1 PURPOSE AND NEED

Naval Surface Warfare Center, Dahlgren Division (NSWCDD), the action proponent, proposes to expand research, development, test, and evaluation (RDT&E) activities within operating ranges, the Mission Area, and special-use airspace (SUA) at Naval Support Facility Dahlgren (NSF Dahlgren).

NSWCDD is a tenant upon NSF Dahlgren on the western shore of the Potomac River in King George County, Virginia (Figure 1-1, Location of NSF Dahlgren). NSF Dahlgren, a United States (US) Department of the Navy (Navy) facility under the supporting command of Naval Support Activity (NSA), South Potomac, Naval District Washington, is located 25 miles (mi) east of Fredericksburg, Virginia and 53 mi south of Washington, DC. NSWCDD is one of the Naval Sea Systems Command (NAVSEA) surface warfare centers. NSWCDD has multiple sites, but this environmental impact statement (EIS) concerns NSWCDD's range and mission area operations at Dahlgren, Virginia and hence will be referred to as NSWCDD in this document.

The EIS focuses on RDT&E activities that take place outdoors and have the potential to affect the human environment. Much of NSWCDD’s research and development takes place inside laboratories and does not generate environmental impacts on the human environment outdoors. NSWCDD’s Safety and Environmental Office ensures that no indoor impacts take place. Many of NSWCDD’s outdoor activities, such as tests of passive sensors, also have no environmental impact, as determined by NSWCDD’s Safety and Environmental Office, and are not considered in this EIS. Many of NSWCDD’s outdoor activities, such as tests of passive sensors, also have no environmental impact, as determined by NSWCDD’s Safety and Environmental Office, and will not be considered in this EIS.

1.1 Proposed Action

The **Proposed Action** evaluated in this EIS is to expand NSWCDD’s RDT&E activities within the Potomac River Test Range (PRTR) and Explosives Experimental Area (EEA) Range complexes, the adjoining Mission Area, and the SUA. These RDT&E activities include outdoor operations that require the use of:

- **Ordnance –** Since its beginnings in 1918 as the US Naval Proving Ground, NSWCDD has been doing proof testing, lot acceptance, safety testing, and RDT&E of large-caliber guns, small arms (which, for the purposes of this EIS, are defined as those with calibers 20 millimeters [mm]) or less, and many other types of ordnance (munitions), some of which result in detonations.
- **Electromagnetic Energy –** Electromagnetic (EM) energy is naturally occurring and man-made energy created by the interaction of fluctuating electrical and magnetic forces that travel through space at the speed of light. The equipment used outdoors at NSWCDD emits EM energy in a frequency range that includes radio waves or radio frequency (RF), microwaves, infrared (IR) light, visible light, and ultraviolet (UV) light (Figure 1-2, Electromagnetic [EM] Energy). Many types of EM energy emitters are present at

NSWCDD, ranging from everyday, low-power radios, cell phones, and car door openers, to higher-power radars and sophisticated, one-of-a-kind test equipment used to test whether electronics and ordnance can withstand pulses of EM energy.

- **Lasers –** While lasers are a form of EM energy, they are treated separately in this EIS because of their unique properties, which create different types of hazards from other EM sources. A laser is a device that emits a coherent beam of light (EM energy). Most light (non-laser) is incoherent, meaning it is made up of many frequencies. Lased light is light of a single wavelength, so it does not scatter but rather stays in a narrow, intense beam without dissipating quickly. NSWCDD's expertise in laser safety and lasers includes RDT&E of sensors, rangefinders, target designators, guidance systems, simulators, communications equipment, and weapons.
- **Chemical and Biological (Chem/Bio) Simulants –** The threat of terrorist attacks has prompted the Department of Defense (DoD) to step up RDT&E to counter chem/bio terrorism. Chem/bio agents are very difficult to detect, and the key to minimizing the effects of an attack is early detection and warning. As the Navy's center for RDT&E on chemical and biological warfare sensors and protection systems, NSWCDD uses chemical simulants rather than dangerous agents in the open air. Simulants are substances – many are found in common, everyday use, such as acetic acid (strong vinegar) and oil of wintergreen – that mimic chemical and biological agents but do not have the agents' adverse health and environmental effects. To imitate the real chemical or biological agents effectively for RDT&E detection purposes, simulants must have at least one physical property similar to that of the agent, such as molecular size, density, or aerosol behavior. Biological simulants have not been used outdoors by NSWCDD thus far.

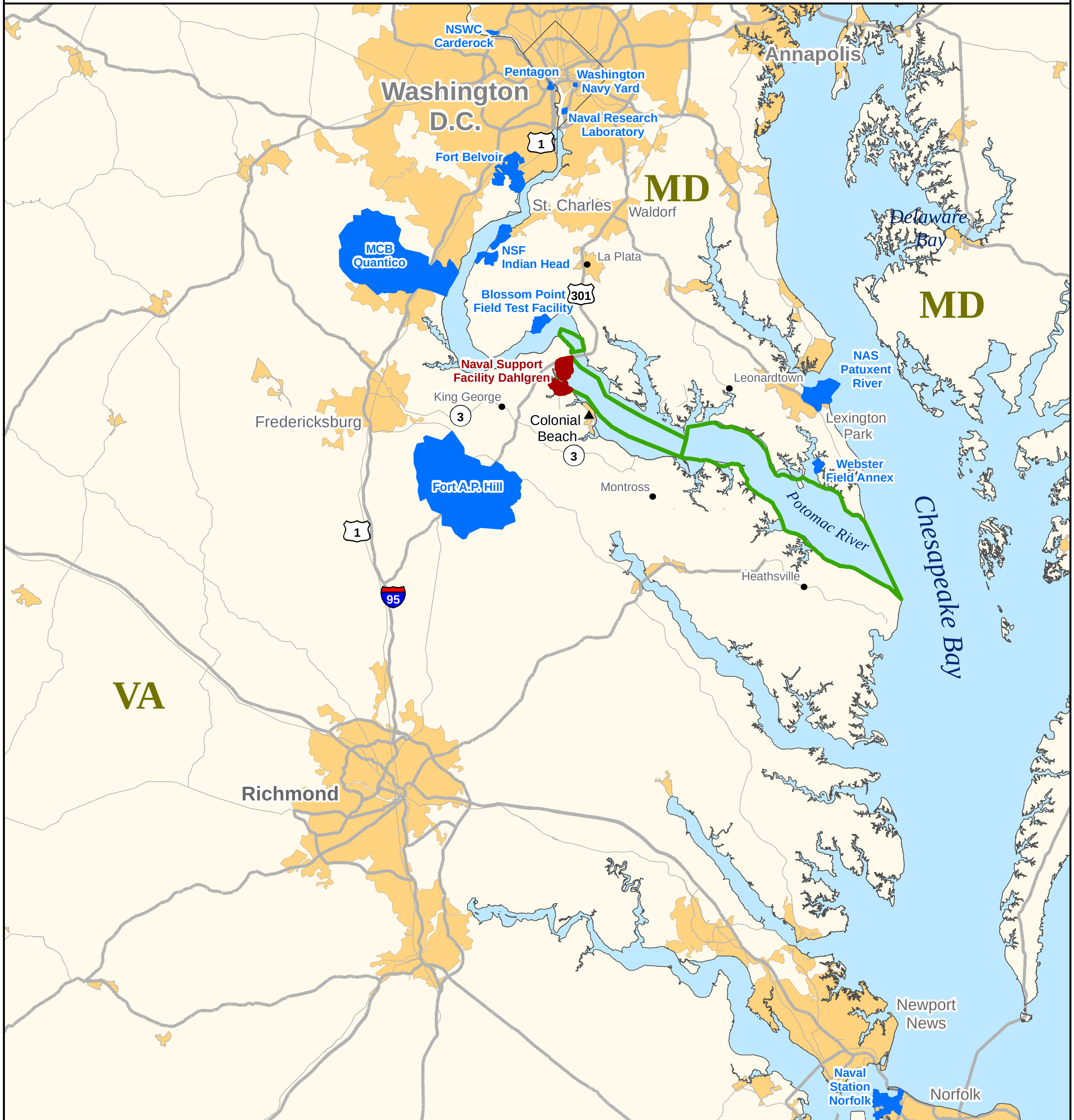
Under the Proposed Action, the average number of events that could take place annually (with the exception of large-caliber gun firing events) would increase above recent levels. To ensure that equipment and materials work effectively, even in less-than-ideal conditions, some activities would take place under conditions in which activities are now rarely/never conducted, such as at dusk, dawn, and night and in adverse weather. Alternatives to implement the Proposed Action are described in Chapter 2.

1.2 Purpose of and Need for the Proposed Action

The **purpose** of the Proposed Action is to enable NSWCDD to meet current and future mission-related warfare and force-protection requirements by providing RDT&E of surface ship combat systems, ordnance, lasers and directed-energy systems, force-level warfare, and homeland and force protection.

Under 10 US Code (U.S.C.) § 5062(d): "The Navy shall develop aircraft, weapons, tactics, technique, organization, and equipment of naval combat and service elements." The **need** for the

Location of Naval Support Facility (NSF) Dahlgren



- County Seat
- Naval Support Facility (NSF) Dahlgren
- Potomac River Test Range (PRTR)
- Military Installation
- Urban Area

20 0 20 Miles

30 0 30 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure 1-1

Source: NSWCDD GIS (2008 - 2011)

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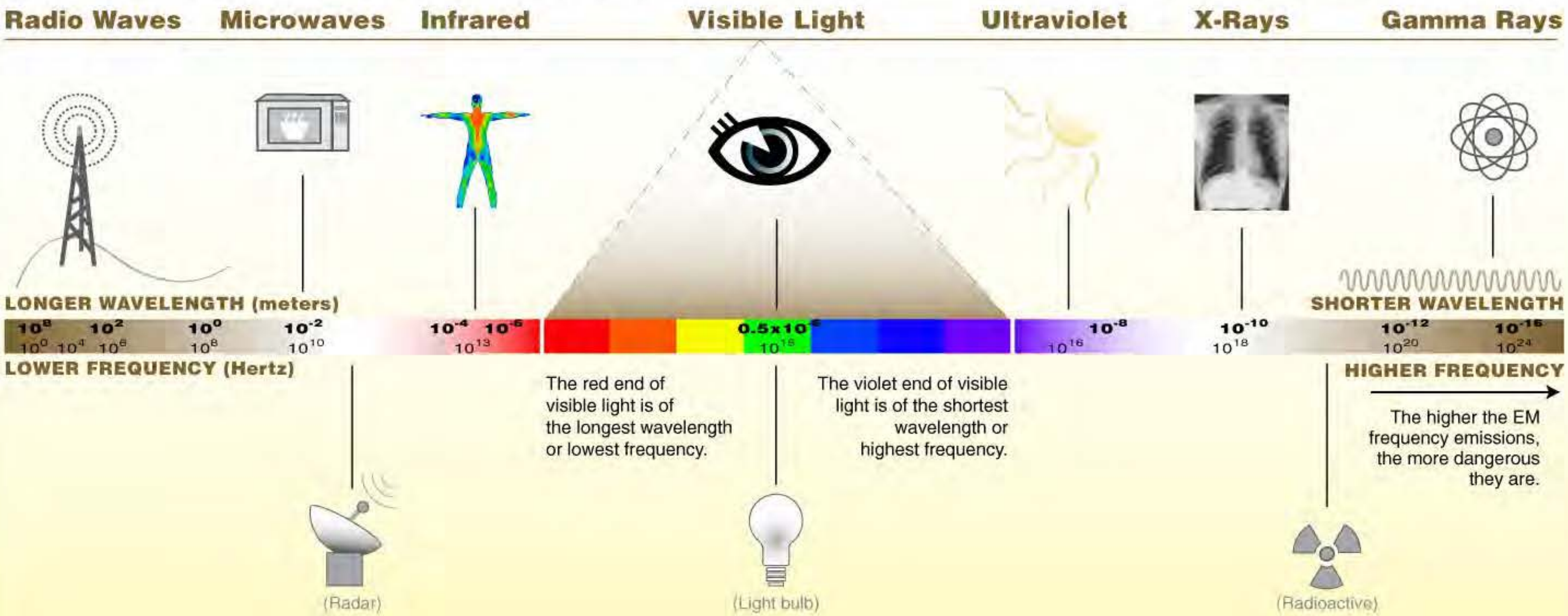
Electromagnetic Energy

What is the Electromagnetic (EM) Spectrum?

Electromagnetic (EM) radiation is energy that travels outwards from a source (i.e., radiates). The EM spectrum is the range of EM radiation and is expressed by frequency (measured in cycles per second called Hertz), wavelength (measured in meters), and energy (measured in electron volts). EM energy travels in waves – the closer together the waves, the higher the frequency; conversely, the farther apart the waves, the lower the frequency. Visible light is part of the EM spectrum. When light passes through a prism, the rays bend at different angles depending on their wavelength and are broken into component colors from red (longer wavelength) to violet (shorter wavelength). EM frequencies lower than visible light are, in order of decreasing frequency: infrared (IR), microwave (MW), and radio frequency (RF). EM frequencies higher than visible light are, in order of increasing frequency: ultraviolet (UV), X-ray, and gamma ray. NSWCDD conducts outdoor EM RDT&E activities in the range from RF to UV.



10^x Wavelength in meters
10^x Frequency in Hertz

Not to scale

Figure 1-2

NSWCDD EIS

NAVSEA DAHLGREN

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Proposed Action is to enable the Navy and other stakeholders to successfully meet current and future national and global defense challenges required under U.S.C. by developing a robust capability to carry out assigned RDT&E activities on range complexes, in the Mission Area, and in SUA at NSF Dahlgren.

1.3 NSWCDD Mission

NSWCDD's 3,000+ highly-skilled scientists and engineers bring their experience and talent to bear on cutting-edge applications. Their work is critical primarily to the Navy and Marine Corps but also to all of the DoD and other federal agencies. In accordance with DoD Directive 5000.01, test and evaluation support is to be integrated throughout the defense acquisition process and structured so as to provide essential information to decision-makers. This testing is used to validate technical performance parameters and to determine whether systems are operationally effective, suitable, survivable, and safe for their intended use. At NSWCDD, such testing is performed on ranges and in the Mission Area.

NSWCDD's mission is to provide RDT&E, analysis, systems engineering, integration and certification of complex naval warfare systems related to surface warfare, strategic systems, and combat and weapons systems associated with surface warfare. NSWCDD is the Navy's leading research organization for naval surface warfare and for the integration of complex warfare systems – ensuring that weapons, sensors, communication systems and warfare systems communicate and work together seamlessly, regardless of the branch of service using the equipment.

Looking northeast towards NSF Dahlgren and the Potomac River

The Navy established NSWCDD in 1918 as an over-water proving ground for naval ordnance. The PRTR Complex (Figure 1-3, Potomac River Test Range [PRTR] Complex) is the nation's largest fully-instrumented, over-the-water gun-firing range. Set in a shallow-water coastal, or littoral, environment bounded by land, the PRTR replicates the littoral areas of the world where almost 45 percent of the world's population lives and in which the Navy operates. As the focus of warfare has shifted from deepwater to coastal regions, testing equipment and technology in a littoral environment similar to those environments in which they will be deployed has become critical to ensure that warfare systems work as designed. Electronics, sensors, and warfare systems react differently in a littoral environment than in a desert, for example, where many systems are initially tested.

NSWCDD's RDT&E strengths include:

- Weapon systems integration
- Directed energy, lasers, and high-power microwave systems

- Optics
- Sensors
- Pulsed power
- Electromagnetic environmental effects
- Counter-terrorism technology
- Chemical, biological, and radiological defense
- Warfare analysis
- Ballistic missile defense technology
- Computer warfare defense technology
- Advanced ordnance

This RDT&E takes place both indoors and outdoors on the ranges and in the Mission Area.

