Operational Range Assessment Phase II Report Fort Indiantown Gap, Pennsylvania

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Prepared for:

US ARMY CORPS OF ENGINEERS - BALTIMORE DISTRICT

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And

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DENIX Report

OPERATIONAL RANGE ASSESSMENT PHASE II REPORT FORT INDIANTOWN GAP, PA

To meet Department of Defense (DoD) requirements and support the United States (U.S.) Army's Sustainable Range Program, the Army National Guard (ARNG) Directorate is conducting assessments to determine whether a release or substantial threat of release of munitions constituents of concern (MCOC) from an operational range to an off-range area creates a potentially unacceptable risk to human health or the environment. The initial Operational Range Assessment (ORA), Phase I, was a qualitative study of whether MCOC sources exist on the operational range footprint, potential migration mechanisms exist, and human or sensitive ecological receptors are present. For the operational range footprints having a potentially complete source-receptor pathway, the ARNG Directorate conducts a Phase II, a quantitative assessment of potentially complete pathways of MCOC to non-operational areas. This ORA Phase II Report presents evaluation of source-receptor pathways at Fort Indiantown Gap, Pennsylvania (PA). URS Group, Inc. and ARCADIS U.S., Inc. conducted the assessment under contract W912DR-09-D-0003/0006 with the U.S. Army Corps of Engineers Baltimore District in support of the ARNG Directorate.

To determine whether MCOC were leaving the operational range by an identified pathway (e.g., groundwater, surface water) and posed a potential risk to off-site receptors, the ORA team considered existing and new data, including sampling data. The ORA team may re-evaluate existing information (e.g., prior sampling, reports), run simulation models, or collect environmental samples to obtain the additional information. The team uses all available information to update the conceptual site model (CSM) and establish a weight-of-evidence[1] case that determines whether there has likely been an MCOC release from the operational range that may pose an unacceptable risk to an off-range receptor.

Fort Indiantown Gap, PA is located on 17,000 acres in the south-central region of Pennsylvania on the southeastern edge of the Appalachian Mountain Range, approximately 26 miles northeast of Harrisburg. There are 22 privately owned properties covering 95 acres within the installation boundary, referred to as "in-holdings", which were not purchased during the acquisition of Fort Indiantown Gap. Fort Indiantown Gap has served as a military training facility on a continuous basis since its establishment in 1931.

Phase II multi-season sampling occurred between 2010 and 2013. **Figure ES-1** shows the installation layout and CSM for the installation. The CSM identifies potential sources of MCOC, pathways by which these constituents could migrate (streams or groundwater) off the operational range footprint, and off-range human and ecological receptors that may be affected by migrating MCOC. The ORA team selected sampling locations to answer the study question: could

[1] The weight-of-evidence is the cumulative strength and value of facts gathered as part of the Phase II assessment (e.g. sampling results, field observations, and professional judgement) which support the conclusions of the assessment.

munitions constituents migrate off the operational range footprint at concentrations that may pose a risk to receptors? **Figure ES-1** shows all of these elements, including sampling locations. The following executive summary sections present the Phase II evaluation of source-receptor pathways.

1 Conceptual Site Model

1.1 Potential Sources

The operational ranges at Fort Indiantown Gap consist of five basic types: training and maneuver areas, live-fire ranges, a non-live-fire range, artillery and mortar firing points, and demolition training ranges. The types of munitions historically and currently fired at Fort Indiantown Gap are small caliber, medium caliber, large caliber, pyrotechnics/obscurants, and other munitions. Munitions constituents for this assessment are:

- Metals (primarily from small arms): lead (Pb), copper (Cu), zinc (Zn) and antimony (Sb)
- Explosives, among which is cyclotrimethylenetrinitramine (RDX)
- Propellants (nitroglycerin [NG] and perchlorate)

1.2 Migration Pathways and Assessment Areas

MCOC (metals, propellants, and explosives) from the range footprint area may migrate via dissolved and particulate runoff into streams, and/or by infiltrating into groundwater. Groundwater may enter streams through seeps or springs either on- or off-installation.

