

Proposed Background Well Justification Summary for the
RVAAP-66 Facility-Wide Groundwater Monitoring Program
Remedial Investigation/Feasibility Study Work Plan
At the Ravenna Army Ammunition Plant

October 10, 2013

Prepared for:



U.S. Army Corps of Engineers, Louisville District
600 Martin Luther King, Jr. Place
Louisville, Kentucky 40202

Prepared by



Environmental Quality Management, Inc.
1800 Carillon Boulevard
Cincinnati, Ohio 45240



Ravenna Army Ammunition Plant
8451 State Route 5
Ravenna, Ohio 44266

October 10, 2013

Mr. Kevin Palombo
Ohio Environmental Protection Agency
Northeast District Office
2110 East Aurora Road
Twinsburg, OH 44087-1924

Subject: Ravenna Army Ammunition Plant
Portage/Trumbull Counties
Facility-Wide Groundwater
Background Well Justification
Remedial Investigation/Feasibility Study Work Plan
Ohio EPA ID # 267-000859-036

Dear Mr. Palombo:

On August 8, 2013, the Army received a letter of correspondence (Certified Mail 7012 1010 0002 2260 4787) from the Ohio Environmental Protection Agency (Ohio EPA), dated August 7, 2013. The letter presented the Ohio EPA comments to the May 23, 2013 comment response letter submitted by the Army for the Ravenna Army Ammunition Plant "*Facility-Wide Groundwater Monitoring Program RVAAP-66 Facility-Wide Groundwater Monitoring Program Remedial Investigation/Feasibility Study Work Plan*" (RI/FS) document. In a telephone conference call between the Army, the Ohio EPA, and EQM on August 15, 2013 it was agreed to have an in person meeting at the NEDO of the Ohio EPA to further discuss groundwater issues related to the RI/FS. The meeting on September 12, 2013 was attended by the Army, the Ohio EPA, and EQM, and the Army was tasked with supplying the Ohio EPA with a summary of possible background wells and justification for their inclusion in the Facility-Wide Groundwater Monitoring Program Remedial Investigation/Feasibility Study (RI/FS) document. The background well justification summary is an attachment to this letter. The Ohio EPA granted an extension until September 30, 2013 for submittal of the background well justification summary, but due to the government shutdown and furlough of Army employees, the submittal was delayed.

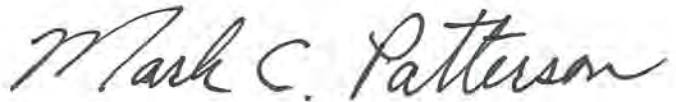
This submittal includes three (3) hard copies of the background well justification summary. The Army acknowledges that the 14 wells proposed as background wells may not meet the Ohio EPA's expectations. These 14 wells are the maximum number of existing wells the Army Team could reasonably propose as background, so please

Subject: Response to the Ohio EPA comments – Background Well Justification – *Facility-Wide Groundwater Monitoring Program RVAAP-66 Facility-Wide Groundwater Remedial Investigation/Feasibility Study Work Plan*™ (Ohio EPA ID # 267-000859-036), Ravenna Army Ammunition Plant, Ravenna, Ohio

review the proposal and indicate which background wells you agree with and which you oppose. From there, the Army will schedule a clarification call to formulate a path forward for the background wells, i.e. how many more wells should be installed, where these background wells will be located. Since no chemicals of concern (COCs) were screened out during the risk assessment portion of the RI/FS based on the background concentrations, the Army requests the RI/FS workplan, and subsequent RI report, continue to be used until the background well set is improved.

Please contact the undersigned at (330)358-7312 or mark.c.patterson@us.army.mil if there are issues or concerns with this response.

Sincerely,



Mark C. Patterson
RVAAP Facility Manager
Base Realignment and Closure Division

cc: Nancy Zikmanis, Ohio EPA, NEDO, DERR
Rodney Beals, Ohio EPA, NEDO, DERR
Kevin Sedlak, ARNG
Brett Merkel, ARNG
Katie Tait, OHARNG Camp Ravenna
Glen Beckham, USACE Louisville
Nat Peters, USACE Louisville
Mark Nichter, USACE Louisville
John Miller, EQM
Mark Patterson, RVAAP Facility Manager/Gail Harris, Vista Sciences
REIMS - attn. Pat Ryan, SAIC

**RAVENNA ARMY AMMUNITION PLANT
RVAAP-66 FACILITY-WIDE GROUNDWATER MONITORING PROGRAM
PROPOSED BACKGROUND WELLS**

A. Introduction

On September 12, 2013, the Army met with the Ohio EPA to discuss a number of issues associated with the facility-wide groundwater investigation and periodic groundwater sampling events including the 14 wells installed in 1998 that were designated as background (BKG) wells. Many of these wells were originally installed to serve as background wells for individual areas of concern without consideration of potential upgradient influences. As a result, the Ohio EPA has previously commented that the background wells may have been impacted by the facility and are not capable of providing representative groundwater samples unaffected by historical facility operations.

At the September 12 meeting, the Army proposed to evaluate 10 existing wells (five unconsolidated wells and five bedrock wells) at RVAAP for comparison against the original background network. The 10 wells are positioned in areas that are believed to have not been adversely affected by historical operations and therefore are a better representation of background conditions. [Note that seven of the proposed wells were from the original background network, and the other three were wells were installed in 2012 as part of the ongoing Remedial Investigation (RI – designated as FWG wells).] Specifically, the Army proposed to compare the chemical concentrations from the 10 selected wells against the original background concentrations to evaluate whether the original data is still viable as background. The Ohio EPA was amenable to re-calculating the background concentrations from a network of new and/or existing wells at RVAAP, but they did not agree to the comparative study for justifying the original background data set since there are several original BKG wells that the Ohio EPA does not believe are representative of background conditions.

The Ohio EPA also indicated that their guidance requires a minimum sample size of a minimum of 12 background wells per each monitored strata for statistical evaluation. As regards the background sample size, the Ohio EPA's *Use of Background for Remedial Response Sites* (August 21, 2009) only presents a minimum sample size of 12 under the title "Recommended Sample Size for Soil Background Calculation." For groundwater, this document states that "If it is not possible to find an appropriate location to determine background levels in ground water on or underlying the site, Ohio EPA DERR may approve the use of groundwater data from other sources." In Chapter 5 of the Ohio EPA's *Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring* (February 1995) regarding placement and number of background wells it states "Dependent upon the complexity of hydrogeologic conditions and the number, location, and size of the pollution source, more than one background well may be necessary." The Army has not identified any federal or state references that dictate a specific number of required background wells for groundwater. The Army believes that the 14 proposed background wells presented herein meet the requirements for determining background values.

At the September 12, 2013, meeting it was agreed that the Army would propose to the Ohio EPA an alternative background well set including some original background wells and some of the

newly installed FWG wells. All of these wells are constructed of polyvinyl chloride (PVC) and have a minimum of four quarters of sampling data since October 2006. The Ohio EPA would then evaluate the proposed background set of wells as they relate to location of historical activities and groundwater flow prior to the Army recalculating background clean levels. The following narrative, tables, and figures present the Army's selections for the new background well set.

B. Proposed Background Wells

As described in the *Guidance for Environmental Background Analysis Volume III: Groundwater* prepared for the Naval Facilities Engineering Command (October 2003) and other documents, background monitoring well locations should be evaluated to identify the locations most likely to be free of groundwater contamination associated with both on-site and off-site sources. This document, as well as the Ohio EPA guidance, also states that naturally occurring and anthropogenic constituents may be present in background wells, including those from agricultural, industrial, and residential nonpoint chemical sources. For example, the RVAAP facility was purchased from farmers during wartime in the early 1940s, pesticides were routinely used during facility operations, and the surrounding area is comprised predominantly of agricultural land. The sporadic presence of pesticides in groundwater in the proposed background wells would be considered anthropogenic since no point source has been identified at the site.

Areas upgradient of the actual, suspected, or potential contaminant sources at the investigation site are typically considered the best locations for background monitoring wells, although side-gradient and down-gradient locations may be considered if they are outside the zone of impact based on groundwater velocities and lateral dispersion potential. Based on groundwater flow in the various aquifers and the relationship of specific wells to areas of concern, the Army has identified 14 existing monitoring wells (eight unconsolidated wells and six bedrock wells) that are believed to be representative of background conditions for facility-wide groundwater at RVAAP. (Note that eight of these wells are BKG wells and were part of the original background network.) Figure 1 shows the various areas of concern at RVAAP; Figure 2 shows the proposed background wells and groundwater flow in the unconsolidated strata; and Figure 3 shows the proposed bedrock background wells and groundwater flow in the Sharon formation. [Note that well FWGmw-005 is completed in the Homewood formation, and SCFmw-006 is completed in the deeper portion of the Sharon formation; these wells were not used to determine groundwater flow in the upper part of the Sharon formation and are only presented on Figure 3 herein to show the locations of all of the proposed bedrock background wells. The groundwater flow patterns in the Homewood and deeper portion of the Sharon are presented on Plates 3 and 5, respectively, in the *Facility-Wide Groundwater Monitoring Program RVAAP-66 Facility-Wide Groundwater Report on the July 2012 Sampling Event* (EQM, May 2013).] The proposed wells that the Army recommends for the new background network are highlighted on Figures 1 through 3. Table 1 lists the proposed background wells and rationale for each. Table 2 presents the historical data for the proposed background wells. Summary information for each of the proposed background wells and the associated inorganic and organic constituents in each well is provided below. Validation qualifiers "J" (estimated) and "B" (blank contamination) are presented with the data in the following summary, where appropriate.