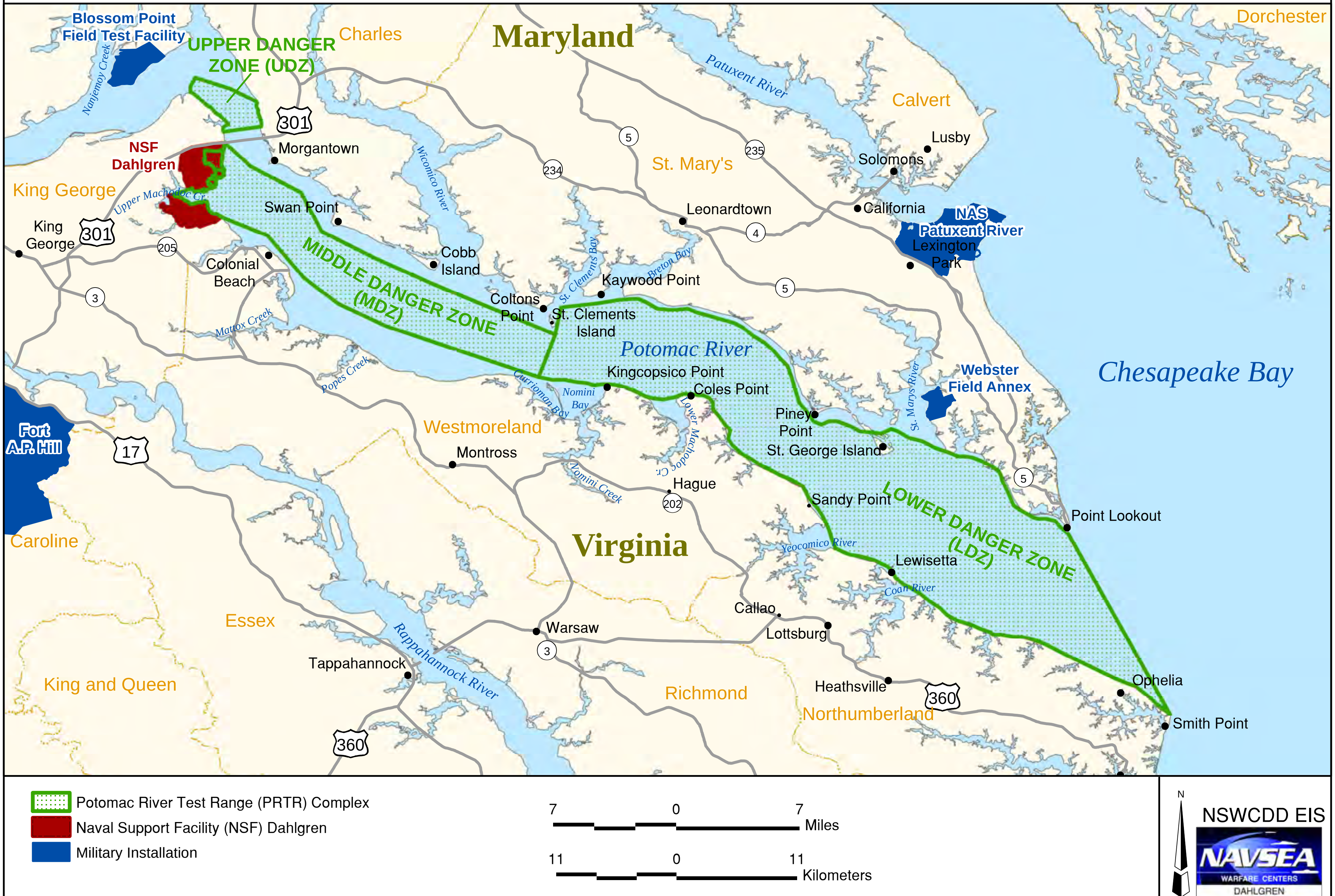
The 2005 Defense Base Closure and Realignment (BRAC) Commission, which reviewed the work of all DoD installations, identified NSWCDD as a center of excellence for weapon systems integration. It also recognized NSWCDD as "unique to the services and a center for Navy surface ship developments." Weapon systems integration allows the weapons and communications systems of all branches of the armed forces to communicate and work together, which is critical to military effectiveness. NSWCDD tests, upgrades, and ensures the seamless functioning of multiple integrated warfare systems. Using the PRTR along with other RDT&E facilities at NSF Dahlgren allows interaction in real time with Navy forces afloat or with other branches of the military to test how well they operate together and how well weapon system components work. This real-time interaction not only provides the Navy with a cost-effective method of developing and evaluating the performance of new weapons and systems, but also speeds their development.

NSWCDD is the designated technical agent for all Navy and Marine Corps hazards of EM radiation to ordnance (HERO) RDT&E and serves many other joint-service and agency clients as well. NSWCDD also serves as the Navy's lead laboratory for RDT&E of issues surrounding E3. These services ensure the operational effectiveness and safety of systems and personnel exposed to the diverse EM environments associated with Navy and joint-service programs.

NSWCDD's laser RDT&E program, which began decades ago, has been recognized by the Navy and the Office of Naval Research (ONR) as a center of excellence for laser RDT&E. As the Lead Technical Laboratory for Navy and Marine Corps laser safety, NSWCDD evaluates lasers and laser systems used on Navy and Marine Corps installations for hazards of EM energy to personnel (HERP).

NSWCDD's Directed Energy Warfare Office (DEWO) is a recognized center of excellence for directed energy (focused EM energy) RDT&E. DEWO's purpose is to lead the development, acquisition, and fielding of directed-energy systems for Navy surface, air, and ground forces.

Potomac River Test Range Complex



Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 1-3

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NSWCDD is the Navy's lead center for chemical and biological defense RDT&E under the DoD's Chemical and Biological Defense Program. As such, NSWCDD is working at the forefront of ways to detect chemical and biological warfare agents and protect against them, particularly in the littoral environment.

1.4 Range Complexes, Mission Area, and Special-Use Airspace

NSWCDD's RDT&E activities take place on the range complexes and the Mission Area described below. Examples are given of the types of activities that take place on each.

1.4.1 Potomac River Test Range (PRTR) Complex

The PRTR Complex (Figures 1-3 and 1-4 [Range Complexes and Mission Area]) consists of land and water test areas that support RDT&E of warfare systems integration, ordnance, lasers, EM energy, sensors, unmanned systems (UMSs), and chemical simulants. The PRTR allows the Navy to conduct testing in a realistic, controlled environment – it effectively operates as a "ship on shore," collecting real-time data from a number of instrument stations. The water portion of the range is 51 nautical miles (NM) long, covers 169 square (sq) NM, and is divided into areas designated on nautical charts as the Upper, Middle, and Lower Danger Zones (UDZ, MDZ, and LDZ, respectively)[1]. The MDZ receives the heaviest use; it is 2.6 NM wide, 15.4 NM long, and covers 39 sq NM. Figure 1-5 (Potomac River Test Range Primary Gunnery Firing Area) shows the main gunnery target area. Danger zones are controlled during test events by NSWCDD range boats and by staff observers stationed at range stations along the Potomac River. Live fire can be performed up to 40,000 yards (yds) or approximately 20 NM down range.

Testing over water is vital when evaluating the performance of detection and engagement systems such as radars and electro-optical tracking systems in order to ensure that systems work over water as well as they do on land. The over-water range provides tracker and sensor testing with low over-water targets in situations in which background clutter, reflectivity, multi-path conditions, and wave height conditions can all vary. The range has a comprehensive instrumentation system, with both fixed and mobile components located along the PRTR to accurately measure test results. The PRTR also serves as a safety buffer for land-based range testing.

NSWCDD's Main Range gun line, which includes every gun currently used on Navy ships, faces down the Potomac River Test Range.

[1] The limits of the danger zones are defined in 33 Code of Federal Regulations (CFR) § 334.230 and shown on National Oceanic and Atmospheric Administration's Nautical Charts: 12288, Lower Cedar Point to Mattawoman Creek; 12286, Potomac River – Piney Point to Lower Cedar Point; and 12233, Chesapeake Bay to Piney Point.

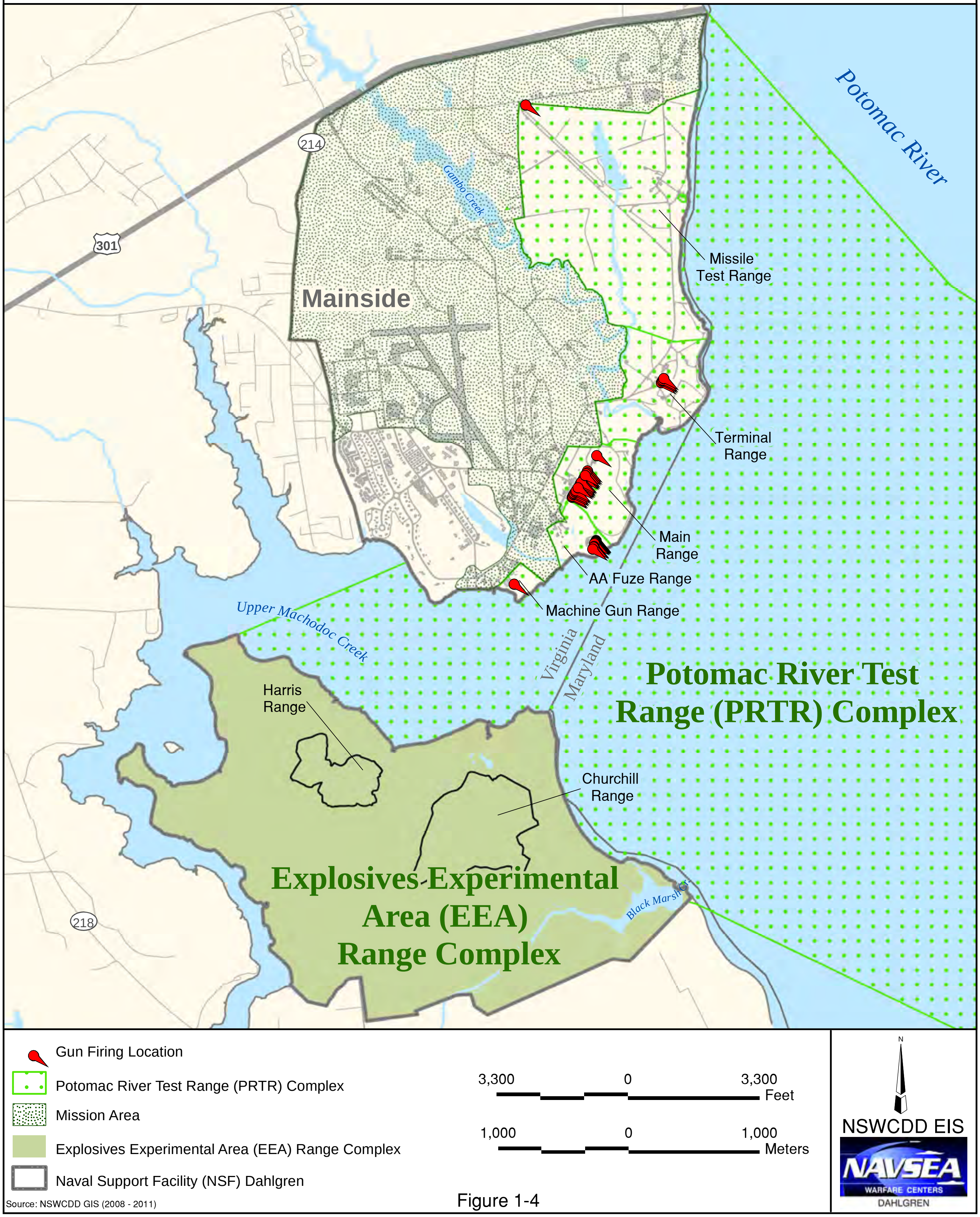
The 725 acres (ac) of land ranges that are part of the PRTR (Figure 1-4) include (with examples of the types of work conducted on each range):

- **Main Range –** Used for systems integration and testing with networked connectivity to most shipboard combat-system elements, the Main Range houses large-caliber gun systems, and includes 39 gun emplacements plus test stands for proof-firing gun-mount oscillating assemblies and gun barrels. The Search and Track Sensor Test Site (STSTS) houses radar systems used for gun fire control, systems integration, scanning the range, and controlling unmanned aerial vehicles (UAVs).
- **Anti-Aircraft (AA) Fuze Range –** Primarily used to test fuzes over the PRTR, the AA Fuze Range also is used to test large-caliber guns and projectile components. Its location adjacent to the PRTR enables over-the-water testing of fuzes – a procedure vital to the success of Navy fuzes. RDT&E support at the AA Fuze Range includes proof tests, barrel wear and heating tests, projectile ramming tests, new-projectile design evaluation, and water-surface burst data at short and long ranges.
- **Missile Test Range –**Despite this range's historic name, no missiles are fired from it these days. Instead, this range is used to conduct overland test and evaluation of vehicles and special-weapon components against targets. The range includes suspended targets, a grazing pad, and portable facilities and analysis equipment. The Electromagnetic Launch Facility (EMLF) for EM launcher RDT&E is located on this range. Shock Tube and Tisdale Roads are used for laser and EM activities. The range includes an explosive ordnance disposal training range for non-fragmenting energetic training activities.
- **Machine Gun Range –** This range consists of four indoor and two indoor/outdoor firing bays and an outdoor test area with multiple gun emplacements. Testing of 40 mm and smaller guns and ammunition is performed here, as well as penetration testing of light-armor materials. The range is also used to evaluate the effectiveness of windshields and protective armor against representative small arms threats, such as improvised explosive devices and other non-conventional threats. The range is equipped to record data such as firing stresses and strains, shock waves, projectile pressure, temperature, position, velocity, and acceleration. The Navy Directed Energy Center (NDEC) is located on this range.
- **Terminal Range –**The Terminal Range supports RDT&E and production testing of weapon systems, components, and other ordnance material (specifically, experimental items). This location allows for tests requiring large quantities of explosives, high chamber pressures, ballistic evaluation of armor plate, and penetration tests of projectiles. A projectile recovery system has been constructed to accommodate the firing of projectiles on land. Emerging-technology projectiles are recovered after tests to study gun-firing effects.

1.4.2 Explosives Experimental Area (EEA) Range Complex

The 1,641-ac EEA Range Complex (Figure 1-4) supports performance, lethality, safety, and insensitive-munitions testing on full-scale weapon systems and components containing explosives, propellants, and inert materials. Although the EEA mainly supports RDT&E and

Range Complexes and Mission Area



Source: NSWCDD GIS (2008 - 2011)

Figure 1-4

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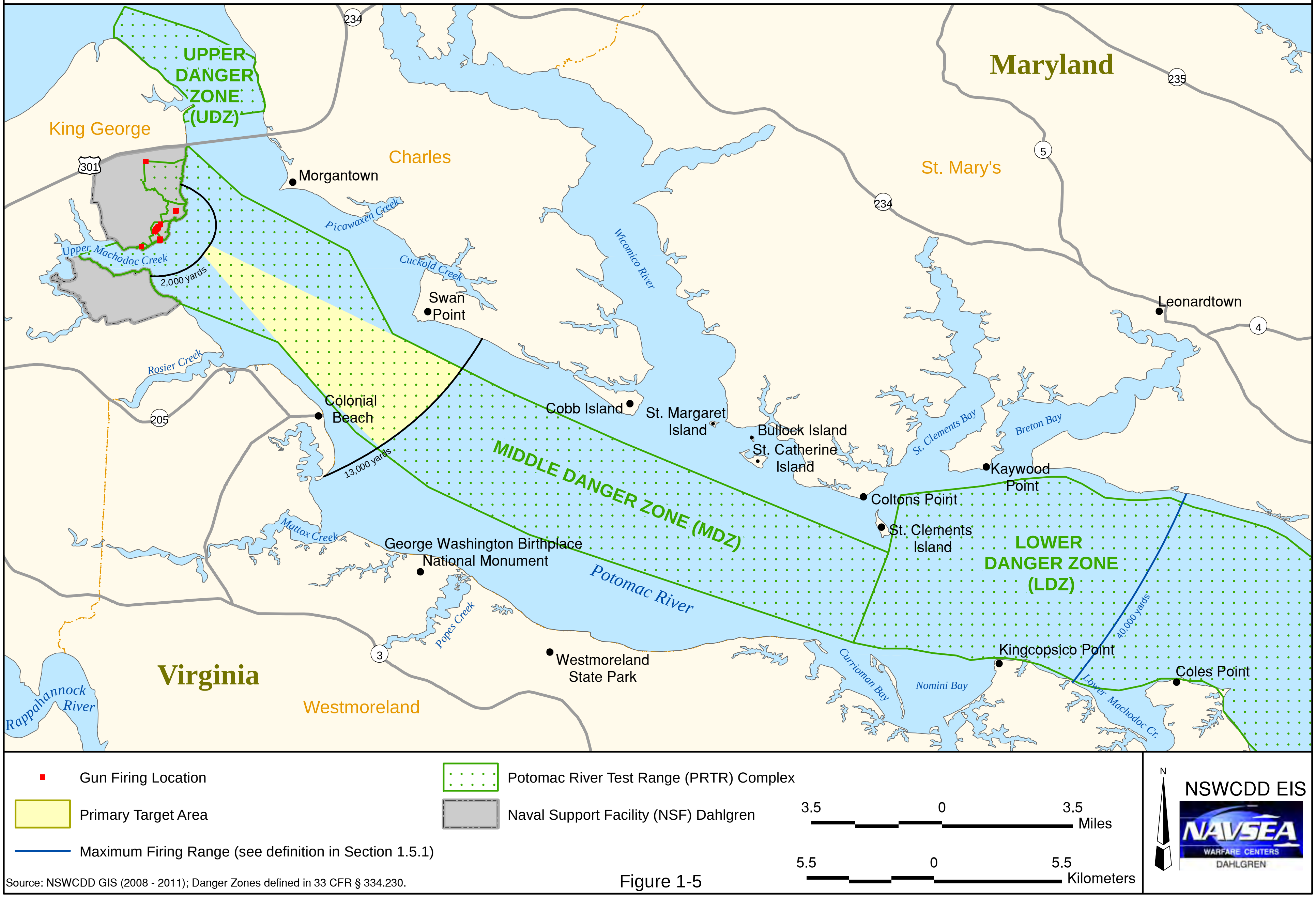
Potomac River Test Range Primary Gunnery Target Area



Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 1-5

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safety testing for ordnance weapon systems, such as rocket-propelled grenades, rockets, and restrained missile launchers, this complex also supports RDT&E of lasers, EM energy, and chem/bio simulants. The EEA is extensively instrumented for conducting explosive tests such as blast measurements, target vulnerability, arena testing, and live-fire tests (described in Section 1.5.1.4). Safety testing of ordnance (munitions) includes temperature and humidity cycling, shock, vibration, and a 40-foot drop. Insensitive-munitions tests include fast cook-off[2], slow cook-off, fragment impact, shaped charge/jet impact, sympathetic detonation, and bullet-impact testing. The Counter Explosive Test Facility (CETFAC), the Naval Ordnance Transient Electromagnetic Simulator (NOTES) facility, and two ranges – Churchill and Harris – are located within the EEA.