Three major surface water drainage basins are present at Fort Indiantown Gap: (1) Range Road area (Vesle Run, Aires Run and Qureg Run), (2) Indiantown Run, and (3) Manada Creek (**Figure ES-1**). Phase II sampling was conducted in each basin, which is referred to as an 'assessment area'.

Based on topography, groundwater is inferred to flow to the east on the east side of the installation and to the west on the west side. The CSM illustrates groundwater flow and where Phase II groundwater sampling was conducted (**Figure ES-1**). For the Range Road assessment area, shallow groundwater that may be affected by the small arms range metals seeps directly into creeks adjacent to the ranges and within the installation boundaries. Groundwater is not an independent pathway to receptors. Therefore, only the surface water system was evaluated during the Phase II for the Range Road assessment area.

1.3 Potential Receptors

Groundwater is used for drinking water outside the installation along its southwestern boundary. In-holding residential properties also have domestic drinking water wells within the Indiantown Run assessment area. Therefore, MCOC migrating in groundwater may affect human receptors at two assessment areas (Manada Creek and Indiantown Run).

A drinking water intake is present on Swatara Creek (Range Road streams empty into Swatara Creek), approximately 14 river miles downstream of the installation boundary. Another drinking

water intake is present on Manada Creek, approximately 12 miles downstream of the installation boundary. MCOC in surface water flowing from the assessment areas may affect public drinking water. However, given the distances to the intakes, the sampling program described below will provide very conservative MCOC concentration estimates because significant dilution would occur downstream.

Ecological receptors are present in streams and wetlands downstream from ranges, both off-installation and within the cantonment area. Potential off-range and off-installation surface water pathways are highlighted on **Figure ES-1**. Potential aquatic or semi-aquatic receptors associated with the streams draining the installation and any associated freshwater forested wetlands off-range include plants, benthic and aquatic invertebrates, reptiles and amphibians, fish, small mammals, wading birds, and piscivorous birds. Within the installation's boundaries, four plants, three mammals, two snakes, and 11 insects were among the identified species of special concern. Of the species of special concern, only the ocellated darner is associated with aquatic environments as it has an aquatic life stage. This assessment uses wetland areas as surrogates for sensitive species.

2 Sampling Program

2.1 Sampling Program Summary

Table ES-1 summarizes the assessment areas, their sampling media, types of MCOC, and the purpose for sample locations.

Range Road Assessment Area: The ranges within the Range Road assessment area were grouped according to use, range layout, concentration of use (i.e., is all firing into berms or is firing dispersed over a large area), presence of mitigating structures (side berms), vegetative cover, and distance from surface water bodies. Based on these criteria, the small arms ranges within the Range Road assessment area were grouped into three separate CSMs for ranges with a high potential for off-range migration, a medium potential for off-range migration, and a low potential for off-range migration. The ORA team sampled locations TV1 (high migration potential), AR1 (medium migration potential), QR1 (low migration potential) for metals downstream from the small arms complex that might impact ecological receptors off the range footprint, but within the installation (cantonment area) boundaries (**Figure ES-1**). The team also sampled for metals concentrations at a reference location, FC1, to facilitate comparisons to naturally occurring metals. Locations VR1 and AR2 assessed the metals MCOC concentrations that might impact off-installation human and ecological receptors. Explosives and or propellants are used infrequently in this assessment area and were therefore not sampled here.

Indiantown Run Assessment Area: The ORA team sampled IR1 and IR2 locations for metals, propellants and explosives to assess impact to ecological receptors in this area. The ORA team used IR1 to represent reference or background concentrations for metals.

The field team collected groundwater samples from a minimum of three intervals from each of the newly installed wells (BW3 and BW4). Samples were analyzed for metals, propellants, and explosives.

Manada Creek Assessment Area: The ORA team sampled MC1 and TM1 locations for metals, propellants and explosives to assess potential impact to ecological receptors in this area. The ORA team used TM1 as the reference location, positioned on a stream segment that flows west to east onto the installation.

Groundwater samples were collected from a minimum of three intervals from each of the newly installed wells (BW1 and BW2) and one existing non-potable well (EW1). Samples were analyzed for metals, propellants, and explosives.