FWGmw-003 (unconsolidated)

- Located in a former coal tipple along North Line Road and northeast of C Block.
- Well FWGmw-003 is side-gradient to the former C Block area and upgradient of the other historical RVAAP operations.
- Well was completed to a depth of 18.5 feet below grade into the unconsolidated water-bearing strata.
- Groundwater flow is generally to the east-southeast in this area of the site.
- Sampled four times since April 2012.
- Ten inorganic constituents (aluminum, arsenic, barium, beryllium, chromium, iron, manganese, nickel, vanadium, and zinc) have been identified in groundwater at well BKGmw-003 on at least one occasion.
 - **Aluminum** was identified during all four sampling events at concentrations ranging from 42 to 1600 µg/L.
 - **Arsenic** was identified on two occasions at estimated concentrations of 3.3 and 5.3 µg/L. Arsenic was not identified during the other two sampling events.
 - **Barium** was identified on four occasions in FWGmw-003 at concentrations ranging from 59 to 85 µg/L.
 - **Iron** was identified at concentrations ranging from 150 to 2300 µg/L.
 - **Manganese** was identified at concentrations ranging from 520 to 700 µg/L during the four sample events at this location.
 - **Beryllium**, nickel, and vanadium were identified at estimated concentrations during one sampling event.
 - **Chromium** and zinc were identified at estimated concentrations during two sampling events.
- **Bis(2-ethylhexyl)phthalate (BEHP)** was identified on three occasions in the groundwater samples from FWGmw-003 at concentrations ranging from 0.84 B to 2.2 µg/L; it was present in the blank on one of these occasions.
- **Acetone** was identified on two occasions in this well, but it was also present in the blank on these occasions.
- **Dimethyl phthalate** was identified at an estimated concentration on one occasion in this well; it was not detected during the other three sampling events.
- **Naphthalene** was identified on one occasion in this well; it was not detected during the other three sampling events.

FWGmw-005 (Homewood)

- Located west of State Route 80 in a forested area next to a former logging road.
- No RVAAP operations reportedly occurred in this area. Well FWGmw-005 is located upgradient of historical operations at RVAAP.
- Well was completed to a depth of 29.5 feet below grade in the upper portion of the Homewood formation.

- Groundwater flow in this area is generally from west to east.
- Sampled for four consecutive quarters beginning in April 2012.
- Eight metals (aluminum, barium, cadmium, cobalt, iron, manganese, nickel, and zinc) have been identified in well FWGmw-005.
 - **Aluminum** and **nickel** were identified at estimated concentrations below the laboratory reporting limit on two occasions; they were not detected during the other two sampling events.
 - **Barium** (50 to 58 µg/L), **iron** (3000 to 4200 µg/L), and **manganese** (280 to 1000 µg/L) were identified during all four sampling events. (The highest iron and manganese concentrations occurred during the initial sampling event in April 2012.)
 - **Cobalt** was identified in groundwater at this location on three occasions; twice at estimated concentrations below the reporting limit. It was not detected during the January 2013 sampling event.
 - **Cadmium** and **zinc** were identified in this well on one occasion.
- **BEHP** was identified on three occasions in this well at concentrations ranging from 0.84 to 11 µg/L; BEHP was found in the blank on one occasion.
- **Acetone** was identified in this well on two occasions; it was identified in the blank during both of these sampling events.

FWGmw-006 (unconsolidated)

- Located in the western portion of RVAAP along McCormick Road in the former A Block.
- Well FWGmw-006 is located in the vicinity of the former A Block bunkers; no facility operations reportedly occurred in this area of the site. This well is located upgradient of historical RVAAP operations.
- Completed to a depth of 17.5 feet in the unconsolidated water-bearing strata.
- Groundwater flow is east-southeast in this area of the site.
- Sampled on four occasions since April 2012 (note that a fifth sampling event was just completed in August 2013; analyses pending).
- Ten inorganic compounds (aluminum, antimony, arsenic, barium, cobalt, iron, manganese, nickel, vanadium, and zinc) have been identified in groundwater at this location on at least one occasion.
 - **Aluminum, antimony, cobalt, nickel, vanadium,** and **zinc** have been identified on one occasion at this location. Cobalt and zinc were present in the blanks as well. Aluminum, nickel, and vanadium were detected during the January 2013 sampling event only.
 - **Arsenic** was identified at concentrations ranging from 2.9 J to 5.2 J µg/L on three occasions.
 - **Barium** was identified at concentrations ranging from 27 to 57 µg/L during all four sampling events.
 - **Iron** was identified at concentrations ranging from 630 to 18,000 µg/L during all four sampling events.

- **Manganese** was identified at concentrations ranging from 210 to 2700 µg/L during all four sampling events.

- Several organic constituents have been identified in FWGmw-006 as single detections, including **2-butanone**, **3,4-methylphenol**, **BEHP**, **carbon disulfide**, **dimethyl phthalate**, and **naphthalene**. None of these compounds were detected at this location during the three other sampling events and none were found above regulatory levels.
- **Benzene** was identified during the first two sampling events in this well at decreasing concentrations of 1.5 and 0.67 µg/L. Benzene was not identified during the two most recent sampling events. (Preliminary results from August 2013 also did not identify this constituent in groundwater at this location.)
- **Toluene** was identified during the first two sampling events in this well at concentrations of 0.65 B and 0.32 µg/L. Toluene was not identified during the two most recent sampling events at this location. (Preliminary results from August 2013 also did not identify this constituent in groundwater at this location.)

FWGmw-008 (unconsolidated)

- Located near State Route 80 in the western portion of RVAAP and southeast of CC-RVAAP-72, a former underground storage tank area.
- Well FWGmw-008 is side gradient to CC-RVAAP-72 and upgradient of other historical facility operations.
- Completed to a depth of approximately 20 feet in the unconsolidated strata.
- Groundwater flow is to the east at this location.
- Sampled on four occasions since April 2012.
- Eight inorganic compounds (aluminum, arsenic, barium, chromium, iron, manganese, nickel, and zinc) have been identified on at least one occasion in groundwater at this location.
 - **Aluminum** was identified on two occasions at concentrations of 24 J and 290 µg/L; aluminum was not detected during the most recent sampling event.
 - **Arsenic** was identified at concentrations ranging from 5.2 J to 7.4 J µg/L during all four sampling events.
 - **Barium** was identified at concentrations ranging from 34 to 40 µg/L during all four sampling events.
 - **Chromium**, **nickel**, and **zinc** have been identified at estimated concentrations on one occasion in this well. Zinc was also present in the blank.
 - **Iron** was identified at concentrations ranging from 520 to 1100 µg/L during all four sampling events.
 - **Manganese** was identified at concentrations ranging from 620 to 760 µg/L during all four sampling events.
- **Acetone** was identified on two occasions in this well; it was also identified in an associated blank during one of these events.

- **BEHP** was identified on three occasions in FWGmw-008 at concentrations ranging from 0.84 to 1.1 J $\mu\text{g/L}$.
- **Endrin ketone** was identified on one occasion in this well; it was not detected during the other three sampling events.
- No petrochemicals have been identified in this well.

FWGmw-014 (unconsolidated)

- Located on the west side of RVAAP along State Route 80 and south of North Line Road.
- No RVAAP operations reportedly occurred in this area, although stockpiling of monazite sand (thorium ore) was conducted north of the well. The monazite sand was removed in the mid-1970s, and several decontamination and survey efforts were conducted from the mid-1970s to 2001, with the most recent remediation occurring in July/August 2004 to remediate small areas of elevated pCi/g in soil. In a letter dated December 16, 2004, the Nuclear Regulatory Commission (NRC) determined that the former monazite sand area (former West Tank Farm) could be released for unrestricted use.
- This well is upgradient of historical RVAAP operations.
- Well was completed to a depth of 18.5 feet in the unconsolidated water-bearing zone.
- Groundwater flow is generally from east-southeast in this area of the site.
- Sampled for four consecutive quarters beginning in April 2012.
- Four inorganic constituents (barium, chromium, cobalt, manganese, and nickel) have been identified in groundwater from this well on at least one occasion.
 - **Barium** was identified at concentrations ranging from 30 to 38 $\mu\text{g/L}$ during all four sampling events.
 - **Chromium** was detected during two events at concentrations of 1.5 J and 6.7 JB $\mu\text{g/L}$. It was identified in the blank during one of these events. Chromium was not detected during the two most recent sampling events.
 - **Manganese** was identified at concentrations ranging from 130 to 210 $\mu\text{g/L}$ during the four sampling events.
 - **Nickel** was identified on two occasions in this well at concentrations of 5.8 and 2.7 J $\mu\text{g/L}$. Nickel was not detected during the two most recent sampling events.
- **BEHP** was identified on one occasion in this well at a concentration of 0.92 $\mu\text{g/L}$; it was not detected during the other three sampling events.
- **Acetone** was identified at concentrations of 1.6 B and 1.3 JB $\mu\text{g/L}$; it was also found in the blank during these two events.
- **Dimethyl phthalate** was identified at an estimated concentration of 0.28 J $\mu\text{g/L}$ during the most recent sampling; this constituent was not identified during the three prior sampling events.
- Radioactive isotopes, **thorium** and **uranium**, were analyzed from groundwater samples collected during the April, July, and October 2012 and January 2013 sampling events.

Thorium was identified in the October 2012 sample at an estimated concentration, and uranium was present in the July, October, and January samples. During the October 2012 event, uranium exceeded the Regional Screening Level (RSL) for this constituent. In addition, RA-226 and Bismuth 214 were identified at concentrations ranging from 23 to 36 pCi/L in April and July 2012; these constituents were not identified during the October and January sampling events. See Section C for further discussion.