- **Churchill Range** –This range is used for destructive testing of items with up to 1,000 pounds (lbs) of explosives, net explosive weight (NEW). Range infrastructure is in place to facilitate fast cook-off, slow cook-off, bullet impact, arena testing, and blast testing, as well as specialized testing, as required. Resource Conservation and Recovery Act (RCRA)-permitted open burn/open detonation (OB/OD) units are located on the Churchill Range.
- **Harris Range** – This range is used for destructive and non-destructive testing of items of up to 600 lbs NEW. Infrastructure is in place to facilitate slow cook-off, fragment impact, arena and other specialized testing, as required. In addition, the Harris Range supports equipment and infrastructure to conduct restrained 40-foot drop testing and full-spectrum shipboard shock testing on both explosive and non-explosive items.

1.4.3 Mission Area

The 1,593-ac Mission Area (Figure 1-4) consists of property adjacent to but not designated as part of the PRTR Complex. This area supports a myriad of outdoor RDT&E activities for NSF Dahlgren and its tenants but excludes destructive ordnance testing (allowed on military ranges including the PRTR and EEA). Facilities in this area include the NSF Dahlgren Airfield, the Maginot Open Air Test Site (MOATS), the Chemical/Biological Defense (CBD) Facility, and the Electromagnetic Environmental Effects (E3) facilities –MOATS, ground planes, airfield hangars, and the abandoned and main runways.

1.4.4 Special-Use Airspace (SUA)

SUA areas have been established by the Federal Aviation Administration (FAA) to prevent hazards to aircraft from NSWCDD's RDT&E activities (Figure 1-6, Special-Use Airspace [SUA]). There are four subdivisions of the SUA areas, two with maximum altitudes of 40,000 ft (SUA R-6611A and SUA R-6613A), and two with maximum altitudes of 60,000 ft (SUA R-6611B and SUA R-6613B). For safety reasons, flights by non-military aircraft in the SUA areas are restricted during testing. When testing is completed early or a scheduled test is cancelled, the

[2] Cook-off or thermally induced firing refers to ammunition exploding prematurely due to heat in the surrounding environment. Fast cook-off is caused by fire whereas slow cook-off is caused by a sustained thermal event less intense than fire.

airspace is returned to the control of the FAA for normal civilian air traffic use. Additionally, a small restricted airspace – SUA R-6612 – lies directly over the EEA, and extends to 7,000 ft.

1.5 Mission Activities Addressed in This EIS

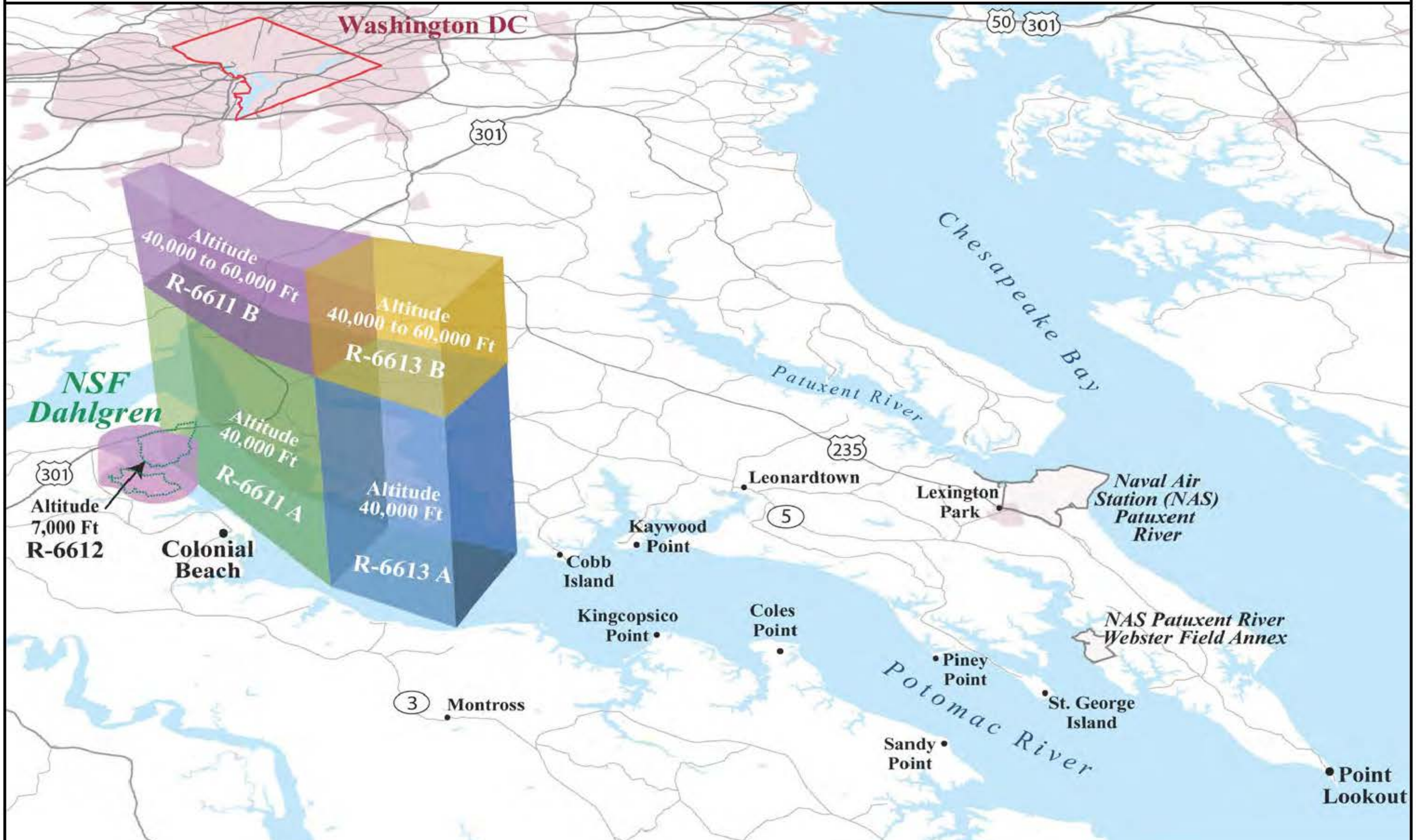
NSWCDD's work encompasses a number of mission/expertise areas within naval surface warfare. The focus of the EIS, however, is specifically on outdoor RDT&E activities that have the potential to significantly affect the human environment. As noted in the introductory paragraphs, much of NSWCDD's work takes places indoors in laboratories with ample safeguards in place to protect human health and safety, so effects on the indoor human environment are limited and are not addressed in this EIS. Similarly, much of the work NSWCDD undertakes outdoors has negligible impact on the human environment and thus is not addressed in this EIS.

NSWCDD's activities that have the potential to significantly affect the human environment involve the use of ordnance, higher-power EM energy, higher-power lasers, and chem/bio simulants, which fall under the following mission/expertise areas:

- **Surface Ship Combat Systems –** RDT&E, systems engineering, and integration to ensure that combat systems on surface ships function correctly. Major areas are air and surface surveillance sensor and detection systems; combat control systems; engagement systems; electronic warfare systems integration; and combat systems engineering, integration, testing, evaluation, and assessment.
- **Ordnance –** RDT&E to ensure the safety and capability of guns, ammunition, energetic materials, logistics, and environmental technology, as well as cartridge-actuated, pyrotechnic, and specialty devices.
- **Lasers and Directed Energy –** RDT&E using focused EM energy, particularly lasers and directed energy, in support of air and surface surveillance; electronic attack; and targeting, detection and engagement systems.
- **Force-Level Warfare –** RDT&E to ensure the integration and interoperability of each element (ship, weapon system, etc.) at the force, battle group, and theater level. Major areas are: warfare systems analysis, architecture and requirements; warfare systems engineering, integration, testing, evaluation, and assessment; and mission assurance.
- **Homeland and Force Protection –** RDT&E solutions to protect the Armed Services, other government agencies, and the nation from emerging and nontraditional terrorist threats. Major areas include: homeland security and measured response options; force protection and chemical and biological defense systems; and mission assurance.

The mission activities currently being conducted by NSWCDD that are addressed in this EIS are described in the following sections.

Special-Use Airspace



Source: FAA, 2005.

Figure 1-6

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1.5.1 Mission Activities Involving Ordnance

Our nation's military must eliminate an array of evolving threats in a variety of physical environments. To do so effectively requires the development of increasingly accurate and effective weapons with the capability to reliably detect, identify, and destroy a range of targets and hazards on sea, on land, and in the air.

Since 1918, NSWCDD has been a national resource for the testing of naval guns and ammunition, as well as for a wide variety of military testing utilizing explosive and non-explosive ordnance. NSWCDD is the Navy's primary RDT&E facility for most surface-launched weapons systems. Large-caliber gun testing is primarily conducted on NSWCDD's Main Range within the PRTR Complex (Figures 1-3 and 1-4) but also on the AA Fuze Range and the Terminal Range. The gun emplacements are capable of firing all types of naval guns. NSWCDD maintains at least one naval gun of each type used in the Fleet as well as older guns no longer used by the Navy but still used on the ships of its allies. Guns are fired downriver with most rounds landing in the main gunnery target area within the Middle Danger Zone (MDZ) (Figure 1-5). The maximum firing range, which refers to the maximum distance a fired projectile would travel, is 40,000 yds (19.7 NM – or approximately 20 NM). The maximum range target area is located at 35,000 yds (approximately 17 NM), which provides a margin of safety for projectiles that may not hit the target area.

1.5.1.1 Ordnance Safety

Before an outdoor ordnance operation takes place, a risk hazard assessment (RHA) and associated standard operating procedure (SOP) are developed, reviewed, validated, and approved, as described in Section 3.8.1. These measures ensure that tests are conducted safely and with a minimum of environmental impact.

Standard Operating Procedure (SOP) and Risk Hazard Assessment (RHA)

A **standard operating procedure (SOP)** is prepared for every operation determined by performance of a **risk hazard assessment (RHA)** to be potentially hazardous**.** SOPs are prepared to ensure the safety of participants and the public and to minimize environmental impacts. An SOP includes a description of the proposed operation; a statement of responsibilities; a listing of what persons will be in charge of what actions; the operational location; a description of personnel and material limits (including buffer zones for safety); safety requirements; emergency response and contingency plans; applicable environmental protection procedures; security requirements; a hazard control brief; an equipment list; and step-by-step descriptions of the procedures to follow, with highlighted warning and caution boxes.

When ordnance activities take place on the PRTR or the EEA, public access to these areas and to the airspace above them is restricted. As described in more detail in Section 3.8.1.1, danger zones are defined on nautical charts for the PRTR (Figure 1-3) to alert mariners that access to the area is restricted during testing to ensure everyone's safety. NSWCDD's Range Operations Center (ROC) restricts the range(s) before testing commences and deploys range boats flying red flags to clear the range of watercraft, if required. The ROC continuously communicates with boaters by radio. SUA is activated during ordnance tests to restrict aircraft (Figure 1-6).

1.5.1.2 Large-caliber Gun Activities

NSWCDD's ordnance mission has evolved from component (single-element) testing to systems integration and testing with networks connected to most shipboard combat-system elements (such as gun fire control, sensors, radars, and the Naval Fire Control System). The largest guns fired at NSWCDD today are the 155 mm (6.1") howitzer used by the US Marine Corps and US Army and the 8" (203 mm) gun. The 155 mm gun is fired infrequently to support the testing of fuzes and projectiles and only occasionally into the river. Typically, the 155 mm gun is fired into a projectile catchment facility on one of the land ranges, particularly the Terminal Range. The 8" gun is no longer used as a weapon but rather is a one-of-a-kind test fixture used to launch canisters containing electronic components for new projectile designs to test their ability to withstand the stress of high levels of gravity or "G" forces during launching. A reduced charge is used to fire the 8" gun; no other explosives are used.

> **Naval Guns**
>
> Naval gun designations generally include the: (1) model or reference designation; (2) modification designation to indicate a change from the original design; (3) caliber (diameter of the bore); and (4) barrel length, which is described in multiples of the diameter of the bore.
>
> For example, the description **MK 45 Mod 1/2 5"/54** means that it is the 45th version of the 5" gun; has the first and second modifications to the Mark (MK) 45 design; has a 5-inch-diameter bore; and has a barrel 5 x 54 inches = 270 inches long.

The largest caliber guns that are fired frequently are the 5" (127 mm) guns. The Mark (MK) 45 Mod 1/2 5"/54, a gun commonly found on ships in the Fleet, has a maximum sustained firing rate of 20 rounds per minute and a maximum firing range of 26,000 yds (approximately 13 NM). The newer, longer-range 5"/62 gun has a maximum range of 30,000 yds (approximately 15 NM).

The number of projectiles (rounds of ammunition) NSWCDD fires annually from large-caliber guns on and from the land ranges of the PRTR Complex varies based on the types of tests being conducted in a given year. For the purpose of this EIS, large-caliber guns are considered to be more than 20 mm (0.8") in bore size. RDT&E is cyclical by nature, and tests on a particular type of weapon, weapon component, or weapon system may take place once every three, five, or even ten years. Testing of a weapon or system may occur over a period of days, weeks, or months. Firing levels may be higher in one year because a new gun or a new type of ammunition is being tested or due to world events. For example, during World War II (WWII) RDT&E occurred daily at NSWCDD.

NSWCDD fired an average of 2,900 projectiles annually in the years from 1995 to 2009, ranging from a low of 910 fired in the year with the smallest number of firings (2005) to a high of 6,170 (all inert) in 2004. In particularly active years since 1995, the average has been approximately 4,700 large-caliber projectiles fired annually.

For the years 1995 to 2009, 74 percent of the projectiles fired from the PRTR land ranges into the Potomac River were inert, and 26 percent were live explosive projectiles. The component most often tested on inert projectiles is the fuze or detonator. A fuze or detonator typically

> **Live and Inert Projectiles**
>
> Projectiles used at Dahlgren can be live (explosive) or inert (non-explosive). Live projectiles are composed of energetic material (the explosive core or the propellant for a projectile), plus an outer casing, fragmentation material, a fuze (a detonating device), sensors, timers, or other items. Inert projectiles have a core composed of sand or concrete with no energetic material – no explosive core – but could have a fuze with less than 0.004 lbs of explosive material, a sensor, or other items for testing.

contains less than 0.004 lbs (2 grams [g]) of explosive material. A fuze usually also contains a few ounces of non-explosive talcum-like powder to produce a puff of smoke to indicate to observers that the fuze has been successfully triggered.

The explosive rounds NSWCDD fires most commonly are 5” projectiles, which typically contain 6-10 lbs of explosives NEW. While 5” projectiles containing up to 16 lbs of explosives are made for specific purposes, NSWCDD’s use of projectiles over 10 lbs NEW is very rare. For example, the Navy developed one special projectile that contained 16 lbs of explosives for the purpose of giving off a large heat signature, but very few were made.

NSWCDD’s largest explosive projectiles are fired from the 155 mm howitzer, which is fired much less frequently than the 5” guns, usually with inert rounds, and mainly into targets on the land ranges. Most live 155 mm projectiles fired by NSWCDD contain 11-15 lbs of explosives. For comparison purposes, while the Navy no longer fires large 16” (406 mm) projectiles into the PRTR, the 16” projectiles fired until the early 1990s each contained over 150 lbs of explosives.

The types of activities conducted at NSWCDD using large-caliber guns include:

- **Lot acceptance and proof testing –** NSWCDD tests to ensure the safety and effectiveness of newly-delivered weapons and ammunition for most types of naval weapons, such as land attack, anti-aircraft guns, missiles, and projectiles, as part of Naval Surface Fire Support, a central mission of the Navy. NSWCDD serves as the final inspection and acceptance point for most naval gun barrels, ammunition, and all associated components, including fuzes, primers and propellants, to ensure that sailors and marines are provided with safe, accurate, and reliable weapons. While missile components are tested at NSWCDD, missiles are not physically launched from range complexes. Lot acceptance and proof testing, once a major portion of NSWCDD’s ordnance activities, now only accounts for about ten percent of its workload.
- **Projectile and fuze testing –** NSWCDD tests projectiles and their fuzes, firing from the actual types of guns used by the Fleet over the PRTR’s combined water and land range to accurately simulate the background “clutter” that occurs in real wartime (at-sea and littoral) environments. Because RF, IR, and other sensor characteristics are affected by water surfaces and moist atmospheric environments differently than when over land, testing on a water range is necessary to realistically assess munitions and fuzes against sea-based targets. Background clutter includes such things as surface reflectivity, optical glint, and EM interference.


MK 45 Mod 1/2 5”/54 gun being fired

- **Reactive materials –** Reactive materials are inert under normal conditions, but when they impact a target at very high speeds, they "react" with a high level of explosive force. Performance and effectiveness of reactive materials are studied at NSWCDD.
- **EM Launcher RDT&E –** NSWCDD is conducting RDT&E of a new type of naval gun. EM launcher technology uses high-power EM energy instead of explosive chemical propellants to propel projectiles farther and faster than any preceding gun. The EM launcher projectile is made with a reactive material that explodes on impact with a target from sheer kinetic force even though there is no chemical explosive as is found in explosive-based ordnance. This capability will allow ships to fire on land targets while staying well-offshore and out of range of enemy fire. The Navy's goal is to employ EM launchers as weapons on future all-electric Navy ships (NSWCDL, 2009a).
- **Development and certification of integrated targeting and fire control systems –** Today, a sensor such as radar or a laser not only detects a target, but also transmits the information to one or more platforms, such as ships and aircraft, simultaneously. NSWCDD is working to enhance the integration of information to enable almost immediate communications among sensors and platforms in order to instantly sense, target, and engage the target, if necessary, with the most appropriate weapon from each platform.
- **Missiles, rockets, and launcher components –** This work focuses on the operation of components, such as sensors and telemetry systems.
- **Operational improvements in reliability, accuracy, and safety of weapons and ammunition –** One example is RDT&E to improve gun-barrel life by using light composite material in gun barrels to produce longer-lasting, lighter weapons.
- **Long-range guns that can fire accurate and reliable projectiles at distances in excess of 50 NM –** While NSWCDD is developing and testing the capabilities of these new guns and projectiles, they would not be tested at full range at this facility.
- **High-speed penetrating projectiles –** NSWCDD is working on developing new forms of high-speed penetrating weapons to serve as "bunker busters."