Table ES-1: Sampling Summary

Location	Sampled Media	Applicable MCOC	Receptors	Purpose
Range Road Assessment Area				
FC1	Surface water Sediment	Metals	NA	Reference; evaluate naturally occurring metals concentrations in area unaffected by range activities
TV1 AR1 QR1	Surface water Sediment	Metals	Ecological	Downstream of small arm ranges (source area); assess metals concentrations migrating off-range in cantonment area. TV1 is near ranges with high potential for off-range migration; AR1 is near ranges with moderate potential for off-range migration; and QR is near ranges with low potential for off-range migration.
VR1 AR2	Surface water Sediment	Metals	Human and ecological	Downstream of small arm ranges (source area); assess metals concentrations migrating off-range and of- installation
Indiantown Run Assessment Area				
IR1	Surface water Sediment	Metals Explosives Propellants	NA	Reference; evaluate naturally occurring metals concentrations in area unaffected by range activities; also evaluates upstream explosives and propellants
IR2	Surface water Sediment	Metals Explosives Propellants	Ecological	Downstream: evaluate metals, explosives, and propellants migrating off-range
BW3 BW4	Groundwater	Metals Explosives Propellants	Human	Downgradient of ranges and upgradient of homeowner wells; evaluates MCOC potentially leaving the operational ranges
Manada Creek Assessment Area				
TM1	Surface water Sediment	Metals Explosives Propellants	NA	Reference; evaluate naturally occurring metals concentrations in area unaffected by range activities
MC1	Surface water Sediment	Metals Explosives Propellants	Human and Ecological	Downstream; evaluate metals, explosives, and propellants migrating off-range

BW1 BW2 EW1	Groundwater	Metals Explosives Propellants	Human	Downgradient of ranges and upgradient of homeowner wells; evaluates MCOC potentially leaving the operational ranges

2.2 Sampling and Analytical Methods

Streams: The ORA team conducted Phase II sampling during both wet and dry seasons, including one storm event. Surface water samples were collected using the 'clean-hands' method (U.S. Environmental Protection Agency [USEPA] Method 1638) as 24-hour or 2-hour composites whenever conditions allowed; grab samples were used when composite samples were unavailable due to safety issues or automated composite samplers malfunctioned. During a dry season event, the team collected composite sediment samples in triplicate from the same depositional areas as the surface water sampling locations.

Groundwater: Four new open-bedrock wells (BW1 to BW4) were installed to depths of approximately 220 feet below ground surface by air-rotary drilling methods. Samples were collected from at least three discrete intervals in each well. The wells were constructed as open boreholes to mimic the construction of potable wells off-installation although slotted steel casing was used where unstable conditions were encountered within the bedrock near the surface at two locations. Geophysical surveys were conducted down the open wells to identify the most productive water-producing zones. These were sampled using submersible pumps with packers installed to isolate each targeted zone. One existing non-potable groundwater well was also sampled (EW1) in a similar fashion with the intervals sampled chosen based on the results of the geophysical survey. Three rounds of groundwater samples were collected at BW1, BW2, and EW1. Two rounds of groundwater samples were collected at BW3 and BW4.

Laboratory Analytical Methods and Project Action Limits (PALs): Surface water, sediment, and groundwater samples were submitted to DoD Environmental Laboratory Approval Program-certified laboratories for analysis. The following analytical methods were used for media-specific analysis.

Surface water was analyzed for:

- Pb, Cu, Sb, and Zn by USEPA Method 1638 plus hardness metals Standard Method 2340B
- Explosives MCOC by USEPA Method 8330B
- Hardness by Standard Method 2340A
- Dissolved metals (calcium, magnesium, potassium, and sodium) for Biotic Ligand Model (BLM) by USEPA Method 6010B
- Anions (sulfate and chloride) for BLM by USEPA Method 300.0
- Alkalinity for BLM by Standard Method 2320B
- Dissolved organic carbon for BLM by Method 9060M

Sediment was analyzed for:

- Munitions-related metals (Pb, Cu, Sb, and Zn) by USEPA Method 6020A
- Explosives MCOC by USEPA Method 8330B

- Total organic carbon by Lloyd Kahn 1988
- Acid Volatile Sulfide / Simultaneously Extracted Metals (AVS/SEM) by USEPA Method 821/R-91-100
- Grain size by American Standard Test Method D-422
- Coarse fraction metals analysis by Standard Operation Procedure #TP-105