BKGmw-005 (unconsolidated)

- Located near the northern property boundary and near the intersection of North Line Road and State Route 80.
- Well BKGmw-005 is located upgradient of historical operations at RVAAP. This well is side gradient of the former monazite sand stockpile area. The monazite sand was removed in the mid-1970s, and several decontamination and survey efforts were conducted from the mid-1970s to 2001, with the most recent remediation occurring in July/August 2004 to remediate small areas of elevated pCi/g in soil. In a letter dated December 16, 2004, the NRC determined that the former monazite sand area (former West Tank Farm) could be released for unrestricted use.
- Well was completed to a depth of 18 feet below grade in the unconsolidated water-bearing zone.
- Groundwater flow is generally to the east-southeast in the unconsolidated strata in this area of the site.
- Sampled on 10 occasions since October 2006.
- Nine inorganic compounds (aluminum, barium, chromium, copper, iron, lead, manganese, nickel, and zinc) have been identified in this well at least once.
 - **Aluminum** has been identified on three occasions at concentrations ranging from 4.9 J to 98.2 µg/L. This constituent was not identified during the other seven sampling events, including the three most recent episodes.
 - **Barium** has been detected during each of the 10 sampling events at concentrations ranging from 13 to 16.3 µg/L.
 - **Chromium**, copper, and lead have been identified on one occasion in groundwater from well BKGmw-005. Chromium was present in the method blank.
 - **Iron** was identified during the first seven sampling events at concentrations ranging from 36.5 J to 493 µg/L. Iron was not detected during the three most recent sampling events.
 - **Manganese** was identified in this well during the first seven sampling events at concentrations ranging from 0.73 J to 18 µg/L. Manganese was not detected during the three most recent sampling events.
 - **Nickel** has been identified at estimated concentrations on two occasions from this well; nickel was not detected during the other eight sampling events.
 - **Zinc** has been identified on four occasions; it was found in the method blank on three of these occasions. Zinc concentrations ranged from 1.6 JB to 12.7 B µg/L.
- Radioactive isotopes, **thorium** and **uranium**, were analyzed from groundwater samples collected during the July 2012 and January 2013 sampling events. Thorium was

identified in the July 2012 sample at an estimated concentration, and uranium was present at estimated concentrations in both samples. Neither was found at concentrations exceeding their corresponding regulatory values. See Section C for further discussion.

- **BEHP** was identified on three occasions in this well, including the two most recent events. BEHP concentrations ranged from 0.87 to 1.1 J µg/L during these three events.
- **HMX** was identified at an estimated concentration of 0.073 J during one sampling event; this constituent was not detected during any of the other eight sampling events.
- **Toxaphene** was identified at an estimated concentration during the October 2006 sampling event. In addition, one rejected result was posted for the January 2012 sampling event; however, the lab reported the value as non-detect. There have not been any other detections of toxaphene in the 281 wells at RVAAP.

BKGmw-006 (Sharon) –

- Located along the northern boundary of the RVAAP property and near the northwestern edge of the Block D Igloo Munitions Response Site (MRS) study area.
- Well BKGmw-006 is located side gradient to historical operations performed in the central portion of RVAAP (e.g., Winkelpeck Burning Grounds and Demolition Area 2) and upgradient of Load Lines 1 through 4 and 12, as well as Ramsdell Quarry, Erie Burning Grounds, Central Burn Pits, etc.
- No residual munitions and explosives of concern (MEC) from the 1943 explosion has been identified in the study area via a geophysical survey; additional investigation is ongoing.
- Well was completed to a depth of 35 feet below grade in the Sharon formation.
- Groundwater flow in the Sharon in this area is generally from west to east in this area.
- Sampled on seven occasions since October 2006.
- Eight inorganic constituents (arsenic, barium, copper, iron, manganese, nickel, thallium, and zinc) have been identified in well BKGmw-006.
 - **Arsenic** was detected at an estimated concentration below reporting limits on one occasion; it was not identified during the other six sampling events.
 - **Barium** was detected during all seven sampling events at concentrations ranging from 8.5 J to 16.1 µg/L.
 - **Copper, nickel, and thallium** have been detected once at estimated concentrations below their reporting limits; these constituents were not identified during the other six sampling events.
 - **Iron** was detected during all seven sampling events at concentrations ranging from 518 to 2400 µg/L.
 - **Manganese** was detected during all seven sampling events at concentrations ranging from 182 to 547 µg/L.
 - **Zinc** was detected on four occasions at estimated concentrations ranging from 2.4 JB to 6.0 JB; this constituent was also found in the method blank on three of the four occasions.
- **BEHP** was identified at estimated concentrations on two occasions in this well.

- *Delta-BHC* was identified at an estimated concentration during one sampling event.
- *Di-n-butyl phthalate* was identified at an estimated concentration during one sampling event.
- *Nitrocellulose* was identified at an estimated concentration during one sampling event.

BKGmw-008 (Sharon)

- Located approximately 4000 feet northwest of Ramsdell Quarry and 4000 feet east of the former Area 2 ore pile storage areas.
- Well BKGmw-008 is located upgradient of Ramsdell Quarry Landfill and side gradient of Load Lines 1 through 3.
- Well was completed at a depth of 25 feet below grade in the Sharon formation.
- Groundwater flow is generally east-northeast in this area of the site within the Sharon.
- Sampled seven times since October 2006.
- Seven inorganic compounds (antimony, barium, cobalt, copper, iron, manganese, and zinc) have been identified in groundwater samples from well BKGmw-008.
 - *Antimony* has been identified on three occasions at estimated concentrations ranging from 0.066 J to 0.26 J µg/L. It was not detected during the other four sampling events.
 - *Barium* has been identified during all seven sampling events at concentrations ranging from 3.7 J to 10.4 µg/L.
 - *Cobalt* was identified during one sampling event from this well; it was not detected during the remaining six events.
 - *Copper* was detected during two sampling events; it was also present in the method blank during one of these events.
 - *Iron* was detected at concentrations ranging from 64.2 J to 135 µg/L during the first five sampling events. Iron was not identified during the two most recent events.
 - *Manganese* has been identified at concentrations ranging from 0.27 J to 91 µg/L. During the first four sampling events manganese was identified at estimated concentrations less than 1.0 µg/L.
 - *Zinc* has been identified in this well on four occasions at concentrations ranging from 3.9 J to 6.4 J µg/L. It was also detected in the method blank on two of these occasions.
- *BEHP* was identified in groundwater in BKGmw-008 at estimated concentrations on two occasions; it was also present in the associated blank during one of these events.
- *Di-n-octylphthalate* and *methoxychlor* were identified at estimated concentrations during one sampling event each. They were not identified during the other sampling events.

BKGmw-015 (Sharon)

- Located along North Line Road, southeast of BKGmw-006, and north of former facility operations.
- Well BKGmw-015 is located side gradient to historical operations performed in the central portion of RVAAP (e.g., Winkelpeck Burning Grounds and Demolition Area 2)

and upgradient of Load Lines 1 through 4 and 12, as well as Ramsdell Quarry, Erie Burning Grounds, Central Burn Pits, etc. This well is downgradient of the Block D Igloo MRS site.

- Well was completed to a total depth of 50 feet below grade into the Sharon formation.
- Groundwater flow in the Sharon in this area is generally to the east.
- Sampled seven times since October 2006.
- Six inorganics (barium, copper, iron, manganese, nickel, and zinc) have been identified in this well.
 - **Barium** was identified in this well at concentrations ranging from 220 to 302 µg/L during all seven sampling events.
 - **Copper** was detected at an estimated concentration on one occasion; it was also found in the method blank.
 - **Iron** was identified in this well on five occasions at concentrations ranging from 95.7 J to 213 µg/L. Iron was not detected during the two most recent sampling events.
 - **Manganese** was identified in well on six occasions at concentrations ranging from 3.1 J to 61.4 µg/L. Manganese was not detected during the most recent sampling event.
 - **Nickel** was identified at estimated concentrations ranging from 2.9 J to 3.7 J µg/L on three successive occasions; it was not detected during the two most recent sampling events.
 - **Zinc** was identified at concentrations ranging from 5.2 JB to 14.2 µg/L on six occasions. Zinc was also found in the blank during the two most recent sampling events.
- **Acetone**, **2-nitrotoluene**, and **methoxychlor** were identified at estimated concentrations during one sampling event each. They were not found in groundwater at this location during any other sampling events.
- **BEHP** was identified on two occasions in this well at estimated concentrations ranging from 1.2 JB to 1.9 µg/L; BEHP was also found in the associated blank during one of these events.

BKGmw-016 (unconsolidated)

- Located along South Service Road, northwest of the former NACA test area.
- Well BKGmw-016 is located upgradient of historical RVAAP operations.
- Well was completed at an approximate depth of 18.5 feet below grade within the unconsolidated strata.
- Groundwater flow is to the east at this location.
- Sampled six times since October 2006.
- Nine inorganic compounds (aluminum, antimony, barium, copper, iron, manganese, mercury, nickel, and zinc) have been identified in this well on at least one occasion.
 - **Aluminum** was identified in groundwater at this location at estimated concentrations ranging from 14.4 JB to 29.8 J µg/L during all six sampling events.
 - **Antimony** was identified at an estimated concentration during one sampling event; this

constituent was not identified during the other five events.

- **Barium** was identified at concentrations ranging from 13.2 to 14.1 µg/L during all six sampling events.

- **Copper** was detected on two occasions at estimated concentrations of 2.4 J and 2.6 J µg/L; copper was not identified in groundwater at this location during the remaining sampling events.

- **Iron** was identified at concentrations ranging from 28.3 J to 111 µg/L on five occasions. Iron was not detected in this well during the most recent sampling event.

