of the Innov-X analyzer. No change to the conditions of this Limited Warranty is valid unless it is made in writing and signed by an authorized representative of Innov-X.

Limitation of Liability

IF YOUR INNOV-X ANALYZER FAILS TO WORK AS WARRANTED ABOVE, YOUR SOLE AND EXCLUSIVE REMEDY SHALL BE REPAIR OR REPLACEMENT. INNOV-X'S MAXIMUM LIABILITY UNDER THIS LIMITED WARRANTY IS EXPRESSLY LIMITED TO THE LESSER OF THE PRICE YOU HAVE PAID FOR THE ANALYZER OR THE COST OF REPAIR OR REPLACEMENT OF ANY COMPONENTS THAT MALFUNCTION IN CONDITION OF NORMAL USE.

INNOV-X IS NOT LIABLE FOR ANY DAMAGE CAUSED BY THE PRODUCT OR THE FAILURE OF THE PRODUCT TO PERFORM INCLUDING ANY LOST PROFITS OR SAVINGS OR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES. INNOV-X IS NOT LIABLE FOR ANY CLAIM MADE BY A THIRD PARTY OR MADE BY YOU FOR A THIRD PARTY.

THIS LIMITATION OF LIABILITY APPLIES WHETHER DAMAGES ARE SOUGHT, OR A CLAIM MADE, UNDER THIS LIMITED WARRANTY OR AS A TORT CLAIM (INCLUDING NEGLIGENCE AND STRICT PRODUCT LIABILITY), A CONTRACT CLAIM, OR ANY OTHER CLAIM. THIS LIMITATION OF LIABILITY CANNOT BE WAIVED OR AMENDED BY ANY PERSON. THIS LIMITATION OF LIABILITY WILL BE EFFECTIVE EVEN IF YOU HAVE ADVISED INNOV-X OR AN AUTHORIZED REPRESENTATIVE OF INNOV-X OF THE POSSIBILITY OF ANY SUCH DAMAGES.

Software

This Limited Warranty does not warrant software products. The Innov-X software installed on the analyzer's system computer is covered by the Innov-X End User Software License Agreement.

Warranty Period

The warranty period for an Innov-X Delta Analyzer is one year. This warranty does not extend to expendable parts. Extended warranties are available from Innov-X.

Warranty Returns

A Return Material Authorization (RMA) Number must be obtained from the INNOV-X Service Department before any items can be shipped to the factory. Returned goods will not be accepted without an RMA Number. Customer will bear all shipping charges for warranty repairs. All goods returned to the factory for warranty repair should be properly packed to avoid damage and clearly marked with the RMA Number.

Warranty Repairs

Warranty repairs will be done either at the customer's site or at the INNOV-X plant, at our option. All service rendered by INNOV-X will be performed in a professional manner by qualified personnel.

Contacting Innov-X

Be sure to have the following information available before you call Innov-X:

- Analyzer serial number, model name, and model number
- Applicable error messages
- Description of problem
- Detailed questions

Methods of Contact

— United States —

- Phone: 1-781-938-5005
- Fax: 1-781-938-0128
- Email: Service@Innov-Xsys.com

- Mail & Shipping Address:
  Innov-X Systems, Inc.
  100 Sylvan Road
  Woburn, MA 01801

— Canada —

- Phone: 1-778-960-6279
- Fax: 1-604-568-2474
- Toll Free FAX: 1-888-873-6598
- Email: service@innovx.ca

- Mail & Shipping Address:
  Innov-X Canada
  1201 West Georgia, Ste. 2
  Vancouver BC
  Canada V6E 3J5

— Europe —

- Phone: +31 (0)73-62 72 590
- Fax: +31 (0)73-62 72 599
- Email: info@innovx-europe.com

- Mail & Shipping Address:
  Innov-X Systems, Inc.
  Kasteleinenkampweg 9R
  5222 AX 's-Hertogenbosch
  The Netherlands

— Australia —

- Phone: 02 9577 9500
- Fax: 02 9519 1850
- Email: service@innovx.com

- Mail & Shipping Address:
  Innov-X Systems Australia PTY LTD
  215 Euston Road, # 6 / L3
  Alexandria, NSW, 2015
  Australia

Or call your local distributor.

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A8. Alloy Grade Libraries

Every Delta unit is supplied with four libraries:

1. "Factory" Library unique to every Model
   - See following pages for tables showing Model/Factory grade names
2. Tramp Library
3. User Library #1 (user may store more than 500 grade names)
4. User Library # 2 (user may store more than 500 grade names)

Libraries are editable. However, InnovX does not recommend that users edit the "Factory" grade library.