Groundwater was analyzed for:

- Explosives by USEPA Method 8330B
- Munitions-related total and dissolved metals (Pb, Cu, Sb, and Zn) by USEPA Method 6020A
- Perchlorate by USEPA Method 6850
- Total dissolved solids by Standard Method 2540C

The clean-hands method (USEPA Method 1638) is used to obtain very low detection limits needed for data to be comparable to low PALs. However, for Zn and Cu results, some uncertainty arose based on the laboratory's quality control data. This was revealed, in part, by comparing sample results from the USEPA Method 1638 method to results from secondary analyses (inputs to the BLM), which included metals by a different method (USEPA Method 6010B). Regardless, Pb is the primary metal associated with small arms ammunition, thus greater weight is given to the Pb results. In other words, PAL exceedances for Zn and/or Cu without exceedances of Pb may not be the result of range related activities and were not considered to indicate complete range-related source-receptor pathways.

PALs for all media sampled were established for the potential MCOC. For Fort Indiantown Gap, PALs are based on the lower of either the ORA Screening Values for freshwater ecological screening levels or human drinking water screening levels (DoD, 2012) or the Pennsylvania Department of Environmental Protection (PADEP) regulatory screening criteria (*025 Pa. Code § 93.8c*). PALs for all media are included in **Table ES-2**.

The ORA screening values for freshwater ecological acute and chronic toxicity of Cu, Pb, and Zn are adjusted by a formula and are inversely proportional to the measured hardness concentration[2]. Therefore, hardness concentrations were measured to calculate screening criteria for those metals with hardness-dependent criteria in surface water. The single lowest hardness value determined in either primary or duplicate samples collected at a given assessment area during a given sampling event was conservatively used to calculate event-specific hardness-dependent PALs. The surface water event/assessment area-specific PALs are illustrated in **Table ES-2**. MCOC concentrations detected in storm event samples were compared to the respective acute screening value and MCOC concentrations detected in all other event samples were

[2] A relative increase in hardness will lower the ecological toxicity of Cu, Pb, and Zn in surface water resulting in an increase in the ecological risk screening criteria/PAL. The PADEP utilizes the same hardness based formulae to calculate the ecological risk screening criteria/PAL.

compared to the respective chronic screening values. Sediment PALs are also presented in **Table ES-2**.

Table ES-2: PALs

	Medium	SURFACE WATER			SEDIMENT	GROUNDWATER
	Screening Criteria Type	Human Health	Ecological		Ecological	Human Health
	Event	All	Dry A Wet A Wet B	Storm	All	All
Analyte	Units	(µg/L)	(µg/L)	(µg/L)	(mg/kg)	(µg/L)
Range Road Assessment Area and Manada Creek Assessment Area						
Lead (Pb)		15[1]	0.54[1]	14[1]	47[2]	5[3]
RDX		0.61[5]	190[6]	190[6]	0.013[2]	0.61[5]
Perchlorate		not evaluated				15[4]
Indiantown Run Assessment Area						
Lead (Pb)		15[1]	0.54[1]	18[1]	47[2]	5[3]
RDX		0.61[5]	190[6]	190[6]	0.013[2]	0.61[5]
Perchlorate		not evaluated				15[4]

Notes:
[1] PADEP values for lead in surface water and groundwater apply (although ORA and PADEP are identical)
[2] Metals in sediment: No PADEP values are available; ORA values apply.
[3] Based upon the Pennsylvania Department of Natural Resources Statewide Health Standards, Medium-Specific Concentrations for Inorganic Regulated Substances in Groundwater.
[4] Perchlorate in groundwater: EPA values apply.
[5] No promulgated standard is available at this time, EPA IRIS values were used for ORA and apply here.
[6] RDX in surface water and sediment: ORA values are lower than PADEP values; ORA values apply.

3 Results and Discussion

Of the three assessment areas, only the Range Road assessment area results indicate a release of munitions constituents (Pb) at concentrations above the PAL for ecological receptors. The results for all three assessment areas are described below.