- **Manganese** was identified at estimated concentrations ranging from 5.0 J to 9.6 J µg/L on six occasions at this location.

- **Mercury** was detected on one occasion at an estimated concentration in well BKGmw-016.

- **Nickel** was identified at estimated concentrations ranging from 2.3 J to 3.9 J µg/L on four occasions.

- **Zinc** was identified at estimated concentrations ranging from 3.6 J to 6.1 JB µg/L on four occasions. Zinc was also present in the blank on two of these occasions.

- **BEHP** and **beta-BHC** were each identified at estimated concentrations during one sampling event; they were not identified during any other event at this location.
- The compound **2-amino-4,6-dinitrotoluene** was identified on one occasion in this well; it was not identified during the remaining sampling events at BKGmw-016.

BKGmw-017 (unconsolidated)

- Located near northern boundary of RVAAP, south of North Line Road, and northeast of C Block.
- Well BKGmw-017 is downgradient of C Block but upgradient of the remaining historical operations at RVAAP.
- Well was completed to an approximate depth of 33 feet in the unconsolidated water-bearing strata.
- Groundwater flow in the unconsolidated in this area of RVAAP is generally east-southeast.
- Sampled on six occasions since October 2006.
- Ten inorganics (aluminum, antimony, arsenic, barium, copper, iron, manganese, nickel, thallium, and zinc) have been identified in this well on at least one occasion.
 - **Aluminum** was identified on two occasions at concentrations of 41.6 J and 419 µg/L; it was not identified during the other four sampling events, including the most recent.
 - **Antimony** was identified on two occasions at estimated concentrations of 0.073 J and 0.18 J µg/L. It was not detected during the other four sampling events, including the two most recent episodes.
 - **Barium** was detected at concentrations ranging from 33.8 to 40.1 µg/L during all six sampling events.
 - **Copper, nickel, and thallium** were detected during the April 2007 sampling event at estimated concentrations. Copper was also found in the method blank at a concentration

greater than ½ the method detection limit during this sampling event, which qualified this sample with a “B” designation. These constituents were not identified at this location during the other five events.

- **Iron** was identified at concentrations ranging from 1420 JB to 2050 µg/L during all six sampling events.

- **Manganese** was identified at concentrations ranging from 190 to 213 µg/L during all six sampling events.

- **Zinc** was identified in this well at concentrations of 12.4 and 4.9 J µg/L; it was not detected during the other four sampling events, including the most recent event.

- **BEHP** was identified at an estimated concentration during one sampling event from this well.
- **PETN** was identified at an estimated concentration during one sampling event from this well.
- **Benzoic acid** was identified at an estimated concentration during one sampling event from this well. Note that benzoic acid also had rejected data for this constituent on three occasions. However, the laboratory had reported the results as non-detect, so there was nothing in the chromatograms to indicate the presence of benzoic acid when the data was rejected.

BKGmw-018 (Sharon)

- Located along the northern boundary of the RVAAP property and west of the Block D Igloo area.
- Well BKGmw-018 is located side gradient to historical operations performed in the central portion of RVAAP (e.g., Winkelpack Burning Grounds and Demolition Area 2) and upgradient of Load Lines 1 through 4 and 12, as well as Ramsdell Quarry Landfill, Erie Burning Grounds, Central Burn Pits, etc.
- Well was completed in the upper Sharon formation; the bottom of the well screen is approximately 24.5 feet below grade.
- Groundwater flow in the Sharon in this area is generally west to east.
- Sampled on seven occasions since October 2006.
- Seven inorganics (aluminum, barium, cadmium, copper, iron, manganese, and zinc) have been identified in this well on at least one occasion.
 - **Aluminum** was detected during the initial two sampling events at estimated concentrations of 2.9 J and 2.8 J µg/L; it has not been detected at this location during the five subsequent sampling events.
 - **Barium** was identified at concentrations ranging from 12 to 22.7 µg/L during all seven sampling events.
 - **Cadmium** was detected during the initial sampling event at an estimated concentration of 0.09 J µg/L; this inorganic constituent has not been identified in groundwater at this location during the six subsequent sampling events.
 - **Copper** was identified at estimated concentrations on two occasions; it has not been detected during the last four sampling events.

- **Iron** was identified at concentrations ranging from 141 J to 490 µg/L during the first five sampling events. Iron was not detected during the two most recent sampling events.
- **Manganese** was identified at concentrations ranging from 0.75 J to 45.6 J µg/L during all seven sampling events.
- **Zinc** was identified at concentrations ranging from 2.4 J to 7.3 J µg/L during the last six sampling events. It was identified in the blank on two occasions.
- Several other constituents have been identified at estimated concentrations during single sampling events at this location, including **2-butanone**, **BEHP**, **chloromethane**, **di-n-octylphthalate**, **methoxychlor**, and **nitrocellulose**. 2-Butanone was also found in the associated blank.

BKGmw-021 (unconsolidated)

- Located near the north entrance to RVAAP along Paris-Windham Road.
- Well BKGmw-021 is paired with FWGmw-002 and side gradient to former RVAAP operations.
- Well was advanced to a depth of 18 feet below grade and completed in the unconsolidated strata.
- Groundwater flow is to the east-northeast in the unconsolidated strata in this area of the site.
- Sampled on 10 occasions since October 2006.
- Nine inorganic compounds (aluminum, antimony, barium, chromium, copper, iron, manganese, vanadium, and zinc) have been identified on at least one occasion in groundwater at this location.
 - **Aluminum** was identified during the two most recent sampling events at concentrations of 60 and 15 J µg/L; this constituent was not detected during the prior eight sampling events.
 - **Antimony** was identified at estimated concentrations on two occasions; antimony has not been detected in this well during the last six sampling events.
 - **Barium** was identified at concentrations ranging from 26 to 43.4 µg/L during all 10 sampling events.
 - **Chromium** was identified during the two most recent sampling events at estimated concentrations of 1.7 J and 1.1 J µg/L; this constituent was not detected during the prior eight sampling events.
 - **Copper** was detected at an estimated concentration during one sampling event; it was also present in the blank. It was not detected during the other nine sampling events.
 - **Iron** was identified at concentrations ranging from 64 J to 392 µg/L during seven sampling events.
 - **Manganese** was identified at estimated concentrations ranging from 0.47 J to 2.4 J µg/L during four sampling events; manganese was not detected during the other six sampling events.
 - **Vanadium** was detected at an estimated concentration of 4.1 J µg/L during the most recent sampling event; it was not identified in this well during the prior nine sampling

episodes.

- **Zinc** was identified at concentrations ranging from 3.0 JB to 10.7 µg/L during five of the 10 sampling events. It was also found in the blank on three of these occasions.

- **Benzoic acid, butyl benzyl phthalate, and chloromethane** were each identified at estimated concentrations during one sampling event at this location. Note that benzoic acid also had rejected data for this constituent on three occasions. However, the laboratory had reported the results as non-detect, so there was nothing in the chromatograms to indicate the presence of benzoic acid when the data was rejected.
- **BEHP** was identified on six occasions in BKGmw-021 at concentrations ranging from 0.88 J to 1.4 B µg/L. BEHP was also found in the associated blank during two of these events.

SCFmw-006 (Sharon)

- Located in the northeastern portion of RVAAP near Sand Creek.
- Well SCFmw-006 is located side gradient of the former ore pile and ammo storage areas, as well as the historical load line operations (i.e., 1 through 4 and 12, as well as Central Burn Pits and Cobbs Pond).
- Completed to a depth of 86 feet in the Sharon Conglomerate.
- Groundwater flow is to the east in this formation.
- Sampled on eight occasions since April 2009.
- Seven inorganic compounds (antimony, arsenic, barium, iron, manganese, mercury, and thallium) have been identified in groundwater at this location on at least one occasion.
 - **Antimony** was identified on one occasion in this well at a concentration of 1.2 µg/L; it was not identified during the most recent sampling event.
 - **Arsenic** was identified on three occasions at estimated concentrations ranging from 0.86 J to 1.0 J µg/L in this well; arsenic has not been detected during the last four sampling events.
 - **Barium** was identified at concentrations ranging from 107 to 191 µg/L during all eight sampling events.
 - **Iron** was identified at concentrations ranging from 84 B to 569 µg/L during all eight sampling events.
 - **Manganese** was identified at concentrations ranging from 153 to 190 µg/L during all eight sampling events.
 - **Mercury** was identified at an estimated concentration of 0.22 J µg/L on one occasion; it was not detected during the other seven events.
 - **Thallium** was identified on three occasions at estimated concentrations ranging from 0.15 J to 0.44 J µg/L; it was also present in the blank on one occasion. Thallium was not identified in the groundwater samples from the four most recent sampling events.
- Several constituents have been identified in SCFmw-006 as single estimated detections, including **1,3,5-trinitrobenzene, 4-nitrotoluene, acetone, beta-BHC, and carbon disulfide**. **Phenol** was also identified on one occasion at a concentration near the

reporting limit. None of these constituents were identified in groundwater at this location during the other seven sampling events.

- **BEHP** was identified in this well on three occasions at concentrations from 2.2 JB to 3.7 JB $\mu\text{g/L}$; it was found in the associated blank on two of these occasions.

C. Non-inorganic Chemical Data for the Proposed Background Wells

As shown in Table 1 and described above, there are several non-inorganic compounds that have been identified in the proposed background wells. The most common is bis(2-ethylhexyl) phthalate (BEHP), which was identified in each of the proposed background wells on at least one occasion. The source of BEHP in groundwater at RVAAP has not been identified, but it is not believed to be the result of historical RVAAP activities. Similarly, acetone was identified in six of the proposed background wells on at least one occasion. Acetone is a common laboratory artifact and not believed to be associated with historical facility operations. Other non-inorganic compounds identified in the proposed background wells include:

Pesticides – toxaphene (BKGmw-005; one event), delta-BHC (BKGmw-006, BKGmw-016, and SCFmw-006; one event each), methoxychlor (BKGmw-008, BKGmw-015, and BKGmw-018; one event each), and endrin ketone (FWGmw-008; one event). All of the pesticide detections were single estimated concentrations below laboratory reporting limits.