Tramp Library

Every analyzer is shipped with a "Tramp" library comprised of seven base alloys. The "Tramp" library supports other grade libraries.

Users can set Tramp Limits, element by element, alloy base by alloy base, to meet their specific requirements.

A single click can select/deselect (globally) the Tramp feature.

How the Tramp Library works:

1. Tramp Grades are matched to alloy bases rather than specific grades.
   — Each sample is determined to be one of seven possible base alloys - see list below
   — Analyzer applies the Tramp Grade/base specific tramp limits from the matching Tramp Grade;
2. These "Tramp Limits" or "alloy base specific" limits are applied when an element is detected in a specific grade.
   — But, the nearest grade match has no specification for that element,
   — And, the concentration of the sample is less than the max limit specified by the matching Tramp Grade.
3. When conditions of #2 are met, the element is reported on the User Interface screen.
   - In **blue**;
   - Is labeled as a **"Tramp"** material in the grade comparison table;
   - But the grade match is not penalized.

PRACTICAL ADVANTAGES of this "tramp element" approach:

- Faster sorting,
- Fewer ambiguous or incorrect matches,
- Improved grade library integrity,
- Prominent labeling of tramp elements.

TRAMP Library Base Alloys

_AlAlloyBase
Common Tramp Elements: Pb, Bi, Sn, Fe, Cu, Zn

_CoAlloyBase
Common Tramp Elements: Al, Ti, V, Cu, Nb, Ta, Zr

_CuAlloyBase
Common Tramp Elements: S, As, Ag, Sb, Sn; not as common Pb, Co, Ni

_FeAlloyBase
Common Tramp Elements: V, Co, Cu, Ni, As - sometimes Si, W, Nb

_GenericAlloyBase
Common Tramp Elements: V, Co, Cu, Ni, As - sometimes Si, W, Nb

_NiAlloyBase
Common Tramp Elements: V, Co, W, Zr, Nb - sometimes Ta, Mo, Cr, Cu

_TiAlloyBase
Common Tramp Elements: Fe is common, Cu & Si show up at low levels.

Factory Grade Library {Table A9.1-Classic}

Aluminums-C

2007
2011
2018
2117
2618
4032
5454
6040
6061
6070
6253
6262
7005
7016
7019
7039
7050
7072
7075
7104
1100-plus
2024-plus
2098-2195
2219-2519
3003 or 4 or 5
355-2
5052-plus
5086-plus
6063-plus
7049-149-249

Cobalt Alloys - C

Alloy 686
AlnicoVIII
Cobalt
Elgiloy
F75
FSX-414
Haynes188
Haynes36
HS-1
HS-12
HS-19
HS-21
HS25-L605
HS-31
HS-4
HS-6B
Jetalloy
MarM302
MarM509
MarM905
MP35N
MPN159
Star J
Ultimet

Specialty Grades- C

60Sn-40Pb
63Sn-37Pb
96-4
AZ31B
AZ91A or C
SAC 300
SAC 305
SAC 400
SAC 405
97-3
Ag
Au
Bi
Cb 103
CP Ta
Cr
Densalloy
Hf
Mn
Mo
Nb
Ni
Pb
Pd
Re
Sb
Se
Sn
TungCarb C
TungCarb S
V
W
Zn
Zr
Zr 2 or 4
Zr 702
Zr 704
Zr 705

Copper Alloys -C

C 110	C 510	C 864
C 172	C 524	C 867
C 194	C 534	C 868
C 210	C 544	C 875
C 220	C 623	C 8932
C 260	C 630	C 903
C 270	C 655	C 922
C 310	C 667	C 932
C 314	C 673	C 937
C 330	C 675	C 955
C 332	C 706	C194HiCu
C 340	C 710	C197HiCu
C 342	C 715	Elec Cu
C 360	C 745	Muntz
C 377	C 752	NarloyZ
C 425	C 814	SeBiLOYI
C 443	C 836	SeBiLOYII
C 464	C 857	SeBiLOYIII
C 482		
C 485		