1.5.1.3 Small Arms Activities

Firing of small arms (defined in this EIS as having a projectile diameter of less than or equal to 20 mm [0.8"]) can take place on any of the ranges, but primarily takes place on the Machine Gun Range, AA Fuze Range, and Main Range. In addition, penetration testing of light-armor materials and of primers (caps or tubes containing a small amount of explosive used to detonate the main explosive charge of a firearm) of all sizes occurs at the Machine Gun Range. Active gun mounts are available for firing a wide variety of small-caliber handguns, machine guns, and rifles. Usually, the projectile of a gun smaller or equal to 20 mm (0.8") is referred to as a "bullet." Approximately 6,000 bullets are fired outdoors on the ranges annually. Most bullets fired are inert – made of solid metal with no explosive filler – but some are explosive.

1.5.1.4 Detonations

Approximately 190 detonation events take place annually, based on an average of annual detonations from 1993 through 2009. Most detonations take place on the EEA's Harris and

Churchill Ranges, but a few may take place on the Explosive Ordnance Disposal training area of the Missile Test Range. In an average year, 95 percent of items detonated for RDT&E activities contain less than 100 lbs NEW of explosives. For example, the NEW of the detonations in 2007 ranged from less than 1 lb up to 623 lbs, with an average of 28 lbs per detonation. However, the NEW of half of the detonations was 5 lbs or less. In 2007 only four detonations had NEWs above 100 lbs – two at 104 lbs NEW, one at 175 lbs NEW, and one at 623 lbs NEW.

Arena Fragmentation Test

The Churchill Range has a 1,000-lb NEW limit. The Harris Range has a 600-lb NEW limit. However, detonations of this size rarely occur as part of RDT&E activities. Large NEW detonations usually take place on the EEA for treatment (the blowing up or destruction) of explosive waste. Treatment of explosive waste takes place at NSWCDD because ordnance subjected to testing is unsafe to transport to other facilities for treatment. In 2007, NSWCDD treated 66 pieces of ordnance with a total NEW of 19,000 lbs.

Pieces of ordnance of over 200 lbs NEW subjected to open detonation treatment are covered with approximately 8 feet (ft) of dirt to reduce noise and flying fragments. Detonations are heard as booms or rumbles. How far away the noise from a detonation is heard varies based on the RDT&E being conducted (e.g., quantity of NEW, burial depth, location of detonation), weather conditions, and the location of the person hearing it.

The types of activities that produce detonations are:

- **Insensitive Munitions (Ordnance) Tests –** Insensitive munitions tests are conducted to ensure that explosive munitions are relatively insensitive to unplanned stimuli, such as those that might occur as a result of an accident or deployment in combat (e.g., fire, fragment impact, or a nearby munition exploding). Insensitive munitions tests include: fast cook-off, slow cook-off, fragment impact, shaped-charge/jet impact, sympathetic detonation, and bullet impact.
- **Environmental Safety Tests –** Ordnance is subjected to extreme temperatures, water, salt fog, vibration, dropping, and shock testing to ensure its reliability and stability when transported by sea, by aircraft, and over land, and when stored in ships' holds. Data collected from these tests are used to determine various threshold limits, to identify and correct weaknesses, to identify safe operating parameters, and to write guidance documents for military personnel to ensure high safety standards and protect personnel and equipment. These tests are conducted in response to various military standard requirements. Occasionally, a piece of ordnance being tested will detonate.
- **Arena Fragmentation Tests –** Fragmentation arenas located on the Churchill Range are used to evaluate blast data; fragment spatial distribution, masses, and velocity; lethality;

warhead performance; and presented areas/shape factors. The circular "arena" is surrounded by panels of metal and wood to capture the fragmentation patterns after detonation. All shell fragments remain within the EEA ranges.

- **Performance and Safety Tests –** In order to characterize performance, tests of performance and safety, such as for warhead detonations, are conducted both within the arena and in other parts of the ranges.

1.5.2 Mission Activities Involving Electromagnetic Energy

EM energy and its application for military use is a major area of RDT&E at NSWCDD. Use of EM technology promises to be one of the most important areas for advancing the ability to communicate, detect objects or substances, protect against enemy weapons, and destroy enemy targets with levels of speed, accuracy, and safety not possible with conventional guns and missiles. Using EM energy, NSWCDD is exploring applications to instantly detect possibly harmful chemical or explosive substances and to use focused beams or directed energy, such as those used by radar or a microwave oven, to destroy incoming missiles.

The work done outdoors at NSWCDD uses EM emitters in the range from RF to UV waves (Figure 1-2). Many types of EM energy emitters are present at NSWCDD, ranging from everyday low-power radios, cell phones, and car-door openers to higher-power, sophisticated one-of-a-kind test equipment.

EM energy devices evaluated in this EIS operate at higher powers. Currently, an annual average of 490 events take place at NSWCDD using EM energy fields in the frequency range of 300 kilohertz (kHz) (or 300,000 cycles per second) up to 300 gigahertz (GHz) (or 300 billion cycles per second) and at average powers ranging from 10 watts (W) to 500 megawatts (MW). Activities employing higher-power EM energy are described below. (While lasers are a type of directed EM energy, they are treated separately because of their distinctive mode of operation).

Electromagnetic Energy

Electromagnetic (EM) energy is naturally occurring and man-made energy created by the interaction of fluctuating electrical and magnetic forces that travel through space at the speed of light. Lightning that accompanies thunderstorms is a vivid example of naturally occurring EM energy. Televisions, radar, microwave ovens, Wi-Fi, cellular phones, and iPods are man-made uses of EM energy.

Operations, Tests, and Events

An **operation** is a group of **tests** that has a common objective and that may take place over one or more days under one **standard operating procedure (SOP)**.

For purposes of this EIS, an **event** consists of **all the tests that take place under one SOP on one day**. If two groups of tests are conducted on the same day under separate SOPs, then each group counts as a separate event.

If an operation continues for a number of days, the tests conducted on each additional day under the same SOP are considered as separate events. As an example, if an operation continues for 10 days with tests taking place on each day under the same SOP, then this operation would include 10 events, for purposes of this EIS.

1.5.2.1 Electromagnetic RDT&E Safety

Most of NSWCDD's EM energy research is on the lower-frequency range of the EM spectrum (Figure 1-2). Research includes UV, visible, and IR light; microwaves; and RF waves, all of which are relatively safe. Prior to conducting any EM tests, NSWCDD personnel consider the frequencies and power the tests will utilize. Because energy and power levels decrease with increasing distance from the source, distances from the source to humans or wildlife in the area are crucial elements in designing the tests and developing SOPs. NSWCDD incorporates into all SOPs strict safety standards, for which levels have been established through extensive national and international research in EM safety. Only after meeting or exceeding these safety levels, and after satisfactorily demonstrating a complete dry run (one in which no energy is emitted), will a senior division manager approve the SOP and allow activities to proceed.

EM Variables

EM energy is classified into several types based on the **frequency** of the waves (see Figure 1-2 and EM energy text box). **Power** is the rate at which energy is transferred per unit **time**. It is measured in **watts (W)** and 1 W is equal to one joule per second.

The standard unit of electric field strength (E-field) is **Volt per meter (V/m),** which is used to specify the **intensity** (power per unit area) of an EM field**.** Energy is inversely proportional to the square of the **distance** from the source, so an object (of the same size) twice as far away, receives only one-quarter the energy.

The term magnetic field is used for two different vector fields denoted as the B- and H-fields. The B-field or magnetic flux density is measured in **tesla (T)** or **gauss (G)** and the H-field or magnetic field strength is measured in **amperes per meter (A/m).**

As with ordnance activities, SOPs developed for each operation using EM energy identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site:

- **Hazards of EM Radiation to Personnel (HERP) safety zones are determined for each EM emitter –** Personnel involved with the test inside the safety zone must either leave the HERP safety zone during operations or limit their time based on approved exposure limits (DoD, 2009). These limits are similar to exposure times recommended for humans to sunbathe safely. Because EM energy dissipates exponentially as the distance from the energy source increases, safety to personnel is usually as simple as moving personnel farther away from the source. Therefore, hazards-to-personnel safety zones are calculated for each EM energy emitter.
- **Hazards of EM Radiation to Fuel (HERF) –** Fuel vapors can be ignited by EM energy field-induced arcs during fuel-handling operations close to high-powered RF radar and transmitting antennas. Therefore, no fuel storage or fueling takes place within HERF safety zones.
- **Hazards of EM Radiation to Ordnance (HERO) safety zones are determined for each EM energy emitter –** Ordnance that might detonate due to EM overexposure must be kept out of the EM source's HERO safety zones during operation.
- **The Potential for Electromagnetic Interference (EMI) –** The potential for EMI is identified prior to operation of higher-power EM energy emitters. EMI includes the potential to affect any device that uses EM energy nearby, ranging from causing static on television sets to interfering with automotive remote-entry control devices or cell phones.

> NSWCDD's engineers and scientists mitigate EMI that could affect the public and other activities on NSF Dahlgren by actions such as shielding, using lower power, or changing where the energy is focused and directed.

Increasing distance from the source dramatically reduces energy and power levels, and, in turn, potential HERP, HERO, HERF, and EMI risks. As a rule of thumb, doubling the distance reduces the energy, and thus the risk, by a factor of four.

1.5.2.2 Electromagnetic Sensors

Active EM Sensors

Active sensors emit EM energy directed towards a target under investigation. The energy reflected from the target is detected and measured by the sensor. Active sensors can obtain measurements regardless of the time of day or weather. Active sensors used by the Navy include radar and lasers.

Passive EM Sensors

Remote sensors that measure naturally-available energy are called passive sensors. For reflected energy, passive sensors can only be used when the sun is providing illumination. Energy that is naturally emitted (such as thermal IR) can be detected day or night, if sufficient energy is available. Passive sensors used by the Navy include optical chemical detectors, passive electro-optical sensors (in both the visible and IR spectrum), and daylight television cameras.

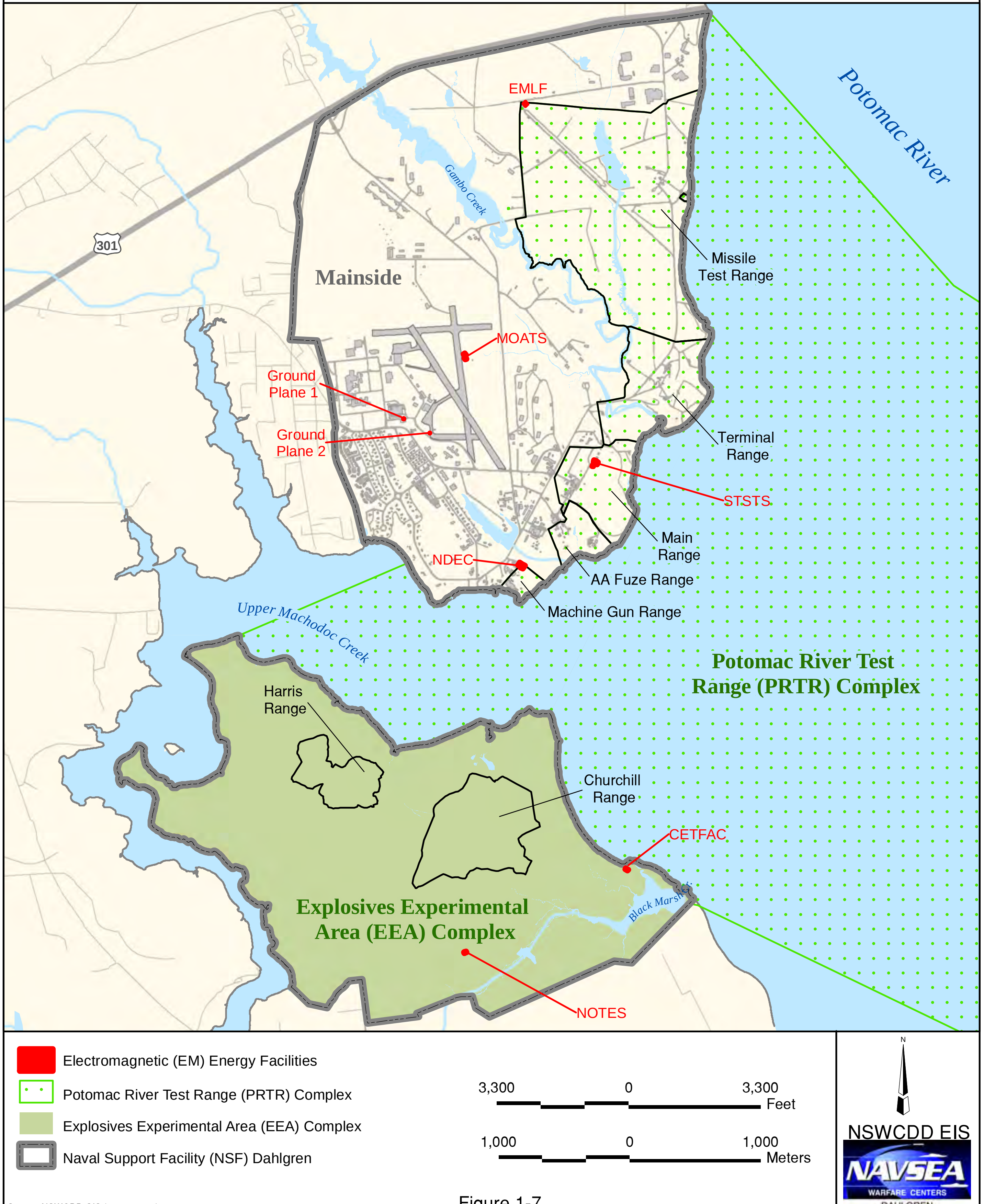
EM sensors such as RF radars are the critical "eyes, ears, and brains" of nearly all military decision-making, tactical and strategic weapon systems, and intelligence collection and processing. In battle areas, sailors and soldiers must be able to respond rapidly and effectively, with little or no tactical warning, to a wide range of uncertain threats, from non-conventional forces with increasing technological sophistication to weapons of mass destruction. The overall technical focus of the sensor program is to provide the military with perfect situational awareness of the expanded battlefield in all environments. Shipboard sensors employ radar for a number of different applications, including detection of high-speed, low-altitude targets (cruise missiles). Ship self-defense is enhanced by using sensors to reduce reaction time, improve target identification, and extend threat-engagement ranges.

Testing the full spectrum of Navy and Marine Corps weapon systems over a combined land and water test area is vital when evaluating the performance of electro-optical tracking systems and their integration with radars and other sensors. NSWCDD's RDT&E using sensors includes providing technical oversight for prototype radar systems, evaluating sensors for acquisition and tracking, studying radar propagation, and locating objects using global positioning systems (GPSs).

NSWCDD's Search and Track Sensor Test Site (STSTS) (location shown on Figure 1-7, Facilities Using Electromagnetic (EM) Energy) houses the RDT&E of passive and active RF and electro-optical sensors for naval warfare systems. The STSTS includes RDT&E of exploratory and advanced sensors, as well as systems and lifecycle support and software support functions for sensor systems in the field.

Search and Track Sensor Test Site (STSTS)

Facilities Using Electromagnetic Energy



Source: NSWCDD GIS (2008 - 2011)

Figure 1-7

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This capability provides quick-reaction, worldwide support to the Fleet to develop new systems, modify existing sensors, and develop and evaluate sensor countermeasures in times of crisis. The STSTS allows over-water testing of individual RF and electro-optical sensors in a littoral environment. Sensor-system testing can also use low-flying subsonic and supersonic targets. STSTS components include a variety of radars, targeting buoys, targeting computers, RF sensors, electro-optical sensors, and systems-integration devices.

RDT&E of EM sensors includes possible ways to defeat or "jam" emissions. Releasing chaff – clouds of thin strips of metal – into the air is an inexpensive and effective radar-jamming technique that was extensively tested over the PRTR and successfully used from WWII through the Vietnam War. NSWCDD also pioneered advances in smoke pots that release dark, thick clouds of smoke to prevent enemy eyes or sensors from seeing through the "smoke screen." Such work will continue in the future, although most jamming research will be based on "soft" or electronic jamming rather than the introduction of physical substances into the air.

Waves of EM energy do not move easily through water because the energy is reflected at the air/water boundary or is quickly absorbed by water molecules. The only successful property that can be accurately detected by sensors in the medium of water is sound – sound travels in water's dense environment much farther and effectively than in the air. NSWCDD occasionally conducts RDT&E in the PRTR using modified sonobuoys. Sonobuoys are small floating devices from which tiny, attached microphones drop down to a fixed depth of water to detect noise, such as might come from a submarine. Any sounds that are picked up by the microphones are amplified by the sonobuoy, and are converted into and transmitted by EM waves in the air to a receiver where the sounds can be analyzed. Such technology lends itself to detecting underwater swimmers or other devices trying to sneak into US harbors. The sonobuoys used by NSWCDD do not generate underwater sounds or noise of their own; they only detect sound.

1.5.2.3 Hazards of Electromagnetic Radiation to Ordnance (HERO) and Electromagnetic Environmental Effects (E3)

Navy ships represent one of the richest technological and EM operating environments in the world. A wealth of onboard devices, including radars, sensors, and other EM energy emitters in close proximity to one another and to humans, radiate high levels of EM energy – well into megawatt (MW) levels of power. EM radiation presents potential health impacts to humans, can cause ordnance to explode under certain conditions, and can affect the operating capabilities of systems, such as radios, sensors, and telecommunications.