Semivolatile organic compounds (SVOCs) – BEHP (all 14 proposed wells; multiple detections), benzoic acid (BKGmw-017 and BKGmw-021; one event each), di-n-octylphthalate (BKGmw-008 and BKGmw-018; one event each), di-n-butyl phthalate (BKGmw-006; one event), butyl benzyl phthalate (BKGmw-021; one event), dimethyl phthalate (FWGmw-003 and FWGmw-006; one event each), naphthalene (FWGmw-003 and FWGmw-006; one event each), 3,4-methylphenol (FWGmw-006; one event), and phenol (SCFmw-006; one event). With the exception of the naphthalene, 3,4-methylphenol, phenol, and occasional BEHP detections, all SVOCs were identified at estimated concentrations below laboratory reporting limits. Only BEHP was identified in any of the wells on more than one occasion. Note that the two wells that contained benzoic acid also had rejected data for this constituent on three occasions each. However, the laboratory had reported the results as non-detect, so there was nothing in the chromatograms to indicate the presence of benzoic acid when the data was rejected.

As with BEHP, the various phthalates are considered plasticizers and are not believed to be the result of historical RVAAP activities. Naphthalene and the phenolics are generally associated with coal tar, which is typically used as a seal coat for paved surfaces or for heating in fired boilers.

Based on this information, the SVOCs identified in the proposed background wells at RVAAP are not consistent with historical facility operations and are believed to be anthropogenic to the site.

Volatile organic compounds (VOCs) – acetone (six wells; see previous discussion), 2-butanone (BKGmw-018 and FWGmw-006; one event each), chloromethane (BKGmw-018 and BKGmw-

021; one event each), carbon disulfide (FWGmw-006 and SCFmw-006; one event each), benzene (FWGmw-006; two events), and toluene (FWGmw-006; two events).

Most of the VOC constituents found in the proposed background wells were identified as estimated concentrations below laboratory reporting limits and, with the exceptions of acetone, and benzene and toluene in well FWGmw-006, the detected VOCs were identified on only one occasion. As mentioned previously, acetone is commonly considered a laboratory contaminant, and its occurrence in the associated blanks generally confirms that the presence of this constituent in groundwater at the site is not the result of historical operations. Benzene and toluene were identified at FWGmw-006 during the first two sampling events conducted at this location, but these constituents were not found in the groundwater samples during the two most recent events. (Note that preliminary sampling results from August 2013 are also non-detect for benzene and toluene in well FWGmw-006.) Carbon disulfide was identified in two proposed background wells on one occasion each; however, the typical usage of this chemical (described in the following paragraph) does not seem to correspond with historical operations at RVAAP. There is no maximum contaminant level (MCL) for carbon disulfide; the regional screening level (RSL) for this constituent at a hazard index (HI) of 1 is 720 µg/L.

The compound 2-butanone is a solvent and may also be used as a nitrocellulose coating. Chloromethane was a common refrigerant and is the most abundant organohalogen, anthropogenic or natural, in the atmosphere. Carbon disulfide may be released by volcanic eruptions or marshes and is frequently used as a building block in organic chemistry; it is used in fumigants, as an insecticide, as an industrial and chemical non-polar solvent, and in the manufacture of viscose rayon, cellophane film, carbon tetrachloride, and electronic vacuum tubes. Benzene and toluene are common petrochemicals.

Due to the sporadic nature of these constituents at RVAAP, the VOCs identified in the background wells do not appear to be the result of historical operations at RVAAP. (There are VOCs in groundwater at RVAAP that are believed to be associated with former operations, but they do not include those found in the proposed background wells with the possible exception of benzene.)

Explosives and propellants – 2-nitrotoluene (BKGmw-015; one occasion), nitrocellulose (BKGmw-006 and BKGmw-018; one time each), HMX (BKGmw-005; one time), 2-amino-4,6-dinitrotoluene (BKGmw-016; one time), PETN (BKGmw-017; one time), 1,3,5-trinitrobenzene (SCFmw-006; one occasion), and 4-nitrotoluene (SCFmw-006; one time). With the exception of the single occurrence of 2-amino-4,6-dinitrotoluene in BKGmw-016, all detections of explosives or propellants were reported as estimated concentrations below laboratory reporting limits. None of the explosives/propellants were identified at these locations more than once.

Explosives and propellants are related to historical on-site operations at RVAAP; however, single estimated detections preceded and followed by non-detect results suggest that the explosive constituents are not common to the proposed background wells, and that the proposed background wells should not be discounted as a result of these detections.

Radioactive Isotopes – The General Services Administration (GSA) historically used a portion of the facility for storage of strategic materials. Among the materials stored at the facility was monazite sand (thorium ore), which contained measurable quantities of natural thorium. The monazite sand was removed in the mid-1970s, and several decontamination and survey efforts were conducted from the mid-1970s to 2001, with the most recent action occurring in July/August 2004 to remediate small areas of elevated pCi/g in soil. In a letter dated December 16, 2004, the NRC determined that the former monazite sand area (former West Tank Farm) could be released for unrestricted use.

FWGmw-014 (one of the new remedial investigation wells in the former monazite sands storage area) and BKGmw-005 were analyzed for alpha, beta, and gamma radionuclides. Well FWGmw-014 was sampled on four occasions for these compounds and BKGmw-005 was sampled twice. The gamma spectroscopy results for the sample from FWGmw-014 in April 2012 indicated that no results exceeded their respective Minimum Detectable Concentrations (MDCs) or MCLs except for Radium 226 (RA-226; 23 pCi/L J) and Bismuth 214 (23 pCi/L J) in the parent sample. The field and laboratory duplicate sample indicated no detections for Ra-226 and Bismuth 214 above their respective MDCs or MCLs.

During the July 2012 sampling event, Ra-226 was identified in well FWGmw-014 at a similar concentration (36 pCi/L) as that found during the April 2012 event. EQM believed the reported Ra-226 concentration was likely a false positive due to a combination of both a misidentification by the gamma spectroscopy software and the elevated reporting limit of the analytical method applied. After discussions with the laboratory technical director, EQM determined that further analysis of the groundwater samples from wells FWGmw-014 (monazite well) and BKGmw-005 (background well) was needed to definitively rule out the presence of Ra-226 and to further investigate the unknown naturally occurring radioactive material (NORM). It is critical to remember that Ra-226 is predominantly an alpha particle emitter, and that the main intent of the monazite sand investigation was to monitor for thorium (isotope of concern from monazite sand).

EQM had the July samples analyzed for total alpha radium by method 903.0 (approved drinking water method for total alpha radium) and total thorium and uranium by ICPMS Method 6020. The results of the reanalysis were as follows: the total alpha radium for both wells was below the EPA drinking water limit of 5.0 pCi/L. The total uranium results were also reported below the EPA limits of 30 µg/L. There is no EPA standard for thorium in drinking water; the thorium results were below the laboratory reporting limit of 2 µg/L. Subsequent sampling in October 2012 and January 2013 also showed the total alpha radium concentrations to be below the EPA drinking water limit. Total uranium was reported below the MCL, and thorium was below the laboratory reporting limit.

REFERENCES

Battelle, *et al.* October 2003. *Guidance for Environmental Background Analysis Volume III: Groundwater* prepared for the Naval Facilities Engineering Command.

Nuclear Regulatory Commission. December 16, 2004. Letter regarding *Final Status Survey Report for the Ravenna Army Ammunition Plant Former West Tank Farm Area*.

Ohio EPA. August 21, 2009. *Use of Background for Remedial Response Sites*.

Ohio EPA. February 1995. *Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring*.