Range Road Assessment Area

Figure ES-2 displays the relevant data for lead from the Range Road assessment area where only the surface water system was evaluated. **Figure ES-3** shows the frequency and distribution of water and sediment Pb concentrations (Pb being the predominant MCOC in small arms ammunition). The weight-of-evidence (concentration data plus conceptual model of range use and proximity to streams) for location TV1 indicate consistent exceedances of state ecological criteria for Pb in surface water and solid particulate Pb occurs in sediment. Due to exceedances at TV1, the team performed a Screening Level Ecological Risk Assessment (SLERA) for this location. This SLERA indicates a potential risk based on an ecological hazard quotient (i.e., the ratio of the maximum detected sediment concentration at TV1 to the corresponding chemical-specific Toxicity Reference Value) of 2 for Pb in sediment, indicating the potential for adverse

health effects for benthic invertebrates and other aquatic receptors in Vesle Run sediments downstream of high use ranges.

While there are Cu and Zn PAL exceedances in surface water at TV1, AR1 and QR1, many of these values may be biased high due to the laboratory quality issue described above. In addition, reference location, FC1, also shows similar values of Zn and Cu, indicating that, at least for locations AR1and QR1, these metals may not be range related.

At the installation boundary locations, VR1 and VR2, no PAL exceedances for either Pb in surface water or sediment occurred (**Figure ES-2**). This indicates that Pb is unlikely to affect human receptors 14 miles downstream on Swatara Creek, off-installation.

Indiantown Run Assessment Area

Streams: Positive detections of propellants (NG), explosives (RDX), and metals MCOC occurred in surface water and sediment from the Indiantown Run assessment area. However, no detections, except for Cu) were above the PALs (**Figure ES-2)**. In fact, the measured concentrations for propellants and explosives are significantly below the ecological PALs by several orders of magnitude. Human receptors are not present in this assessment area.

Cu was above the PAL in surface water in one of the four samples collected (concentration of 9.92 micrograms per liter [µg/L]), but not sediment, in this assessment area. However, there was no readily discernible trend of Cu concentrations increasing (or decreasing) between the reference (IR1) and downstream (IR2) sampling locations; therefore, the Cu detections are likely not range related. This is particularly likely since there are no notably elevated Pb concentrations.

Groundwater: Human receptors exist downgradient of this assessment area. No explosives were detected in wells BW3 and BW4, but perchlorate was detected. However, perchlorate concentrations (0.33 - 0.47 µg/L) are well below the human drinking water PAL (15 µg/L) for all sampling events and is therefore not a concern.

Manada Creek Assessment Area

Streams: Metals MCOC were detected in both surface water and sediment samples; however, all concentrations were below the human health and ecological PALs except for Cu in surface water. Surface water concentrations of Cu exceeded the ecological PAL in two of four samples collected at MC1 (downstream). However, one of these exceedances was associated with equipment blank contamination, and in both samples, the Cu concentration in the reference sample (TM1) was comparable to or higher than the Cu concentration in the downstream sample (MC1). This indicates Cu is likely unrelated to range activities and therefore not a concern.

RDX was detected in three of the five surface water samples collected at MC1, with the maximum concentration of 1.6 µg/L (**Figure ES-2**). Potential surface water receptors in this assessment area include both human and ecological receptors. Measured values are several orders of magnitude below the ecological PALs for RDX (see **Figure ES-2** and **Table ES-2**). The presence of RDX at MC1 is likely due to range activities, as RDX is not naturally occurring. The detected concentration may be related to the groundwater pathway, since the sample with the

highest concentration was collected during the dry season, when Manada Creek predominantly contains groundwater from seeps and springs originating within Fort Indiantown Gap. No other explosives or propellant MCOC were detected in surface water samples collected for this assessment area. Although RDX was present in surface water in one of the samples collected above the human health PAL, the concentration was still below the USEPA's lifetime health advisory level for RDX. Additionally, the sample location is 12 stream miles from the nearest drinking water intake on Manada Creek which is fed by a number of significant tributary streams between the sampling location and the drinking water intake.