From decades of experience operating in a high-energy EM environment, NSWCDD has evolved into an advanced RDT&E center for resolving problems related to the potential for EM energy to accidentally activate ordnance, thereby leading to safety (premature firing) or reliability (failure to fire when required) consequences as well. NSWCDD is the designated technical agent for all Navy and Marine Corps HERO RDT&E and serves many other joint-service and agency clients.

NSWCDD serves as the Navy's lead laboratory for the RDT&E of issues surrounding EM environmental effects (E3). NSWCDD provides these RDT&E services to ensure the operational effectiveness and safety of systems exposed to the diverse EM environments associated with Navy and joint-service programs. The goal of this testing is to identify, predict, and eliminate E3-related problems associated with operating equipment and systems before personnel are affected. NSWCDD develops E3 control measures to resolve equipment and system weaknesses and incompatibilities. NSWCDD uses a broad suite of transmitters that provide a range of EM power and frequencies to simulate nearly all EM operating environments. During the last ten years, NSWCDD has performed such HERO and EM testing for most shipboard systems in the Navy and Marine Corps inventory.

NSWCDD currently uses three main outdoor facilities for E3 and HERO testing (Figure 1-7):

- **Naval Ordnance Transient Electromagnetic Simulator (NOTES) –** This unique facility, located on the EEA, is a simulator that produces an EM field similar to what might be produced on the earth's surface from a high-altitude nuclear blast. The facility subjects equipment to extremely short-duration – less than one millionth of a second (1 microsecond) – high-intensity EM pulses in order to determine whether electronic components have been adequately designed to withstand EM fields. The facility includes a building with an electric pulser that directs the EM pulses into an outdoor network of poles and wires within which the equipment or ordnance being tested is placed. Operations take place once or twice a year. Most of the field energy is contained within the facility structure. When in operation, a hazard safety zone is in effect around the test site. An environmental assessment (EA) prepared in compliance with the National Environmental Policy Act (NEPA) evaluated the environmental impacts of operating the NOTES facility (NSWCDD, 1992) and a Finding of No Significant Impact (FONSI) was signed on September 30, 1992 (DoN, 1992).
- **Maginot Open Air Test Site (MOATS) –** EM testing of electronic equipment is performed at MOATS, located in the Mission Area on Mainside. The MOATS equipment radiates a target using one or more RF or microwave emitters located at or above ground level. Tests are performed to determine the effects of EM emissions on electronic and other components and to verify/validate modeling of radiation propagation and its effects on targets. For a typical test, EM energy is emitted an average of 14 times a day, with 90 percent of the energy emitted in instantaneous short pulses. Non-instantaneous energy emitted lasts an average of 1.5 seconds (s). Up to 100 kilowatts (kW) of average power are used for each operation. Operations typically take place 12 to 15 times per year. When in operation, a hazard safety zone is in effect around the test site.
- **Ground Planes –** A ground plane is a flat surface of ferrous metal (such as a ship's deck) that acts as a return path for radiated EM energy. NSWCDD's two ground planes simulate a ship's deck environment and replicate the full range of EM frequencies that would be found on a ship. Tests subject electrical and electronic systems to high-power EM energy to evaluate component and overall system vulnerability, leading to solutions that protect such systems from EM energy sources. Based on data averaged from 2001 to 2005, up to 390 events take place annually using the ground

AGM-84 Harpoon Testing at Ground Plane

planes. Frequencies emitted can range up to 300 GHz, but more than 99 percent of the test events involved frequencies of between 2 megahertz (MHz) and 50 GHz. When in operation, a hazard safety zone is in effect around the test site.

1.5.2.4 Directed Energy

Directed Energy

When EM energy is focused, or directed, it can be concentrated on a small area without significantly affecting the surrounding area. Infrared heaters and kerosene heaters commonly found in stores often have a parabolic-shaped mirror behind the heating element that focuses the EM energy (in the IR spectrum, in this case) to the area directly in front of the heater, but there is little heat outside the focus area. The parabolic shape allows the heat to be more intense directly in front of the heater. Similarly, a strong magnifying glass can focus the energy from the sun onto a tiny spot, and if held long enough, can cause a leaf to smolder. The same principle applies to using a microwave or radar to focus and harness a beam of EM energy.

NSWCDD has been conducting RDT&E using directed EM energy and developing pulsed power systems that enable the technology since the 1970s, but for most of this time, the work was done in indoor laboratories. In recent years, the confluence of advances in directed-energy weapons technology and the Secretary of the Navy's decision to make future surface combat ships, such as the DDG-1000, all-electric with integrated power-supply systems, has spurred directed-energy RDT&E. This fundamental shift to electric propulsion opens the door for a new generation of electric weapons, including directed-energy weapons, lasers, and EM launchers described in the following sections.

Integrated power systems can dedicate most of the power onboard a ship to electric propulsion motors for high-speed operations, but when the tactical situation requires, the power can be shared with electric weapons and sensors. With an expected 80 MW of installed electrical power, future electric warships will have ample power to operate directed-energy weapons, lasers, and EM launchers, and will not need to carry or use chemical explosives.

As is the case with EM launchers, NSWCDD's RDT&E work with high-power lasers and directed energy is expected to advance the technologies, but full-scale testing of weapons based on the technology would take place at other military facilities.

Increases in directed-energy levels results in energy beams becoming more powerful and traveling farther. With sufficient power, radar can detect targets hundreds of miles away. When properly focused with the same amount of power, this radar can direct very intense EM energy at short range that can damage electronics, so that it becomes a weapon. One such use might be to defeat potential enemy electronics by detonating an improvised explosive device before it triggers explosives near passing troop vehicles. NSWCDD conducts this sort of RDT&E with the use of directed EM energy.

NSWCDD is in the process of moving directed energy from indoor laboratory science to outdoor development, test, and evaluation. The PRTR provides a unique test capability not found elsewhere within DoD: an instrumented maritime range with a high-power microwave propagation source close to the water, allowing study of the effects of maritime conditions on high-power microwave tests using non-lethal harbor scenarios, open-water boat swarms, and counter-drug interdictions. Directed-energy propagation-path outcomes are not well understood because laboratory conditions cannot capture the shifting humidity and wind conditions outdoors.

In 2009, NSWCDD constructed and began operating two structures to transmit directed energy (microwaves, RF, and lasers) outdoors across the waters of the Potomac River within the PRTR. The buildings accommodate NSWCDD's directed-energy warfare RDT&E mission: the Navy Directed Energy Center (NDEC) is located on the Machine Gun Range at the northern entrance to Upper Machodoc Creek, and the Counter Explosive Test Facility (CETFAC) is located on the EEA adjacent to the PRTR (Figure 1-7). The Directed Energy Warfare Office (DEWO) conducts directed-energy RDT&E to protect sailors and soldiers and enhance their capabilities. Testing includes RDT&E of pulsed-power sources, non-lethal directed energy, electronic attack technologies, improved detectors and diagnostics, associated effects testing and analysis, and modeling and simulation techniques. An EA for construction and operation of CETFAC and NDEC (NSF Dahlgren, 2006) covered eye-safe laser and non-lethal RF and microwave transmissions between the two facilities and a FONSI was signed on December 17, 2006 (DoN, 2006).

1.5.2.5 Electromagnetic (EM) Launchers

As mentioned under Ordnance (Section 1.5.1), NSWCDD is conducting RDT&E on EM launchers. An electric motor is normally thought of as using electricity to create an EM field that spins a rotor. The rotor is connected to something such as a gear or pulley to produce useful work. Such motors can be tiny fans cooling a laptop computer, or they can be the propulsion power of large ships, such as the Queen Elizabeth II. However if an electric motor is configured differently from the norm, the same EM field can produce thrust in a straight line instead of in a circle, and this is called a linear induction motor. Such a motor can accelerate extremely quickly and can push heavy objects. At Naval Air Engineering Station Lakehurst, New Jersey, the Navy has launched jet aircraft using this technology.

NSWCDD is focusing primarily on applying this technology to ordnance – to firing projectiles without using explosives. To a lesser degree, NSWCDD is testing the technology's capabilities to propel "launch packages" such as logistic supplies and other heavy objects over short distances or to launch small unmanned aircraft as described in Section 1.6.3.1. An example of an EM launcher that is being developed and tested for ordnance purposes by NSWCDD is the railgun.

1.5.3 Mission Activities Using Lasers

Lasers, as a type of directed EM energy, have been the subject of RDT&E at NSWCDD since the 1970s. Today, NSWCDD's laser RDT&E program is recognized by the Navy and ONR as a center of excellence for laser RDT&E. Just as lasers have become ubiquitous in the daily lives of Americans – in laser pointers, scanners, leveling devices, printers, corrective eye surgery, and toys – they share an equally important, varied, and growing

Lasers – Coherent Beams of Light

The word "laser" is an acronym for "light amplification by stimulated emission of radiation." A laser is a device that emits a coherent beam of light (EM energy). Most light is incoherent, meaning it is made up of many frequencies, which scatter and diffuse quickly, such as light from a flashlight. Lased light is light of a single wavelength, so it does not scatter and stays in a narrow, intense beam without dissipating quickly.

Lasers work by using electricity to excite the atoms or molecules of a gas, liquid, or other substance to a state in which more of the atoms or molecules are at higher energy levels than lower energy levels, which creates the laser beam of light.

role within the Navy, and therefore in NSWCDD's RDT&E programs. NSWCDD's expertise in laser safety and lasers includes RDT&E of sensors, rangefinders, target designators, guidance systems, simulators, communications equipment, and weapons.

NSWCDD is developing novel military applications of lasers and assessing potential hazards to materials and personnel from the use of lasers by enemy forces. Because of its coastal location and over-water range instrumentation, NSWCDD is a particularly valuable site for laser propagation studies that assess the environmental science for low-altitude, over-water laser beam propagation. Low atmospheric turbulence has been found to cause significant break-up in the energy of laser beams.

The lasers that NSWCDD tests fall within the range of frequencies from IR to UV light, which includes visible light (Figure 1-2). Lasers are categorized into four classes according to the power of the light they emit, expressed in watts (Table 1-1). NSWCDD tests all four classes of lasers outdoors.

Table 1-1
Laser Power

Laser Class	Description	Energy Emitted	Safety Issues	Examples
Class 1*	Low-powered devices considered safe from all potential hazards.	Minimal – cannot cause damage	No injury, regardless of exposure time, to eyes or skin. No safety measures necessary.	Laser printers, toys, CD players, CD ROM devices, laboratory analytical equipment.
Class 2*	Low-power, visible-light lasers that could possibly cause damage to a person's eyes.	< 1 milliwatt (mW)	Usually safe. Eye protection normally afforded by the aversion response (turning away from a bright light source or closing or blinking eyes). If directly viewed for long periods of time with no blinking or with binoculars, damage to eyes could result.	Pointers used in presentations, toys, range- finding equipment, aiming devices.
Class 3**	Medium Power	1 - 500 mW	May be hazardous to eyes under direct and specular reflection (almost perfect reflection, such as from a mirror) viewing conditions.	Laser scanners, military hand-held laser rangefinders, entertainment light shows, target illuminators.
Class 4	High power	> 500 mW	Direct beam or specular reflection is hazardous to eyes and skin. May pose a diffuse reflection (reflection off a rough surface) hazard or fire hazard.	Medical surgery, research, drilling, cutting, welding, aircraft target designator used for guided weapons, military laser weapons.

Source: ANSI, 2007.
*Class 1M and 2M categories also exist, which have the same parameters, except that direct viewing with an optical instrument such as a telescope could be potentially hazardous.
**Two subcategories exist under Class 3: Class 3R lasers are potentially hazardous if the eye is appropriately focused and stable, but the probability of injury is low. Class 3B may be hazardous under direct and specular reflection viewing conditions.

Diffuse reflection is laser energy reflected from a rough surface, which causes the laser beam to scatter in all directions (Figure 1-8a, Diffuse Reflections from Laser Beam's Striking a Rough Surface). Specular reflection is laser energy reflected from a mirror-like surface, such as still water on a pond (Figure 1-8b, Specular Reflections from Laser Beam's Striking a Mirror-like

Surface). Specular reflections retain more energy than diffuse reflections, and hence, are more hazardous to eyes and skin.

1.5.3.1 Laser Safety

NSWCDD has implemented a detailed RHA/SOP process for the use of Class 3 and Class 4 lasers – high-energy or HE lasers – outdoors, which identifies and implements controls to ensure the safety of installation personnel and the public. The SOP ensures that each outdoor laser operation complies with Chief of Naval Operations Instruction (OPNAVINST) 5100.27/Marine Corps Order 5104.1A *Navy Laser Hazards Control Program* (September 24, 2002), which incorporated the industry standard, American National Standards Institute (ANSI) Z136.1, *Safe Use of Lasers* (ANSI, 2007), into its requirements. SOPs are also prepared in accordance with DoD Instruction 6055.15, *DoD Laser Protection Program* (DoD, 2007). Each operation must be approved by NSWCDD's Laser System Safety Officer and the Navy's Laser Safety Review Board (LSRB) to ensure that adequate safety criteria are incorporated within the SOP and observed during the operation.

Like EM hazard zones, laser-hazard areas are determined for each outdoor HE laser test event based on the power of the laser being used, and personnel are either not allowed in these areas or must use protective eyewear. Because the focused energy of lasers can burn skin and injure eyes, many safety measures are in place to ensure that the range is clear of wildlife and people before and during the brief lasing events. Before an operation begins, laser operating corridors and adjacent areas are cleared of people and wildlife, barricades are erected, and in the river, range boats patrol the operating area. Tests are conducted to ensure that the laser is aligned with the target. When the laser is emitting – a period of time lasting from an instant to a few minutes – trained observers, electronic monitors, and cameras watch the corridor so that the test can be stopped if people or wildlife approach the laser corridor. Lasers are fixed almost horizontally and fire slightly downward at targets surrounded by backstops, which are made of rough, dark materials to absorb the energy of the laser and minimize diffuse and specular reflections. Sensors surround the target within the backstop area; if a preliminary, low-power laser beam strikes slightly to the side of the intended center of the target, the laser is refocused before higher-power tests are conducted. Safety measures are described in more detail in Section 3.8.4.

1.5.3.2 Current Laser Activities

NSWCDD's RDT&E of lasers is centered in two programs:

- As the Lead Technical Laboratory for Navy and Marine Corps laser safety, NSWCDD evaluates lasers and laser systems used on Navy and Marine Corps installations for hazards to personnel.
- DEWO conducts laser RDT&E of lethal and non-lethal directed-energy, electronic-attack technologies, improved detectors and diagnostics, associated effects testing and analysis, and modeling and simulation techniques.

Figure 1-8a Diffuse Reflections from Laser Beam's Striking a Rough Surface

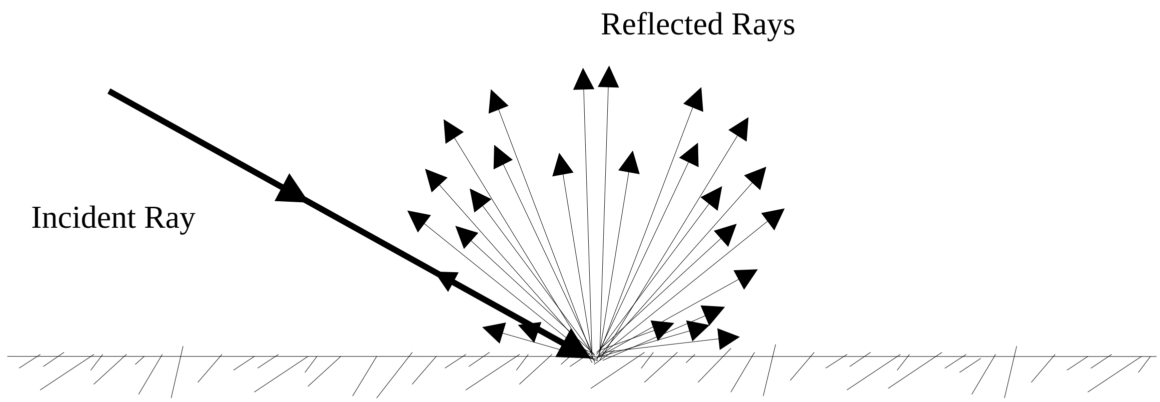
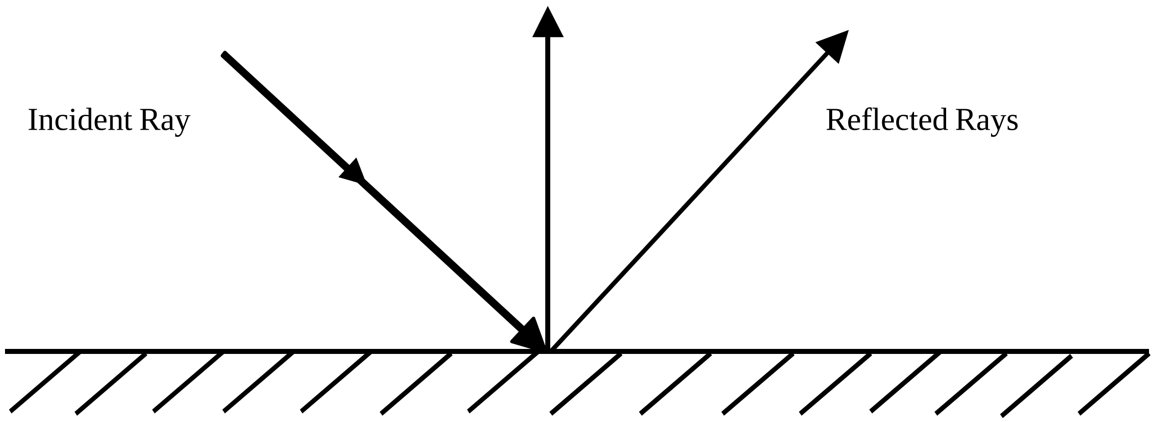


Figure 1-8b Specular Reflections from Laser Beam's Striking a Mirror-like Surface



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Existing HE lasers do not perform well in the marine environment, particularly during inclement weather such as fog and rain. In dry environments – such as the deserts where HE lasers have mainly been tested until now – laser beams remain coherent over longer distances. NSWCDD's RDT&E with lower-power lasers in maritime conditions indicates that in the maritime environment that prevails at NSWCDD, laser beams become less coherent and more diffuse, and more easily distorted by density and temperature variations, functioning differently than in dry conditions. The Navy is working to overcome these problems in order to use lasers in the maritime environment – the Navy's operational environment and the location of many of our nation's cities. Therefore, testing different types of lasers, using different frequencies and power levels, in various weather conditions, is necessary to ensure that they function properly and to make the necessary changes to them if they do not.

