Final
June 2014

Decision Document for Groundwater (Covering TNT Areas and Red Water Pond Areas) FUDS Project No. G05OH001826

Former Plum Brook Ordnance Works Sandusky, Ohio

US Army Corps of Engineers

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(Covering TNT Areas and Red Water Pond Areas)
FUDS Project No. G05OH001826
Former Plum Brook Ordnance Works, Sandusky, Ohio

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June 27, 2014

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Subject: ***Submittal of the Final Decision Document for Groundwater (Covering TNT and Red Water Pond Areas) Former Plum Brook Ordnance Works, Sandusky, Ohio Contract No. W912QR-08-D-0013: Shaw Project Number 136639***

Dear Ms. Coleman:

In accordance with the requirements of Delivery Order No. DX16 of Contract No. W912QR-08-D-0013 awarded to CB&I Federal Services LLC, we are pleased to submit this Final Decision Document for Groundwater (Covering TNT and Red Water Pond Areas) at the Former Plum Brook Ordnance Works (PBOW) located in Sandusky, Ohio. This document was prepared incorporating responses to the comments that were provided on the previous drafts and pertinent comments associated with other proposed plans and decision documents that we have received since submittal of the Draft Groundwater Decision Document. This Decision Document was prepared consistent with U.S. Environmental Protection Agency guidance, the Final Proposed Plan for Groundwater, and the Final Decision Document for the Reservoir No. 2 Burning Ground.

Enclosed are four hard copies of this document with compact disks. Copies have also been sent to those on the distribution list as indicated for their records.

Should you have any questions or require additional information regarding this submittal, please do not hesitate to contact me at (865) 694-7496.

Sincerely,

Steven. T. Downey, PE, PMP
Project Manager

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Project Description: Decision Document for Groundwater (TNT and RWP Areas) Former Plum Brook Ordnance Works, Sandusky, Ohio

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NOTICE: By signature above, parties certify that the subject document has been prepared by and/or reviewed by them (as appropriate), that all review comments have been resolved, and that the document is ready for submittal.

Final

Decision Document for Groundwater
(Covering TNT Areas and Red Water Pond Areas)
Former Plum Brook Ordnance Works
Sandusky, Ohio
DERP-FUDS Project No. G05OH001826

Prepared by:
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June 2014

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List of Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
BHHRA	basewide human health risk assessment
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
COPC	chemical of potential concern
cy	cubic yards
D&M	Dames & Moore, Inc.
DERP	Defense Environmental Restoration Program
DNT	dinitrotoluene
DoD	U.S. Department of Defense
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FFS	focused feasibility study
FS	feasibility study
ft^2	square feet
ft^3	cubic feet
FUDS	Formerly Used Defense Sites
GSA	General Services Administration
HI	hazard index
HQ	hazard quotient
HTF	Hypersonic Tunnel Facility
ICI	International Consultants, Inc.
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
ISEB	in situ enhanced bioremediation
IT	IT Corporation
LRD	Great Lakes and Rivers Division
µg/L	micrograms per liter
mg/kg-day	milligrams per kilogram of body weight per day

List of Acronyms (Continued)

mg/L	milligrams per liter
MNA	monitored natural attenuation
NAC	nitroaromatic compound
NACA	National Advisory Committee of Aeronautics
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NTCRA	non-time-critical removal action
OAC	Ohio Administrative Code
Ohio EPA	Ohio Environmental Protection Agency
PBOW	former Plum Brook Ordnance Works
PRRWP	Pentolite Road Red Water Pond
P&T	pump-and-treat
RAB	Restoration Advisory Board
RAO	remedial action objective
RfD	reference dose
RG	remedial goal
RI	remedial investigation
RWP	Red Water Pond
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWR	Secondary Drinking Water Regulation
SF	slope factor
Shaw	Shaw Environmental, Inc.
SI	site inspection
SMCL	secondary maximum contaminant level
TAPP	Technical Assistance for Public Participation
TDS	total dissolved solids
TNT	2,4,6-trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
USACE	U.S. Army Corps of Engineers
WAA	War Assets Administration
WARWP	West Area Red Water Ponds

1.0 Declaration

1.1 Site Name and Location

Groundwater (Covering TNT Areas and Red Water Pond Areas)
Former Plum Brook Ordnance Works
Sandusky, Ohio

1.2 Statement of Basis and Purpose

This Decision Document presents the selected final remedy for contamination in groundwater that is attributable to releases associated with historical operations at the three TNT Areas and two Red Water Pond (RWP) Areas, located on the former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio. These include TNT Area A (TNTA), TNT Area B (TNTB), TNT Area C (TNTC), the Pentolite Road Red Water Pond (PRRWP) Area, and the West Area Red Water Ponds (WARWP) Area. PBOW is a Defense Environmental Restoration Program (DERP) project under the U.S. Army Corps of Engineers (USACE) Great Lakes and Ohio Rivers Division (LRD) Formerly Used Defense Site (FUDS) program. The TNT and RWP Areas groundwater is identified as FUDS Project No. G05OH001826.

Execution of the FUDS Program was delegated by U.S. Department of Defense (DoD), through the Headquarters of the Army, to the USACE. The delegation made the USACE the chief executor for environmental restoration activities at FUDS. The FUDS program was established under DERP and addresses releases or threatened releases attributable to DoD that occurred prior to 17 October 1986. The cleanup mission for the FUDS program is to perform appropriate, cost-effective cleanup of contamination caused by DoD and to protect human health, public safety, and the environment (U.S. Army Office of the Assistant Chief of Staff for Installation Management, 2004).

The USACE is charged with planning and implementing environmental investigations and remedial actions at PBOW associated with past DoD activities at FUDS-eligible properties. The USACE Louisville District is the project and program management office for all FUDS property in the USACE Great Lakes and Ohio River Division. The USACE Huntington District provides overall project management of FUDS activities at PBOW for the Louisville District as well as acting as the contracting and oversight office for remedial actions. The USACE Nashville District provides design support services for environmental investigations at PBOW and provides technical review. The remedy selection has been made in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as

amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) under CERCLA (U.S. Environmental Protection Agency [EPA], 1990). The investigation, reporting, and project decision process were conducted consistent with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) and subsequent guidance materials, including *Guidance on Implementation of the Superfund Accelerated Cleanup Model (SACM) under CERCLA and the NCP* (EPA, 1992). This decision is based on the Administrative Record (AR) file for groundwater covering the TNT and RWP Areas.

This document has been prepared for the U.S. Department of the Army, the lead agency for response actions at PBOW. The remedy for this site has been selected by the USACE. The State of Ohio, as represented by the Ohio Environmental Protection Agency (Ohio EPA), concurs with this remedy.

1.3 Description of the Selected Remedy

The remedy selected in this Decision Document, No Further Action, addresses the DoD activity-related contamination associated with TNT and RWP Area groundwater. Because soil remedial action that addresses possible sources of groundwater contamination has taken place and/or is ongoing in the three TNT Areas and the PRRWP Areas, this remedy is “No Further Action.”

1.4 Statutory Determinations

The Selected Remedy of No Further Action is protective of human health and the environment and complies with applicable or relevant and appropriate requirements (ARAR), as none were identified. Because the Selected Remedy is No Further Action, the statutory determinations for treatment (i.e., CERCLA Section 121 and 40 Code of Federal Regulations 300.430[f][1][D]&[E]) are not necessary (EPA, 1999).

1.5 State Concurrence

The Ohio EPA has been involved with the decision-making process in remedy selection for TNT and RWP Areas groundwater as part of the remedial investigation (RI)/feasibility study (FS) process. This involvement includes, but is not limited to, document review comments, quarterly Project Delivery Team meetings, quarterly Restoration Advisory Board (RAB) meetings, and teleconferences as needed. Representatives of the Ohio EPA attended the March 29, 2012 Public Meeting at which the Preferred Alternative for TNT and RWP Areas groundwater, No Further Action, was presented. The Ohio EPA made no objection to the Selected Remedy during the

meeting and provided no comments during the public comment period, which extended from March 29, 2012 through April 30, 2012.

It is emphasized that an institutional control is not part of the Selected Alternative, nor is the implementation of an institutional control a condition for the implementation of the Selected Alternative. Ohio EPA legal counsel agreed to work with the National Aeronautics and Space Administration (NASA) to address any future institutional controls for the PBOW property under NASA's control.

The State of Ohio, as represented by the Ohio EPA, is expected to formally indicate concurrence with the Selected Remedy for TNT and RWP Areas groundwater in a letter that will be issued after the Decision Document for TNT and RWP Areas groundwater is signed by the DoD. The concurrence letter will be appended to the Decision Document in the AR.

1.6 Authorizing Signature

This Decision Document presents the selected response action for groundwater associated with the TNT and RWP Areas, Plum Brook Ordnance Works, Sandusky, Ohio. The USACE is the lead agency under the DERP at the PBOW FUDS and has developed this Decision Document consistent with CERCLA, as amended, and the NCP. This Decision Document will be incorporated into the larger AR file for PBOW, which is available for public view at Firelands Library, Bowling Green State University Firelands Campus, Huron, Ohio. This document, presenting a No Further Action selected remedy with a present worth cost estimate of $0, is approved by the undersigned, pursuant to Memorandum, DAIM-ZA, September 9, 2003, subject: Policies for Staffing and Approving Decision Documents (DD), and to Engineer Regulation 200-3-1, Formerly Used Defense Sites (FUDS) Program Policy.

Luke T. Leonard
Colonel, Corps of Engineers
Commanding

21 July 2014
Date

1.6 Authorizing Signature

This Decision Document presents the selected response action for groundwater associated with the TNT and RWP Areas, Plum Brook Ordnance Works, Sandusky, Ohio. The USACE is the lead agency under the DERP at the PBOW FUDS and has developed this Decision Document consistent with CERCLA, as amended, and the NCP. This Decision Document will be incorporated into the larger AR file for PBOW, which is available for public view at Firelands Library, Bowling Green State University Firelands Campus, Huron, Ohio. This document, presenting a No Further Action selected remedy with a present worth cost estimate of $0, is approved by the undersigned, pursuant to Memorandum, DAIM-ZA, September 9, 2003, subject: Policies for Staffing and Approving Decision Documents (DD), and to Engineer Regulation 200-3-1, Formerly Used Defense Sites (FUDS) Program Policy.

_____ _____

Luke T. Leonard
Colonel, Corps of Engineers
Commanding

Date

2.0 Decision Summary

2.1 Site Name, Location, and Description

This Decision Document describes the determination that No Further Action is required for TNT and RWP Areas groundwater. Only groundwater associated with the TNT and RWP Areas is covered by this Decision Document. The Decision Summary provides an overview of information presented in greater detail in the groundwater investigation reports (IT Corporation [IT], 1997, 1999; Shaw Environmental & Infrastructure, Inc. [Shaw] [a CB&I company], 2005), Baseline Human Health Risk Assessment (BHHRA) of groundwater (Shaw, 2006), Feasibility Study (FS) (Shaw, 2008), FS Addendum (Shaw, 2011), and other documents on file as part of the AR for PBOW groundwater associated with the TNT and RWP Areas. A summary of pertinent documents which are part of the AR for TNT and RWP groundwater is provided in the text box on the following page.

TNT and RWP Area groundwater comprises 1 of 18 DoD projects at PBOW; the other 17 DoD projects are identified in Section 2.4. The preferred remedial alternative, as described in the Proposed Plan (USACE, 2012), was presented to the public on March 29, 2012 during a public meeting at the Bowling Green State University Firelands Campus Library in Huron, Ohio. The remedial decision is recorded in this Decision Document in consultation with the Ohio EPA and the community.

This Decision Document is being issued by the USACE in consultation with the State of Ohio, as represented by the Ohio EPA, and is consistent with EPA (1999) guidance. As the lead agency for DoD environmental response actions at PBOW, the USACE is responsible for planning and implementing remedial action at the site. The partner support agencies include the Ohio EPA and NASA. The Ohio EPA is the support agency pursuant to the NCP and is also the lead regulator for the State of Ohio. The environmental restoration of PBOW is being pursued by the USACE under the LRD DERP-FUDS program. The USACE Louisville District is the project and program management office for all FUDS property in the USACE Great Lakes and Ohio River Division. The USACE Huntington District provides overall project management of FUDS activities at PBOW for the Louisville District as well as acting as the contracting and oversight office for remedial actions. The USACE Nashville District provides design support services for environmental investigations at PBOW and provides technical review.

The FUDS program was established under DERP to clean up properties that were under the jurisdiction of the Secretary of Defense and owned by, leased to, or otherwise possessed by the United States at the time of actions leading to contamination or safety hazards caused by DoD.

Primary Background Documents for the TNT Areas and Red Water Pond Areas Groundwater

U.S. Army Corps of Engineers (USACE), 2012, ***Proposed Plan for Groundwater (Covering the TNT Areas and Red Water Pond Areas), Former Plum Brook Ordnance Works, Sandusky, Ohio,*** March.

Shaw Environmental, Inc. (Shaw), 2011, ***Feasibility Study Addendum for Groundwater, TNT and RWP Areas, Final, Sandusky, Ohio***, July.

U.S. Army Corps of Engineers (USACE), 2011, ***Decision Document for Soils, TNT Area A, Former Plum Brook Ordnance Works, Sandusky, Ohio***, July.

U.S. Army Corps of Engineers (USACE), 2009a, ***Decision Document for Soils, TNT Area B, Former Plum Brook Ordnance Works, Sandusky, Ohio***, September.

U.S. Army Corps of Engineers (USACE), 2009b, ***Decision Document for Soils and Sediment, TNT Area C, Former Plum Brook Ordnance Works, Sandusky, Ohio***, December**.**

McTech Corp., 2009, ***Non-Time Critical Removal Action Report, Soil Excavation, Composting, and Disposal***, Plum Brook Ordnance Works, Pentolite Road Red Water Ponds, Sandusky, Ohio, April.

Shaw Environmental, Inc. (Shaw), 2008, ***Final, Feasibility Study for Groundwater, TNT and RWP Areas, Sandusky, Ohio***, December.

Shaw Environmental, Inc. (Shaw), 2006, ***Baseline Human Health Risk Assessment of Groundwater, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio***, September.

Shaw Environmental, Inc. (Shaw), 2005, ***2004 Groundwater Data Summary and Evaluation Report, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio***, April.

Shaw Environmental, Inc. (Shaw), 2004, ***Ninth Quarterly (March 2004) Background Groundwater Report, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio***, June.

Shaw Environmental, Inc. (Shaw), 2003, ***2002 Groundwater Data Summary and Evaluation Report, Former Plum Brook Ordnance Works, Sandusky, Ohio***, June.

IT Corporation (IT), 2002, ***2001 Groundwater Remedial Investigation, Former Plum Brook Ordnance Works, Sandusky, Ohio***, March.

International Consultants Inc. (ICI), 1999, ***Community Relations Plan, Plum Brook Ordnance Works, Sandusky, Ohio,*** September.

IT Corporation (IT), 1999, ***Summary Report, Site-Wide Groundwater Monitoring (1997-1998), Final, Former Plum Brook Ordnance Works, Sandusky, Ohio,*** June.

Dames and Moore, Inc. (D&M), 1997a, ***TNT Areas Site Investigation, Final Report, Plum Brook Ordnance Works, Plum Brook Station/NASA, Sandusky, Ohio,*** prepared for U.S. Army Corps of Engineers, Nashville District/Huntington District, April.

Dames and Moore, Inc. (D&M), 1997b, ***Red Water Ponds, Focused Remedial Investigation, Final Report, Plum Brook Ordnance Works, Plum Brook Station/NASA, Sandusky, Ohio,*** prepared for U.S. Army Corps of Engineers, Nashville District/Huntington District, April.

Dames and Moore, Inc. (D&M), 1997c, ***Final Report, Sitewide Groundwater Investigation, Plum Brook Ordnance Works, Plum Brook Station/NASA, Sandusky, Ohio,*** prepared for U.S. Army Corps of Engineers, Nashville District/Huntington District, April.

IT Corporation (IT), 1997, ***Site-Wide Groundwater Investigation Report, Plum Brook Ordnance Works, Sandusky, Ohio,*** September.

International Consultants Inc. (ICI), 1995, ***Site Management Plan, Plum Brook Ordnance Works, Sandusky, Ohio,*** September.

Morrison-Knudsen Corporation, 1994, ***Site Inspection Report***, Plum Brook Station, Sandusky, Ohio, January.

Science Applications International Corporation, 1991, ***Plum Brook Station Preliminary Assessment,*** June.

The Army is the executive agent for the FUDS program, and the USACE executes the program. The cleanup mission for the FUDS program is to perform appropriate, cost-effective cleanup of

contamination caused by DoD and to protect human health, public safety, and the environment (U.S. Army Office of the Assistant Chief of Staff for Installation Management, 2004)).

2.1.1 Site Location

PBOW is located approximately 4 miles south of Sandusky, Ohio, 7 miles southwest of Huron, Ohio, and 59 miles west of Cleveland (Figure 2-1). Although located primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. The area surrounding PBOW is mostly agricultural and residential (Shaw, 2006). The former PBOW facility property that was within the PBOW fence is currently used by NASA as the Glenn Research Center, Plum Brook Station, and is the home of the center's four world-class test facilities. NASA has not conducted any known activities in these areas that have contributed to the environmental contamination originally resulting from the former DoD actions on the property.