Groundwater: RDX was detected in groundwater samples in the Manada Creek assessment area in August 2011, the first of three sampling events. RDX was not detected in groundwater samples in the two subsequent sampling events. To highlight the August 2011 results, RDX was found in:

- two of the three sampled intervals at BW1; one exceeded the PAL of 0.61 µg/L
- all three of the sampled intervals at BW2; two exceeded the PAL
- all three sampled intervals at EW1; none exceeded the PAL

Higher than normal rainfall may have temporarily increased water infiltration into the groundwater system after the initial August 2011 sampling event; Hurricanes Irene and Lee occurred after the initial RDX detections and may have contributed to dilution and non-detection in the subsequent sampling events. Uncertainty remains regarding whether RDX is migrating off the range footprint at concentrations of concern to human receptors in the Manada Creek assessment area.

The PAL for RDX is the USEPA's Integrated Risk Information System screening value of 0.61 µg/L. Screening values tend to be conservative and it is notable that there is no RDX drinking water maximum contaminant level (Federal standard) or state standard available for comparison. The USEPA does list 2.0 µg/L as a lifetime health advisory level for RDX. All measured concentrations in surface water and groundwater during this assessment fall well below this value.

4 Conclusion

The results of the Fort Indiantown Gap ORA Phase II assessment confirm the presence of a complete source, surface water pathway, receptor interaction in the high use range CSM in one of the three assessment areas (Range Road), and indicate that a release of lead above PADEP ecological surface water criteria has occurred off-range but not off-installation. This is based upon the difference between upstream and reference location lead concentrations and by screening level exceedances downstream at TV1. Based on the MCOC concentrations detected at the TV1 location and the SLERA, there is a potential risk to ecological receptors in Vesle Run within the installation boundary. Uncertainty remains regarding whether RDX has migrated off the range footprint at concentrations of concern to human receptors in the Manada Creek assessment area.

Implementation of appropriate best management practices will reasonably reduce future MCOC migration from the potential MCOC sources associated with the operational footprint at Fort Indiantown Gap.