Nickel Alloys - C

B 1900	I-617	MarM421
B-1900 Hf	I-625	Monel400
C-1023	I-690	Monel411
GMR235	I-700	MonelK500
GTD222	I-702	MuMetal
Hast BC1	I-706	Ni 200
HastB	I-713	NichromeV
HastB2	I-718	Nim101
HastB3	I-720	Nim263
HastC2000	I-722	Nimonic75
HastC22	I-725	Nimonic80A
HastC276	I-738	Nimonic90
HastC4	I-750	PWA1480
HastF	I-792	PWA1484
HastG	I-800	RA333
HastG2	I-801	Rene125
HastG3	I-825	Rene142
HastG30	I-901	Rene220
HastN	I-903	Rene41
HastR	I-907-909	Rene77
HastS	I-939	Rene80
HastW	IN100Mar	Rene95
HastX	M002	Supertherm
Haynes230	MarM200	Udimet500
HR160	MarM246	Udimet520
HyMu80	MarM247	Udimet700
I-102I-49		Waspaloy
I-600		
I-601		

Low Alloy Steels-C

3310
4130
4140
4340
8620
9310
12L14
A10
Carb 1-2
Moly
Carbon
Steel
20Mo4

Chrome-Moly Steels -C

1 1-4 Cr
2 1-4 Cr
5 Cr
9 Cr
P91

Factory Grade Library {Table A9.2-Classic}

Stainless Grades - C		
201	21-6-9	Haynes556
203	25-4-4	Incoloy840
304	254SMO	Invar 36
309	26-1	Kovar
310	29-4	M152
316	29-4-2	Maraging350
317	29-4C	MaragingC200
321	302HQ	MaragingC250
329	410 Cb	MaragingC300
330	410-16-20	N-155
347	904L	Ni-hard#1
422	A-286	Ni-hard#4
430	AL6XN	Ni-Span902
431	Alloy42	Nitronic40
434	AlnicoII	Nitronic50
440	AlnicoIII	Nitronic60
441	AlnicoV	RA330
446	AMS350	RA85H
2003	AMS355	Zeron100
2101	CD4MCU	
2507	Custom450	
13-8 Mo	Custom455	
15-5 PH	Duplex2205	
15Mn7Cr	E-bite	
17-4 PH	Ferallium255	
17-7 PH	GreekAs-coloy	
19-9DL	H12	
19-9DX	H13	
20Cb3		
20Mo6		

Ti Grades - C
Cp Ti
Cp Ti Pd
Ti 12
Ti 17
Ti 3 2-5
Ti 6-22-22
Ti 6-2-4-2
Ti 6-2-4-6
Ti 6-4
Ti 6-6-2
Ti 8
Ti 8-1-1
Ti10-2-3
Ti15-3-3-3
Ti3-11-13
Ti5 - 2-5
Ti6-2-1-1
TiBetaC

Tool Steels- C
A2
A6
A7
D2 or D4
D7
H-11
M1
M2
M4
M42
O1
O2
O6
O7
S1
S5
S6
S7
T1

Factory Grade Library {Table A9.3-Standard}

Delta STANDARD

Aluminums-S

319
333
380
383
384
2007
2011
2018
2024
2117
2618
3004
4032
5042
5052
5083
5086
5154
5454
6040
6061
6070
6253
6262
7005
7016
7019
7039
7050
7072
7075
7104
1100-plus
2014-17 std
2024-plus
2098-2195
2219-2519
3003 or 4 or 5
3003 or 5
355-2
356-57-std
5052-plus
5056-82
5086-plus
6063-plus
7049-149-249

Cobalt Alloys - S

Alloy 686
AlnicoVIII
Cobalt
Elgiloy
F75
FSX-414
Haynes188
Haynes36
HS-1
HS-12
HS-19
HS-21
HS25-L605
HS-31
HS-4
HS-6B
Jetalloy
MarM302
MarM509
MarM905
MP35N
MPN159
Star J
Ultimet

Low Alloy Steels-S

3310
4130
4140
4340
8620
9310
12L14
A10
Carb 1-2
Moly
Carbon Steel
P20
135 N

Specialty Grades- S

60Sn-40Pb
63Sn-37Pb
96-4
AZ31B
AZ91A or C
SAC 300
SAC 305
SAC 400
SAC 405
97-3
Ag
Au
Bi
Cb 103
CP Ta
Cr
Densalloy
Hf
Mn
Mo
Nb
Ni
Pb
Pd
Re
Sb
Se
Sn
TungCarb C
TungCarb S
V
W
Zn
Zr
Zr 2 or 4
Zr 702
Zr 704
Zr 705