2.1.2 Site Description

The groundwater associated with the three TNT and two RWP Areas addressed by this Decision Document is within the former PBOW property, which had comprised approximately 9,100 acres. The PBOW property is within an area that is relatively flat and generally slopes slightly to the north. Several small streams bisect the PBOW property and flow generally north-northeast toward Lake Erie. There are various vegetative communities throughout PBOW ranging from mown grassy areas to woodlands. The following paragraphs provide brief descriptions of the TNT and RWP Areas and the groundwater associated with them. Please refer to the Site Characteristics (Section 2.5) for further descriptions of these areas and the underlying groundwater.

The three TNT Areas (Figure 2-2) are the locations of the former 2,4,6-trinitrotoluene (TNT) manufacturing facilities, each of which housed multiple manufacturing lines. Each line was composed of various process buildings including the wash houses, bi-/tri-nitrification houses, fortifier houses, and nail houses. TNTA was located in the eastern portion of PBOW and contained four TNT manufacturing lines. Three TNT manufacturing lines were located at TNTB, which was located in the south-central portion of PBOW. TNTC, located in the western part of PBOW, included five manufacturing lines.

The two RWP Areas (Figure 2-2) received treated TNT manufacturing process waste water from the waste water treatment plants. The PRRWP Area included a single waste water pond that covered an area of approximately 2 acres. This unlined pond, located in the north-central portion

of PBOW, received waste water from Waste Water Treatment Plant No. 1. This water originated from TNTA and TNTB. The WARWP Area included two unlined ponds which together comprised an area of approximately 7 acres. The two unlined WARWP Area ponds received waste water from Waste Water Treatment Plant No. 2. This waste water originated from TNT manufacturing operations at TNTC.

The TNT and RWP Areas are underlain by two water-bearing units. These include an upper overburden/shale unit and a deeper limestone unit. The overburden/shale water-bearing unit within the TNT and RWP Areas is isolated, discontinuous, and seasonally dependent, generally yielding a low and undependable volume of groundwater where it exists. This water, where it exists, from this unit was found to be generally of naturally low quality both within and upgradient of PBOW.

The limestone unit typically yields a volume of groundwater adequate for a drinking water source, but the Ohio Department of Natural Resources (1962) regards it as being of regionally low quality because of high mineral content. Naturally elevated concentrations of sulfate were observed in three limestone unit wells (in TNTA, TNTC, and the WARWP Area), and the off-gassing of hydrogen sulfide was observed in several wells. The limestone unit groundwater within the TNT and RWP Areas was also found to have elevated concentrations of naturally occurring total dissolved solids (TDS), hydrogen sulfide, metals, and petroleum compounds. Therefore, groundwater from the limestone unit underlying the TNT and RWP Areas is nonpotable due to naturally poor quality that is unrelated to former DoD activities. Please refer to Section 2.5.1 for additional groundwater quality description.

2.2 Site History and Statutory Authority

2.2.1 Site History

The former Plum Brook Ordnance Works (PBOW) was established by the War Department as a government-owned, contractor-operated (GOCO) facility for the production of 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), and pentolite during World War II. The PBOW site originally consisted of approximately 9,100 acres, approximately 3,500 acres of which was used as a buffer area outside the facility fence line. The property was acquired in the name of the United States of America in 1941. The government contractor, Trojan Powder Company, operated the production facility from December 1941 until 1945. It is estimated that during this period more than 1 billion pounds of nitroaromatic explosives were manufactured.

At the end of production in September 1945, PBOW was placed in standby operation status and the Army conducted decontamination and decommissioning activities. On December 17, 1945 the U.S. Army Ordnance Department (Ordnance Department) obtained physical control of the site. The Ordnance Department continued decontamination efforts until August 1946. In 1946 over 6,200 acres, 3,231 being located within the fenced area, were transferred to the War Assets Administration (WAA), and approximately 2,800 acres were transferred to the Ravenna Arsenal. This 2,800-acre parcel, transferred to Ravenna Arsenal and referred to as the Magazine Area (and also the Plum Brook Depot), was transferred again in July 1947 to the Erie Ordnance Depot, LeCarne, Ohio (War Department, 1947). The Magazine Area included approximately 2,300 acres inside the fence line and 500 acres of the buffer area, outside of the fence line.

In 1949, the GSA took control of WAA's portion of the PBOW property, which included an indeterminate amount of acreage outside of the fence line due to conveyances by WAA to private landowners during the late 1940s and early 1950s. It is believed that farmers were given the opportunity to buy back land in the buffer area, outside the fence line.

In June 1954, the Army reacquired the 3,231 acres within the PBOW fence line that was previously transferred to the WAA and subsequently to GSA. From August 1954 to sometime in 1958, further decontamination was performed by the Army. The decontamination included removal of and disposal of contaminated surface and subsurface soil around the buildings and wooden and ceramic waste disposal lines containing TNT. This included thousands of pounds of TNT which were discovered in catch basins that were removed and incinerated at the burning grounds.

Two property use agreements were entered into by the Army and the National Advisory Committee of Aeronautics (NACA), the predecessor of NASA, in March 1956 and January 1958, respectively. The first agreement was for approximately 500 acres on which NACA built a nuclear reactor. The second agreement gave NACA (NASA as of October 1958) use of an additional 2,700 acres within the fenced area but outside the Magazine Area, for a total of 3,231 acres under the two use agreements. At this time, NASA had use of all property inside the PBOW fence except the 2,300 acres in the Magazine Area. The Army declared this 3,231-acre property as excess in October 1958.

In September 1961, the Army declared the Magazine Area as excess, and NASA formally requested custody of the property in October 1961 (NASA, 1961). On March 15, 1963, accountability and custody of the PBOW property (6,031 acres) were transferred from the Department of the Army to NASA.

However, prior to NASA's acceptance of the property in March 1963, Ravenna Arsenal performed additional decontamination and subsequently certified 500 acres of the former PBOW property was decontaminated and suitable for unrestricted future use. This decontamination certification was only for the 500 acres in the former pentolite manufacturing area (area where NASA built the nuclear reactor) under the first use agreement. NASA identified additional DoD activity-related contamination in 1963, after transfer of the property. NASA performed further decontamination efforts and the removal of structures in 1964.

NASA has operated and maintained the property inside the fence line since 1963, and the facility currently located there is the NASA Glenn Research Center, Plum Brook Station. NASA operates the property as a space research facility in support of its John Glenn Research Center at Lewis Field, Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the site have been demolished, or are currently on standby or inactive status. During 1967 through 1971, NASA purchased approximately 2,000 acres outside of the fence line from local farmers as "buffer." On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. This excess included approximately 1,500 acres of farmland outside the fence, including those acres purchased from farmers beginning in 1967, and was sold as farmland (NASA, 2013). Also, 46 acres outside of the fence in the northeast corner of the PBOW facility near the guard house was conveyed to the Perkins Township Board of Education and is used as a bus transportation area. In addition, the 2,152 acres of PBOW declared excess included a 604-acre parcel in the western part of the fenced area known as "Parcel 59." This area, although previously declared excess, was not transferred and remains under NASA control. According to a NASA newsletter, NASA presently controls approximately 6,432 acres (NASA, 2013); this includes approximately 5,500 acres within the fence line and 900 acres outside of the fence which have been leased for agriculture (NASA, 2012).

The former PBOW FUDS property includes the entire 9,100 acres, but the only project areas that have been approved (or proposed) for the property are located within the fenced area (currently controlled by NASA). The fence generally runs along the patrol road. The area outside the fence was used as a buffer zone during the PBOW manufacturing period, and there is no known or suspected DoD activity-related contamination outside the fence line.

The Former PBOW DERP/FUDS property includes the entire 9,100 acres but the only known project areas are within the fenced area controlled by NASA. The area outside the fence was a buffer zone during the PBOW manufacturing period and there are no known or suspected projects outside the fence line. The TNT and RWP Areas are within the former PBOW and

current NASA fence line. No NASA facilities are located at TNTC or the RWP Areas. NASA constructed its Administration Building and associated parking lots on TNTA. Two NASA facilities are present at TNTB: the Nitrogen Dewar Tanks, which supply the B2 test facility, and the Hypersonic Tunnel Facility, which is in standby. NASA is not known to have used TNTC, the PRRWP Area, or the WARWP Area for any beneficial purpose. NASA has not conducted any identified activities in the vicinities of the TNT and RWP Areas that are known to have contributed to the environmental contamination resulting from the former DoD activity-related actions on the property. Former groundwater pumping at the NASA Reactor Building may have affected localized groundwater flow, but there is currently no information to indicate that this pumping noticeably affected contaminant migration associated with any of the TNT or RWP Areas.

2.2.2 Statutory Authority

The PBOW property was acquired by DoD in 1941 for the U.S. Army Plum Brook Ordnance Works and operated as a government-owned, contractor-operated facility under their direction until late 1945. Therefore, the PBOW is administered as a FUDS site, and any contamination on the property that is a result of these activities is the responsibility of the Army under the DERP-FUDS program, as described in Section 2.1.

Under CERCLA, the President delegated authority to DoD (Secretary of Defense) for cleanup of active and formerly used defense sites. In addition, SARA (Section 211) required the Secretary of Defense to carry out the DERP, which in turn delegated these authorities to the USACE, thereby granting the USACE the authority to conduct removal/remediation projects such as the groundwater underlying the TNT and RWP Areas.

2.3 Community Participation

Community relations activities are required under the NCP, CERCLA, and FUDS. The objective of this program is to provide a mechanism for the communication and exchange of information among Army agencies, government agencies, residents of local communities, and residents adjacent to and downgradient from PBOW. In January 1997, the PBOW RAB, composed of approximately 20 local citizens with varying backgrounds, was established to promote a two-way dialog not only to keep local citizens informed about site progress but also to facilitate the opportunity for them to provide input to site decisions. Since its inception, the RAB has been the basis for community involvement. The RAB holds quarterly meetings that are co-chaired by a representative of the community and the USACE point of contact. Through this communication process, the community has had active involvement in the selection of the remedy for the TNT and RWP Areas.

In compliance with CERCLA (Section 113), the USACE has developed the AR to provide documentation as to how and why decisions specific to the site remediation are made. To date, the investigations and assessments completed for the TNT and RWP Areas groundwater are as follows: Site-Wide Groundwater Investigation Report (IT, 1997), 2004 Groundwater Summary and Evaluation Report (Shaw, 2005), BHHRA (Shaw, 2006), FS (Shaw, 2008), and FS Addendum for Groundwater (Shaw, 2011). The AR contains these final documents as well as all others for the PBOW site. Currently, the final reports are located in the AR, maintained at the USACE Huntington District Office, 502 Eighth Street, Huntington, West Virginia, 25701. An electronic copy of the AR is also maintained locally in the public repository at the Firelands Library, Bowling Green State University Firelands Campus, Huron, Ohio. Free public computer access is available.

A community relations plan (ICI, 1999) was prepared that outlines the procedures through which the community is involved with the restoration of PBOW. In addition to providing access to the AR file, these procedures involve the following activities, which are performed or initiated by the USACE Huntington District:

- AR file maintenance
- Quarterly fact sheets and policy letters
- Bulletin boards for the RAB to post pertinent information within the community
- Project-specific exhibits for community functions
- Direct two-way communication with RAB members
- News releases
- An annual PBOW newsletter
- Exhibits at public activities.

The PBOW RAB received a Technical Assistance for Public Participation (TAPP) grant from DoD on March 29, 2005. TAPP grants have a $25,000 per-year maximum and a lifetime ceiling of $100,000. The purpose of the TAPP grant is to provide a mechanism for the RAB to obtain professional technical assistance to help its members understand the restoration program. Also, the RAB holds quarterly meetings, which are co-chaired by a representative of the community and the USACE point of contact. Through this communication process, the community has had active involvement in the selection of the remedy for TNT and RWP Areas groundwater.

A preferred remedial alternative was presented in the Proposed Plan (USACE, 2012). Notice of the Proposed Plan for TNT and RWP Areas groundwater was published in the March 29, 2012 Sandusky Register, and the Proposed Plan was presented to the RAB and other interested

members of the community at a public meeting at Firelands Library on March 29, 2012. RAB members and other members of the public who requested to be on the mailing list also received their choice of either email or standard mail notification of the public meeting. At this public meeting for the Proposed Plan, representatives of the USACE and the Ohio EPA were present to answer questions, address concerns, and receive additional community input. The public comment period for the Proposed Plan extended from March 29 through April 30, 2012. The remedial decision is recorded in this Decision Document in consultation with the Ohio EPA and the community. The TNT and RWP Areas groundwater documents were made available to the public in the AR file maintained at the Firelands Library, Bowling Green State University Firelands Campus, Huron, Ohio.

Community comments and concerns, as well as how the USACE addressed these comments and concerns, are included in the Responsiveness Summary (Chapter 3.0).

2.4 Scope and Role of TNT and RWP Areas Groundwater

One of DoD's specific goals from the Defense Planning Guidance for the DERP is to reduce risk to human health and the environment through implementation of effective, legally compliant, and cost-effective response actions. To that end, the environmental investigation of PBOW has been divided into 18 areas of concern, also referred to as DERP-FUDS projects, to address the potential concerns presented by each area associated with former DoD activities. Separate closeout documents are required for each of the 18 DERP-FUDS projects. This current Decision Document specifically addresses groundwater associated with the TNT and RWP Areas. This groundwater is DERP-FUDS Project No. G05OH001826; other media at the TNT and RWP Areas are addressed under separate DERP-FUDS projects.

Currently, soil cleanup actions that have led to site closeout, or that are expected to lead to site closeout once completed, have been or are being implemented by the USACE under three other PBOW DERP-FUDS projects. These projects are for TNTA, TNTB, and TNTC (exclusive of groundwater). Soil actions at three additional DERP-FUDS projects have been proposed; once implemented and complete, these two are likewise expected to lead to site closure. Three other DERP-FUDS project sites have been closed out under no (further) action with State concurrence. Other DERP-FUDS projects are at various stages of the CERCLA process.

This Decision Document directly addresses only the groundwater associated with the TNT and RWP Areas. The status of this project is summarized below. Because of their relatedness to the

TNT and RWP Areas groundwater, the status of each TNT Area and the RWP Areas DERP-FUDS projects are likewise summarized in the following paragraphs.

TNT and RWP Areas Groundwater. A BHHRA of groundwater associated with the three former TNT Areas and two former RWP Areas was finalized in September 2006, and an FS for groundwater associated with these areas was finalized in December 2008. An addendum to the groundwater FS was finalized in July 2011 (Shaw, 2011) and a proposed plan was presented to the public on March 29, 2012. The groundwater associated with these five areas is being addressed in this Decision Document. Note that groundwater associated with each of the other active DERP-FUDS projects is expected to be addressed as part of the separate Decision Document specific to each of those DERP-FUDS projects.

TNTA. A Focused Feasibility Study (FFS) for soils and sediment was completed in 2003. A decision document for TNTA soils was signed on June 22, 2011, and state concurrence was received on July 20, 2011. Remedial action for TNTA soils was completed in December 2013.

TNTB. An FS for soils was completed in 2001. An Action Memorandum for a non-time-critical removal action (NTCRA) regarding soils was presented to the public on March 28, 2002. The Action Memorandum was finalized in June 2003, and the removal action was completed in December 2006. The final report of the interim soil removal action was issued in 2007. A proposed plan recommending No Further Action was presented during a July 16, 2009 public meeting. No comments were provided during the subsequent public comment period. A no-further-action Decision Document was signed on September 23, 2009, and state concurrence was received on September 29, 2009. The project closeout report was signed on March 31, 2010.

TNTC. An FFS for soils and sediment was completed in 2003. A proposed plan was submitted in March 2009. A decision document was signed by DoD on December 7, 2009, and a concurrence letter, dated January 15, 2010, was received from the State of Ohio, as represented by the Ohio EPA. Remedial action of TNTC soil and sediment has been completed, and the project is in the close-out process.

Red Water Pond Areas. An FFS for the Red Water Pond Areas soil was completed in December 2002. Remedial alternatives were developed and evaluated for PRRWP Area soil in the FFS because the human health risks associated with PRRWP Area soil were determined to be unacceptable under unrestricted land use. Because human health and ecological risks for WARWP Area soil were determined to be within acceptable levels for unrestricted land use, it

was not necessary to develop remedial alternatives for the WARWP Area soil. An Action Memorandum was presented to the public in September 2002 for an NTCRA regarding PRRWP Area soil. An interim removal action at the PRRWP Area began in January 2003 under the NTCRA. During the NTCRA soil removal, the need for additional soil sampling was recognized based on the discovery of a dark layer of contaminated soil. A windrow composting action was selected to remediate this soil under the NTCRA. Composting began in 2007 and was completed in September 2008. Post-NTCRA delineation sampling was performed in spring and summer 2009. Because of residual human health risks, additional delineation sampling was completed in November 2010. Through these sampling events, the extent of soil contamination at the PRRWP Area was successfully delineated. A soil delineation report and risk evaluation have been prepared in support of an addendum to the FFS, which was finalized in May 2013. A proposed plan is currently being prepared and is scheduled to be finalized and presented to the public in 2014.