Table 2. Historical Background Well Data at RVAAP

Well No.	Constituent	Units	Oct-06	Jan-07	Apr-07	Jul-07	Oct-07	Jan-08	Apr-08	Jul-08	Oct-08	Jan-09	Apr-09	Jul-09	Oct-09	Jan-10	Apr-10	Jul-10	Oct-10	Jan-11	Apr-11	Jul-11	Oct-11	Jan-12	Apr-12	Jul-12	Oct-12	Jan-13	MCL	RSL (10 ⁻⁶ & HI=0.1)		
SCFmw-006 (bedrock)	1,3,5-Trinitrobenzene	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.047 J	0.20 U	0.20 U	0.20 UJ	NT	0.11 U	0.095 U	0.11 U	0.10 U	NT	NT	NT	NT	NT	NT	NT	NT	NS	46	
	4-Nitrotoluene	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.48 U	0.51 U	0.50 U	0.51 U	NT	0.18 J	0.48 U	0.54 U	0.51 U	NT	NT	NT	NT	NT	NT	NT	NT	NS	3.7	
	Acetone	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	10 UJ	10 UJ	10 U	10 U	NT	4.9 JB	10 U	10 U	10 U	NT	NT	NT	NT	NT	NT	NT	NT	NS	1200
	beta-BHC	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.05 U	0.05 U	0.05 U	0.05 U	NT	0.20 J	0.30 U	0.30 U	0.30 U	NT	NT	NT	NT	NT	NT	NT	NT	NS	0.022
	bis(2-ethylhexyl)phthalate	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	3.6 J	1.1 U	1.0 U	1.0 U	NT	3.7 JB	10 U	10 U	2.2 JB	NT	NT	NT	NT	NT	NT	NT	NT	6.0	4.8
	Carbon disulfide	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1.0 U	1.0 U	1.0 U	0.54 J	NT	1.0 U	1.0 U	1.0 U	1.0 U	NT	NT	NT	NT	NT	NT	NT	NT	NS	72
	Phenol	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1.0 U	1.0 U	1.0 U	1.0 U	NT	1.0 U	1.0 U	1.2	1.2 U	NT	NT	NT	NT	NT	NT	NT	NT	NS	450
	Antimony	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	1.0 J	0.98 J	5.0 U	0.86 J	NT	2.0 U	2.0 U	2.0 U	2.0 U	NT	NT	NT	NT	NT	NT	NT	NT	6.0	0.60
	Arsenic	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	12.9	12.6	12.3	13.8	NT	12.8	13.7	9.3	13.5	NT	NT	NT	NT	NT	NT	NT	NT	10	0.045
	Barium	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	112	118	191	127	NT	107	118	118	118	NT	NT	NT	NT	NT	NT	NT	NT	2000	290
	Iron	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	318	417	560	569	NT	332	518	84 B	502	NT	NT	NT	NT	NT	NT	NT	NT	300	1100
	Manganese	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	176 J	171	171	190	NT	153	172	164	177	NT	NT	NT	NT	NT	NT	NT	NT	50	32
	Mercury	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.20 U	0.20 U	0.20 U	0.20 U	NT	0.20 U	0.20 U	0.22 J	0.20 U	NT	NT	NT	NT	NT	NT	NT	2.0	0.063	
	Thallium	µg/L	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	2.0 U	0.15 J	0.44 J	0.18 JB	NT	1.0 U	1.0 U	1.0 U	1.0 U	NT	NT	NT	NT	NT	NT	NT	NT	2.0	0.16

Values in *italics* are detected results.

Values in **bold** exceed either the MSL or RSL at the COPC screening level.

J = estimated value below laboratory reporting limit.

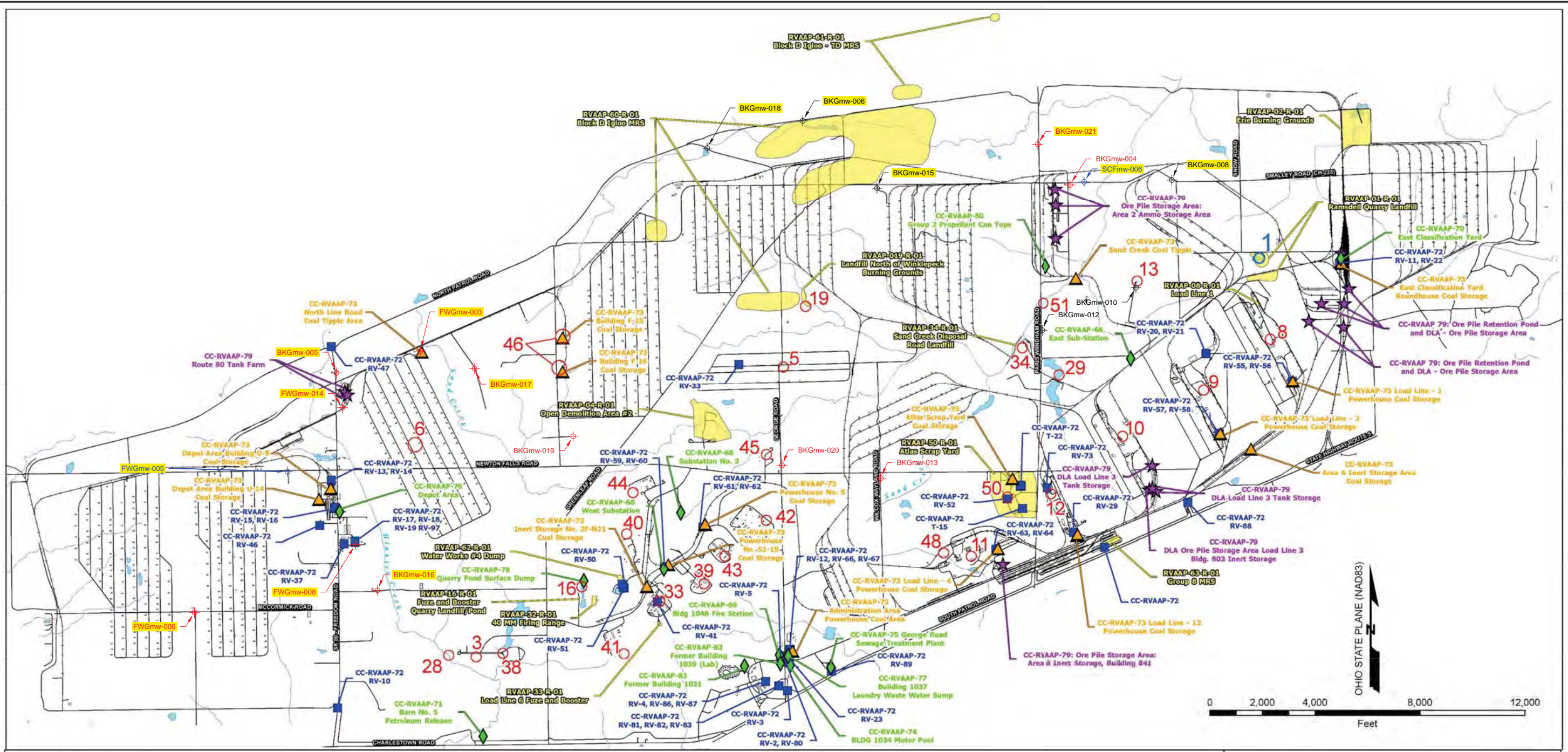
B = contaminant also found in the method blank or any of the field blanks.

U = analyte was analyzed for but not detected.

UJ = analyte was not detected at an estimated reporting limit.

NT = not tested.

ND = not detected. Thorium and uranium were not detected at a minimum detectable concentration of 210 pCi/L using EPA Method 901.1 in April 2012.