Chrome-Moly Steels -S

1 1-4 Cr
2 1-4 Cr
5 Cr
9 Cr
P91

Copper Alloys -S

C 110	C 510	C 864
C 172	C 524	C 867
C 194	C 534	C 868
C 210	C 544	C 875
C 220	C 623	C 8932
C 260	C 630	C 903
C 270	C 655	C 922
C 310	C 667	C 932
C 314	C 673	C 937
C 330	C 675	C 955
C 332	C 706	C194HiCu
C 340	C 710	C197HiCu
C 342	C 715	Elec Cu
C 360	C 745	Muntz
C 377	C 752	NarloyZ
C 425	C 814	SeBiLOYI
C 443	C 836	SeBiLOYII
C 464	C 857	SeBiLOYIII
C 482		
C 485		

Nickel Alloys - S

20Mo4	I-102	MarM247
B 1900	I-49	MarM421
B-1900 Hf	I-600	Monel400
C-1023	I-601	Monel411
Colmonoy 6	I-602	MonelK500
GMR235	I-617	MuMetal
GTD222	I-625	Ni 200
Hast BC1	I-690	NichromeV
HastB	I-700	Nim101
HastB2	I-702	Nim263
HastB3	I-706	Nimonic75
HastC2000	I-713	Nimonic80A
HastC22	I-718	Nimonic90
HastC276	I-720	PWA1480
HastC4	I-722	PWA1484
HastF	I-725	RA333
HastG	I-738	Rene125
HastG2	I-750	Rene142
HastG3	I-792	Rene220
HastG30	I-800	Rene41
HastN	I-801	Rene77
HastR	I-825	Rene80
HastS	I-901	Rene95
HastW	I-903	Supertherm
HastX	I-907-909	Udimet500
Haynes214	I-939	Udimet520
Haynes230	IN100	Udimet700
HR160	MarM002	Waspaloy
HyMu80	MarM200	
	MarM246	

Factory Grade Library {Table A9.4-Standard}

Stainless Grades - S		
201	17-4 PH	H12
203	17-7 PH	H13
303	19-9DL	Haynes556
304	19-9DX	Incoloy840
309	20Cb3	Invar 36
310	20Mo6	Kovar
316		M152
317	21-6-9	Maraging350
321	25-4-4	MaragingC200
329	254SMO	MaragingC250
330	26-1	MaragingC300
347	29-4	
410	29-4-2	N-155
416	29-4C	Ni-hard#1
420	302HQ	Ni-hard#4
422	410 Cb	Ni-Span902
430	410-16-20	Nitronic40
431	904L	Nitronic50
434	A-286	Nitronic60
440	AL6XN	RA330
441	Alloy42	RA85H
446	AlnicoII	Zeron100
2003	AlnicoIII	
2101	AlnicoV	
2205	AMS350	
2205	AMS355	
2507	CD4MCU	
13-8 Mo	Custom450	
15-5 PH	Custom455	
15Mn7Cr	E-bite	
	Ferallium255	
	GreekAscoloy	

Ti Grades - S
Cp Ti
Cp Ti Pd
Ti 12
Ti 17
Ti 3 2-5
Ti 6-22-22
Ti 6-2-4-2
Ti 6-2-4-6
Ti 6-4
Ti 6-6-2
Ti 8
Ti 8-1-1
Ti10-2-3
Ti15-3-3-3
Ti3-11-13
Ti5 - 2-5
Ti6-2-1-1
TiBetaC

Tool Steels- S
A2
A6
A7
D2 or D4
D7
H-11
M1
M2
M4
M42
O1
O2
O6
O7
S1
S5
S6
S7
T1

Factory Grade Library {Table A9.5-Premium}

Delta PREMIUM

Aluminums-P

319
333
356
357
380
383
384
1100
2007
2011
2018
2024
2117
2618
3002
3003
3004
3005
3105
4032
5005
5042
5052
5083
5086
5154
5454
5657
6040
6061
6063
6070
6253
6262
7005
7016
7019
7039
7050
7072
7075
7104
1100-plus
2014-17
2024-plus
2098-2195
2219-2519
3003 or 4 or 5
355-2
5052-plus
5056-82
5086-plus
6063-plus
7049-149-249

Cobalt Alloys - P

Alloy 686
AlnicoVIII
Cobalt
Elgiloy
F75
FSX-414
Haynes188
Haynes36
HS-1
HS-12
HS-19
HS-21
HS25-L605
HS-31
HS-4
HS-6B
Jetalloy
MarM302
MarM509
MarM905
MP35N
MPN159
Star J
Ultimet