2.5 Site Characteristics

2.5.1 Site Overview

Nitroaromatic explosives were manufactured at PBOW from 1941 through 1945 as part of the World War II effort, as described in Section 2.2.1. Groundwater underlying the TNT Areas became contaminated with nitroaromatic compounds (NAC) and associated chemicals involved in the manufacturing processes as the result of surface spills and subsurface pipeline leaks and subsequent leaching. At the RWP Areas, groundwater likely became contaminated as the result of contaminants in these surface impoundments migrating to groundwater. Figure 2-3 is a generalized diagram of the source types and subsurface conditions at the TNT and RWP Areas.

The former PBOW property comprises 9,009 acres in an area that is relatively flat and generally slopes slightly to the north. Several small streams bisect the PBOW property and flow generally north-northeast toward Lake Erie. There are various vegetative communities throughout PBOW, from mown grassy areas to woodlands. The three TNT Areas and the two RWP Areas are described in the following paragraphs. A description of the groundwater underlying these areas is also provided.

TNTA Characteristics. TNTA currently consists of an area of approximately 114 acres in the northeastern part of PBOW, with Columbus Avenue bisecting the site (Figure 2-2). Aboveground features associated with past TNTA operations include roads, fire hydrants, water valves, railroad beds, and sections of former building pad foundations. Several below-ground

features are also present: manholes, drains, and underground lines (indicated by aboveground water valves).

NASA constructed its administration building on the east side of Columbus Avenue, in the central portion of TNTA. The NASA Administration Building and associated parking areas cover a small portion of the site, including the footprint of one of the former TNT process buildings. The remainder of TNTA is predominantly open grassland areas with less than 25 percent woodlands.

TNTA is slightly hilly, generally increasing in elevation from southeast to northwest. Lindsley Ditch and smaller connecting ditches transect the site. The smaller ditches are dry during periods with little rainfall.

A decision document for TNTA soil remediation using alkaline hydrolysis and/or windrow composting and off-site disposal was signed in June 2011 (USACE, 2011). This remedial action is based on human health and environmental risks associated with direct soil contact. Remediation for TNTA soils commenced in the fall of 2011.

TNTB Characteristics. TNTB consists of an area of approximately 55 acres at the south-central portion of PBOW immediately north of West Scheid Road (Figure 2-2). Significant evidence of former PBOW facilities exists at TNTB in the form of roads, hydrants, aboveground water valves, and ditches. All buildings and structures associated with the manufacturing process have been demolished and removed. Two NASA facilities are present at the site and currently active for research purposes: the Hypersonic Tunnel Facility (HTF) and Nitrogen Dewar Tanks. The HTF is located in the northwest portion of TNTB and consists of a single building, aboveground and underground piping and utilities, and paved parking areas. The Nitrogen Dewar Tanks are located in the center of TNTB, with aboveground piping and underground utilities leading to the northwest, toward HTF, and then off site to the northeast.

This area is relatively flat and is covered with old field and shrubby vegetation. The intermittent headwaters of Ransom Brook are located in the northwest portion of TNTB. Numerous intermittent drainage ditches within TNTB were dry during site visits. These ditches likely serve only as wet weather conveyances.

A TNTB soil remedial action using windrow composting and off-site disposal was completed in December 2006 under an NTCRA. This remedial action was based on human health and

environmental risks associated with direct soil contact. Based on the NTCRA efforts, a no-further-action Decision Document was signed in September 2009 (USACE, 2009a).

TNTC Characteristics. TNTC occupies approximately 119 acres of land in the western portion of PBOW (Figure 2-2). Several aboveground features are currently evident at TNTC, indicating former PBOW facilities. These include roads, fire hydrants, water valves, a water valve control well, railroad beds, and former building pad foundations. Several below-ground features are also present: manholes, drains, and underground lines (indicated by aboveground water valves). There are no NASA buildings on the site, and NASA does not currently use the area. One building present on the site was constructed and used by the EPA to perform noise abatement testing in the 1980s.

Currently, TNTC consists mostly of early and late old field combined with shrubby thicket vegetation and is less than 10 percent wooded. The area is relatively hilly compared to other PBOW areas. Some wetland vegetation was found along TNTC drainage ditches and streams. During rain events, drainage from the ditches flows into any of three small streams that eventually flow to Pipe Creek, located northwest of TNTC. The areas east of TNTC are primarily old field and shrub, and to the southwest of TNTC are old field and early shrub thicket. The remaining areas bordering TNTC are primarily forested.

A decision document for TNTC soil and sediment remediation using alkaline hydrolysis and/or windrow composting and off-site disposal was signed in December 2009 (USACE, 2009b). This remedial action was based on human health and environmental risks associated with direct soil contact. The remedial action was completed in December 2013.

PRRWP Area Characteristics. The unlined pond received waste process water from Wastewater Treatment Plant No. 1 during PBOW operations via an elevated discharge pipe. This waste originated from the manufacture of TNT at TNTA and TNTB. The pond covered between 1 and 2 acres during plant operations. In 1977, retention dikes and sump pits were installed at the PRRWP Area in response to the observation of reddish-brown water in an adjacent surface ditch. In April and May 1977, approximately 60,000 gallons of the reddish-brown water were removed. The original basin was then backfilled so that the original pond area would be higher in elevation than the surrounding area; this was done to prevent ponding in the area of the original PRRWP footprint (D&M, 1997a).

An NTCRA was completed at PRRWP Area in September 2008 (McTech Corp., 2009) to remediate the area of a dark soil seam found to be associated with elevated TNT concentrations. In a subsequent investigation conducted outside of the NTCRA area, the presence of additional NAC soil contamination was identified. The contaminated soil outside of the NTCRA area has been delineated and evaluated as part of an addendum to the RWP Areas FFS for soil. A proposed plan for the RWP Areas is currently being finalized.

Currently, the PRRWP Area is covered in old field vegetation, scrub/shrub, and moderate forest, with isolated areas of standing water and emergent wetland vegetation. The approximately 0.6-acre NTCRA area was seeded with Indian grass (*Sorghastrum nutans*), a native species, in 2008. Seasonally ponded areas, which have been observed since the regrading activities, are present near the PRRWP but outside of the original PRRWP footprint. A drainage ditch, which has been observed as algae-covered and containing a few inches of flowing water, is located along the eastern edge of the PRRWP Area. No buildings are present, and the PRRWP Area is not used by NASA.

WARWP Area Characteristics. The two unlined ponds received TNTC waste process water via an elevated discharge pipe from Wastewater Treatment Plant No. 2 during PBOW operations. The WARWP Area consisted of an “east pond” and a “west pond.” Together, these ponds covered approximately 7 acres. The east pond contained water from the 1940s until the late 1970s, when NASA breached the berm between the two ponds to drain the eastern pond. At present, the east pond is typically dry, with the exception of localized water near the location of the former berm. The west pond has existed since the1940s. The area of water within the west pond, combined with residual water in the east pond (near the former berm), comprises approximately 3.5 acres. The area adjacent to the pond is vegetated with mown grass, moderate forest, and late forest. The WARWP Area is not used by NASA, and no buildings are present.

Characteristics of Groundwater Underlying the TNT and RWP Areas. Two groundwater units underlie the TNT and RWP Areas: an upper overburden/shale water-bearing unit and the deeper Delaware Limestone bedrock unit. Figure 2-3 presents a generalized block diagram conceptual model of PBOW showing the possible contaminant migration routes, the overburden/shale and limestone bedrock water-bearing units, the geologic units, and the interrelationship between the water-bearing zones. Groundwater flow in the overburden/shale is generally toward the north-northeast, but because this unit is discontinuous, lateral flow is limited. Groundwater flow in the limestone bedrock unit is generally toward the north-northeast and dominated by fracture flow.

The overburden/shale water within the TNT and RWP Areas is isolated, discontinuous, and seasonally dependent, generally yielding a low and undependable volume of groundwater where it exists. The groundwater tends to occur in discrete pockets in the overburden/shale and does not represent a contiguous lateral unit. Wells screened in competent shale sections indicate that vertical contaminant transport downward from the overburden is limited.

A direct-push groundwater investigation undertaken in 2001 was discontinued because no groundwater was encountered in more than 80 percent of the borings. Additionally, groundwater from background wells in competent shale bedrock was found to have elevated concentrations of chloride, sulfate, iron, manganese, and TDS. Some of these concentrations, especially those of sulfate and TDS, were found at levels that far exceed the respective EPA Office of Groundwater Secondary Drinking Water Regulations (SDWR) or health advisories (EPA, 2012). The SDWRs are non-enforceable levels that are based on aesthetic properties (e.g., taste, odor, color) or cosmetic effects (e.g., skin or tooth discoloration). The following list compares concentrations of analytes in samples from off-site upgradient background shale groundwater unit wells to their respective Office of Drinking Water SDWRs or health advisories. The SDWR values for the listed analytes have been promulgated by the State of Ohio as secondary maximum contaminant levels (SMCL) (Ohio Administrative Code [OAC] 3745-82-02). An SMCL is defined as the advisable maximum level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system" (OAC 3745-82-01[B]), and public water systems are required to be regularly monitored for analytes with SMCLs (OAC 3745-82-03[A]).

- ***Chloride*** – Fifty percent of the background wells exceeded the chloride SDWR of 250 milligrams per liter (mg/L) The maximum background concentration (3,540 mg/L) was 14 times higher than the SDWR.

- ***Sulfate*** – Eleven percent of the background wells exceeded the sulfate SDWR of 250 mg/L. The maximum background concentration (514 mg/L) was approximately twice the SDWR.

- ***Iron*** – Thirty-two percent of the background wells exceeded the iron SDWR of 0.3 mg/L. The maximum background concentration (1.55 mg/L) was approximately 5 times higher than the SDWR.

- ***Manganese*** – Sixty-one percent of the background wells exceeded the manganese SDWR of 0.050 mg/L. The maximum background concentration (0.728 mg/L) was nearly 14 times higher than the SDWR.

- ***Sodium*** – One hundred percent of the background wells exceeded the sodium health advisory level of 20 mg/L. The maximum background concentration (1,390 mg/L) was approximately 70 times higher than the sodium health advisory level. (No SDWR exists for sodium.)

- ***TDS*** – Eighty-two percent of the background wells exceeded the TDS SDWR of 500 mg/L. The maximum background concentration (6,850 mg/L) was nearly 14 times higher than the SDWR.

Based on high naturally occurring TDS and other analytes as described previously, this groundwater unit is consistent with the EPA guidelines for Class III nonpotable groundwater. Therefore, overburden/shale groundwater is not a suitable drinking water source based on yield and quality.

The limestone bedrock unit groundwater flows generally toward the north or north-northeast. As mentioned, groundwater flow in the limestone bedrock unit is dominated by fractures. Groundwater flowpaths and velocity in this unit are dictated by the frequency, orientation, density, fracture size, and connectivity of these bedrock fractures. Also, there appears to be a groundwater trough that extends off site toward the north-northeast and bisects PBOW in the vicinity of the PRRWP Area.

Groundwater withdrawal (i.e., dewatering) is known to have occurred in and around PBOW. Within the site itself, NASA had operated a groundwater extraction and treatment system in the north-central portion of PBOW to address groundwater contamination associated with underground storage tanks. The system reportedly removed approximately one million gallons of water per year from the overburden/shale water-bearing zone. In the northern portion of PBOW at the Reactor Building area, sump wells installed in the limestone bedrock unit dewatered the overburden/shale and shallow limestone bedrock units to prevent water from infiltrating the basement of the Reactor Building. The Reactor Building is located north of the PRRWP Area, near the groundwater trough described in the previous paragraph. The amount of groundwater removed by this Reactor Building sump system is unknown. Groundwater pumping at the Reactor Building ceased in 2011, and the groundwater flow patterns may have changed in this area. Any flow changes would not affect the selected remedy.

The limestone bedrock unit typically yields an adequate volume of groundwater for a drinking water source, but groundwater in the region is regarded by the Ohio Department of Natural Resources (1962) as being of low quality because of high mineral content. Naturally elevated concentrations of sulfate were observed in three limestone bedrock unit wells (one each in

TNTA, TNTC, and the WARWP Area), and the off-gassing of hydrogen sulfide was observed in several wells. The maximum sulfate concentration (2,660 mg/L) among these wells was over 10 times the SDWR of 250 mg/L. Additionally, all limestone bedrock unit wells except one exhibited naturally occurring petroleum, and more than two-thirds of limestone bedrock unit groundwater samples were found to have benzene (a natural petroleum component) concentrations that exceed the drinking water standard (Section 2.6 of the groundwater FS [Shaw, 2008]). The limestone unit groundwater within the TNT and RWP Areas also meets the EPA guidelines for Class III nonpotable groundwater based on elevated concentrations of naturally occurring TDS, hydrogen sulfide, metals, and petroleum compounds. Depending on location, the limestone bedrock unit generally provides an adequate quantity of groundwater for use, but the natural quality of this water would fail drinking water standards. Therefore, groundwater from the limestone unit underlying the TNT and RWP Areas is nonpotable due to naturally poor quality that is unrelated to former DoD activities.

Reducing conditions were found to be present in the TNT and RWP Areas limestone bedrock unit groundwater, but not in the overburden/shale unit. The low dissolved oxygen concentrations (less than 1 mg/L) and low oxidation-reduction potential (-0.298 to -0.358 millivolts) measured in the limestone unit groundwater are indicative of reducing conditions. Naturally occurring petroleum hydrocarbons were found in the TNT and RWP Areas limestone bedrock unit groundwater. These compounds are common in groundwater in this region of northern Ohio. The petroleum hydrocarbons can provide a carbon source for microbes in groundwater that can deplete the available oxygen, creating anoxic, reducing conditions. The relationship between petroleum hydrocarbons present in the TNT and RWP Areas bedrock limestone groundwater and microbes may be the cause of the reducing conditions in this groundwater unit.

Groundwater Modeling. A site-specific groundwater model was run to support the BHHRA and the FS. This model included VLEACHSM (EPA, 1997) to simulate concentrations in groundwater based on leaching from soil, in combination with MODFLOW (McDonald and Harbaugh, 1988) and MT3D (Zheng, 1992) to model both the existing and modeled contaminant plumes over time. Leaching and transport were modeled for the three primary contaminants associated with former PBOW activities: TNT, 2,4-DNT, and 2,6-DNT.

At the time of the groundwater FS submittal, soil remediation, based on risks associated with direct soil contact, had already been completed at TNTB and at a hot spot at the PRRWP Area. Therefore, these removal actions represented baseline conditions. The model was run assuming soil remediation of TNTA, TNTC, and the PRRWP Area that had been planned or anticipated at

the time. Additionally, the model was run assuming various groundwater remedial actions including in situ enhanced bioremediation (ISEB) in various areas of the overburden/shale groundwater, and groundwater pump-and-treat (P&T) of the limestone bedrock unit groundwater plumes. Each model was simulated to run for 150 years.

The baseline conditions were used for the BHHRA (Section 2.7.1). The maximum modeled concentration of each of the three contaminants over the 150-year baseline model run was conservatively assumed in the BHHRA (Section 2.7.1) for each site area.

In the FS modeling effort, emphasis was placed on the cleaning up of contaminants in the overburden/shale and in the limestone bedrock. Even under modeling runs that include the application of ISEB, P&T, and soil removal, the model results indicate that the cleanup effort in the limestone bedrock groundwater is difficult. The results of the model show that residual contaminants, especially 2,4-DNT and 2,6-DNT, will still exist above the remedial goals (RG) (Section 2.8) after 150 years. The model identified 26 areas within the limestone bedrock unit groundwater under the three TNT Areas that are predicted to exceed the RG concentrations in the future. Please note that whether or not residual NACs were to exist decades into the future, the groundwater would still be nonpotable due to naturally occurring substances.

Using groundwater modeling as a supportive tool provides a scientific platform for the evaluation and comparison of different remedial alternatives. However, there are numerous uncertainties in the use of groundwater models. These include the behavior of models such as MODFLOW when applied to fractured bedrock such as the Delaware Limestone unit which underlies the TNT and RWP Areas. Also, the seasonal variability of precipitation results in water level fluctuations, especially in the overburden/shale unit, may not be adequately addressed by the model. The hydraulic properties of the aquifers are derived from slug tests and pumping tests from limited areas which are extrapolated to other areas between wells. Similarly, fate and transport models rely on data (e.g., soil bulk density and organic carbon content) from limited samples that may not be adequately representative of actual conditions across the site. Preferential flowpaths and seasonal fluctuations, both of which are present in the groundwater units, cannot be addressed by the models based on existing data. Finally, the PBOW groundwater model simulations assume that the groundwater plumes will be subject to natural attenuation with advection (dilution), dispersion, and adsorption (retardation), but no biodegradation or abiotic degradation component was included in the model. As described previously, the reducing conditions in the Delaware Limestone bedrock groundwater are conducive to both biotic and abiotic degradation of NACs. If natural attenuation is occurring to a significant degree, this

would result in the model greatly overestimating both DoD activity-related contaminant concentrations and the associated time frames for meeting RGs.