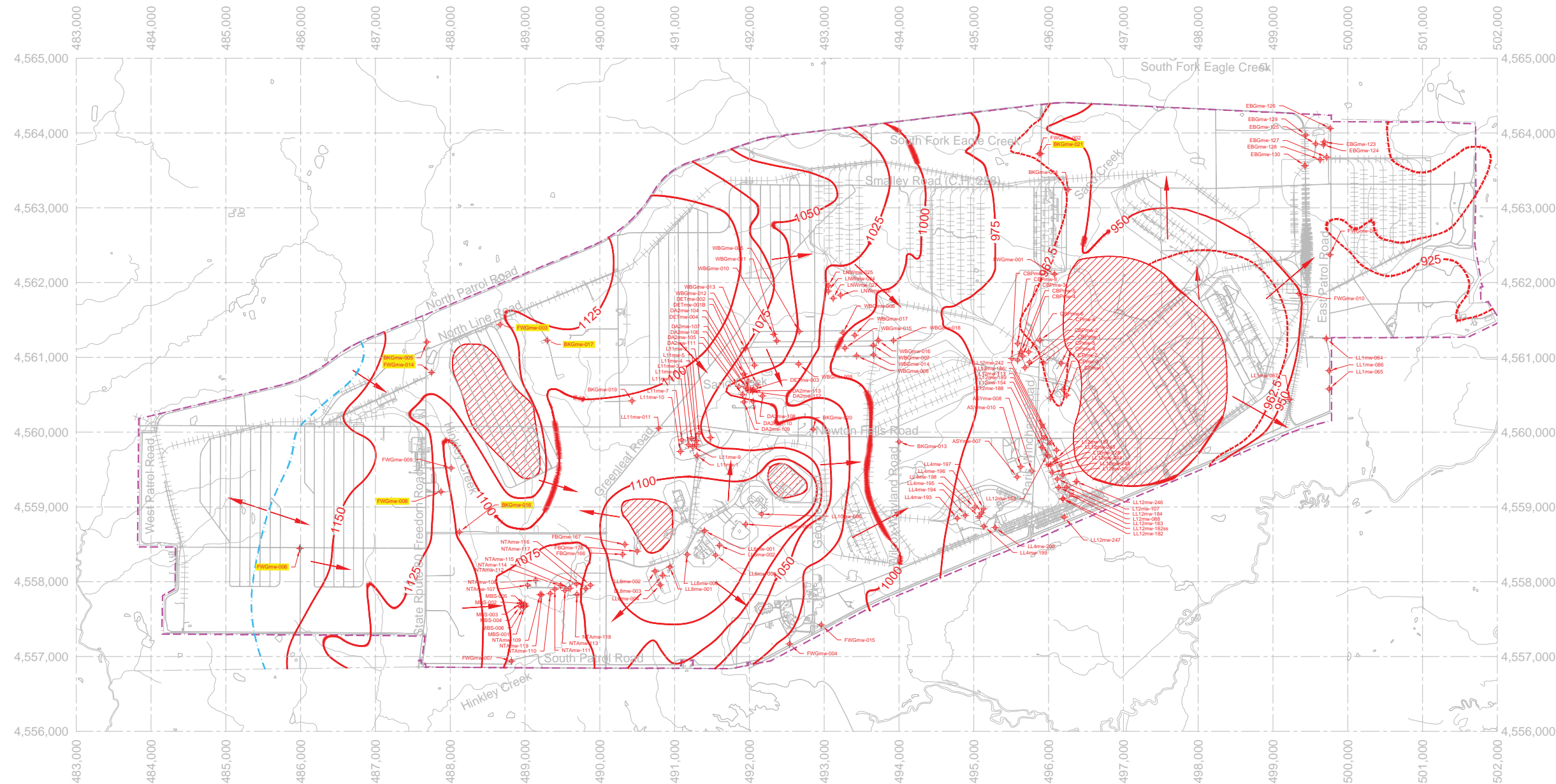
LEGEND OF SITES

IRP SITES (29 SITES)	RVAAP-33	LOAD LINE 6	RVAAP-67	FACILITY-WIDE SEWERS	CC-RVAAP-87	FORMER BUILDINGS 1031 AND 1039	RVAAP-02-R-01	GROUP 8 MRS	
RVAAP-01	RAMSDELL QUARRY LANDFILL	RVAAP-34	SAND CREEK DISPOSAL ROAD LANDFILL	COMPLIANCE RESTORATION SITES (13 SITES)	CC-RVAAP-88	ELECTRIC SUBSTATIONS (E.W.No 3)	RVAAP-03-R-01	RAMSDELL QUARRY LANDFILL MRS	
RVAAP-03	OPEN DEMOLITION AREA 1	RVAAP-38	NACA TEST AREA	CC-RVAAP-89	BUILDING 1048 - FIRE STATION	CC-RVAAP-70	EAST CLASSIFICATION YARD	RVAAP-04-R-01	OPEN DEMOLITION AREA #2 MRS
RVAAP-05	WINKLEPECK BURNING GROUNDS	RVAAP-40	LOAD LINE 7	CC-RVAAP-71	BARN NO. 5 PETROLEUM RELEASE	CC-RVAAP-72	FACILITY-WIDE USTS	RVAAP-05-R-01	LOAD LINE 1 MRS
RVAAP-06	C BLOCK QUARRY	RVAAP-41	LOAD LINE 8	CC-RVAAP-73	FACILITY-WIDE COAL STORAGE	CC-RVAAP-74	BUILDING 1034 MOTOR POOL HYDRAULIC LIFT	RVAAP-06-R-01	FUZE AND BOOSTER QUARRY MRS
RVAAP-08	LOAD LINE 1	RVAAP-42	LOAD LINE 9	CC-RVAAP-75	GEORGE ROAD SEWAGE TREATMENT PLANT	CC-RVAAP-77	BUILDING 1037 LAUNDRY WASTE WATER SUMP	RVAAP-07-R-01	LANDFILL NORTH OF WINKLEPECK MRS
RVAAP-09	LOAD LINE 2	RVAAP-43	LOAD LINE 10	CC-RVAAP-78	DEPOT AREA	CC-RVAAP-79	DLA ORE STORAGE SITES	RVAAP-08-R-01	LOAD LINE 2 MRS
RVAAP-10	LOAD LINE 3	RVAAP-44	LOAD LINE 11	CC-RVAAP-79	DLA ORE STORAGE AREAS (7 SITES)	CC-RVAAP-80	GROUP 2 PROPELLANT CAN TOPS	RVAAP-09-R-01	LOAD LINE 3 MRS
RVAAP-11	LOAD LINE 4	RVAAP-45	LOAD LINE 12	CC-RVAAP-81	FORMER BUILDING 1039 (LAB)	CC-RVAAP-82	FORMER BUILDING 1031	RVAAP-10-R-01	LOAD LINE 4 MRS
RVAAP-12	LOAD LINE 12	RVAAP-46	BUILDINGS F-15 AND F-16	CC-RVAAP-83	FORMER BUILDING 1031	CC-RVAAP-83	FORMER BUILDING 1031	RVAAP-11-R-01	LOAD LINE 1 MRS
RVAAP-13	BLDG 1200 AND DILLUTION/SETTLING POND	RVAAP-48	ANCHOR TEST AREA	CC-RVAAP-84	LAUNDRY WASTE WATER SUMP	CC-RVAAP-84	LAUNDRY WASTE WATER SUMP	RVAAP-12-R-01	LOAD LINE 2 MRS
RVAAP-16	FUZE AND BOOSTER QUARRY LANDFILL/PONDS	RVAAP-50	ATLAS SCRAP YARD	CC-RVAAP-85	BLDG 1048 FIRE STATION	CC-RVAAP-85	BLDG 1048 FIRE STATION	RVAAP-13-R-01	LOAD LINE 3 MRS
RVAAP-19	LANDFILL NORTH OF WINKLEPECK BURNING GROUND	RVAAP-51	DUMP ALONG PARIS-WINDHAM ROAD	CC-RVAAP-86	BLDG 1048 FIRE STATION	CC-RVAAP-86	BLDG 1048 FIRE STATION	RVAAP-14-R-01	LOAD LINE 4 MRS
RVAAP-26	MUSTARD AGENT BURIAL SITE	RVAAP-55	ATLAS SCRAP YARD	CC-RVAAP-87	BLDG 1048 FIRE STATION	CC-RVAAP-87	BLDG 1048 FIRE STATION	RVAAP-15-R-01	LOAD LINE 5 MRS
RVAAP-29	UPPER AND LOWER COBBS POND	RVAAP-59	DUMP ALONG PARIS-WINDHAM ROAD	CC-RVAAP-88	BLDG 1048 FIRE STATION	CC-RVAAP-88	BLDG 1048 FIRE STATION	RVAAP-16-R-01	LOAD LINE 6 MRS
		RVAAP-68	FACILITY-WIDE GROUNDWATER	CC-RVAAP-89	BLDG 1048 FIRE STATION	CC-RVAAP-89	BLDG 1048 FIRE STATION	RVAAP-17-R-01	LOAD LINE 7 MRS
				CC-RVAAP-90	BLDG 1048 FIRE STATION	CC-RVAAP-90	BLDG 1048 FIRE STATION	RVAAP-18-R-01	LOAD LINE 8 MRS
				CC-RVAAP-91	BLDG 1048 FIRE STATION	CC-RVAAP-91	BLDG 1048 FIRE STATION	RVAAP-19-R-01	LOAD LINE 9 MRS
				CC-RVAAP-92	BLDG 1048 FIRE STATION	CC-RVAAP-92	BLDG 1048 FIRE STATION	RVAAP-20-R-01	LOAD LINE 10 MRS
				CC-RVAAP-93	BLDG 1048 FIRE STATION	CC-RVAAP-93	BLDG 1048 FIRE STATION	RVAAP-21-R-01	LOAD LINE 11 MRS
				CC-RVAAP-94	BLDG 1048 FIRE STATION	CC-RVAAP-94	BLDG 1048 FIRE STATION	RVAAP-22-R-01	LOAD LINE 12 MRS
				CC-RVAAP-95	BLDG 1048 FIRE STATION	CC-RVAAP-95	BLDG 1048 FIRE STATION	RVAAP-23-R-01	LOAD LINE 1 MRS
				CC-RVAAP-96	BLDG 1048 FIRE STATION	CC-RVAAP-96	BLDG 1048 FIRE STATION	RVAAP-24-R-01	LOAD LINE 2 MRS
				CC-RVAAP-97	BLDG 1048 FIRE STATION	CC-RVAAP-97	BLDG 1048 FIRE STATION	RVAAP-25-R-01	LOAD LINE 3 MRS
				CC-RVAAP-98	BLDG 1048 FIRE STATION	CC-RVAAP-98	BLDG 1048 FIRE STATION	RVAAP-26-R-01	LOAD LINE 4 MRS
				CC-RVAAP-99	BLDG 1048 FIRE STATION	CC-RVAAP-99	BLDG 1048 FIRE STATION	RVAAP-27-R-01	LOAD LINE 5 MRS
				CC-RVAAP-100	BLDG 1048 FIRE STATION	CC-RVAAP-100	BLDG 1048 FIRE STATION	RVAAP-28-R-01	LOAD LINE 6 MRS

**RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
(12/23/2011)**

**FIGURE 1
RVAAP
FACILITY MAP**

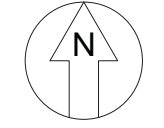




SHAPE Area	SHAPE ID	Point Number	SHAPE Area	SHAPE ID	Point Number	SHAPE Area	SHAPE ID	Point Number	SHAPE Area	SHAPE ID	Point Number	
Leaf 1	LL1m-001	851.78	LL1m-101	873.75	DE1m-001	947.26	DE1m-101	1043.24	DE1m-201	1068.71	DE1m-301	1080.00
	LL1m-002	862.28	LL1m-102	875.16	DE1m-002	956.50	DE1m-102	1060.50	DE1m-202	1075.13	DE1m-302	1088.00
	LL1m-003	869.71	LL1m-103	873.02	DE1m-003	965.81	DE1m-103	1065.50	DE1m-203	1078.00	DE1m-303	1090.00
	LL1m-004	872.00	LL1m-104	873.75	DE1m-004	971.26	DE1m-104	1070.50	DE1m-204	1082.00	DE1m-304	1095.00
	LL1m-005	874.00	LL1m-105	875.00	DE1m-005	977.50	DE1m-105	1075.00	DE1m-205	1085.00	DE1m-305	1100.00

LEGEND

- ⊕ UNCONSOLIDATED WELL
- - - PROPERTY LINE
- 1100 — LINE OF EQUAL GROUNDWATER ELEVATION (ft.,amsl) [DASHED WHERE INFERRED]
- GROUNDWATER DIRECTION
- [Diagonal Lines] UNCONSOLIDATED AQUIFER MISSING
- - - INFERRED GROUNDWATER DIVIDE
- [Yellow Box] PROPOSED BACKGROUND WELLS



0 500 1000
SCALE (METERS)

NOTES
1. POTENTIOMETRIC SURFACE OF UNCONSOLIDATED AQUIFER (JULY 2012).