NSWCDD currently conducts approximately 60 outdoor HE laser events a year in a wavelength range from 500 nanometers (nm) (500 billionths of a meter) to 11 micrometers (μm) (11 millionths of a meter) and a power range from less than 500 milliwatts (mW) up to 100 kW.

HE laser activities take place outdoors in a variety of weather conditions, mainly during the day, but occasionally at dawn and dusk, and rarely at night. NSWCDD's outdoor HE laser program is conducted along five corridors (Figure 1-9, High-Energy Laser Current Operation Locations), which range from 1,650 ft to 12,000 ft in length. Two of the corridors – Shock Tube Area and Terminal Range-to-Missile Test Range – are on the PRTR's developed land ranges. Three of the corridors – Terminal Range-to-CETFAC, NDEC Area-to-CETFAC, and NDEC Area-to-EEA Dock Area – cross the waters of the PRTR from one land range to another. An EA addressed the impacts of increasing the power levels of outdoor HE laser activities up to 100 kW in these five corridors (NSWCDL, 2009b) and a FONSI was signed on October 7, 2009 (DoN, 2009).

Figure 1-10, 100 kW High-Energy Laser Eye-Hazard Zones, shows the eye-safety hazard zone calculated for a laser operating at 100 kW of power toward a target/backstop 100 ft from the Potomac River shoreline (such as CETFAC or the EEA Dock Area). The backscatter from directing a 100-kW HE laser beam from the Terminal Range or NDEC over the waters of the PRTR to a target within or near CETFAC or in the EEA dock area, either of which would be 100 ft from the shoreline, was calculated to be eye-hazardous within 80 ft of the target for both specular and diffuse reflections. Therefore, the area of eye-hazardous backscatter would be 20 ft from the shoreline. The eye-hazard area around the laser beam would be about 6 ft in diameter and at least 6 ft above mean water level. Test personnel near the target would be completely enclosed in a personnel shelter during eye-hazardous laser activities. ROC observers on land or on range control boats would be kept well away from the eye-hazardous zone around the laser beams.

For current operations, both the laser emitter and the target/backstop are fixed and the laser emits almost horizontally. The laser is pre-aimed at a fixed target slightly downgrade from the laser and is not able to move in either elevation or azimuth, except for minute corrections to the aim point. For over-water operations, the laser beam begins a minimum of 12 ft above mean water level on the Terminal Range, from NDEC, or from in front of NDEC, and terminates at a target in or near CETFAC or the EEA Dock Area at a minimum of 9 ft above mean water level. For overland operations, the laser beam is a minimum of 6 ft above ground level.

1.5.4 Mission Activities Involving Chem/Bio Simulants

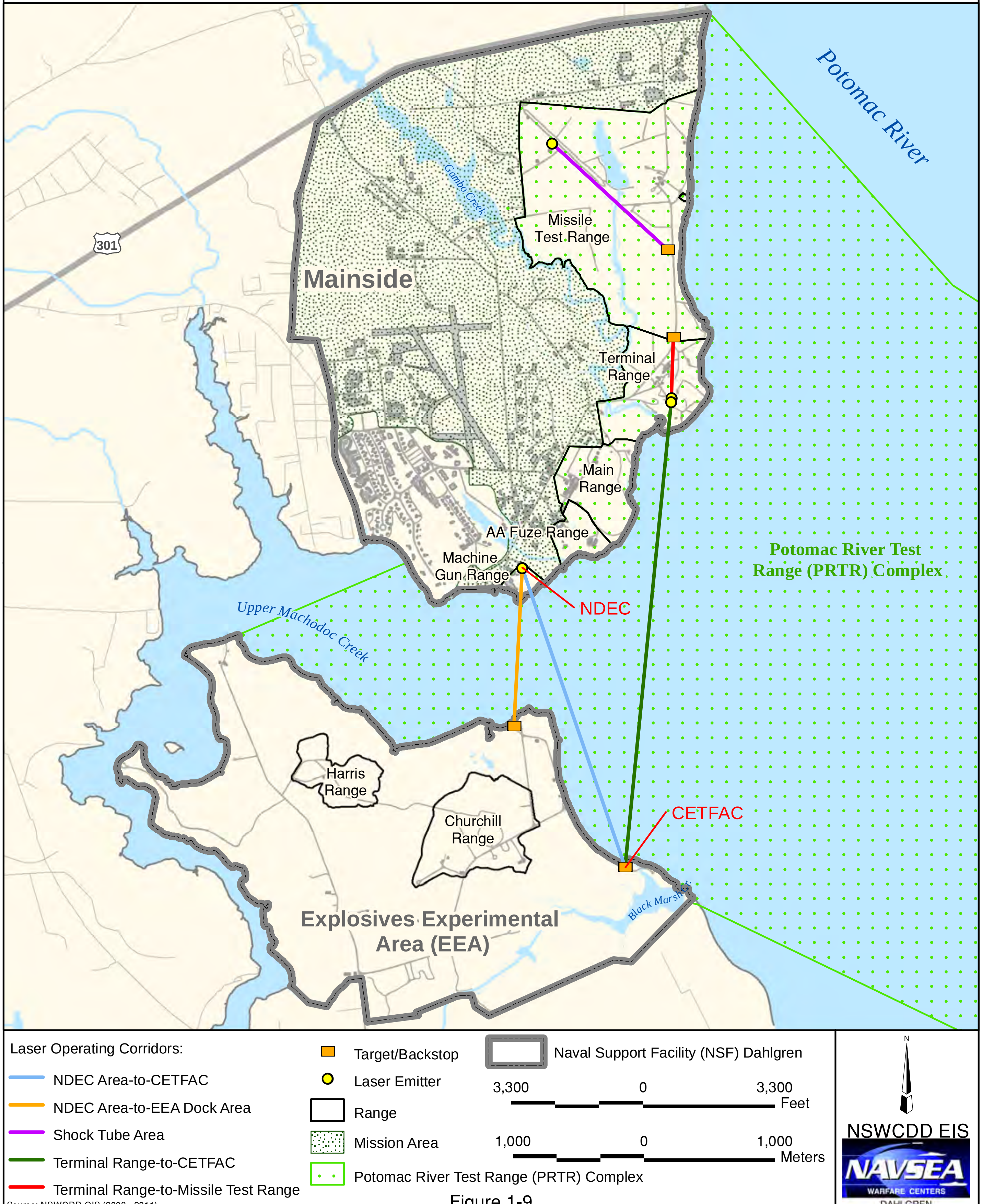
The increased threat of terrorist attacks on our nation, military personnel, embassies and bases overseas, and allies has prompted the DoD to step up RDT&E to counter chem/bio terrorism. Chem/bio agents are very difficult to detect, and the key to minimizing the effects of an attack is early detection and warning. The capability of the military to respond to such threats is greatly enhanced by RDT&E to characterize, predict, detect, and mitigate chem/bio threats. As the Navy's lead laboratory supporting the DoD's Chemical and Biological Defense Program (CBDP), NSWCDD has been working with other DoD agencies, the Department of Homeland Security (DHS), and civilian industry to develop rapid and accurate models and systems for detecting dangerous biological and chemical agents. NSWCDD is also developing methods to protect personnel from contact with these agents, such as protective clothing and equipment, as well as methods for decontaminating people and equipment exposed to these agents while minimizing danger to others.

The program-level impacts of work that DoD performs under the CBDP are addressed in the *Chemical and Biological Defense Program Final Programmatic Environmental Impact Statement* (US Army Medical Research and Materiel Command, 2004). The program-level (as distinct from operational-level) impacts of NSWCDD's chem/bio defense RDT&E program are evaluated in the CBDP Final EIS (FEIS), which found that with appropriate safeguards, there are no significant impacts resulting from continuing to implement the CBDP at any site, including at NSF Dahlgren.

The use of actual chemical and biological agents in open-air testing is prohibited in the US unless certain procedures (e.g., testing is necessary for national security and precautionary measures to protect public health and safety) are met (Public Law 91-121, Defense Appropriation Act of 1970, as extended under 50 U.S.C. § 1512). Instead of the actual agents, NSWCDD uses simulants in outdoor RDT&E activities to minimize hazards to workers, the public, and the environment. A simulant is a chemical or a biological organism that has at least one physical property similar to that of the biological or chemical agent under study but that is much less hazardous than the agent. Simulants are reasonably safe to handle and use without significant environmental or health effects. Examples of the simulants that have been used outdoors at NSWCDD include glacial acetic acid (GAA) (a strong form of the acid in vinegar), methyl salicylate (MeS) (oil of wintergreen, used as flavoring in foods), and polyethylene glycol (PEG) (used in laxatives, skin creams, and toothpaste).

Most of NSWCDD's chem/bio RDT&E takes place in indoor laboratories. At some point in the RDT&E process, chem/bio sensors must be tested outdoors in the types of environments in which they will be deployed – over water, on land, and in the air. Sunlight, wind, and weather affect how the sensors work and cannot be fully replicated in any laboratory. In addition to environmental factors, substances likely to occur or be released intentionally during a battle, such as smoke – an obscurant from weapons firing – or diesel emissions – an interferent – can impede sensor effectiveness and must be tested. Even items commonly found aboard ships, such as oil, fuel, bleach, ammonia, paint or floor cleaner, can interfere with the sensors' ability to detect an actual threat and therefore, must be included in testing. NSF Dahlgren provides a coastal environment that replicates the shipboard conditions under which detectors must function to

High-Energy Laser Current Operation Locations



Source: NSWCDD GIS (2008 - 2011)

Figure 1-9

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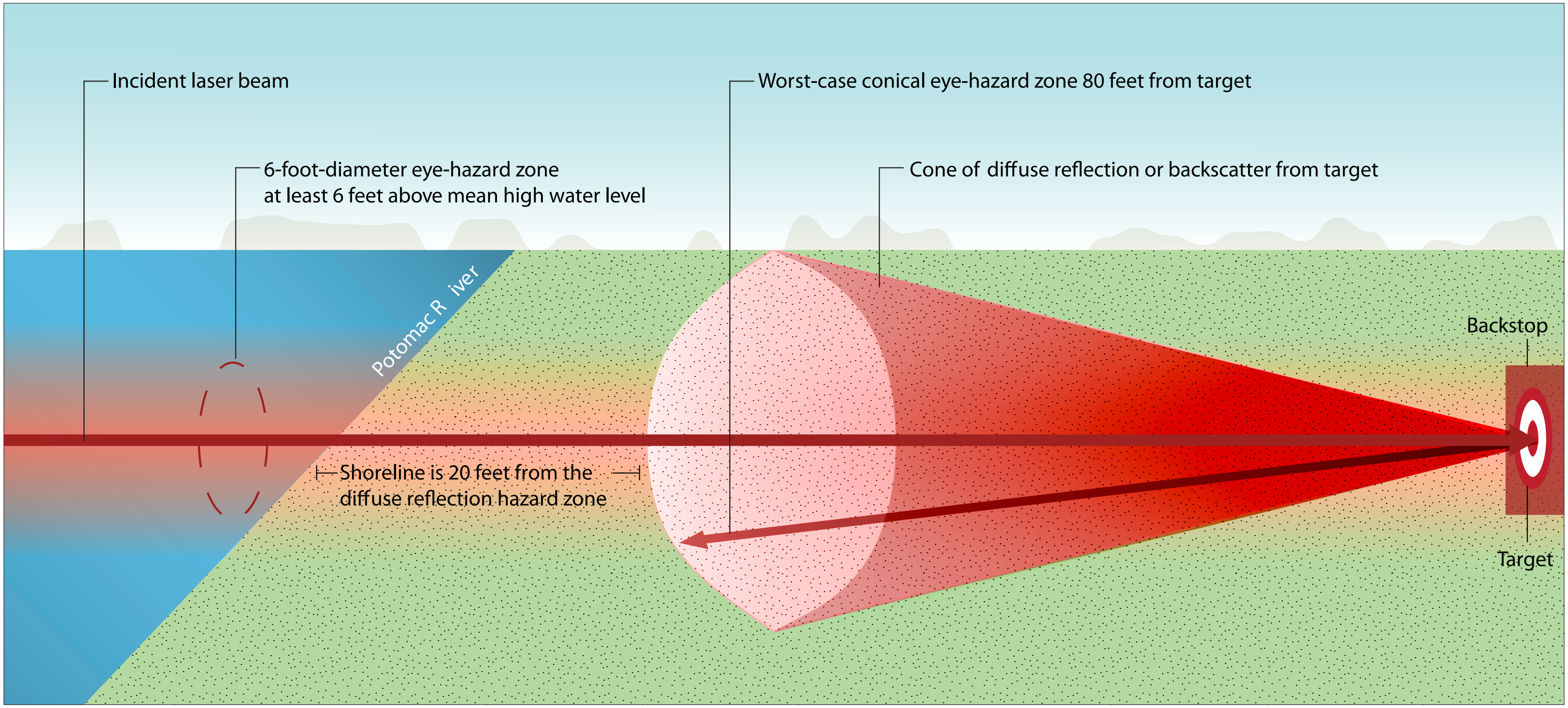
100 kW High-Energy Laser Eye-Hazard Zones



Eye-hazard zones were calculated for a 100 kW laser. In this scenario, a laser beam striking a target/backstop located 100 feet from the shoreline of the Potomac River would result in:

- An eye-hazard zone around the laser beam at least 6 feet above mean water level
- An eye-hazard zone extending 80 feet from the target in a cone shape. The eye-hazard cone would end 20 feet away from the river.

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure 1-10

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protect our service men and women and has the equipment necessary to effectively perform the testing.

The DoD Joint Service Lightweight Stand-off Chemical Agent Detector (JSLSCAD) Test Integration Working Group, a joint effort of the Navy, Army, Air Force, and Marine Corps, has been conducting open-air testing of the effectiveness of the JSLSCAD and similar chemical stand-off detectors in various environments since 1995. This testing involves the release of a vapor of chemical "simulant" to challenge the instrument. These simulants absorb IR radiation at wavelengths similar to the wavelengths absorbed by chemical and biological agents. Therefore, use of simulants can determine the sensitivity of the JSLSCAD and future similar sensors to perceive actual chem/bio agents.

JSLSCAD Infrared Detector

NSWCDD conducted chemical simulant releases on the Churchill Range in 1986 (a precursor to JSLSCAD) and on the PRTR in 1996. For the 1986 operation, documented in a Preliminary EA, a combination of PEG 200 and MeS were sprayed from a helicopter over the Churchill Range to test the feasibility of using the CH-46 helicopter as a dispersal platform for chemical simulants (NSWC Dahlgren, 1986). The 1986 Preliminary EA concluded that the potential environmental impacts of the proposed operations were insignificant and uncontroversial, and that the action should be considered categorically excluded. The Record of Categorical Exclusion was signed on June 16, 1986. The operations in 1996 challenged early prototype hardware in support of the JSLSCAD program using sulfur hexafluoride (SF_6) as the chemical simulant (NSWCDL, 1996). [Because SF_6 is a potent greenhouse gas it was added to DoD's Emerging Contaminant Action List in 2009 (Yaroshak and Ransom, 2010). NSWCDD has been and will most likely continue to substitute the refrigerant gases R-134 and R-152a for future activities].

In 2003 and 2005, NSWCDD tested a fully-operational JSLSCAD IR chemical-agent sensor system on the PRTR using one chemical simulant to calibrate the system and two additional simulants to challenge the sensor. Figure 1-11, Chemical Simulant Operations Area in 2003, 2005, and 2009, shows the area of the PRTR that was used. Tests were designed to verify that the system would perform as expected in a coastal environment. In each year, approximately 55 events took place. An EA was prepared prior to testing (NSWCDD, 2003) and a FONSI was signed on June 17, 2003 (DoN, 2003). Field tests and modeling were conducted prior to testing on the PRTR to predict human and ecological health risks associated with the proposed release of the chemical simulants as a vapor. The chemical simulants used were SF_6 for calibration and triethyl phosphate (TEP) and GAA to challenge the sensor. A third simulant, para [p]-xylene, was approved by state authorities, but never used. The PRTR was cleared of vessel and air traffic during testing. The EA concluded that human and ecological health risks would be minimal, which was supported by actual field monitoring during the tests in 2003 and 2005.

In 2009, NSWCDD conducted chemical simulant tests on the PRTR similar to those conducted in 1996, 2003, and 2005. The 2009 test activities involved release of the liquids MeS, TEP, GAA, and the gases R-134 and R-152a. MeS falls within the same range of deposition, vapor concentration, potential water concentration, toxicity, and environmental impacts as the previously-used liquid simulants TEP and GAA and has been used as a chemical simulant outdoors over the Cooper River at Naval Weapons Station Charleston, South Carolina (US Army, Dugway Proving Ground, 2003).