2.5.2 Investigation Overview

Field activities were conducted specifically to investigate environmental media at TNTA, TNTB, TNTC, and the RWP Areas, including soil, surface water, sediment, and groundwater. Even though this Decision Document addresses only groundwater, the sampling efforts for the other media are mentioned below to provide an accurate context of the investigation history of the TNT and RWP sites. The analytical results and characteristics for media other than groundwater are not presented in this Decision Document. Please note that these other media have been or will be addressed in other Decision Documents.

A total of 135 direct-push overburden/shale groundwater samples had been planned for collection in 2001, 45 within each of the TNT areas. However, after 32 borings were installed in the three TNT Areas, groundwater samples were collected from only 6 of these borings, as the other 26 borings lacked groundwater. Therefore, this sampling effort was abandoned due to a lack of groundwater.

The groundwater results are summarized for each of the TNT and RWP Areas in this section. There were numerous detections of NACs in the overburden/shale groundwater, but because the groundwater within the overburden/shale is discontinuous, no plumes were identified in this unit. For the overburden/shale unit, the monitoring well and direct-push groundwater samples were evaluated individually. The direct-push groundwater samples, which are far less expensive and take far less time to collect, were used to determine the presence or absence of detectable levels of NACs but are not regarded as being of sufficient quality for quantitative analysis. However, the direct-push groundwater sampling results were used in the development of the GW-3 and GW-4 remedial alternatives which are described in Section 2.9.

In the limestone bedrock unit, the groundwater FS identified two NAC plumes. Each has relatively low concentrations. One is north of the PRRWP Area (Figure 2-4) and contains both 2,4-DNT and 2,6-DNT. The other plume is in the vicinity of the WARWP Area (Figure 2-5) and is limited to 2,4-DNT only.

TNTA. Prior to the RI activities, one surface soil sample, two surface water samples, and two sediment samples were collected in 1993 in support of an initial site inspection (SI) completed in 1994. Thirty-six soil samples were collected during 1994, as reported in the 1997 SI report

(D&M, 1997b). With respect to groundwater, three overburden/shale unit wells were sampled in 1993 and five were sampled in 1994, 1996, 1997, and 1998.

RI activities were conducted separately for TNTA soils (479 samples), surface water (8 samples), and sediment (10 samples) in 2000 and for site groundwater in October 2001 through April 2002 (semiannual sampling from 2 overburden/shale wells and 2 limestone bedrock wells). One of the overburden/shale unit wells could not be sampled in 2001 because it was dry. The RI also evaluated five overburden/shale unit well samples collected in 1997 and the five samples collected in 1998.

A total of 11 direct-push overburden/shale groundwater samples were collected in 2000 and 2001; these also were used in the RI. A total of 45 temporary piezometer groundwater samples had been planned in 2001 for TNTA, but only 2 were collected due to a lack of groundwater in the overburden/shale.

Two limestone bedrock wells, one of which is located downgradient (BEDMW-17), were sampled in 1994, 1996, 1997, 1998, 2001 and 2002; the samples collected from these wells in 1997, 1998, 2001, and 2002 were used in the RI. A third bedrock well (TNTA-BEDGW-001) was installed and sampled in 2001 and sampled again in 2002 as part of the RI.

The maximum detected NAC concentration was 110 micrograms per liter (µg/L) of TNT. This DoD activity-related contaminant was detected in 27 percent of TNTA overburden/shale well samples, and TNT was detected at much higher concentrations in TNTA direct-push overburden/shale groundwater samples, up to 32,400 µg/L near Building 185 (a former PBOW DNT-nitrating house building). The soil in the vicinity of this direct-push sample is being remediated as part of the TNTA soil remedial action because of high soil concentrations of NACs and risks associated with direct contact. Based on sampling results from PBOW as well as other sites, analytical results from direct-push groundwater samples tend to be biased high for metals and NACs. This has been attributed both to the higher turbidity in direct-push groundwater samples and to contamination from overlying soil being dragged down into the groundwater during sampling. For these reasons, direct-push groundwater samples, as mentioned, are not regarded as being of adequate quality for quantitative evaluation of groundwater contamination.

The maximum detected NAC concentration among the TNTA limestone bedrock well samples was 3.6 µg/L of 2,6-DNT, which was detected in only one of six TNTA bedrock groundwater

samples. Note that TNT, detected in the overburden/shale groundwater, was not detected in any of the TNTA bedrock wells.

TNTB. RI activities were conducted separately for TNTB soils (431 samples), surface water (2 samples), and sediment (5 samples) in 1998 and for site groundwater in October 2001 through August 2004 (semiannual sampling from 2 overburden/shale wells and 4 bedrock wells). Two of these bedrock wells were installed in 2001. Two samples each of surface soil, surface water, and sediment were collected during 1993 in support of the SI completed in 1994, and 34 soil samples were collected in 1994 for the SI completed in 1997. Prior to the groundwater RI, the two overburden/shale unit wells were sampled in 1993, 1994, 1996, 1997, and 1998, and the two bedrock wells were sampled prior to the RI in 1996, 1997, and 1998. The groundwater samples collected in 1997 and 1998 were also evaluated as part of the RI.

A total of 45 temporary piezometer groundwater samples had been planned in 2001 for TNTB. Groundwater samples were collected from only two of these piezometer locations because of a lack of groundwater in the overburden/shale unit, and one of the samples had insufficient yield for complete analyses.

The maximum detected NAC concentration among the TNTB overburden/shale wells was 68 µg/L of TNT, which was detected in 80 percent of TNTB overburden/shale unit well samples. TNT was detected only once in the TNTB overburden/shale groundwater samples collected using direct-push technology and at a very low concentration (0.14 µg/L) and was not detected in TNTB limestone bedrock groundwater samples.

TNTC. RI activities were conducted separately for TNTC soils (415 samples), surface water (10 samples), and sediment (15 samples) in 2000 and for site groundwater in October 2001 through April 2002. Two overburden/shale unit wells were sampled in 2000, and three were sampled in 2002. Two limestone bedrock unit wells were sampled in both 2001 and 2002. As part of the RI, nine samples were collected from temporary piezometers in 2000, and samples were collected from two additional temporary piezometers in 2001 (though 12 other TNTC piezometer locations were dry). Prior to the groundwater RI activities, five overburden/shale wells were sampled in 1997 and 1998. One of the bedrock wells (BED-MW13) was also sampled in 1994, 1996, 1997, and 1998.

As part of the SI, one collocated surface water and sediment sample pair was collected in 1993 just downstream of the confluence of Pipe Creek and a small tributary running east-to-west in the

northern portion of TNTC. Two TNTC soil samples were collected during the SI (Morrison-Knudsen Corporation, 1994), and 19 soil samples were collected in 1994 during the SI (D&M, 1997c).

Numerous temporary piezometer groundwater samples had been planned in 2001 for TNTC, but only two of these could be collected due to a lack of groundwater in the overburden/shale unit.

The only NAC detected among the 15 TNTC overburden/shale unit well samples was TNT at 0.61 µg/L. TNT was detected at much higher concentrations in the TNTC direct-push overburden/shale unit groundwater samples (up to 20,100 µg/L), and 2,4-DNT was detected at an even higher concentration (37,600 µg/L). These concentrations of TNT and 2,4-DNT were detected near Building 683. The soil in the vicinity of this direct-push sample is being remediated as part of the TNTC soil remedial action because of high soil concentrations of NACs. As mentioned in the discussion for TNTA, the concentrations found in direct-push groundwater samples are commonly elevated due to a drag-down effect resulting from contamination in overlying soil. No NACs were detected in TNTC limestone bedrock unit groundwater.

RWP Areas. Focused RI sampling was performed for the RWP Areas in 1994. A total of 104 soil samples, 7 overburden/shale groundwater samples, and 4 bedrock groundwater samples were collected from both RWP Areas; 5 surface water and 12 sediment samples were collected from the WARWP Area alone.

Additional soil, sediment, surface water, and groundwater sampling was conducted during a direct-push investigation conducted in 1998. In the PRRWP Area, 20 surface soil, 39 subsurface soil, 20 overburden/shale unit groundwater, 4 surface water, and 4 sediment samples were collected from the PRRWP Area. This sampling effort also included 19 surface soil, 37 subsurface soil, 14 overburden/shale unit groundwater, 6 surface water, and 6 sediment samples collected from the WARWP Area. In addition to the samples collected during the focused RI and direct-push investigation, groundwater samples have been collected from overburden/shale unit and limestone bedrock monitoring wells associated with the two RWP Areas since 1997.

1,3,5-Trinitrobenzene was detected in 64 percent of the PRRWP Area overburden/shale well samples, with a maximum concentration of 6,900 µg/L. 1,3,5-Trinitrobenzene was detected in only 5 percent of the PRRWP Area direct-push samples and at a much lower concentration (600 µg/L) than in the overburden/shale well samples; note that as stated previously, the direct-

push samples are not of adequate quality for quantitative analysis. 2,4-DNT was the NAC detected in the PRRWP direct-push groundwater samples at the highest concentration (9,200 µg/L) and the greatest frequency (62 percent); this compound was detected in the overburden/shale well samples at a maximum concentration of 4,100 µg/L.

The maximum detected NAC concentration among the PRRWP Area limestone bedrock well samples was TNT at 1.6 µg/L in well PB-BED-MW15. TNT was detected in two of six PRRWP Area bedrock groundwater samples. 2,4-DNT and 2,6-DNT were each detected at a concentration of 0.89 µg/L in well PB-BED-MW15, and 2,4-DNT was also detected at a concentration of 1.5 µg/L in the former well BED-MW27, which has since been abandoned. Therefore, 2,4-DNT and 2,6-DNT in this area have been identified as a single low-concentration plume in the limestone bedrock unit groundwater (Figure 2-4). Note that the abandonment of well MW-27 was conducted consistent with Ohio EPA and Ohio Department of Natural Resources guidance, with appropriate forms submitted to the Ohio Department of Natural Resources.

Although 3-nitroaniline was the NAC detected at the highest concentration (estimated at 330 µg/L) among the PRRWP Area wells, it was detected only twice and the other sample had a much lower concentration (3.3 µg/L). 2,4-DNT was detected in 38 percent of the overburden/shale unit well samples in the PRRWP Area at a maximum concentration of 55 µg/L. Among NACs in the direct-push overburden/shale groundwater samples, 2,4-DNT had the highest concentration (950 µg/L). As noted for TNTA and TNTC, direct-push groundwater samples are not regarded as being of sufficient quality for quantitative evaluation of contamination because of soil drag-down.

The maximum detected NAC concentration among the WARWP Area limestone bedrock well samples was that of 3-nitrotoluene, which was detected only once at an estimated concentration of 150 µg/L. 2,4-DNT was detected twice in bedrock well samples at 19 and 16 µg/L. This 2,4-DNT area is identified as a groundwater plume on Figure 2-5.

2.5.3 Contamination Characterization

A total of 11 DoD activity-related contaminants were identified in the FS as chemicals of concern (COC) for the TNT and RWP Areas limestone bedrock unit groundwater. These 11 contaminants are either nitroaromatic explosives or nitrogen-containing chemicals that are either breakdown products or impurities, and include the following: TNT, 2,4-DNT, 2,6-DNT, 2-amino-4,6-dinitrotoluene (2-ADNT), 4-amino-2,6-dinitrotoluene (4-ADNT), 2-nitrotoluene,

4-nitrotoluene, nitrobenzene, 4,6-dinitro-2-methylphenol, 3-nitroaniline, and nitrate. Each of these 11 chemicals is an NAC, with the exception of nitrate.

Typically, COCs are chemicals for which remediation is required; most of these 11 contaminants were identified as COCs in the FS based on human health risk assessment results. However, subsequent to the BHHRA, use of the limestone bedrock groundwater unit was identified as an incomplete exposure pathway. Therefore, the human health risks associated with these 11 contaminants in limestone bedrock groundwater are regarded as negligible, and the presence of these chemicals in groundwater does not warrant remediation. For sake of clarity, these 11 DoD activity-related contaminants are identified in this section as the "FS contaminants," rather than "COCs."

Nine of these FS contaminants were identified based on the groundwater BHHRA, and two additional FS contaminants (2-ADNT and 4-nitrotoluene) were added because they were identified as soil COCs in the separate TNT Areas and RWP Areas (Section 2.7.1) and are closely related to one or more other groundwater FS contaminants. Table 2-1 provides data summaries of the FS contaminants in limestone bedrock groundwater for each TNT and RWP Area in which any of these 11 FS contaminants were detected. These summaries include frequencies of detection, concentration ranges, and the exposure point concentrations (EPC) used in the BHHRA (Section 2.7.1). Please note that no FS contaminants were detected in TNTC limestone bedrock unit groundwater.

2.5.3.1 Spatial Distribution and Potential Sources

The 11 FS contaminants are either nitroaromatic explosives or related nitrogen-containing compounds that are likely impurities or breakdown products. These chemicals are present as the result of surface spills and subsurface leaks that leached to the overburden/shale groundwater and then migrated downward to the limestone bedrock groundwater. This section provides an overview of FS contaminants in the limestone bedrock groundwater that is based on information presented in Table 2-1. Detections of NACs in the limestone bedrock groundwater underlying the TNT and RWP Areas are typically sporadic. This sporadic nature may be the result of reducing conditions in this groundwater unit which may affect the natural attenuation of NACs in this groundwater unit.

TNTA. Six FS contaminants were detected among the TNTA limestone bedrock groundwater samples: 2,4-DNT, 2,6-DNT, 2-ADNT, 4-ADNT, 2-nitrotoluene, and nitrobenzene. Of these, 2-ADNT was the most prevalent, as it was detected in 50 percent of samples. 2,6-DNT was

detected at the highest concentration (3.6 µg/L). This is the highest concentration among any of the TNT or RWP Area samples. However, 2,6-DNT was not detected in any other TNTA samples. Therefore, this detection of 2,6-DNT is regarded as sporadic and not representative of typical conditions underlying TNTA and the immediate vicinity.

TNTB. Nitrate is the only FS contaminant detected in TNTB limestone bedrock unit groundwater. It was detected in only one sample, and at a concentration (48 µg/L) that is less than the screening value used in the BHHRA (1,000 µg/L).

TNTC. No FS contaminants were detected in TNTC limestone bedrock unit groundwater.

PRRWP Area. Five FS contaminants were detected among the PRRWP Area limestone bedrock unit groundwater samples: TNT, 2,4-DNT, 2,6-DNT, 4-ADNT, and nitrobenzene. Of these, TNT was the most prevalent, as it was detected in 33 percent of samples. TNT was also detected at the highest concentration (1.6 µg/L).

WARWP Area. Five FS contaminants were detected among the WARWP Area limestone bedrock groundwater samples: 2,4-DNT, 4,6-dinitro-2-methylphenol, 3-nitroaniline, nitrobenzene, and nitrate. Of these, nitrate was the most prevalent, as it was detected in all samples. 3-Nitroaniline was detected at the highest concentration (150 µg/L). The WARWP Area is the only location where 4,6-dinitro-2-methylphenol and 3-nitroaniline were detected in limestone bedrock unit groundwater. 2,4-DNT was found at a higher concentration (19 µg/L) than in limestone bedrock groundwater from any of the other TNT or RWP Areas.

Downgradient. Five FS contaminants were detected among the TNTA limestone bedrock unit groundwater samples: 2,4-DNT, 2,6-DNT, 2-nitrotoluene, 4-nitrotoluene, and nitrobenzene. Of these, 2,6-DNT was the most prevalent, as it was detected in 17 percent of the downgradient samples. 2,4-DNT was detected at the highest concentration (1.5 µg/L), which is slightly higher than the highest concentration of 2,6-DNT (1.4 µg/L).

2.5.3.2 Volume of Contaminated Groundwater

Two groundwater plumes have been identified in the limestone bedrock unit groundwater (Section 2.5.2): one associated with the PRRWP Area (Figure 2-4) and another at the WARWP Area (Figure 2-5). The areal extent of the current 2,4-DNT and 2,6-DNT plume extending northeastward from the PRRWP Area to the vicinity of abandoned well BED-MW27 (Figure 2-4) is approximately 810,000 square feet (ft^2). The average thickness of the contamination

within the limestone bedrock groundwater at this location was estimated based on well construction data as 50 feet, which equals a formation volume of 40.5 million cubic feet (ft^3). Based on an effective porosity in the limestone of 0.2, the volume of contaminated groundwater within the PRRWP Area plume is estimated (0.2 × 40.5 million ft^3 × 7.48 gallons/ft^3) as 61 million gallons.

The current WARWP 2,4-DNT plume thought to extend northeastward from the WARWP Area to the vicinity of well BED-MW14 is approximately 570,000 ft^2 in area. The average thickness of the contamination within the limestone bedrock unit groundwater at this area was estimated as 53 feet. The formation volume of this plume is thus equal to 30.2 million ft^3. Based on an effective porosity in the limestone of 0.2, the volume of contaminated groundwater within the WARWP Area plume is approximately 45 million gallons.