Low Alloy Steels-P

3310
4130
4140
4340
8620
9310
12L14
A10
Carb 1-2
Moly
Carbon Steel
P20
135 N

Specialty Grades- P

60Sn-40Pb
63Sn-37Pb
96-4
AZ31B
AZ91A or C
SAC 300
SAC 305
SAC 400
SAC 405
97-3
Ag
Au
Bi
Cb 103
CP Ta
Cr
Densalloy
Hf
Mn
Mo
Nb
Ni
Pb
Pd
Re
Sb
Se
Sn
TungCarb C
TungCarb S
V
W
Zn
Zr
Zr 2 or 4
Zr 702
Zr 704
Zr 705

Chrome-Moly Steels -P

1 1-4 Cr
2 1-4 Cr
5 Cr
9 Cr
P91

Copper Alloys -P

C 110
C 172
C 194
C 210
C 220
C 240
C 260
C 270
C 310
C 314
C 330
C 332
C 340
C 342
C 360
C 377
C 425
C 443
C 464
C 482
C 485
C 510
C 524
C 534
C 544
C 623
C 630
C 642
C 655
C 667
C 673
C 675
C 687
C 706
C 710
C 715
C 745
C 752
C 814
C 836
C 857
C 861
C 863
C 864
C 867
C 868
C 875
C 8932
C 903
C 922
C 932
C 937
C 954
C 955
C194HiCu
C197HiCu
Elec Cu
Muntz
NarloyZ
SeBiLOYI
SeBiLOYII
SeBiLOYIII

Nickel Alloys - P

20Mo4
B 1900
B-1900 Hf
C-1023
Colmonoy
6
GMR235
GTD222
Hast BC1
HastB
HastB2
HastB3
HastC2000
HastC22
HastC276
HastC4
HastF
HastG
HastG2
HastG3
HastG30
HastN
HastR
HastS
HastW
HastX
Haynes214
Haynes230
HR160
HyMu80
I-102
I-49
I-600
I-601
I-602
I-617
I-625
I-690
I-700
I-702
I-706
I-713
I-718
I-720
I-722
I-725
I-738
I-750
I-792
I-800
I-801
I-825
I-901
I-903
I-907-909
I-939
IN100
MarM002
MarM200
MarM246
MarM247
MarM421
Monel400
Monel411
MonelK500
MuMetal
Ni 200
NichromeV
Nim101
Nim263
Nimonic75
Nimonic80A
Nimonic90
PWA1480
PWA1484
RA333
Rene125
Rene142
Rene220
Rene41
Rene77
Rene80
Rene95
Supertherm
Udimet500
Udimet520
Udimet700
Waspaloy

Factory Grade Library {Table A9.6-Premium}

Stainless Grades - P		
201	17-4 PH	H12
203	17-7 PH	H13
303	19-9DL	Haynes556
304	19-9DX	Incoloy840
309	20Cb3	Invar 36
310	20Mo6	Kovar
316	21-6-9	M152
317	25-4-4	Maraging350
321	254SMO	MaragingC200
329	26-1	MaragingC250
330	29-4	MaragingC300
347	29-4-2	N-155
410	29-4C	Ni-hard#1
416	302HQ	Ni-hard#4
420	410 Cb	Ni-Span902
422	410-16-20	Nitronic40
430	904L	Nitronic50
431	A-286	Nitronic60
434	AL6XN	RA330
440	Alloy42	RA85H
441	AlnicoII	Zeron100
446	AlnicoIII	
2003	AlnicoV	
2101	AMS350	
2205	AMS355	
2205	CD4MCU	
2507	Custom450	
13-8 Mo	Custom455	
15-5 PH	E-bite	
15Mn7Cr	Ferallium255	
	GreekAscoloy	

Ti Grades - P
Cp Ti
Cp Ti Pd
Ti 12
Ti 17
Ti 3 2-5
Ti 6-22-22
Ti 6-2-4-2
Ti 6-2-4-6
Ti 6-4
Ti 6-6-2
Ti 8
Ti 8-1-1
Ti10-2-3
Ti15-3-3-3
Ti3-11-13
Ti5 - 2-5
Ti6-2-1-1
TiBetaC

Tool Steels- P
A2
A6
A7
D2 or D4
D7
H-11
M1
M2
M4
M42
O1
O2
O6
O7
S1
S5
S6
S7
T1

GO TO

- See **"***Delta User Interface Guide"* (PN 103202) for a complete description for using Alloy modes' new capabilities such as:
  - Grade Match Messaging,
  - SmartSorting,
  - Nominal Chemistry, and
  - Tramp Library management.