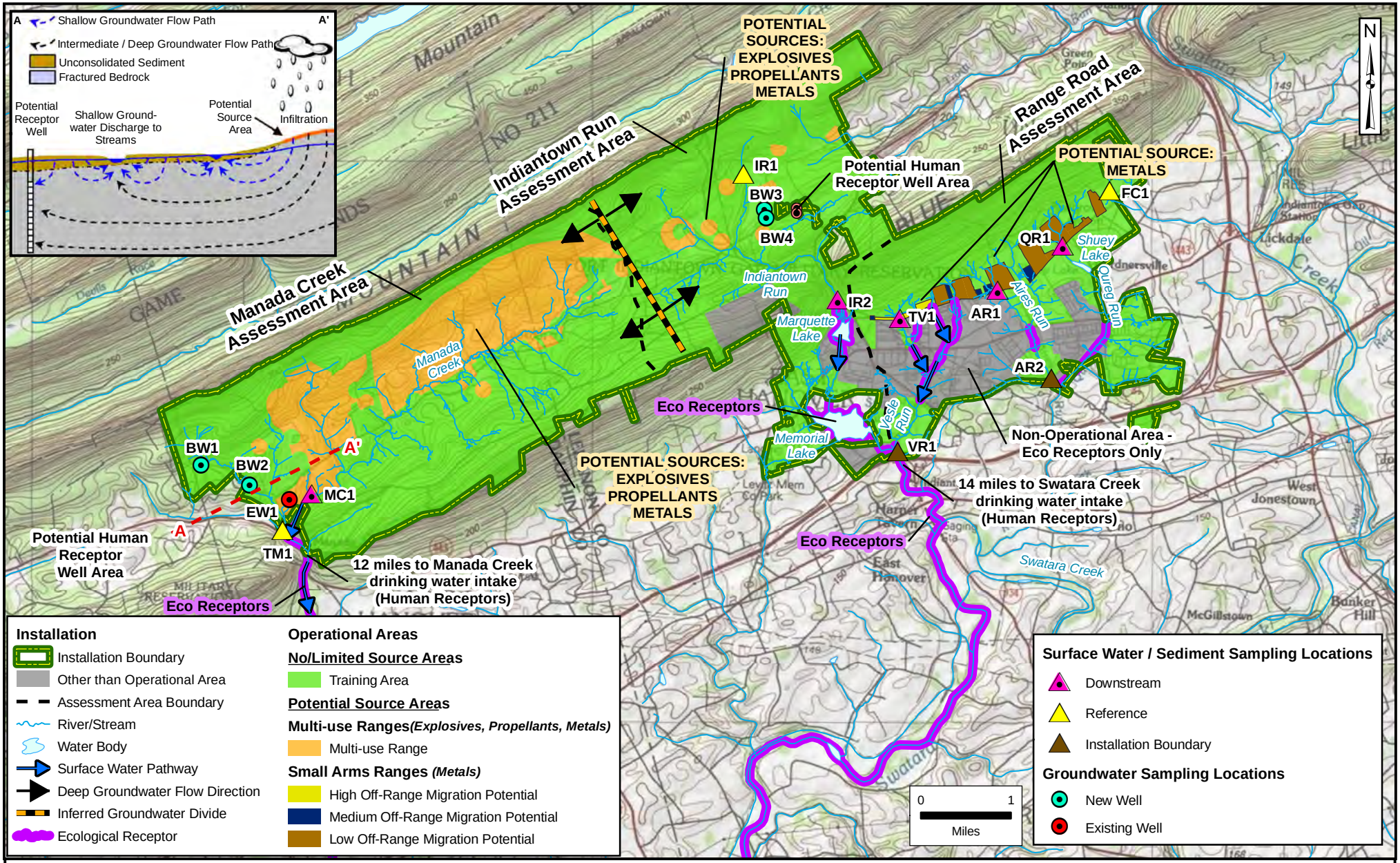

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Figure 1
Sampling Locations and Rationale

Data Sources:
AEC, ARID-GEO, 2005
ESRI, ArcGIS Online, USGS Topo

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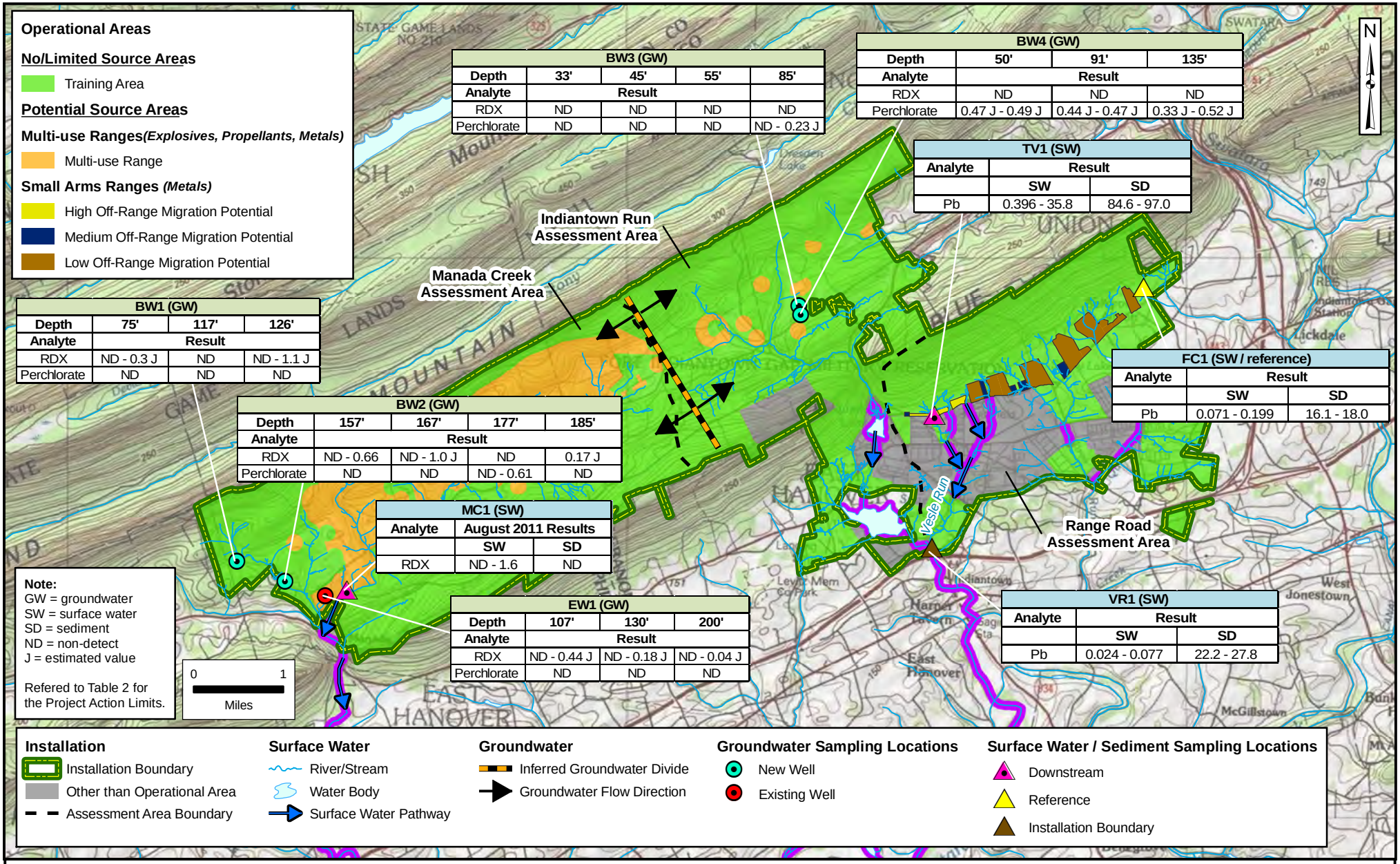