Additionally, contamination in the overburden/shale unit groundwater (Section 2.5.2) may migrate downward to the limestone bedrock unit groundwater. A groundwater fate and transport model was run and the results were used to determine the areas of contamination within the overburden/shale groundwater unit that may adversely affect the limestone bedrock unit groundwater. The volume for each of the areas in the overburden/shale unit groundwater is as follows:

- TNTA – 2,533,000 gallons
- TNTB – 25,000 gallons
- TNTC – 770,000 gallons
- PRRWP Area – 6,224,000 gallons
- WARWP Area – 13,839,000 gallons.

This equals an overall volume of approximately 23,400,000 gallons.

2.5.3.3 Toxicity and Mobility of Contaminants

The toxic characteristics of the 11 limestone bedrock unit FS contaminants are presented in Section 2.7.1.3. In summary, 2,4-DNT, 2,6-DNT, TNT, 2-nitrotoluene, 4-nitrotoluene, and 3-nitroaniline are regarded as carcinogens. Each of these 11 FS contaminants also have known adverse noncancer effects, as presented in Section 2.7.1.3.

FS contaminants present in groundwater are generally in the dissolved phase; thus, their potential mobility is determined by groundwater flow. Based on analytical data, lateral movement of contamination in the overburden/shale is limited. The groundwater tends to occur in discrete pockets in the overburden and does not represent a contiguous lateral unit. Wells screened in

underlying competent shale indicate that vertical contaminant transport downward from the overburden is limited. In areas where the competent shale is thin to absent (i.e., WARWP and PRRWP), NACs have been detected sporadically and at low concentrations. This behavior suggests that contamination from the overburden may be released in slugs directly to the underlying limestone bedrock during periods of high precipitation. The strongly reducing conditions within the limestone bedrock likely result in the degradation of the NACs, which is evidenced by sporadic and only low concentrations of the 10 NACs which are FS contaminants.

2.5.3.4 Potential Human and Ecological Receptors at Risk

Human health and ecological risks are summarized in Sections 2.7.1 and 2.7.2, respectively. No current human receptors appear to be at risk with respect to DoD activity-related chemicals, as the groundwater underlying the PBOW facility is not currently used. The natural poor quality of the groundwater should preclude its use, especially for potable purposes. The corrosiveness associated with naturally occurring hydrogen sulfide of the limestone bedrock unit groundwater would seemingly preclude any use of this water because of its damaging effects on metal components of pumps, well casings, and plumbing fixtures. Although by agreement between the USACE and Ohio EPA, potable use of TNT and RWP Areas groundwater was quantitatively evaluated in the BHHRA, use of groundwater underlying PBOW is regarded as an incomplete exposure pathway. However, there are currently no legal constraints to prevent a future resident from installing a well and using the groundwater as household tap water. Please refer to the summary of the BHHRA in Section 2.7.1 for additional information. As stated in Section 2.7.2, no groundwater exposure pathways have been identified for ecological receptors.

2.6 Current and Potential Future Land Uses

The PBOW facility is currently surrounded by a chain-link fence, and the perimeter is patrolled regularly. Access by authorized personnel is limited to established checkpoints. Public access is restricted except during the controlled annual deer hunting season. Portions of each of the TNT and RWP Areas have been hunted at some point during these times. There are no regular uses of any of the TNT or RWP Areas except for TNTA, a portion of which includes the NASA Administration Building. Groundwater is not used for any purpose within the PBOW facility.

Two deep or limestone bedrock groundwater aquifer systems are utilized for drinking water in the area: a carbonate aquifer to the west and a shale aquifer to the east (IT, 1997). PBOW is located within the transition of the two systems. Groundwater underlying PBOW is not currently used for any purpose. A majority of residents in Erie County receive water from public utilities whose sources are surface water. Only public utilities may use surface water as a drinking water

source, as the Erie County Health Department does not allow the use of surface water as private drinking water.

At some point in the future, it is possible that NASA may desire to either use or excess any or all of the TNT or RWP properties. If a decision were made to excess, the GSA would be contacted to facilitate transfer of the property through their process. The TNT and RWP Areas could potentially be developed in the future, either for commercial/industrial or residential purposes, as there are currently no land-use controls or restrictions on the TNT and RWP Areas. The remedial alternatives in this Decision Document were developed assuming both residential and unrestricted land use. This assumption is appropriate because the area surrounding the former PBOW facility is rural and residential.

As discussed in Section 2.5.1, the groundwater underlying the TNT and RWP areas is of poor natural quality. This finding is borne out by the observation that none of the residents within 1 mile downgradient of PBOW use the water as a potable source. Given the low groundwater quality, including the hydrogen sulfide off-gassing (which produces offensive odors that may represent a health hazard and damage pump, well casing, and plumbing components) and the availability of municipal water within the vicinity, it is unlikely that any individual will use groundwater underlying the TNT and RWP Areas.

2.7 Summary of Site Risks

Potential risks to human health and the environment were evaluated for groundwater underlying the TNT and RWP Areas. The purposes of this section are as follows:

- Provide a brief summary of the relevant portions of the BHHRA (Section 2.7.1).
- Provide a statement regarding environmental hazards with respect to groundwater (Section 2.7.2).
- State the basis for taking action at the site (Section 2.7.3).

2.7.1 Summary of Human Health Risks

The BHHRA for TNT and RWP groundwater was completed in 2006 (Shaw, 2006). The identification of COCs, exposure assessment, toxicity assessment, and risk characterization are described in Sections 2.7.1.1 through 2.7.1.4. Only validated analytical data were used in the BHHRA.

2.7.1.1 Identification of Chemicals of Concern

COCs were identified as those chemicals in groundwater that contributed most to an additional cancer risk, referred to as an incremental lifetime cancer risk (ILCR), exceeding 1×10^{-5} or an additional noncancer hazard index (HI) exceeding 1. In addition, NACs that were identified as soil COCs in any of the TNT or RWP Areas were added as groundwater COCs because of their potential to leach to groundwater. The following 11 chemicals were identified as COCs for limestone bedrock unit groundwater: TNT, 2,4-DNT, 2,6-DNT, 2-ADNT, 4-ADNT, 2-nitrotoluene, 4-nitrotoluene, nitrobenzene, 4,6-dinitro-2-methylphenol, 3-nitroaniline, and nitrate.

2.7.1.2 Exposure Assessment

Exposure assessment presents the exposure pathways evaluated, the populations potentially exposed to the chemicals of potential concern (COPC), the data and assumptions used to characterize EPCs, and assumptions about exposure frequency and duration included in the exposure assessment. The mathematical output of the exposure assessment is the chronic daily intake (CDI), which represents the level of exposure to a chemical that an individual would receive under a given set of exposure assumptions. The EPCs are based on reasonable maximum exposure assumptions (EPA, 1989); either the 95 percent upper confidence limit of the mean or the maximum detected concentration, whichever is less, was used (Shaw, 2006). The EPC values for the COCs in limestone bedrock unit groundwater are included in Table 2-1 for TNTA, the PRRWP Area, and the WARWP. No COCs were detected in TNTC limestone bedrock unit groundwater, and nitrate, the only COC detected in TNTB limestone bedrock unit groundwater, was detected at a concentration less than the screening value. For this reason, exposure to nitrate was not quantitatively evaluated in the BHHRA and thus no EPC was calculated.

Exposure is typically evaluated based on plausible exposure pathways. Exposure associated with the COPCs was evaluated using the following human receptors as surrogates to represent all exposed or potentially exposed groups of people at the TNT Areas, RWP Areas, and downgradient areas under current land use, future land use, or both. Because groundwater is not used within the PBOW facility for any purpose, there is no current on-site exposure pathway involving contaminated groundwater. Groundwater from off-site, downgradient private wells is not currently used for purposes other than watering gardens or washing cars, and no DoD activity-related chemicals were detected in downgradient groundwater. Therefore, current exposure to groundwater was not evaluated.

The overburden/shale unit groundwater underlying the TNT and RWP Areas is spatially discontinuous and produces inadequate yield for use. Therefore, this upper groundwater unit was not evaluated for exposure under either current or future scenarios.

Use of limestone bedrock unit groundwater underlying the TNT and RWP Areas, as well as downgradient areas, was quantitatively evaluated in the BHHRA in a future land-use scenario. A review of the analytical data evaluated in the BHHRA indicates that the naturally occurring constituents in the limestone bedrock groundwater samples, including petroleum hydrocarbon compounds, hydrogen sulfide, and TDS, render the water nonpotable. Thus, use of the groundwater underlying the TNT Areas, RWP Areas, and downgradient areas is regarded as implausible, although it is noted that no current legal restrictions exist that would prevent a future on-site resident (or current off-site resident) from using the limestone bedrock unit groundwater as a source of household tap water. Also, municipal water is readily available in the area. Typically, the BHHRA evaluates only plausible exposure scenarios. This evaluation of an implausible exposure pathway represents a departure from standard risk assessment practice. The groundwater exposure pathways and human receptors evaluated in the BHHRA are depicted on Figure 2-6. Each of the receptors is briefly described below.

Future On-Site Worker. In a future land use scenario, an adult on-site worker was assumed to be exposed to on-site groundwater which is theoretically developed as a source of drinking water in the future in an industrial/commercial setting. This individual is assumed to be exposed via ingestion of water for drinking and dermal exposure associated with hand washing.

Future On-Site Resident. In a future land use scenario, an on-site resident was assumed to be exposed to groundwater which is theoretically developed as a source of drinking water for household use, despite the fact that municipal water is readily available. This individual is assumed to be exposed via ingestion of water for drinking, dermal exposure for bathing, and inhalation of contaminants that have volatilized to indoor air. The on-site residential scenario was evaluated using both an adult and a young child (ages 1 through 6 years). Cancer risk was estimated as the sum of the risks calculated for the adult and the child. The child was used for the noncancer evaluation to capture the greater conservativeness of the larger water ingestion and dermal exposure rates for the child, when normalized for body weight.

Future Off-Site Resident. This receptor is evaluated the same as the future on-site resident but at the downgradient property boundary rather than on site.

2.7.1.3 Toxicity Assessment

The toxicity assessment provides information regarding the type and severity of adverse health effects that could result from exposure to COPCs and a measure of the dose-response relationship for each chemical. The dose-response relationships for oral, inhalation, and dermal toxicity are expressed quantitatively as noncancer chronic reference doses (RfD) and cancer slope factors (SF).

RfDs are chemical-specific values that have been developed by EPA for indicating the potential for adverse noncancer health effects resulting from exposure. RfDs, which are expressed in units of milligrams per kilogram of body weight per day (mg/kg-day), are estimates of lifetime daily exposure levels for humans, including sensitive individuals. SFs are developed by EPA and were used to estimate excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. SFs, expressed in cancer incidence per mg/kg-day ($[\text{mg/kg-day}]^{-1}$), were used in the BHHRA to provide an upper-bound estimate of the ILCR associated with exposure to contaminants in TNT and RWP Areas groundwater. A weight-of-evidence classification is placed on each SF by the EPA's Carcinogenic Assessment Group, as shown in Table 2-2.

These chemical-specific RfD and SF values were obtained from the EPA Integrated Risk Information System (IRIS) database (EPA, 2013) or from other EPA sources if no values were available from IRIS. Target organ information for noncancer effects and additional toxicity information were likewise obtained from IRIS or other sources if not available on IRIS. Please note that the IRIS database is continuously updated and that the IRIS information used in the BHHRA (which was finalized in 2006) is from 2005. Toxicity values and associated information used in the BHHRA for the COCs are shown in Table 2-2.

2.7.1.4 Risk Characterization

Cancer risk and noncancer hazard values were calculated separately for each receptor and exposure scenario. Cancer risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as the result of exposure to the carcinogen. The ILCR represents the "excess" risk posed by exposure to the specific carcinogen source in question. The baseline cancer risk for the U.S. population has been estimated at approximately 40 percent. EPA's generally acceptable risk range (EPA, 1990; 1991a; 1999) is between 1×10^{-4} (1 in 10,000) and 1×10^{-6} (1 in 1,000,000). The Ohio EPA uses a goal of 1×10^{-5}. For the sake of illustration, if it were assumed that an individual had exactly a 40 percent chance (400,000 in 1,000,000) of developing cancer without a specific exposure, an additional exposure at an ILCR of 1×10^{-5} (1 in 100,000) would result in an overall cancer risk of 400,010 in 1,000,000.

The ILCR is calculated from the following equation:

$$ILCR = CDI \times SF \qquad \text{Eq.1}$$

where:

ILCR = incremental lifetime cancer risk of an individual developing cancer over a lifetime (unitless)
CDI = chronic daily intake averaged over a 70-year lifetime (mg/kg-day)
SF = slope factor ([mg/kg-day]$^{-1}$).

The potential for noncancer effects is evaluated by comparing an exposure level over a specified time period (e.g., 30 years) with an RfD appropriate for that time period (i.e., chronic). An RfD is the threshold level at which one could be exposed and not suffer any deleterious effect. The ratio of exposure to the RfD is the hazard quotient (HQ). The HQ values were calculated for PBOW as follows:

$$HQ = CDI/RfD \qquad \text{Eq. 2}$$

where:

HQ = noncancer hazard quotient
CDI = chronic daily intake, averaged over a specific chronic period (mg/kg-day)
RfD = chronic reference dose.

Thus, a CDI less than the RfD results in an HQ of less than 1. The HI is calculated by adding the HQ values of the COCs that affect the same target organ in a given environmental medium (e.g., soil) or across all media to which an individual is assumed to be exposed. An HI of less than or equal to 1 indicates that adverse noncancer effects are unlikely to occur; an HI exceeding 1 indicates that adverse effects may potentially occur.

Risk characterization results for the groundwater COCs in limestone bedrock unit groundwater are summarized by TNT and RWP Area, including downgradient locations, in Tables 2-3 through 2-21. The results for TNTA (Tables 2-3 through 2-6) are followed by those of TNTB (Table 2-7), TNTC (Table 2-8), PRRWP Area (Tables 2-9 through 2-12), WARWP Area (Tables 2-13 through 2-16), and the downgradient areas at the property boundary (Tables 2-17 through 2-21). Cancer and noncancer risk characterization results are presented in two ways for each area: 1) based on measured concentrations from the monitoring wells associated with the various areas individually, and 2) based on concentrations of the three COCs (TNT, 2,4-DNT, and 2,6-DNT) in limestone bedrock unit groundwater that are modeled from soil and

overburden/shale unit groundwater concentrations that leach to limestone bedrock unit groundwater. This model is described in Section 2.5.1. These three COCs were selected for modeling because they are generally the most prevalent COCs in TNT and RWP Areas soil and groundwater with respect to concentration and risk. The measured and modeled concentrations are presented in separate tables.

The tables that present risks based on measured groundwater concentrations also present the combined total risk/hazard for all detected chemicals, including those which are naturally occurring. The risks associated with naturally occurring, non-DoD activity-related chemicals are included in these tables to demonstrate the considerable contribution of these chemicals in the low-quality groundwater unit (Section 2.5.1), as a whole, to overall risks in this medium. Table 2-22 presents a summary of the risks and hazards associated with DoD activity-related chemicals (i.e., COCs) in comparison to risks and hazards associated with non-DoD activity-related, naturally occurring chemicals for all TNT and RWP sites for reference. These are shown in the columns on Table 2-22 with the respective headings "DoD Activity-Related" and Non-DoD Activity-Related" for noncancer hazard and cancer risk. The summed risks and hazards associated with non-DoD activity-related, naturally occurring chemicals that are presented in Table 2-22 are the total risks and hazards shown in Tables 2-3 through 2-18, minus the DoD activity-related contributions shown on these same tables. Note that Table 2-22 is the only table which presents risks and hazards for TNTB and TNTC based on measured concentrations of chemicals in groundwater; the measured concentrations of COCs in TNTB and TNTC groundwater were found to be negligible or all nondetected. Table 2-23 presents a comparison of the risk/hazards associated with the COCs to those of naturally occurring background groundwater with respect to percentage associated with COCs versus background.

TNTA Groundwater Risk Characterization Results Summary

- ***DoD Activity-Related Risks Using Current Measured Concentrations.*** Using current measured concentrations, DoD activity-related risks/hazards of the COCs associated with residential use of TNTA groundwater (ILCR=4×10^{-5}; HI=2) (Tables 2-3 and 2-4) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal and the target HI goal, but those associated with on-site worker use (ILCR=1×10^{-5}; HI=0.2) would not. DoD activity-related cancer risks associated with the TNTA on-site resident (Table 2-3) and worker (Table 2-5), based on current concentrations, are within the NCP acceptable range (1×10^{-6} to 1×10^{-4}). For each receptor, the DoD activity-related risks/hazards account for 4 percent or less of the total; for TNTA, non-DoD activity-related chemicals account for 96 percent or more of the total risks/hazards (Table 2-23).