COORDINATE SYSTEM UTM NAD 83 ZONE 17

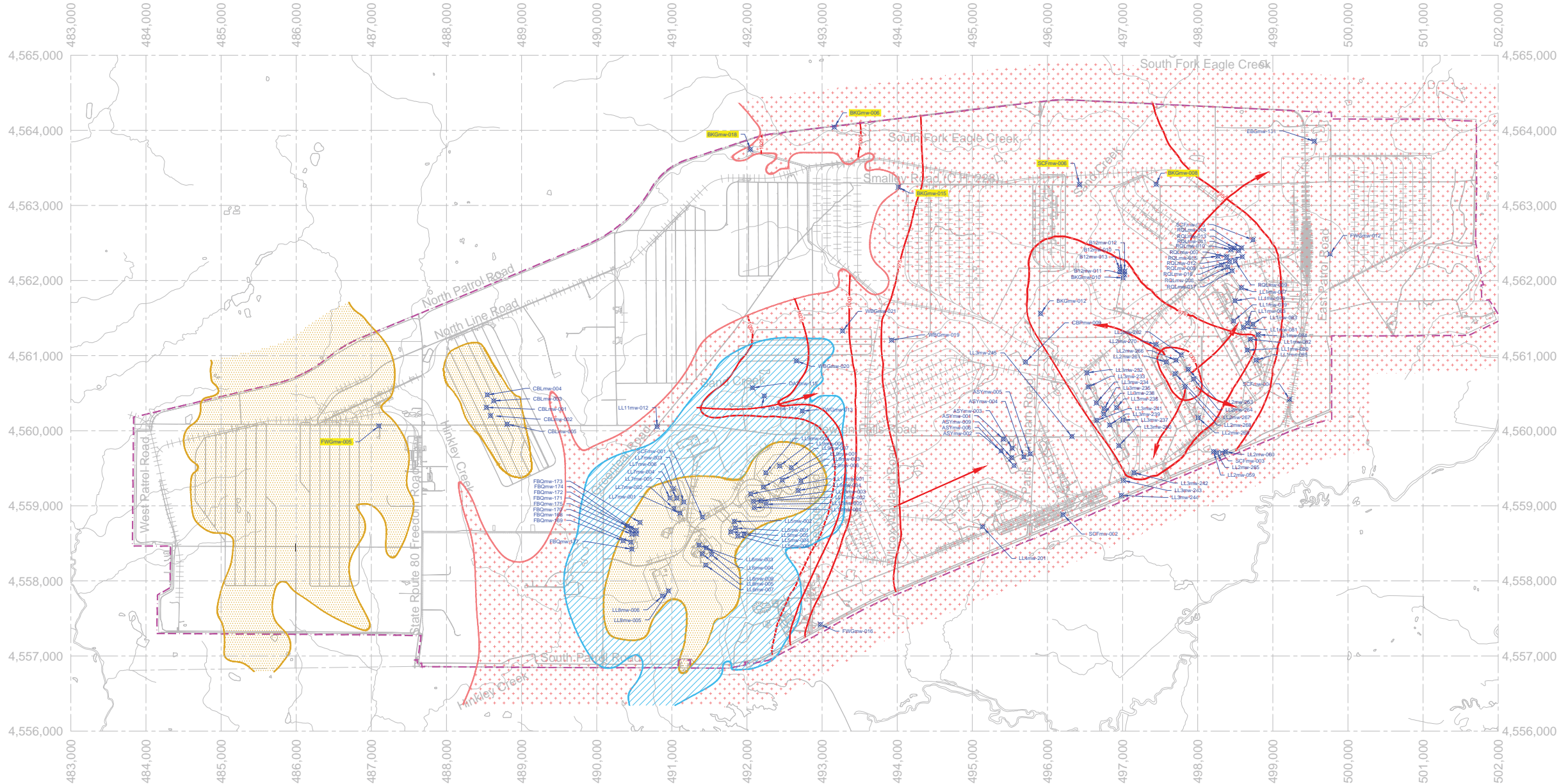
REV	DESCRIPTION	DATE	APPROVED

**ENVIRONMENTAL QUALITY
MANAGEMENT, INC.**
1800 CARLTON BLVD., CINCINNATI, OHIO 45240
PHONE 513.625.7600 | FAX 513.625.7495
WWW. EQM.COM

DRAWN	R. RUSSELL	09-20-2013
CHECKED	S. SPESHARDT	09-23-2013
APPROVED	J. MILLER	09-23-2013

RVAAP
PROPOSED UNCONSOLIDATED
BACKGROUND WELLS

SCALE:	AS SHOWN
SIZE:	PROJECT NO. E 030174.0016
DWG NO.:	FIGURE 2
REV:	



WELL ID	PROPOSED BACKGROUND WELL	WELL ID	PROPOSED BACKGROUND WELL
LLSmw-001	888.45	ADSmw-001	988.38
LLSmw-002	888.74	ADSmw-002	975.60
LLSmw-003	888.80	ADSmw-003	988.00
LLSmw-004	888.14	ADSmw-004	988.00
LLSmw-005	888.04	ADSmw-005	988.04
LLSmw-006	877.09	ADSmw-006	988.11
LLSmw-007	888.14	ADSmw-007	988.11
LLSmw-008	888.04	ADSmw-008	987.08
LLSmw-009	882.29	ADSmw-009	987.42
LLSmw-010	883.04	ADSmw-010	987.84
LLSmw-011	882.19	ADSmw-011	988.00
LLSmw-012	882.19	ADSmw-012	987.84
LLSmw-013	882.19	ADSmw-013	987.84
LLSmw-014	882.19	ADSmw-014	987.84
LLSmw-015	882.19	ADSmw-015	987.84
LLSmw-016	882.19	ADSmw-016	987.84
LLSmw-017	882.19	ADSmw-017	987.84
LLSmw-018	882.19	ADSmw-018	987.84
LLSmw-019	882.19	ADSmw-019	987.84
LLSmw-020	882.19	ADSmw-020	987.84
LLSmw-021	882.19	ADSmw-021	987.84
LLSmw-022	882.19	ADSmw-022	987.84
LLSmw-023	882.19	ADSmw-023	987.84
LLSmw-024	882.19	ADSmw-024	987.84
LLSmw-025	882.19	ADSmw-025	987.84
LLSmw-026	882.19	ADSmw-026	987.84
LLSmw-027	882.19	ADSmw-027	987.84
LLSmw-028	882.19	ADSmw-028	987.84
LLSmw-029	882.19	ADSmw-029	987.84
LLSmw-030	882.19	ADSmw-030	987.84
LLSmw-031	882.19	ADSmw-031	987.84
LLSmw-032	882.19	ADSmw-032	987.84
LLSmw-033	882.19	ADSmw-033	987.84
LLSmw-034	882.19	ADSmw-034	987.84
LLSmw-035	882.19	ADSmw-035	987.84
LLSmw-036	882.19	ADSmw-036	987.84
LLSmw-037	882.19	ADSmw-037	987.84
LLSmw-038	882.19	ADSmw-038	987.84
LLSmw-039	882.19	ADSmw-039	987.84
LLSmw-040	882.19	ADSmw-040	987.84
LLSmw-041	882.19	ADSmw-041	987.84
LLSmw-042	882.19	ADSmw-042	987.84
LLSmw-043	882.19	ADSmw-043	987.84
LLSmw-044	882.19	ADSmw-044	987.84
LLSmw-045	882.19	ADSmw-045	987.84
LLSmw-046	882.19	ADSmw-046	987.84
LLSmw-047	882.19	ADSmw-047	987.84
LLSmw-048	882.19	ADSmw-048	987.84
LLSmw-049	882.19	ADSmw-049	987.84
LLSmw-050	882.19	ADSmw-050	987.84

- NOTES**
- BEDROCK GEOLOGY ADOPTED FROM "GEOLOGY AND GROUND-WATER RESOURCES OF PORTAGE COUNTY, OHIO" (WINSLOW AND WHITE, 1966). NOT ALL LITHOLOGIC UNITS ARE PRESENTED.
 - POTENTIOMETRIC SURFACE OF UPPER SHARON AQUIFER (JULY 2012).
 - GROUNDWATER FLOW IN THE HOMEWOOD IS PRESENTED IN PLATE 3 OF THE JULY 2012 QUARTERLY MONITORING REPORT. WELL FWGmw-005 IS COMPLETED IN THE HOMEWOOD FORMATION.

LEGEND

- × BEDROCK WELL
- - - - - PROPERTY LINE
- 1100 — LINE OF EQUAL GROUNDWATER ELEVATION (ft.,amsl)
- · - · - · 1030 - (INTERMEDIATE DASHED)
- GROUNDWATER DIRECTION
- [Orange Hatched] HOMEWOOD MEMBER
- [Red Dotted] SHARON MEMBER
- [Blue Hatched] SHARON SHALE
- [Yellow Box] PROPOSED BACKGROUND WELLS



0 500 1000
SCALE (METERS)

COORDINATE SYSTEM UTM NAD 83 ZONE 17

<p>ENVIRONMENTAL QUALITY MANAGEMENT, INC. 1800 CARLTON BLVD., CINCINNATI, OHIO 45240 PHONE 513.825.7500 FAX 513.825.7495 WWW.EQM.COM</p>		<p>DRAWN R. RUSSELL 09-20-2013</p> <p>CHECKED S. SPESSHARDT 09-23-2013</p> <p>APPROVED J. MILLER 09-23-2013</p>	<p>RVAAP PROPOSED BEDROCK BACKGROUND WELLS</p>
<p>REV DESCRIPTION DATE APPROVED</p> <p>REVISIONS</p>	<p>SCALE: AS SHOWN</p>	<p>SIZE PROJECT NO. DWG. NO. REV</p> <p>E 030174.0016 FIGURE 3</p>	