1.6 Range Operations

All RDT&E operations that take place outdoors on range complexes and the Mission Area have factors in common. They:

- Follow stringent safety procedures (specific to each test)
- Usually (but not always) take place within specified times on weekdays
- When needed, restrict SUA and PRTR access as a safety precaution
- Require that specific target areas be determined for each test
- May require the use of vessels and/or manned or unmanned aircraft
- Are announced to the public via the NSWCDD web site and telephone number if access may be restricted or if the effects may be noticeable off of the ranges and the Mission Area

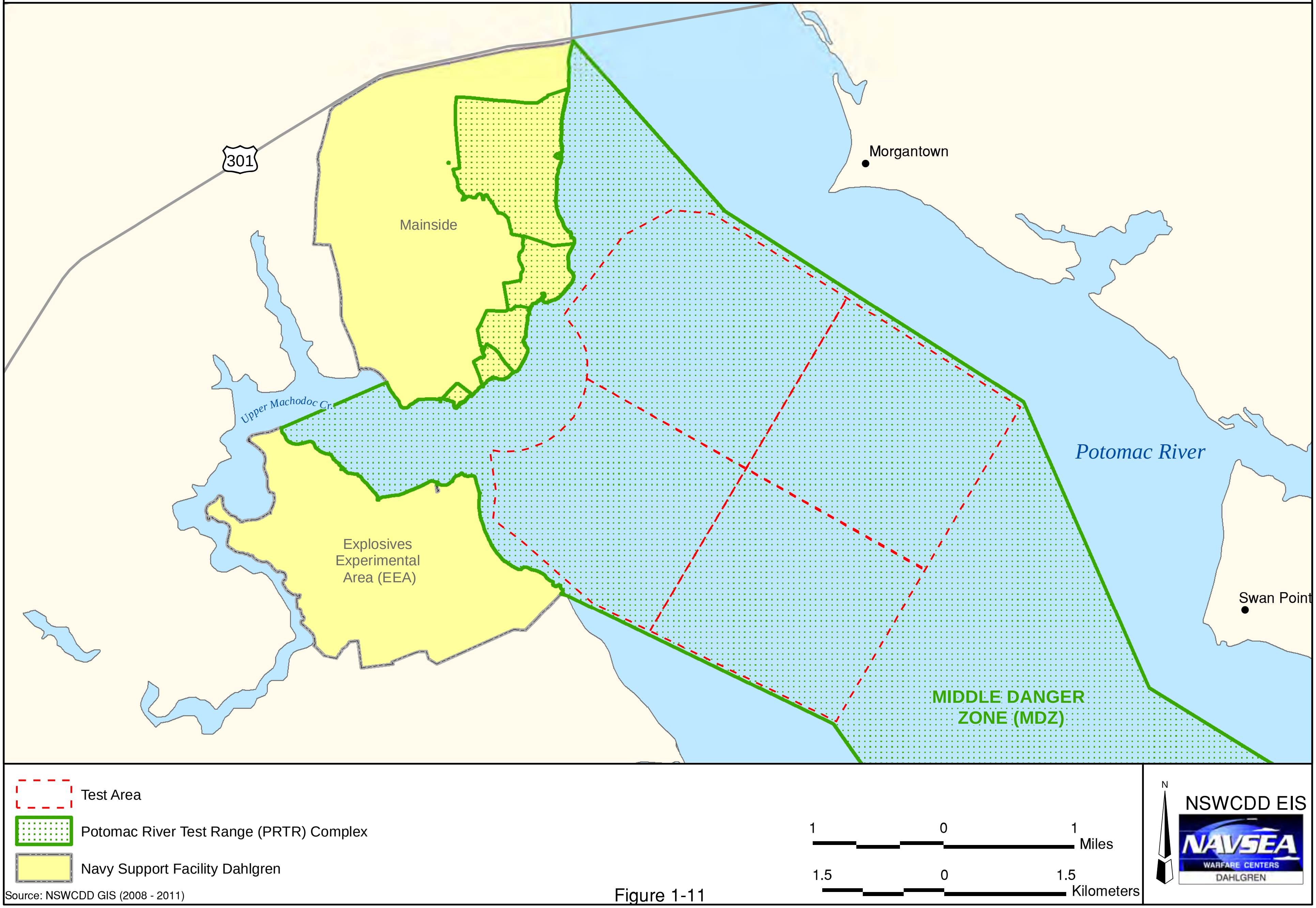
The processes common to all outdoor RDT&E activities are described below.

1.6.1 Frequency of Testing

NSWCDD conducts all ordnance activities Monday through Friday between 8 am and 5 pm. Set-up for testing may begin before 8 am. Outdoor RDT&E activities using lasers, EM energy, or chem/bio simulants may take place at dawn, dusk, or night and on weekends. Weekend activities, however, are rare. HE lasers are tested occasionally at dawn or dusk across the PRTR from land range to land range and rarely at night. The frequency of weekend and dawn and dusk activities is influenced by the progress of the particular RDT&E program and its findings, by surges in or changes in the types of global threats, by technological developments, and by budget constraints and is difficult to predict in advance.

The daily operations schedule is available in advance on NSWCDD’s website or by calling the toll-free range telephone number. NSWCDD’s ROC notifies the public through the website and toll-free number when activities will take place beyond normal range hours, for example after 5 pm or on a weekend.

Chemical Simulant Operations Area in 2003, 2005, and 2009



Source: NSWCDD GIS (2008 - 2011)

Figure 1-11

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1.6.2 Range Control and Safety

Before an outdoor RDT&E operation takes place, RHAs and SOPs are developed, reviewed, validated, approved, and implemented, as described in Section 1.5.1 and in more detail in 3.8.1. These measures ensure that tests are conducted safely and with a minimum of environmental impacts, following NSWCDD's Environmental Management System (EMS).

Range Operations Center (ROC)
Notifies Public of Upcoming Range Activities

In order to inform the public about upcoming range activities, ROC provides notification through:

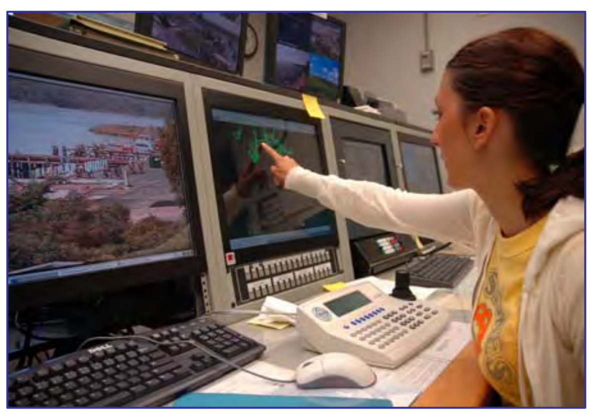
- The NSWCDD website: http://www.navsea.navy.mil/nswc/dahlgren/ RANGE/ rangeschedule.aspx
- A toll-free telephone recording (877-845-5656).

Daily range schedules, types of tests (such as firing single or multiple shots or detonations), the use of substances (such as smoke for smokescreens), hours of testing, where on the PRTR the tests will take place, whether tests are on schedule, whether noise will be made, and contact numbers to obtain more information are included on the website and in the recorded message.

As described in more detail in Section 3.8.1.1, NSWCDD danger zones are defined on nautical charts for the PRTR (Figure 1-3) to alert mariners that access to the areas may be restricted when tests are taking place, so as to ensure their safety. Access may be restricted either because activities are taking place on the river or because safety zones for activities taking place on the land ranges extend into the river. NSWCDD's ROC restricts access to the range(s) before testing begins and deploys range boats to clear the range of watercraft.

Current activities require that all or part of the PRTR MDZ be cleared for testing approximately 750 hours a year (based on the number of hours range control boats are deployed). While activities take place occasionally on the UDZ and LDZ, the types of activities conducted do not currently require access restrictions on either of these areas. Some types of tests – such as large gun firing – require that all or most of the MDZ be restricted. Other types of tests – such as the use of lasers across the entrance to Upper Machodoc Creek – require that only that part of the MDZ be restricted during testing.

ROC personnel take care to minimize delays to both commercial and recreational boat traffic. The ROC minimizes inconvenience to the public by restricting access only to the areas of the PRTR that are needed for tests and by taking advantage of frequent lulls in testing for equipment adjustments and the like to allow watercraft to move through the PRTR. Depending on the type of operation, river traffic frequently can be safely rerouted around the test area. The ROC monitors two marine ship-to-shore channels and responds to requests for information.



NSWCDD's Range Operations Center (ROC)

Even when access to most of the MDZ is restricted for testing, small watercraft can move up and down the river along the Maryland shoreline, just outside the PRTR boundary. They cannot move past NSF Dahlgren along the Virginia shoreline because the range restrictions extend up to the shoreline. Deep-draft vessels that need to stay in the main channel, which runs through the range, may be advised to slow before reaching the range or may be delayed up to an hour near the range, though in practice the delays are usually less than 30 minutes. During breaks in the testing, ROC personnel work with smaller watercraft to allow them to cross the range from one side of the river to the other, and with deep-draft vessels to allow them to proceed up and down the river channel.

SUA zones (Figure 1-6) over the EEA and PRTR are in effect from 8 am to 5 pm daily, excluding weekends and holidays, to restrict civilian aircraft during gun testing, as well as during laser, EM energy, and chemical-sensor tests. The airspace is reserved for an average of 2,120 hours annually, and may be restricted at other times, in which cases a Notice to Airmen (NOTAM) is issued by the FAA. The zones extend from sea level to 40,000 ft and from 40,000 to 60,000 ft above the river surface over the PRTR, and from ground level to 7,000 ft over the EEA (Figure 1-6). However, the zones from 40,000 to 60,000 ft over the PRTR are only reserved on rare occasions. When activation of the SUA is not required, even though it is scheduled, NSWCDD turns control of the SUA back to the FAA for use by civilian aircraft.

1.6.3 Use of Aircraft and Vessels for Activities

Outdoor RDT&E activities may employ manned and unmanned watercraft, ground vehicles, and aircraft to:

- Serve as tracking objects to test sensors
- Tow targets or tracking objects
- Observe tests and measure outcomes
- Test active and passive sensors such as radar
- Carry new sensor systems for evaluation
- Disperse chem/bio simulants
- Serve as platforms for targets, weapons, or aerostats
- Act as links in tests of integrated systems
- Act as targets
- Act as reflectors

Military use of unmanned systems (UMSs) is increasing rapidly because they provide a way to gather intelligence, provide surveillance, perform reconnaissance, and target enemy activity while keeping personnel out of harm’s way. Manned and unmanned vehicles not only participate in tests on the PRTR for the types of activities that are part of the Proposed Action in this EIS, but also for a broad range of other types of activities that generate little environmental impact. An example is the use of “go-fast” boats – high-performance, high-speed boats used by pirates, smugglers, and terrorists as well as by US agencies trying to stop them – in recent years to test various strategies to repel terrorists who, for example, might be trying to approach a US Navy or Coast Guard vessel in a foreign port, as was the case with the USS Cole in the Port of Aden in 2000. Equipment that can be rapidly deployed, such as gear-entanglement nets to ensnare the propellers, are being tested. Similar types of RDT&E activities are also taking place at NSWCDD to counter drug runners.

1.6.3.1 Unmanned Systems (UMSs)

UMSs include unmanned, self-propelled aerial, terrestrial, sea-borne, or submersible platforms that operate without a human being positioned on or within the vehicle/platform. Instead, their operation is achieved through either autonomous or remote tele-operated control. Tele-operations are controlled by a human operator at a remote location via a communications link. The remote operator directs the vehicle either by visual observation or remote sensing. Autonomous operations are controlled by onboard pre-programmed auto-processors, and after a flight pattern is selected prior to the flight, vehicles can operate without human assistance. NSWCDD blends these two modes of control: they use tele-operations control during landings and takeoffs and autonomous control thereafter unless changes in weather or problems arise, in which case operators switch back to remote tele-operations control. NSWCDD operates all types of UMSs except submersible vehicles as part of RDT&E. UMSs used by NSWCDD include:

Soldier launching an RQ-11 Raven micro aerial vehicle

Unmanned Aerial Vehicles (UAVs)

With increasing frequency, NSWCDD is using UAVs – also called “drones” – for various aspects of RDT&E activities, as listed above. In particular, NSWCDD’s UAVs are used as platforms for weapons-system integration. To test that all systems are working together, UAVs variously carry payloads of sensors, lasers, radars, and ordnance. On battlefields, UAVs are used for targeting, reconnaissance, and surveillance, and as communications relays.

UAVs can range in size from wingspans of less than one foot to full-sized aircraft. However, the UAVs used by NSWCDD are on the smaller end of the size scale. NSWCDD’s UAVs range in size from micro aerial vehicles, which are small enough to be carried, assembled, and launched by a Marine or soldier on the battlefield (see figure of a serviceman launching a Raven, which weighs less than 5 lbs and has a wingspan of 5-6 ft) to UAVs such as the Tiger Shark, which, depending on the model, has a 17-21-ft wingspan and a maximum takeoff weight of 400 lbs.

Tiger Shark LR-3 UAVs take off and land on runways

Smaller, lighter UAVs can be launched by hand, from a hand-held or fixed launcher (see the figure of a 6-ft wingspan Scan Eagle being launched from Main Range), or from a fast-moving vehicle. NSWCDD's heavier UAVs, such as the Tiger Shark, require a runway to take off and land. NSF Dahlgren has two runways on the Terminal and Churchill ranges (Figure 1-12, Unmanned Aerial Vehicle Runways) dedicated to UAV use. Military UAVs must fly within military SUA, so NSWCDD's UAVs fly over the PRTR Complex and the EEA but cannot fly over the Mission Area or land on the airfield in the Mission Area.

Scan Eagle UAV being launched from Main Range

When operating, NSWCDD's UAVs fly at approximately 2,000 to 3,000 ft in altitude, but may occasionally ascend to 5,000 ft. In 2009, NSWCDD's UAVs logged approximately 200 hours of flight time (more than one may be aloft at a time).

NSWCDD also uses aerostats tethered to the ground or to a platform in the river, such as a barge. Aerostats are stationary, lighter-than-air objects, such as balloons or blimps. Aerostats can be used as platforms for radar and other sensors, or as targets. NSWCDD routinely uses weather balloons outfitted with sensors to collect weather information prior to performing tests.

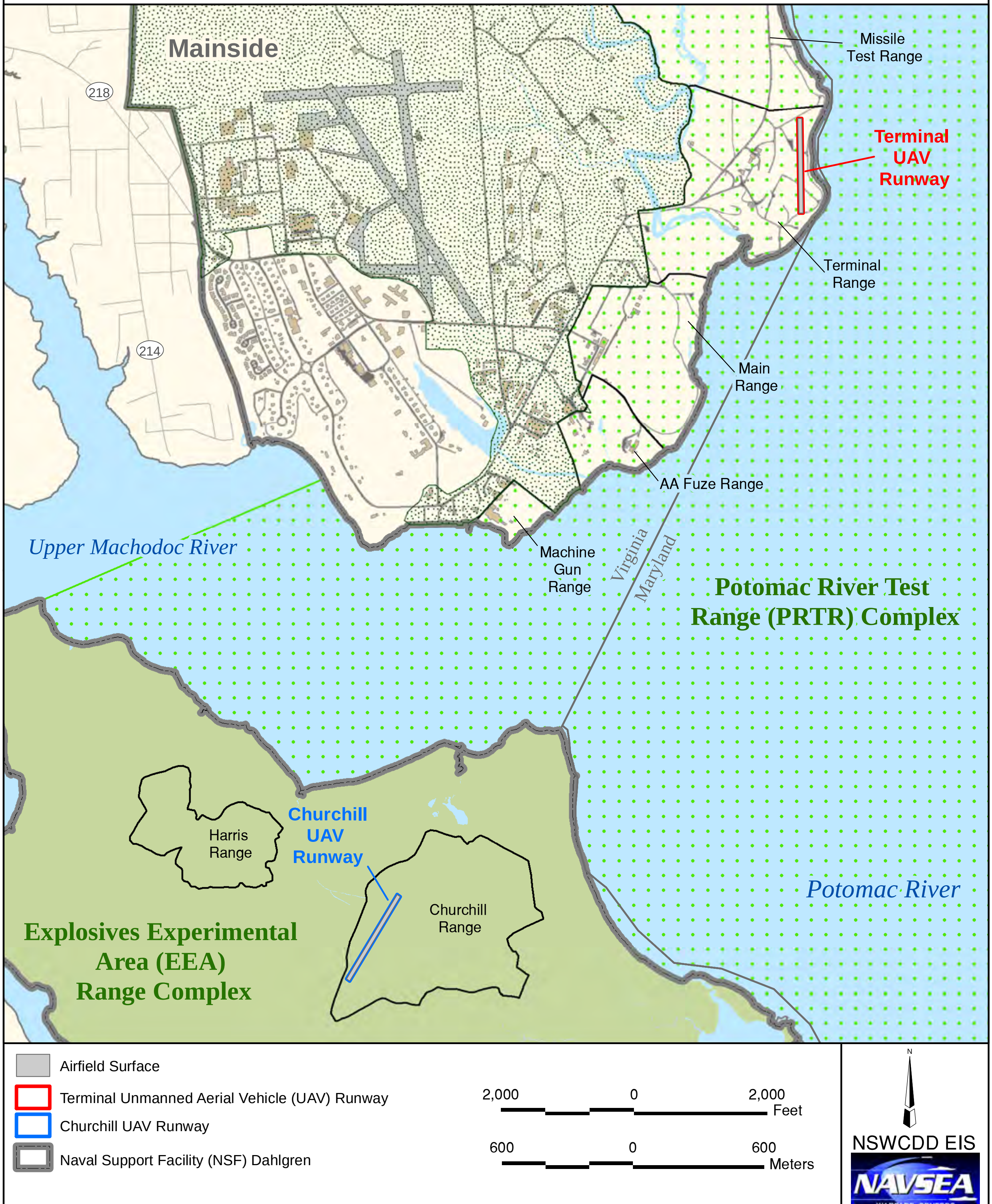
Unmanned Surface Vehicles (USVs)

Unmanned surface vehicles (USVs) are boats or amphibious craft that travel on the surface of the water. NSWCDD maintains a group of small watercraft in Upper Machodoc Creek, some of which can be used as USVs. For example, go-fast boats, Seadoos, and other small craft are used as USVs. They may be used to test the ability of radar to detect them and scan their contents, or for their reaction to counter-terrorism measures, or to disable their equipment, stop them, or destroy them. USVs may be used as one component in tests of integrated warfare systems.