- ***DoD Activity-Related Risks Using Modeled Future Concentrations.*** Using modeled future concentrations that include modeled future potential impact from overburden/shale unit groundwater, DoD activity-related risks/hazards associated with residential use of TNTA groundwater (ILCR=5×10^{-4}; HI=4) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal and the target HI goal. Likewise, the cancer risk for the worker (1×10^{-4}) would exceed the Ohio EPA goal, but the worker HI (0.5) would not (Table 2-8). Assuming future modeled concentrations, DoD activity-related cancer risks associated with the TNTA on-site resident exceed the NCP acceptable range; DoD activity-related cancer risks associated with the worker are at the upper limit of the NCP acceptable range (1×10^{-6} to 1×10^{-4}).

- ***Non-DoD Activity-Related Risks Using Current Measured Concentrations.*** The naturally occurring, non-DoD activity-related cancer risks associated with residential use (ILCR=2×10^{-3}) and worker use (ILCR=2×10^{-4}) indicate unacceptable cancer risks for the resident with respect to both the Ohio EPA (1×10^{-5}) cancer risk goal and NCP acceptable risk range (1×10^{-6} to 1×10^{-4}). Also, the noncancer HI values for the resident (HI=345) and for the worker (HI=10) exceed the target HI goal of 1 (Table 2-22). These ILCR and HI values clearly indicate unacceptable risks and hazards associated with naturally occurring, non-DoD activity-related chemicals under a residential or worker use scenario. For each receptor, the non-DoD activity-related risks/hazards account for 96 percent or more of the total (Table 2-23).

TNTB Groundwater Risk Characterization Results Summary

- ***DoD Activity-Related Risks Using Current Measured Concentrations.*** The groundwater BHHRA identified no DoD activity-related COPCs in the TNTB limestone bedrock groundwater unit. Cancer risks and noncancer hazards associated with DoD activity-related chemicals in TNTB groundwater, based on measured concentrations, are considered negligible.

- ***DoD Activity-Related Risks Using Modeled Future Concentrations.*** Using modeled future concentrations that include modeled future potential impact from overburden/shale groundwater, DoD activity-related cancer risks (ILCR=2×10^{-5}) for the resident would slightly exceed the Ohio EPA target cancer risk goal but would be well within the NCP acceptable range. The DoD activity-related cancer risk estimate for the worker (ILCR=6×10^{-6}) would meet the Ohio EPA target cancer risk goal. Noncancer hazards for the resident (HI=0.1) and worker (HI=0.02) based on modeled concentrations would meet the target goal of 1 (Table 2-7).

- ***Non-DoD Activity-Related Risks Using Current Measured Concentrations.*** The naturally occurring, non-DoD activity-related cancer risks associated with residential use (ILCR=3×10^{-4}) and worker use (ILCR=7×10^{-5}) indicate unacceptable cancer risks with respect to the Ohio EPA (ILCR=1×10^{-5}) cancer risk goal. The cancer risk for the resident exposed to naturally occurring chemicals in TNTB groundwater also exceeds the NCP acceptable range. The

noncancer HI value for the resident (18) exceeds the target HI goal of 1, whereas the HI value for the worker (0.8) does not (Table 2-22). The ILCR and HI values clearly indicate unacceptable risks and hazards associated with naturally occurring, non-DoD activity-related chemicals under a residential use scenario. Virtually 100 percent of risks and hazards associated with exposure to TNTB groundwater are associated with non-DoD activity-related, naturally occurring chemicals (Table 2-23).

TNTC Groundwater Risk Characterization Results Summary

- ***DoD Activity-Related Risks Using Current Measured Concentrations.*** The groundwater BHHRA identified no DoD activity-related COPCs for the TNTC limestone bedrock groundwater unit. Cancer risks and noncancer hazards associated with DoD activity-related chemicals in TNTC groundwater, based on measured concentrations, are considered negligible.

- ***DoD Activity-Related Risks Using Modeled Future Concentrations.*** Using modeled future concentrations that include modeled future potential impact from overburden/shale groundwater, DoD activity-related risks/hazards associated with residential use of TNTC groundwater (ILCR=2×10^{-3}; HI=8) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal and the target HI goal. Likewise, the cancer risk for the worker (ILCR=4×10^{-4}) would exceed the Ohio EPA goal for cancer risk, but the worker HI (1) would not exceed the target HI threshold of 1. Assuming future modeled concentrations, DoD activity-related cancer risks associated with both the TNTC on-site resident and worker exceed the NCP acceptable range (Table 2-8).

- ***Non-DoD Activity-Related Risks Using Current Measured Concentrations.*** The naturally occurring, non-DoD activity-related cancer risks associated with residential use (ILCR=1×10^{-3}) and worker use (ILCR=9×10^{-5}) indicate unacceptable cancer risks for the resident with respect to the Ohio EPA (ILCR=1×10^{-5}) cancer risk goal. The ILCR associated with naturally occurring, non-DoD activity-related chemicals for the resident also exceeds the NCP acceptable risk range. The non-DoD activity-related noncancer HI value for the resident (65) exceeds the target HI goal of 1; that of the worker equals this goal (Table 2-22). These ILCR and HI values clearly indicate unacceptable risks and hazards associated with naturally occurring, non-DoD activity-related chemicals under a residential use scenario. Virtually 100 percent of risks and hazards associated with exposure to TNTC groundwater are associated with non-DoD activity-related, naturally occurring chemicals (Table 2-23).

PRRWP Area Groundwater Risk Characterization Results Summary

- ***DoD Activity-Related Risks Using Current Measured Concentrations.*** Using current concentrations, DoD activity-related cancer risks associated with residential use of PRRWP Area groundwater (ILCR=2×10^{-5}) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal (Table 2-9), but the noncancer hazard (HI=0.6) would meet the target HI goal (Table 2-10). The residential cancer risk would be

within the NCP acceptable range. DoD activity-related cancer risks associated with on-site worker use of groundwater (ILCR=4×10^{-6}) would meet the Ohio EPA cancer risk goal, and noncancer hazards (HI=0.07) for the worker would meet the noncancer target HI of 1 (Table 2-11). For each receptor, the DoD activity-related risks/hazards account for 1 percent or less of the total; for PRRWP groundwater, non-DoD activity-related chemicals account for more than 99 percent of the total risks/hazards (Table 2-23).

- ***DoD Activity-Related Risks Using Modeled Future Concentrations.*** Using modeled future concentrations that include modeled future potential impact from overburden/shale unit groundwater, DoD activity-related risks associated with residential use of PRRWP Area groundwater (ILCR=2×10^{-4}) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal; the target noncancer hazard (HI=0.7) would meet the target HI goal of 1. Likewise, the cancer risk for the worker (4×10^{-5}) would exceed the Ohio EPA goal, and the worker HI (0.1) would not exceed the target goal of 1. Assuming future modeled concentrations, DoD activity-related cancer risks associated with the PRRWP Area on-site resident exceed the NCP acceptable range; DoD activity-related cancer risks associated with the worker are within the NCP acceptable range (Table 2-12).

- ***Non-DoD Activity-Related Risks Using Current Measured Concentrations.*** The naturally occurring, non-DoD activity-related cancer risks associated with residential use (ILCR=7×10^{-3}) and worker use (ILCR=5×10^{-4}) indicate unacceptable cancer risks with respect to the Ohio EPA (1×10^{-5}) cancer risk goal. Also, the residential and worker cancer risks associated with exposure to non-DoD activity-related chemicals in groundwater exceed the NCP acceptable risk range. The noncancer HI values for both the resident (234) and the worker (15) exceed the target HI goal of 1 (Table 2-22). These ILCR and HI values clearly indicate unacceptable risks and/or hazards associated with naturally occurring, non-DoD activity-related chemicals under a residential or worker use scenario. For each receptor, the non-DoD activity-related risks/hazards account for more than 99 percent of the total (Table 2-23).

WARWP Area Groundwater Risk Characterization Results Summary

- ***DoD Activity-Related Risks Using Current Measured Concentrations.*** Using current measured concentrations, DoD activity-related cancer risks associated with residential use of WARWP Area groundwater (ILCR=2×10^{-4}) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal (Table 2-13), and the noncancer hazard (HI=59) would exceed the target HI goal (Table 2-14). The residential cancer risk would also exceed the NCP acceptable range. DoD activity-related cancer risks associated with on-site worker use of groundwater (ILCR=6×10^{-5}) would exceed the Ohio EPA cancer risk goal but would be within the NCP acceptable range. Noncancer hazards (HI=9) for the worker would exceed the noncancer target HI of 1 (Table 2-15). For each receptor, the DoD activity-related cancer risks account for

approximately 53 percent of the total WARWP cancer risks, and DoD activity-related hazards account for approximately 91 percent of total WARWP hazards (Table 2-23).

- ***DoD Activity-Related Risks Using Modeled Future Concentrations.*** Using modeled future concentrations that include modeled future potential impact from overburden/shale groundwater, DoD activity-related risks associated with residential use of WARWP Area groundwater (ILCR=2×10^{-4}) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal; the target noncancer hazard (HI=0.6) would meet the target HI goal of 1. Similarly, the cancer risk for the worker (4×10^{-5}) would exceed the Ohio EPA goal, and the worker HI (=0.09) would meet the target goal of 1. Assuming future modeled concentrations, DoD activity-related cancer risks associated with the PRRWP Area on-site resident exceed the NCP acceptable range; DoD activity-related cancer risks associated with the worker are within the NCP acceptable range (Table 2-16).

- ***Non-DoD Activity-Related Risks Using Current Measured Concentrations.*** The naturally occurring, non-DoD activity-related cancer risks associated with residential use (ILCR=2×10^{-4}) and worker use (ILCR=5×10^{-5}) indicate unacceptable cancer risks with respect to the Ohio EPA (1×10^{-5}) cancer risk goal (Table 2-22). Also, the residential cancer risks associated with exposure to non-DoD activity-related chemicals in groundwater exceed the NCP acceptable risk range. The noncancer HI value for the resident (4) exceeds the target HI goal of 1, but that of the on-site worker (0.6) does not (Table 2-22). These ILCR and HI values clearly indicate unacceptable risks and hazards associated with naturally occurring, non-DoD activity-related chemicals under a residential use scenario. Approximately 47 percent of the cancer risk and 9 percent of the summed noncancer hazard are associated with naturally occurring, non-DoD activity-related chemicals in groundwater.

Downgradient Boundary Groundwater Risk Characterization Results Summary

- ***DoD Activity-Related Risks Using Current Measured Concentrations.*** Using current measured concentrations from all downgradient areas nearest the property boundary, DoD activity-related risks/hazards associated with residential use of downgradient groundwater, the ILCR (ILCR=3×10^{-5}) would exceed the 1×10^{-5} Ohio EPA target cancer risk goal but would be within the NCP acceptable risk range (Table 2-17). The HI (0.4) would meet the target HI goal (Table 2-18). The DoD activity-related cancer risks account for approximately 7.5 percent of the total downgradient cancer risks, and DoD activity-related hazards account for approximately 0.4 percent of total hazards associated with measured concentrations in downgradient groundwater (Table 2-23).

- ***DoD Activity-Related Risks Using Modeled Future Concentrations for Areas Downgradient of TNTA.*** Using modeled future concentrations of locations downgradient from TNTA, the cancer risk (ILCR=4×10^{-7}) meets the Ohio EPA goal of 1×10^{-5}. The noncancer HI for groundwater in areas downgradient of TNTA is 0.002, which meets the target HI value of 1 (Table 2-19).

- ***DoD Activity-Related Risks Using Modeled Future Concentrations for the Area Downgradient of TNTB, TNTC, and the PRRWP Area.*** Using modeled future concentrations of locations downgradient from TNTB, TNTC, and the PRRWP Area, the resultant predicted cancer risk (ILCR=2×10^{-5}) slightly exceeds the Ohio EPA goal of 1×10^{-5} but is within the NCP acceptable range. The noncancer hazard (HI=0.08) meets the target goal of 1. It is noted that the modeled concentrations and the resultant ILCR values are likely to be overestimates of future conditions (Table 2-20).

- ***DoD Activity-Related Risks Using Modeled Future Concentrations for Areas Downgradient of the WARWP Area.*** Using modeled future concentrations of locations downgradient from the WARWP Area, the cancer risk (ILCR=1×10^{-6}) meets the Ohio EPA goal of 1×10^{-5}. The noncancer HI of 0.006 for areas downgradient of the WARWP Area meets the target HI value of 1 (Table 2-21).

- ***Non-DoD Activity-Related Risks Using Current Measured Concentrations.*** Using current measured concentrations, the naturally occurring, non-DoD activity-related cancer risks associated with residential use of groundwater from all downgradient areas nearest the property boundary is 4×10^{-4}, which exceeds both the Ohio EPA goal and the NCP acceptable range. Similarly, the noncancer hazards associated with naturally occurring chemicals at the property boundary (HI=99) exceed the target HI of 1. These ILCR and HI values clearly indicate unacceptable risks and hazards associated with naturally occurring, non-DoD activity-related chemicals under a residential use scenario (Table 2-22). Approximately 99.6 percent of the cancer risk and 92.5 percent of the summed noncancer hazard based on residential use of downgradient groundwater are associated with naturally occurring, non-DoD activity-related chemicals in groundwater.

Uncertainty Analysis. Numerous uncertainties, many of which are difficult to quantify, exist throughout the risk assessment process and may affect the ILCR and HI estimates. The most substantial uncertainty associated with the TNT and RWP Areas groundwater BHHRA is that of the plausibility of potential use of groundwater underlying PBOW. As described in Section 2.5.1, groundwater underlying PBOW is of low natural quality. Background overburden/shale groundwater unit exceeds SDWRs for numerous parameters, especially chloride, manganese, sodium, and TDS. This groundwater unit underlying the TNT and RWP Areas was also found to be of low yield where water was present. Similarly, the limestone bedrock unit groundwater is of low quality and would fail potable criteria, chiefly because of the presence of naturally occurring petroleum-related compounds, hydrogen sulfide, inorganics, and TDS. The assumption of using this groundwater as a source of tap water greatly exaggerates exposure, which would appear to be negligible or nonexistent.

Another area of considerable uncertainty is the use of the groundwater flow and fate and transport models to derive estimated future concentrations. The uncertainties of these models are discussed in Section 2.5.1. These uncertainties associated with the model would tend to add a high bias to modeled concentrations and associated risks presented in the BHHRA. Other uncertainties associated with the BHHRA include sample location selection, EPC estimates, exposure assumption values, toxicity, and risk characterization practices. In general, most of these uncertainties are biased conservatively, resulting in overestimates of risk, under the implausible assumption of groundwater use as a source of tap water.

BHHRA Conclusion. Exposure to the naturally occurring constituents in groundwater underlying each of the TNT Areas, RWP Areas, and downgradient areas would result in cancer risks that exceed the NCP risk management range and would result in noncancer hazards that exceed the noncancer HI goal of 1 (Table 2-22). With respect to DoD activity-related contaminants measured in groundwater, only TNTA and the WARWP Area have associated cancer risks that exceed the NCP risk management range, and only the WARWP Area has a noncancer HI that exceeds the HI goal (Table 2-22). In each of the areas except the WARWP Area, the naturally occurring constituents comprise over 92 percent of the cancer risks and over 99 percent of the noncancer hazards to the hypothetical resident (Table 2-23). Only in the WARWP Area groundwater does the DoD activity-related cancer risk or noncancer hazard exceed the respective cancer risk contributions from naturally occurring chemicals. However, as mentioned, the cancer risks and noncancer hazards of the naturally occurring chemicals alone (i.e., without contributions from DoD activity-related contaminants) in WARWP Area groundwater exceed the respective NCP risk management range and the HI criterion of 1.

It should be noted that the site-specific risk assessment for groundwater was included to satisfy administrative requirements, including FUDS requirements. The poor natural quality of the groundwater (Section 2.5.1), which is evident from the results of the BHHRA, should preclude any attempt to use this groundwater, even though there are currently no legal impediments for a property owner in the vicinity of PBOW to install a well. Therefore, use of this water is regarded as implausible, especially given the ready availability of municipal water in the area. The results of the BHHRA should thus be considered as hypothetical and an illustration that the DoD contributions to risks and hazards are negligible in comparison to those resulting from naturally occurring conditions for all areas except the WARWP Area, which likewise has risks and hazards associated with the naturally occurring constituents that exceed the NCP risk criteria and hazard criteria.

2.7.2 Ecological Risk Summary

Ecological risks were not evaluated for groundwater because no exposure pathway was identified via which ecological receptors may come into contact with groundwater.

2.8 Description of Alternatives

As agreed by the Project Delivery Team, a range of remedial alternatives was developed and evaluated in the FS and FS Addendum. These alternatives represent a broad range of remedial alternatives that allow the project risk managers to assess the relative cost-effectiveness of different remedial strategies that employ varying degrees of active remediation and/or monitoring, as well as No Further Action. The development of these remedial alternatives had been based on meeting remedial action objectives (RAO), which were defined based on chemical-specific RGs for groundwater. The RGs had been developed in the FS based on the assumption of potable groundwater use.