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Figure 2
Relevant Phase II Detected MCOC at Fort Indiantown Gap: Spring 2011- Fall 2012

Data Sources:
AEC, ARID-GEO, 2005
ESRI, ArcGIS Online, USGS Topo

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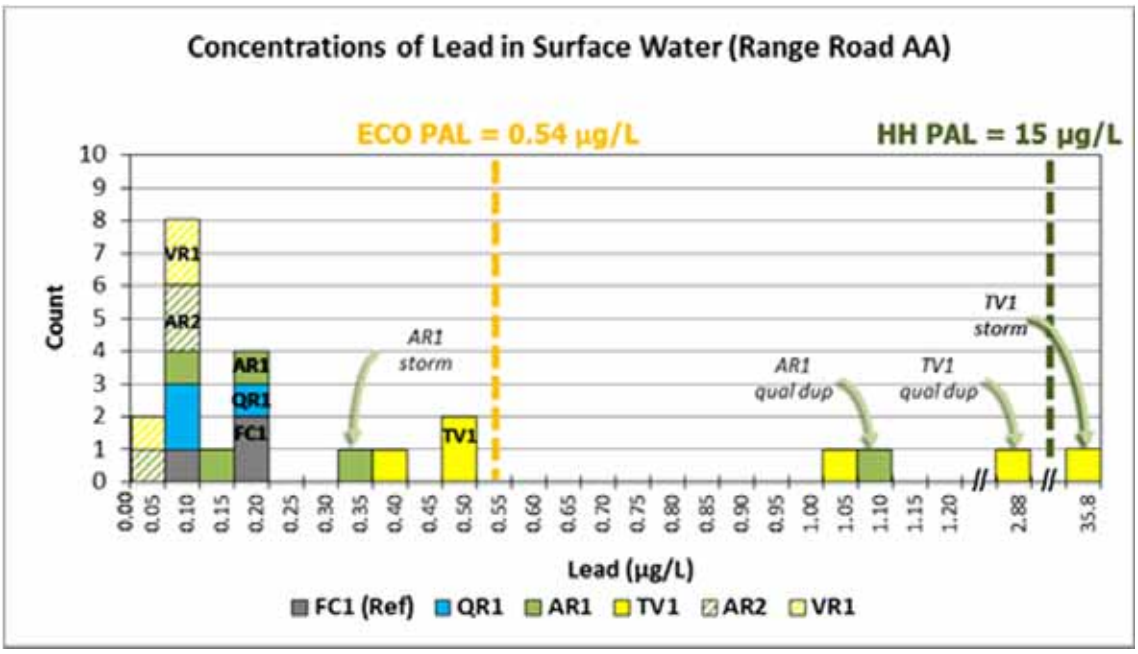
Figure ES-3: Detected Lead Concentrations (Range Road Assessment Area)

(a) Surface Water



(b) Sediment