Unmanned Ground Vehicles (UGVs)

Unmanned ground vehicles (UGVs) travel on the land surface. Like UAVs, UGVs range in size from small and toy-like to full-sized. They can operate autonomously or through remote tele-operation. NSWCDD uses UGVs as platforms for sensors and weapons on the land ranges and the Mission Area. Sensing UGVs can gain information about an area that may be dangerous for personnel and relay it back. Weapon-equipped UGVs can both detect people and other vehicles and fire upon them.

Unmanned Aerial Vehicle Runways



Source: NSWCDD GIS (2008 - 2011)

Figure 1-12

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Manned Vehicles

NSWCDD also uses manned ground, surface, and air vehicles in RDT&E activities. Surface vessels used include manned go-fast boats, inflatable Zodiac-type craft, landing craft, patrol boats, and barges. Sometimes larger Navy or Coast Guard vessels come up the river to participate in activities, but they are not based at NSF Dahlgren.

NSWCDD occasionally uses manned fixed-wing aircraft and helicopters for activities of the types listed above (but not as targets to be destroyed). In a typical test scenario, an aircraft makes passes, flying in the SUA, to test a sensor system either onboard the aircraft or helicopter or on the ground. Aircraft may fly from Naval Air Station (NAS) Patuxent River to participate in activities but may also originate at other bases or be rented commercially. Aircraft used in recent years include CA-8 and C182 Cessna-type small, fixed-wing airplanes and Baron N503W and Bell helicopters. Fixed-wing aircraft used in RDT&E activities do not land on NSF Dahlgren's airfield, which currently is closed for fixed-wing aircraft landings. NSWCDD does not maintain any manned aircraft. Helicopters use the airfield now and then to transport personnel, or – in one recent instance – for Marine aircraft landing and takeoff training.

1.6.4 Target Areas

1.6.4.1 Ordnance Target Areas

- **Potomac River Test Range –** Most large-caliber gunfire is directed at target areas in the MDZ. Figure 1-5 shows primary gun target areas in the MDZ. Most projectiles are fired into this area. The main target area for the 76 mm and 57 mm guns is typically between 5,000 and 9,000 yds from the Main Range. The main target area for the 5"/54 guns is between 9,000 and 13,000 yds from the Main Range. The main target area for small-caliber guns and fuze testing is typically between 2,000 and 6,000 yds from the Main Range. While NSWCDD fires occasionally at target areas 32,000 to 35,000 yds from the firing point, which is in the upper part of the LDZ, the main long-range target area, used in recent years for the 5"/62 gun, is short of this – in the vicinity of 27,000 to 28,000 yds. NSWCDD does not fire projectiles into the UDZ.

  Gunnery targets in the MDZ include primarily virtual targets but also floating targets. By design, some targets may be destroyed or damaged by gunfire, such as floating radar reflectors, fixed platforms in the river, UMSs, aerostats, vessels, towed sleds, and causeway sections. The environmental impacts of fragmenting these targets are minimized by removing hazardous materials such as batteries, oil, gasoline, and antifreeze to the extent possible prior to destroying or damaging them. After the target is impacted and the test completed, all visible remaining debris and waste is cleaned up. Tracking and calibration targets, which are not fired upon but rather used for taking bearings, may include UAVs, manned aircraft, aerostats, range control boats, diving tenders and other vessels, pilings in the river, land vehicles, and points of land.

- **Land Ranges –** Some large-caliber gunfire is directed at target areas on land within the Terminal Range. Gunnery targets on land may include armor plate or butts (impact areas designed to withstand and contain projectile impact and resulting fragmentation).

Examples of land tests include, but are not limited to, fuze impact tests and ballistic tests for target vulnerability, ordnance penetration, and projectile fragmentation, which take place on the Terminal and Missile Test Ranges. Small-caliber gunfire can take place on all of the ranges, but most commonly takes place on the Machine Gun Range, Main Range, and the AA Fuze Range. On the Machine Gun Range, guns are usually fired into butts.

1.6.4.2 EM Target/Operations Areas

- **Potomac River Test Range –** Targets used to test EM sensors can include many of the gunnery targets described above. Tests of EM sensors and directed-energy equipment mainly take place in the MDZ. Some types of tests can also take place in the UDZ and LDZ, such as a test of whether sensors could detect vessels or aircraft. Microwaves and RF waves are emitted from NDEC to CETFAC across the PRTR (Figure 1-9).
- **Land Ranges and Mission Area –** NOTES facility tests take place within the EEA. MOATS and ground-plane tests take place within the Mission Area.

1.6.4.3 Laser Operations Areas

- **Potomac River Test Range –** As shown on Figure 1-9, laser corridors crossing the waters of the PRTR include NDEC Area-to-CETFAC, Terminal Range-to-CETFAC, and NDEC Area-to-EEA Dock Area.
- **Land Ranges –** Laser corridors on the land ranges include the Shock Tube Area, and Terminal Range-to-Missile Test Range (Figure 1-9).

1.6.4.4 Chem/Bio Operations Areas

- **Potomac River Test Range –** Outdoor tests of chemical simulants in 2003, 2005, and 2009 took place in the MDZ within 2,000 to 6,000 yds of Main Range (Figure 1-11).
- **Land Ranges and Mission Area –** Outdoor tests of chemical simulants have taken place on Main Range in the past, but have not been used recently.

1.7 Authority, Relevant Statutes, and Regulations

This EIS has been prepared pursuant to the NEPA of 1969; the Council on Environmental Quality’s (CEQ) implementing regulations at 40 Code of Federal Regulations (CFR) Parts 1500 to 1508; and Department of the Navy (DoN) regulations implementing NEPA (32 CFR Part 775).

This EIS is also intended to support other associated environmental reviews, including but not limited to:

- Compliance with the Clean Water Act (CWA) of 1977 as amended, 33 U.S.C. §§ 1251 *et seq*.
- Compliance with the Clean Air Act (CAA) of 1970 as amended, 42 U.S.C. §§ 7401 *et seq*.

- Compliance with the Resource Conservation and Recovery Act (RCRA) of 1976, 42 U.S.C. §§ 6901 *et seq*.
- Compliance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, 42 U.S.C. §§ 9601 *et seq*.
- Federal consistency determination under provisions of the Coastal Zone Management Act (CZMA), 15 U.S.C. §§ 1451-1456.
- Consultation under Section 106 of the National Historic Preservation Act (NHPA) of 1966, 16 U.S.C. §§ 470 *et seq*.
- Consultation under Section 7 of the Endangered Species Act (ESA), 16 U.S.C. §§ 1531-1544.
- Compliance with the Marine Mammal Protection Act (MMPA), 16 U.S.C. §§ 1361-1421.
- Performance of essential fish habitat (EFH) analysis under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), 16 U.S.C. §§ 1801-1882.
- Compliance with the Migratory Bird Treaty Act (MBTA) of 1918, as amended, 16 U.S.C. §§ 703 *et seq*.
- Compliance with the Bald and Golden Eagle Protection Act (BGEPA) of 1940, as amended, 16 U.S.C. § 668.

1.8 Scope of the EIS

The scope of this EIS encompasses all reasonably foreseeable environmental impacts to socioeconomic, physical, cultural, and biological resources that could potentially result from an expansion of NSWCDD's RDT&E activities using ordnance, EM energy, HE lasers, and chem/bio simulants on range complexes and the Mission Area. Consistent with CEQ's regulations, the scope of the impact analysis presented in this EIS was defined by the range of potential environmental effects that would result from implementation of the Proposed Action and alternatives.

The environmental impact analysis in this EIS (Chapter 4) addresses activities that take place outdoors on range complexes and in the Mission Area. The analysis does not encompass all of NSWCDD's work, much of which takes place indoors in laboratories. These indoor activities are addressed in other NEPA documents – environmental assessments or categorical exclusions, as appropriate. However, the cumulative impacts of NSWCDD's indoor activities when combined with outdoor activities taking place on range complexes and the Mission area are considered in the cumulative impact analysis (Chapter 5) in this EIS.

This EIS does not address activities that take place within the base's housing and community support area, or base-support activities that are not affected by the Proposed Action.

The EIS addresses enhancements to existing technologies now being used at NSWCDD that employ ordnance, EM energy, HE lasers, and chem/bio simulants, but it does not address new technologies. NEPA requires that only reasonably foreseeable impacts be considered in the EIS.

Evaluating the unforeseeable impacts of new technologies is beyond the scope of this EIS and would require additional NEPA documentation.

However, the impact analysis in this EIS will allow NSWCDD to determine whether new technology, variations on existing tests, and other new testing and evaluation activities fall within the effects limits established by the EIS. Tests involving new technology or variations on existing tests could proceed if they are found to be within the effects limits. Actions that fall outside the scope of this EIS (i.e., actions that might increase the effects or create new effects) would be assessed separately in other NEPA documents as they are proposed.

1.9 Public Involvement

1.9.1 EIS Public Involvement Process

Public involvement is an integral component of the NEPA process. Comments made by the public become part of the decision-making process with respect to the action being proposed. The Navy takes this seriously because it works hard at being a good neighbor. A large part of being a good neighbor involves keeping the public informed about what is being planned and listening to what our neighbors have to say.

NSWCDD developed a public-outreach program specifically for this EIS. The program began in 2003 with 96 interviews with various community leaders, business owners, on-base residents, and residents of the five counties bordering the PRTR about their concerns with respect to NSWCDD's current activities. These concerns were taken into consideration in developing the work plan for the EIS.

NSWCDD also established a Public Involvement Working Group (PIWG) comprised of representatives from the five counties surrounding the PRTR, of whom most were identified during the interviewing process. The participants provided feedback on the public involvement process and materials that described NSWCDD's mission and programs while they were being developed for NSWCDD's website, for community meetings, and for the EIS scoping meetings.

EIS public scoping meeting held in St. Mary's County

The next step in the program was notifying the public that NSWCDD was considering expanding certain RDT&E activities and was going to prepare an EIS to evaluate potential impacts. A notice of intent (NOI) to prepare an EIS was published in the *Federal Register* on June 18, 2007 (72 Federal Register 33456). Soon after, notices were placed in six newspapers in the counties around the PRTR Complex, advising readers of the EIS process and inviting them to come to one or more of five public scoping meetings to learn more about, and comment on, the proposed scope of the EIS. Letters were sent to public agencies to inform them of the process.

1.9.2 Scoping Meetings and Comments

The scoping meetings – one in each of the counties around the PRTR: King George, Westmoreland, and Northumberland counties in Virginia; and Charles and St. Mary's counties in Maryland – were held in the last two weeks of July 2007. Seventy-seven people attended. Comments were received from twenty individuals and three agencies (the Virginia Department of Environmental Quality [VDEQ], the Virginia Department of Game and Inland Fisheries [VDGIF], and the Maryland Transportation Authority [MdTA]). These comments were submitted at the meetings, via the project website, or by telephone, fax, e-mail, or US mail.

NSWCDD's overall mission garnered the most comments (13), with seven of these supporting NSWCDD's programs. Several of the supporters noted that they had lived along the river for decades and did not find operations to be a problem. People who were less accepting of NSWCDD's programs cited concerns that testing damages the environment and affects human and animal health and safety. Several people wanted NSWCDD to stop testing.

Eight of the 12 people who commented on noise and vibration (the second most common topic), reported that noise and/or vibration levels are high enough to be disturbing to them or to their property. The remaining four – all of whom indicated that they were long-time residents of the area – mentioned that NSWCDD makes noise, but that noise levels were higher in the past, and that they do not find current noise levels bothersome.

Nine people commented on the environment. Two said that NSWCDD protects the environment and minimizes impacts, while seven expressed concerns that NSWCDD's activities may be damaging the environment. The term "environment" included the Potomac River, water quality, and effects on organisms in the river and on the test ranges.

Other topics that generated one or more comments from the public included: aspects of the scoping meetings themselves; the positive effect of NSWCDD on jobs; negative effects on boating-related commerce during testing; negative effects of noise on quality of life and community; potential negative impacts to public safety from the effects of chemical, biological, and EM energy tests; potential negative effects on human and animal safety from noise and hazardous materials; effects on air quality; whether UAVs would be used in the airspace; and what the contents of the EIS would be.

VDEQ identified itself as responsible for the coordination of federal environmental documents in Virginia and also as the lead agency for coordinating Virginia's review of federal coastal determinations prepared under the Coastal Zone Management Act (CZMA) and provided a list of the agencies to whom they were sending NSWCDD's letter and the NOI. VDEQ recommended that the federal coastal consistency determination be included as part of the DEIS so that a single review, rather than two separate reviews, could take place and provided information on federal consistency under the CZMA.

VDGIF sent a list of wildlife resources known from sites associated with the PRTR, EEA, Mission Area, and SUA.

MdTA's concerns focused on the potential impacts of the proposed action on the adjacent Governor Harry W. Nice Bridge improvement project, which was just getting underway. MdTA asked for information on the extent of the UDZ (which is north of the bridge) and the types of activities conducted there. NSWCDD began coordination with MdTA and sent them a response to their letter discussing such issues as coordinating bridge reconstruction activities with RDT&E

activities and advising them that EM activities will not interfere with existing or expanding electronic toll collection activities.

The comments and concerns raised during the scoping process were considered in developing the EIS work plan and were addressed in the impact analysis of the Draft EIS (DEIS).

1.9.3 DEIS Public Hearings

When the DEIS was completed, a notice of availability was published in the *Federal Register* on August 17, 2012, beginning a 45-day public review period during which the DEIS was available for review in five local libraries, on the project website, or by mail, upon request. Letters indicating that the DEIS was available for review were sent to the distribution list in Chapter 8 of the Draft EIS accompanied by paper or compact disk copies of the DEIS. Notices of the DEIS' availability were published in local newspapers. Public hearings were held to describe the environmental impacts of the Proposed Action and alternatives and to receive comment on the impacts analysis. These comments have been taken into consideration in preparing this Final EIS (FEIS).

Public hearings for the DEIS were held in King George and Westmoreland counties, Virginia, and Charles County, Maryland the week of September 10, 2012. Twenty-nine people attended the hearings. By the end of the comment period, comments had been received from ten individuals, two non-governmental organizations (the Potomac River Association and the Swan Point Property Owners Association), and the following public agencies:

- US Environmental Protection Agency Region III
- US Department of the Interior
- Fort A.P. Hill
- Maryland Transportation Authority
- Maryland Department of the Environment
- Maryland Department of Planning
- Maryland Department of Natural Resources
- Maryland Historic Trust
- Virginia Department of Conservation and Recreation
- Virginia Department of Environmental Quality
- Virginia Department of Game and Inland Fisheries
- Virginia Department of Historic Resources
- Virginia Department of Health, Office of Drinking Water
- St. Mary's County
- Charles County

These comments were submitted orally or in writing at the meetings or by fax, e-mail, or US mail. Appendix A displays the comments in their original form and a matrix that includes each comment and a response to the comment, which may have resulted in revisions to the FEIS.

1.9.4 FEIS Process

A notice of availability was published in the *Federal Register* to inform the public that the Final EIS has been released. Publication of the notice of availability began the 30-day wait period. A notice that the Final EIS was ready for review was also sent to the distribution list in Chapter 8 and published in local newspapers. Comments received during the 30-day review period will be considered in reaching the final decision. Following the 30-day wait period, a Record of Decision (ROD) will be prepared. The ROD will state the decision, identify alternatives considered (including the environmentally preferable alternative), address substantive comments received on the Final EIS that were not previously addressed, discuss other considerations that influenced the final decision, and address mitigation, if needed. Following signing of the ROD, the Navy will publish a notice of availability of the ROD in the *Federal Register*.

1.10 Issues Eliminated from Further Analysis

Based on current projections, the Proposed Action would not result in significant personnel increases, new building construction, land acquisition, or expansion of the ranges and the Mission Area. Therefore, the following issues have been eliminated from evaluation in this EIS:

- Construction of new facilities.
- Acquisition of land.
- Significant personnel increases.

Because there would be little to no increase in personnel, the following topics also are eliminated from evaluation in this EIS:

- **Housing –** There would be no increase in demand for housing or housing construction in the region around NSF Dahlgren as a result of the Proposed Action.
- **Community Services –** There would be no increase in demand for community services such as schools, community centers, fire and rescue units, hospitals, clinics, police, or libraries.
- **Roadway Transportation System –** There would be no increase in traffic on the region’s highways and roads, and therefore no need to build new roadways. However, the effects of the Proposed Action on river traffic and air traffic are considered.
- **Taxes –** The Proposed Action would not affect government tax revenues.
- **Prime or Unique Farmland –** No farmland, or land of any kind, would be required.

If in the future, new buildings, additional land, or more personnel are required beyond current projected needs, NEPA documents would be prepared to evaluate the impacts of these proposed changes.