During preparation of the proposed plan, it became evident that groundwater underlying the vicinity of the TNT and RWP Areas could not be used as a potable source or any other use that may potentially result in significant exposure. Therefore, it has been determined by the USACE that protection of human health by limiting groundwater exposure has already been achieved under No Further Action. Where No Further Action is required, typically no FS is performed; thus, no remedial alternatives are evaluated (EPA, 1999). However, because remedial alternatives were developed in the FS and the FS Addendum and presented accordingly in the proposed plan, these alternatives are described in this Decision Document. The RAOs and RGs that had been developed in the FS are mentioned in relation to the action-based remedial alternatives which used these as their basis for action and monitoring. However, because the RAOs and the RGs are not applicable to the groundwater remedial decision, they are not presented in this Decision Document.

Four alternatives were initially evaluated in the FS to address potential risks associated with groundwater in the TNT and RWP Areas. Subsequent to the final submittal of the FS, the USACE identified the need for an alternative that includes groundwater monitoring and/or institutional controls only, to present a more complete range of remedial alternatives than was presented in the FS. Therefore, Alternative GW-5 was added to the FS Addendum, and the comparative analysis of remedial alternatives was revised accordingly. This addendum was completed in July 2011 (Shaw, 2011). The following five remediation alternatives were evaluated in the FS Addendum for TNT and RWP groundwater:

- ***Alternative GW-1:*** No further action.
- ***Alternative GW-2:*** Groundwater monitoring, monitored natural attenuation (MNA), and institutional controls.
- ***Alternative GW-3:*** ISEB/P&T for mitigation/protection of the limestone bedrock unit groundwater, groundwater monitoring, and institutional controls.
- ***Alternative GW-4:*** ISEB/P&T for mitigation/protection of the overburden/shale and limestone bedrock groundwater, groundwater monitoring, and institutional controls.
- ***Alternative GW-5:*** Groundwater monitoring and/or institutional controls.

Alternative GW-1 is the NCP-required no-further-action alternative. Under Alternative GW-1, no further action would be performed to remediate or monitor groundwater or to ensure that administrative controls such as groundwater use restrictions were maintained at the TNT and RWP Areas.

Each of the five groundwater alternatives, including the no-further-action alternative, includes a set of baseline conditions that may be helping to effect the attenuation of DoD activity-related contaminant concentrations in groundwater associated with the TNT and RWP Areas and may prevent exposure to groundwater. These baseline conditions include soil remediation actions at the three TNT Areas and the PRRWP Area under other PBOW DERP-FUDS projects, and the naturally reducing conditions in the limestone bedrock groundwater unit. Although the soil remediation actions at TNTA, TNTB, TNTC, and the PRRWP Area are being implemented to reduce potential risks of direct contact with soil, they also represent a potential groundwater source removal. These actions include a total of approximately 38,000 cubic yards (cy) of contaminated soil that have been or are currently being excavated for remediation/disposal from the three TNT Areas. A total of approximately 8,000 cy have been removed from the PRRWP Area for remediation/disposal, and it is anticipated that approximately an additional 28,000 cy will be removed from the PRRWP Area for remediation/disposal. Also, because of naturally occurring, chemically reducing conditions in the underlying bedrock limestone groundwater and the observation that detections of DoD activity-related contaminants in this unit are sporadic, it is likely that NACs which may have leached from the soil are being naturally degraded in this groundwater unit.

In addition, the limestone bedrock groundwater associated with the TNT and RWP Areas is of naturally low quality, due primarily to the presence of naturally occurring petroleum and

hydrogen sulfide off-gassing. This poor quality makes it highly unlikely that any attempt would be made to use the groundwater, especially as a potable source; thus, the poor quality of the groundwater militates against potential exposure. NASA has recently expressed to the Ohio EPA its intentions of specifically adding a prohibition of groundwater use in the NASA Plum Brook Station Master Plan and to include a groundwater use prohibition that would extend in perpetuity (PBOW Project Delivery Team, 2013). Therefore, it is anticipated that the future baseline conditions will also include a prohibition of groundwater use related to the TNT and RWP Areas. This prohibition would completely eliminate the potential for exposure to groundwater within the Plum Brook Station boundary. These groundwater institutional controls are not an element of the selected remedy of No Further Action because they would be implemented by NASA.

Alternatives GW-2 through GW-5 are regarded as action-based because they include monitoring, institutional controls, and/or active remediation. Because the former PBOW property is not under DoD control, the USACE cannot implement an institutional control prohibiting well installation. However, Alternatives GW-2 through GW-5 were developed and evaluated with institutional controls as described.

Each of the four action-based alternatives includes a 5-year review, at which point the monitoring program and the effectiveness of the remedy are evaluated. Changes in the remedy may be recommended during the 5-year review. Prior to implementation, any changes would be documented in the AR as appropriate, depending on the nature of the change (i.e., letter to the AR, Explanation of Significant Differences, or Decision Document Amendment).

Alternatives GW-2 through GW-4 include groundwater monitoring and institutional controls, which are assumed be in place under these three alternatives until RGs are met. Each of these alternatives employs the installation of an estimated 29 new wells in the limestone bedrock groundwater unit and the sampling of these and 4 existing monitoring wells. It was estimated in the FS for costing purposes that a total of 33 wells would be sampled under Alternatives GW-2 through GW-4 for 30 years. The well locations are based on groundwater modeling results (Section 2.5.1), which predict that 26 locations in the TNT areas will exceed the groundwater RGs for TNT, 2,4-DNT, and/or 2,6-DNT in the limestone bedrock groundwater unit; the additional 7 wells are to monitor bedrock groundwater in the two RWP Areas. Alternatives GW-3 and GW-4 also include additional overburden/shale wells as presented in the descriptions of the individual alternatives that follow.

Alternative GW-5 was developed to monitor groundwater underlying the site and the downgradient PBOW property boundary. Unlike Alternatives GW-2 through GW-4, Alternative GW-5 does not necessarily assume that monitoring will continue until RGs are met. The focus of GW-5 monitoring is to verify that COC concentrations are not migrating off site. GW-5 includes sampling of existing monitoring wells and/or the installation and sampling of up to 15 monitoring wells. Please note that the actual monitoring regime, including the number of wells, sampling frequency, and sampling duration, would be developed by the USACE, considering input from the Ohio EPA, as part of the long-term monitoring program.

Institutional controls are included in action-based Alternatives GW-2 through GW-4 to prevent human exposure to groundwater COCs, prohibiting the use of groundwater until the RGs are met. The groundwater use restrictions would prevent use of all groundwater in contaminated areas. These institutional controls consist of legal mechanisms that would be designed to control exposure to chemicals in groundwater and may include deed notices, well drilling prohibitions, and zoning restrictions. Alternative GW-5 was developed so that it may include institutional controls as well, but may include monitoring only.

For costing purposes, it is assumed the limestone bedrock groundwater unit would be monitored for 30 years, which is generally used as a default upper-limit duration for monitoring.

It is noted that even if all DoD activity-related contaminants were to meet RGs, the BHHRA found that the groundwater underlying each TNT and RWP Area has naturally occurring chemicals at concentrations that would represent an unacceptable human health risk if used as a source of tap water (Section 2.7.1).

Alternative GW-1 – No Further Action

A no-further-action alternative is developed as required by the NCP. Under this alternative, no further remedial action or monitoring would be conducted specifically for contaminated groundwater at the site. Note that soil remedial actions (TNTB [Figure 2-7], TNTC [Figure 2-8], PRRWP Area [Figure 2-9], and TNTA [Figure 2-10]) described in Section 2.4 represent source removal actions with respect to protection of groundwater. It is conservatively estimated that when complete, these soil actions will result in the remediation of more than 70,000 cy of soil at a cost of more than $20,000,000. Also, early decontamination efforts, beginning in 1945, were previously completed that removed potential groundwater sources. Therefore, GW-1 is a no-further-action alternative rather than a no-action alternative.

The following estimated costs and durations are associated with Alternative GW-1:

Present Worth Capital Cost:	*$0 M (excluding soil actions)*
Present Worth Total Operation/Maintenance Costs:	*$0 M*
Present Worth Total Cost:	*$0 M*
Present Worth Total Cost with 50% Contingency:	*$0 M*
Total Cost in 2012 Dollars with 50% Contingency:	*$0M*
Time to Implement:	*(not applicable)*
Time to Achieve RAOs:	*(not applicable: see note below)*

Note: The RAOs are currently met because there are no complete exposure pathways to contaminated on-site groundwater and contamination has not been observed in off-site groundwater. The water is not used and will not reasonably be used in the foreseeable future because of its naturally low quality associated with petroleum hydrocarbons and constituents (e.g., benzene and xylenes), hydrogen sulfide, and inorganics.

Alternative GW-2: Groundwater Monitoring, Monitored Natural Attenuation, and Institutional Controls

This alternative would include no active remedial action to reduce the concentrations of DoD activity-related contaminants in groundwater. Alternative GW-2 would include an MNA component as part of the long-term monitoring program described previously for Alternatives GW-2 through GW-4. The objective of this MNA component is to collect and evaluate the potential for natural attenuation to be occurring in the limestone bedrock groundwater unit to complement the other long-term monitoring data showing spatial and temporal changes in the extent of contamination. As described previously, Alternative GW-2 also includes institutional controls.

The presence of naturally occurring petroleum hydrocarbons and reducing conditions in the limestone bedrock aquifer may stimulate the anaerobic biodegradation of DoD activity-related NACs. Further evaluation of MNA had been considered as a possible enhancement to the groundwater monitoring program based on the analytical data collected for the site. The data indicate that NACs are only detected sporadically within the limestone bedrock and are generally not detected in bedrock wells that are also impacted by naturally occurring petroleum compounds. MNA could shorten the required monitoring period or decrease the frequency of monitoring in the future.

Natural attenuation potential would be evaluated by site capacity and biomarker tests. Site capacity tests are batch shaker or column tests that measure the potential of the limestone bedrock groundwater unit to adsorb or transform DoD activity-related NACs from the overburden/shale groundwater unit. These tests quantify the removal of DoD activity-related

contaminants from samples of rock/groundwater spiked with NACs (Pennington et al., 1999). Biomarker tests are used to detect the involvement of microorganisms as biocatalysts for the degradation and/or transformation of NACs. Radiorespirometry measures the potential of microbes in the limestone bedrock to degrade NACs from the overburden/shale. The test quantifies a mineralization rate by measuring the production of $^{14}CO_2$ in anaerobic microcosms of rock/groundwater slurries spiked with ^{14}C-labeled NACs (Pennington et al., 1999). For cost estimating purposes, it is assumed that five samples of rock and groundwater from the limestone bedrock, including one sample from each area of concern, would be collected for site capacity and radiorespirometry tests.

The following estimated costs and durations are associated with Alternative GW-2:

Present Worth Capital Cost:	*$0.73 M*
Present Worth Total Operation/Maintenance Costs:	*$1.5 M*
Present Worth Total Cost:	*$2.2 M*
Present Worth Total Cost with 50% Contingency:	*$3.3 M*
Total Cost in 2012 Dollars with 50% Contingency:	*$4.3M*
Time to Implement:	*1 Year*
Time to Achieve RAOs:	*(not applicable: see note below)*

Note: The RAOs are currently met because there are no complete exposure pathways to contaminated on-site groundwater and contamination has not been observed in off-site groundwater. The water is not used and will not reasonably be used in the foreseeable future because of its naturally low quality associated with petroleum hydrocarbons and constituents (e.g., benzene and xylenes), hydrogen sulfide, and inorganics.

Alternative GW-3: ISEB/P&T for Mitigation/Protection of the Limestone Bedrock Groundwater, Groundwater Monitoring, and Institutional Controls

In addition to long-term monitoring and institutional controls, Alternative GW-3 would include active remediation. ISEB would be used within the overburden/shale aquifer to reduce the concentrations of contaminants to RGs within 12 targeted areas of the overburden/shale groundwater unit. These 12 areas would require an estimated 4,600 injection points, spaced approximately 10 feet apart, over an area of approximately 829,000 ft^2. An estimated 1.03 million pounds of emulsified vegetable oil would be injected. The emulsified oil and injection points are regarded as rough estimates; a pilot test would be required to more accurately estimate substrate requirements.

The 12 targeted areas are shown on Figures 2-11 through 2-15 for the three TNT Areas and two RWP Areas. The objective of the ISEB component under GW-3 is to protect the underlying limestone bedrock aquifer via the migration of contamination from the overburden/shale zone

groundwater. Restoration of the entire overburden/shale aquifer to drinking water quality is not an objective.

P&T would be used within the 2,4-DNT plumes in the limestone aquifer in the PRRWP and WARWP Areas (Figures 2-14 and 2-15, respectively). Five recovery wells would be installed in the PRRWP Area at a total flow rate of 10.5 gallons per minute, and three wells would be installed in the WARWP Area at a total flow rate of 6.0 gallons per minute. The objective of the P&T component is to reduce the concentrations of DoD activity-related NACs to RGs in the limestone bedrock groundwater unit.

The following estimated costs and durations are associated with Alternative GW-3.

Present Worth Capital Cost:	*$9.3 M*
Present Worth Total Operation/Maintenance Costs:	*$4.7 M*
Present Worth Total Cost:	*$13.9 M*
Present Worth Total Cost with 50% Contingency:	*$20.9 M*
Total Cost in 2012 Dollars with 50% Contingency:	*$24.2M*
Time to Implement:	*1 Year*
Time to Achieve RAOs:	*(not applicable: see note below)*

Note: The RAOs are currently met because there are no complete exposure pathways to contaminated on-site groundwater and contamination has not been observed in off-site groundwater. The water is not used and will not reasonably be used in the foreseeable future because of its naturally low quality associated with petroleum hydrocarbons and constituents (e.g., benzene and xylenes), hydrogen sulfide, and inorganics.

Alternative GW-4: ISEB/P&T for Mitigation/Protection of the Overburden/Shale and Limestone Bedrock Groundwater, Groundwater Monitoring, and Institutional Controls

Alternative GW-4 uses the same components as Alternative GW-3. This alternative differs from GW-3 in that the goal of GW-4 is to restore all overburden/shale groundwater, in addition to bedrock limestone groundwater, to RGs. Therefore, instead of selecting 12 targeted areas to implement ISEB in the overburden/shale, ISEB would be implemented in 27 target areas. These 27 areas would require an estimated 8,200 injection points and 1.91 million pounds of emulsified oil. The remediation area of the overburden/shale plumes is estimated to cover more than 1,400,000 ft^2. The 27 targeted areas are shown on Figures 2-11 through 2-15 for the three TNT Areas and two RWP Areas. The P&T component of GW-4 is the same as that for GW-3.

The following estimated costs and durations are associated with Alternative GW-4:

Present Worth Capital Cost:	*$12.8 M*
Present Worth Total Operation/Maintenance Costs:	*$4.7 M*
Present Worth Total Cost:	*$17.6 M*
Present Worth Total Cost with 50% Contingency:	*$26.4 M*
Total Cost in 2012 Dollars with 50% Contingency:	*$29.6 M*
Time to Implement:	*1 Year*
Time to Achieve RAOs:	*(not applicable: see note below)*

Note: The RAOs are currently met because there are no complete exposure pathways to contaminated on-site groundwater and contamination has not been observed in off-site groundwater. The water is not used and will not reasonably be used in the foreseeable future because of its naturally low quality associated with petroleum hydrocarbons and constituents (e.g., benzene and xylenes), hydrogen sulfide, and inorganics.

Alternative GW-5: Groundwater Monitoring and/or Institutional Controls

Alternative GW-5 protects human health and the environment. The alternative would provide an additional measure to prevent human exposure in comparison to Alternative GW-1 if groundwater-use restrictions were implemented to prevent exposure to contaminated groundwater on site. Groundwater monitoring would provide further information. Specifically, the monitoring results would be expected to further verify that DoD activity-related NACs are not migrating off site and/or demonstrate that the potential for contamination to migrate off site is low by determining that concentrations of these chemicals in groundwater are not increasing. Also, the GW-5 monitoring program would help to clarify whether new groundwater flow patterns have developed since 2011, when groundwater pumping ceased at the NASA Reactor Building. The monitoring program would also verify that these new patterns have not resulted in the increase in concentration or extent of DoD activity-related contaminants.

A long-term monitoring program would be developed, the results of which would be evaluated at each 5-year review. For costing purposes, it is assumed that up to 15 new bedrock limestone monitoring wells will be installed to monitor downgradient groundwater and that these 15 wells will be sampled every 5 years. This will provide new data for each 5-year review cycle. For costing purposes, it is assumed that all 15 wells are sampled during each sampling event and that the monitoring duration is 30 years. The actual monitoring regime, including the number of wells, sampling frequency, and sampling duration, would be developed by the USACE, considering input from the Ohio EPA, when a long-term monitoring program is developed.

At each 5-year review, a determination would be made whether to sample more/fewer wells with greater/less frequency. Based on the findings and recommendations of the 5-year review, monitoring requirements may change over time. For example, later in the monitoring period, fewer wells might be sampled in the limestone bedrock or the sampling frequency might be decreased if DoD activity-related contaminant concentrations in groundwater exhibited a decreasing trend or a lack of detections. If based on the new data, contaminant concentrations were found to have increased and/or extended off site, this observation would be addressed as part of the 5-year review process through additional evaluation or perhaps other actions. Statistical techniques may be used to evaluate the trends in groundwater concentrations. The monitoring program would be terminated and the project subsequently closed out after enough data were gathered to demonstrate that groundwater concentrations in the bedrock aquifer are not increasing and do not pose a threat to off-site groundwater.

Alternative GW-5 also includes the option for institutional controls that prohibit groundwater use. As stated previously, implementation of an institutional control as part of a remedy would require agreement with NASA and local and/or state governments.

The following estimated costs and durations are associated with Alternative GW-5:

Groundwater Monitoring Only

Present Worth Capital Cost:	*$0.35 M*
Present Worth Total Operation/Maintenance Costs:	*$0.36 M*
Present Worth Total Cost:	*$0.71M*
Present Worth Total Cost with 50% Contingency:	*$1.1 M*
Total Cost in 2012 Dollars with 50% Contingency:	*$1.4 M*
Time to Implement:	*1 Year*
Time to Achieve RAOs:	*(not applicable: see note below)*

Institutional Controls Only

Present Worth Capital Cost:	*$0.03 M*
Present Worth Total Operation/Maintenance Costs:	*$0.21 M*
Present Worth Total Cost:	*$0.24 M*
Present Worth Total Cost with 50% Contingency:	*$0.36 M*
Total Cost in 2012 Dollars with 50% Contingency:	*$0.54 M*
Time to Implement:	*1 Year*
Time to Achieve RAOs:	*(not applicable: see note below)*

Note: The RAOs are currently met because there are no complete exposure pathways to contaminated on-site groundwater and contamination has not been observed in off-site

groundwater. The water is not used and will not reasonably be used in the foreseeable future because of its naturally low quality associated with petroleum hydrocarbons and constituents (e.g., benzene and xylenes), hydrogen sulfide, and inorganics.

2.9 Comparative Analysis of Alternatives

Each of the five groundwater alternatives was evaluated with respect to the following nine criteria, as required by the NCP at 40 Code of Federal Regulations 300.430(e)(9)(iii). Criteria 1 and 2 are the threshold criteria, which must be met, criteria 3 through 7 are the primary balancing criteria, and criteria 8 and 9 are the modifying criteria.

Threshold Criteria

1. Overall Protectiveness of Human Health and the Environment
2. Compliance with Applicable or Relevant and Appropriate Requirements

Primary Balancing Criteria

3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost

Modifying Criteria

8. State Support/Agency Acceptance
9. Community Acceptance.

The threshold criteria are requirements that a remedial alternative must meet to be eligible for selection. The five primary balancing criteria are used to determine the trade-offs between alternatives. The modifying criteria are public and state acceptance. An analysis of each alternative against these criteria is presented in Table 2-24. A comparison among the remedial alternatives with respect to these criteria is provided in this section.

Threshold Criteria. Each of the five alternatives meets the threshold criteria for protection of human health and the environment and compliance with ARARs. The groundwater at the five areas of concern is not currently used, nor is it a potential source of drinking water because the quality of the groundwater in both the overburden/shale and limestone units renders it as Class III nonpotable groundwater (Section 2.5.1). No COCs have been detected in off-site downgradient groundwater, and groundwater contamination does not present a threat to off-site downgradient groundwater. Municipal water, the only source of drinking water in the vicinity of PBOW, is readily available both on site and near the site boundary. This municipal water does not originate from groundwater. Contaminated groundwater does not present a threat to

ecological receptors or other environmental media, because impacted groundwater does not discharge to surface water. Groundwater within the overburden/shale is discontinuous, seasonally dependent, and as mentioned, of poor natural quality.

A survey of current off-site use of groundwater was conducted by the USACE. The results of the survey indicated that, while private wells were present in downgradient areas, they are not used for potable water. Thus, the naturally poor water quality and limited yield in the overburden/shale and naturally poor water quality in the limestone in effect deter use as a potable source for drinking water. This results in an incomplete exposure pathway for off-site groundwater.

The combination of strongly reducing conditions and naturally occurring organic carbon in the limestone bedrock may be contributing to the microbial degradation and transformation of NACs. These conditions should prevent concentrations of COCs in the overburden/shale from contributing to downgradient bedrock groundwater contamination. Available groundwater analytical data indicate that DoD activity-related contamination is limited to on-site areas.

Alternative GW-5 would provide additional information by implementing additional groundwater monitoring and would specifically prohibit the use of groundwater if the option of institutional controls were selected. As discussed in Section 2.8, it is expected that institutional controls to restrict groundwater use will be implemented by NASA, independent of this Decision Document. Alternative GW-2 includes the GW-5 measures and also evaluates the capacity of the limestone bedrock to naturally attenuate COCs that may migrate from the overburden/weathered shale. Groundwater monitoring would be used to monitor and further evaluate limestone bedrock groundwater quality. Alternatives GW-3 and GW-4 would implement active groundwater remediation. The objective of groundwater remediation under Alternative GW-3 is to reduce the concentrations of DoD activity-related contaminants in the limestone bedrock groundwater to RGs. The objective of groundwater remediation under Alternative GW-4 is to reduce the concentrations of DoD activity-related contaminants in the overburden/shale and the limestone bedrock to RGs. Both GW-3 and GW-4 would generate appreciable greenhouse gases associated with the P&T system.

The compliance with ARARs threshold criterion is met because ARARs have not been identified for any of the remedial alternatives.

Primary Balancing Criteria. Alternatives GW-3 and GW-4 would meet the preference for treatment technologies that result in a reduction in toxicity, mobility, or volume. Both of these alternatives rely on treatment technologies. The other three alternatives do not include treatment technologies. However, it should be noted that the soil remedial actions completed at TNTB, the ongoing actions at the PRRWP Area and TNTC, and those being implemented for TNTA (Section 2.4) involve treatment of the potential ongoing groundwater contamination sources within these areas. These remedial actions for soil are implicitly associated with each of the five groundwater alternatives. These soil remediation measures include treatment that reduces toxicity and/or mobility through composting, stabilization, and alkaline hydrolysis.

The short-term effectiveness of each of the five alternatives would be virtually equal. There would be no risks to the community associated with the implementation of any of these five alternatives. Workers would be protected in the implementation of Alternatives GW-2 and GW-5 through a remedial action safety and health plan. Alternative GW-1 would require the least effort and time. The technological components of GW-3 and GW- 4 (i.e., ISEB and P&T) are proven and readily implementable.

The cost differential among the five alternatives is considerable. Even among the four action-based alternatives, costs may span over two orders of magnitude. The costs of these alternatives from least to most expensive are as follows:

- Alternative GW-1 – $0.00M (excluding soil actions)
- Alternative GW-5 (institutional controls component only) – $0.5M
- Alternative GW-5 (monitoring component only) - $1.4M
- Alternative GW-2 – $4.3M
- Alternative GW-3 – $24.1M
- Alternative GW-4 – $29.6M.

Modifying Criteria. A single public comment was received that requested ongoing monitoring; the comment and the USACE response is included in the Responsiveness Summary (Chapter 3.0). No other comments were received from the public on any of the other alternatives, and the State of Ohio, as represented by the Ohio EPA, provided no comments on any of the alternatives. However, the Ohio EPA expressed to NASA and the USACE the need for NASA to implement measures to prevent future use of groundwater within the Plum Brook Station boundary.

2.10 Principal Threat Waste

The NCP establishes a preference for methods that employ treatment that reduces toxicity, mobility, or volume (300.430[e][9][ii][D]). This especially includes the expectation that

treatment will be used to address principal threats posed by a site when practicable (300.430[a][1][iii][A]). The term “principal threat wastes” refers to source materials, but does not include contaminants dissolved or suspended in groundwater (EPA, 1991b). Therefore, no principal threat wastes exist in TNT and RWP Areas groundwater. However, some of the contaminated soil overlying the TNT Areas and PRRWP Area groundwater that are being remediated and/or have been remediated under other DERP-FUDS projects and decision documents based on direct contact exposure soil may represent principal threat waste. Treatment that reduces toxicity is a principal component for soil in each of these areas.

2.11 Selected Remedy

2.11.1 Rationale for Selection

The rationale for selecting Alternative GW-1, No Further Action, as the Selected Remedy is that this alternative meets both of the threshold evaluation criteria and provides the best overall set of tradeoffs in meeting the primary balancing criteria. Alternative GW-1 is estimated to be the least expensive alternative for TNT and RWP Areas groundwater.

Based on an evaluation using the primary balancing criteria, Alternative GW-1 was selected over the other alternatives because it is far less expensive than these alternatives. None of the four action-based alternatives would provide any tangible benefit based on the following observations:

- The quality of both the overburden/shale and limestone bedrock groundwater is low due to naturally occurring chemicals and renders this water Class III nonpotable.
- For limestone bedrock groundwater underlying each of the TNT and RWP Areas except the WARWP, the human health risks/hazards associated with naturally occurring, non-DoD activity-related chemicals are much higher than those associated with DoD activity-related chemicals.
- The overburden/shale groundwater unit is of a very low and seasonally dependent yield.
- Municipal tap water, rather than groundwater, is used by NASA as well as all residences in the area.

If the TNT/RWP Areas groundwater were used for potable purposes, the human health risks associated solely with naturally occurring chemicals in groundwater would exceed the NCP acceptable range and the risks associated with DoD activity-related contaminants. Therefore, no

regulatory justification exists to perform any further remedial action (including monitoring) with respect to the TNT and RWP Areas groundwater.

2.11.2 Description of Selected Remedy

Remedial Alternative GW-1 will be implemented for TNT and RWP Areas groundwater as the Selected Remedy. The alternative includes No Further Action with respect to groundwater underlying the TNT and RWP Areas. Baseline conditions include soil removal actions that have been completed or are anticipated, independent of this Decision Document, with respect to the TNT and RWP Areas that potentially affect future concentrations DoD activity-related contaminants in groundwater. Also, the naturally occurring reducing conditions may attenuate concentrations of DoD activity-related contaminants in groundwater under No Further Action, and the naturally poor water quality serves to prevent exposure to groundwater. These baseline conditions, further described in Section 2.8, are not part of this remedy.

2.11.3 Estimated Costs of Selected Remedy

There are no costs associated with the Selected Remedy, GW-1, No Further Action.

2.11.4 Expected Outcome of Selected Remedy

The expected outcome of the Selected Remedy is that DoD activity-related contaminant concentrations in the limestone bedrock groundwater underlying the TNT and RWP Areas will diminish over time. This is partly due to the soil source removal/remedial actions performed at TNTB, and being performed at TNTA, TNTC, and the PRRWP Area under different DERP-FUDS projects and decision documents. Exposure to DoD activity-related contaminant in groundwater is otherwise militated against by the naturally poor quality which discourages groundwater use.

2.12 Documentation of Significant Changes

The Proposed Plan for TNT and RWP Areas groundwater was released on March 29, 2012. This Proposed Plan (USACE, 2012) identified Alternative GW-1, No Further Action, as the Preferred Alternative. The USACE reviewed all comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

3.0 Responsiveness Summary

The purposes of the Responsiveness Summary are to a) summarize information concerning the views of the public and support agencies regarding the remedial alternatives and any general concerns about the site that were submitted during the public comment period, and b) provide documentation in the AR as to how these public comments were integrated into the decision-making process for remedy selection.

3.1 Summary of Proposed Plan Communication, Stakeholder Issues, and USACE Responses

A presentation of the Proposed Plan for Groundwater (Covering TNT Areas and Red Water Pond Areas) was provided by the USACE to the community during a March 29, 2012 public meeting. This meeting was in addition to the regular quarterly RAB meetings which are held to inform the public and receive public feedback regarding DERP-FUDS projects at PBOW. As stated in Section 2.3, this meeting was announced in the *Sandusky Register* on March 22, 2012. RAB members and other members of the public who requested inclusion on the mailing list received email notification of the public meeting. Several members of the local community attended. The State of Ohio was represented by the Ohio EPA at the public meeting. During this meeting, opportunity was given to ask questions and express concerns. No substantive questions were asked and no concerns were expressed with respect to the preferred alternative or any other alternatives by the public or the State during the public meeting.

During the public comment period, only one written comment was submitted. The comment was submitted on April 28, 2012, by a member of the public, requesting continued monitoring of groundwater. No changes to the Preferred Alternative, No Further Action, were deemed necessary based on this comment. The full comment and USACE response are presented in Section 3.2. No comments were received from the State on the Proposed Plan.

3.2 Detailed Comment and Response

A public member of the RAB submitted a written comment on April 28, 2012 in response to the Proposed Plan. This comment and the USACE response are presented below.

> **Comment:** The importance of the overall environmental condition of ground water cannot be minimized. Over the course of the massive project to remediate the TNT/DNT sites at Plum Brook, it is evident that significant soils contamination has occurred. The

Army Corps of Engineers should be recognized for their tenacity to uncover and clean up the site.

Testing of ground water sources, both in the overburden/shale and in the bedrock substrates have posed some significant challenges over the period, During the time, Bennett & Williams (Julie Weatherington-Rice, hired as a contractor to advise the RAB) performed evaluations that also included some offsite investigations (which were not included in the work performed for the RAB). Her perspectives are important for a number of reasons. First must be her familiarity with glacial deposits in the state of Ohio. Second is her full understanding of clay soils and their physical changes as water tables rise and subside. Finally, her expertise in the rock formations which form the underburden at Plum Brook. Her research and commentary are part of the public record and must be considered now and in the future.

While the research provided by the contractors used by the Army Corps of Engineers has been exemplary, the installation of sampling wells has always been a "best guess" for location. It is safe to say that driving a hole in the ground for a sampling well could easily miss a joint, fracture or karst feature in the rock that could be used to transport ground water carrying contaminants either vertically or horizontally from one point to another, even off site.

No one reviewing the research and remediation of the Plum Brook Ordnance Works could argue that an environmental impact took place. While the work has been extensive, there is no guarantee that 100 percent of the problems have been uncovered and cleaned-up.

To close, if I may make the comparison between a cancer patient and the site. Anyone who has been treated for cancer, undergoes years testing to assure that remission has occurred. Similarly, the Plum Brook Ordnance Works should be measured post remediation to assure that any remaining contamination has been removed. I can find no better way to make that determination than the continued testing of wells, both in the overburden/shale and the bedrock to check for signs that, (1) past remediation was successful, indicative of a reduction in chemical impact or, (2) future remediation must be initiated if chemical levels show that another point source exists.

Response: The USACE appreciates the reviewer's recognition of the efforts and the associated costs that have been expended on investigating, evaluating, and remediating source areas at PBOW, including the TNT Areas and Red Water Pond Areas. However, the USACE remediated these source areas based on potential human health risks and environmental concerns associated with direct contact with soil. Remediation under these circumstances is consistent with FUDS regulations, CERCLA, and the NCP.

With respect to groundwater, there is no legal basis for the Army to appropriate FUDS funding to remediate this groundwater, which is nonpotable because of its naturally poor quality. The limestone groundwater's nonpotability is due to naturally occurring contaminants including petroleum hydrocarbons, hydrogen sulfide, and, total dissolved solids, and other naturally occurring chemicals. Although human health risks were evaluated based on exposure to this groundwater assuming potable use, such use is hypothetical. Further, the human health risks associated with hypothetical potable use were generally minimal in comparison to those associated with naturally occurring chemical constituent in the groundwater.

Comments previously provided by The TAPP contractor were reviewed and considered by the USACE, and thorough responses were provided (Shaw, 2008; 2006). It is agreed that much uncertainty exists with respect to well placement in a fracture-dominated groundwater flow regime. It is not uncommon for a given borehole in the limestone bedrock to fail to encounter water, where a nearby well produces ample water. However, well placement in the limestone bedrock was based partly on information obtained from various geological studies at PBOW, including a fracture trace study (D&M, 1997c); wells were placed accordingly to intercept areas where greater flow would be expected based on the exiting hydrogeological information. Wells were also placed within and downgradient of the areas with the highest NAC concentrations in the soil. Based on the entire site-wide limestone bedrock well network the following is clear: 1) DoD activity-related NACs are detected only sporadically throughout years of monitoring, and only at a few locations; 2) NACs have not been detected in off-site wells; 3) naturally occurring constituents in the bedrock render the groundwater nonpotable, 4) given the historical analytical results to date and the remedial actions that remove potential source areas, there is little basis on which to expect groundwater concentrations of DoD activity-related contaminants to increase.

Please note that lateral flow within the overburden/shale unit is very limited areally, as the unit occurs in discrete pockets and does not represent a contiguous lateral unit. Therefore, flow within this unit is downward toward the limestone bedrock, and off-site migration of contamination within the overburden is not plausible. A groundwater use prohibition of the on-site groundwater would therefore eliminate all exposure to impacted overburden groundwater.

The USACE appreciates the input of the public PBOW RAB members and the public in general with respect to their interests, concerns, involvement, and willingness to communicate regarding environmental issues at PBOW. The USACE also appreciates the compliments concerning our investigative and remediation work at PBOW in general.

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TABLES

FIGURES