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January 18, 2017

New Jersey Department of Environmental Protection
Bureau of Case Management
Mail Code 401-05F
P.O. Box 420
Trenton, NJ 08625-0420

Attn: Donna Gaffigan, Case Manager

Re: *Site-Wide Groundwater Progress Report*
Hoffmann-La Roche Inc.
340 Kingsland Street
Nutley, New Jersey
SRP PI #s 009949, 614465, and 625447
TRC Project No. 105009/198233

Dear Ms. Gaffigan:

On behalf of Hoffmann-La Roche Inc. (Roche), TRC Environmental Corp. (TRC) is submitting the attached Site-Wide Groundwater Progress Report, dated January 18, 2017. This report presents the results of quarterly groundwater monitoring events (September 2015, December 2015, March 2016, and June 2016) and other Site groundwater activities. An evaluation of the Site's groundwater flow regime and contaminant distribution over time was conducted in support of future remedial programs.

The field programs reported herein, were performed in accordance with the NJDEP's Technical Requirements for Site Remediation (N.J.A.C. 7:26E) and applicable NJDEP Guidance, the approved Site-Wide Groundwater Sampling Plan – IRM Implementation Period (July 2015), and associated requests for Approval-Modification of the Site-Wide Groundwater Sampling Plan – IRM Implementation Period – July 2015 (February and May 2016), Roche Remediation Road Map (September 2012), and associated correspondence (NJDEP comments, Roche Response letters).

We look forward to meeting with you to discuss the contents of this report once you have had a chance to review it. In the interim, if you have any questions or need additional information, please feel free to contact Art Goeller at 908-988-1621 or agoeller@trcsolutions.com, or Dan Nachman at 908-988-1637 or dnachman@trcsolutions.com.

Very truly yours,

Arthur F. Goeller, LSRP (No. 591661)
Sr. Project Director
TRC Environmental Corporation

Daniel Nachman
Vice President
TRC Environmental Corporation

Cc: Chandra Patel, Roche

Site-Wide Groundwater

Progress Report

For the

Hoffmann-La Roche Inc. Facility

Nutley, New Jersey

Prepared For:

Hoffmann-La Roche Inc.
800 Bloomfield Avenue, Suite 127
Nutley, NJ 07110-1199
PI ID #'s 009949, 614465, and 625447

Prepared By:

TRC Environmental Corporation
41 Spring Street, Suite 102
New Providence, NJ 07974

January 18, 2017

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1.0 INTRODUCTION

On behalf of Hoffmann-La Roche Inc. (Roche), TRC Environmental Corporation (TRC) has prepared this Site-Wide Groundwater Progress Report (GWPR) to summarize supplemental groundwater characterization activities conducted at the 120-acre Roche facility (Site), specifically results from quarterly groundwater monitoring events (conducted between August 2015 and July 2016) and from targeted programs completed in selected Site areas, to assess groundwater contaminant concentration trends over time. This is the third GWPR being submitted to the New Jersey Department of Environmental Protection (NJDEP), and should be considered a supplement to the Site-wide Groundwater Remedial Investigation Report (GWRIR) dated April 2, 2014 and the GWPRs submitted in January 2015 and December 2015. The focus of this GWPR is to monitor and document groundwater quality and contaminant concentration trends along the Site perimeter and in select interior areas of the Site during the implementation phase of various interim remedial measure (IRM) programs.

The investigation activities documented in this report include the results of the last four quarters of groundwater monitoring (September 2015, December 2015, March 2016, and June 2016), as proposed in the NJDEP-approved *Site-Wide Groundwater Sampling Plan – Interim Remedial Measures (IRM) Implementation Period Rev. 1* (July 2015). This report also includes findings from investigations completed in Investigative Area 11 (IA-11) from March through June 2016.

The monitoring and remedial wells installed during this reporting period helped to further refine the understanding of contaminant distribution within the aquifer system and support ongoing pilot tests and IRM activities. The data collected during the past four quarterly monitoring events (September 2015 through June 2016) may be used to assist future remedial decisions and will be used to support the development of a revised Conceptual Site Model (CSM).

These supplemental activities were conducted in accordance with the NJDEP's Technical Requirements for Site Remediation (TRSR) (N.J.A.C. 7:26E) and applicable guidance documents, the NJDEP's Field Sampling Procedures Manual (2005), and the *Site-Wide Groundwater Sampling Plan – Interim Remedial Measures (IRM) Implementation Period Rev. 1* (July 2015).

1.1 Document Organization

This document is organized into the following sections:

- Section 2.0 provides a review of background information on Site location and history, the physical setting (topography, surface water hydrology, geology, and hydrogeology), historic regulatory compliance, and a summary of pre-design investigation (PDI), pilot tests, and IRM programs;

- Section 3.0 provides a technical overview (scope/methods) of the supplemental groundwater programs;

- Section 4.0 provides supplemental investigation findings for IA-specific investigations and Site-wide groundwater monitoring programs, and provides a time-series evaluation of groundwater elevations and water quality;

- Section 5.0 provides a schedule of future activities; and,

- Section 6.0 provides a list of references.

2.0 SITE BACKGROUND

2.1 Site Description and History

The Site occupies approximately 120 acres straddling the municipal/county boundary of the Township of Nutley, Essex County and the City of Clifton, Passaic County in northeastern New Jersey (Figure 1). It is bounded to the north by New Jersey State Highway Route 3 (Route 3); to the south by Kingsland Street, Nichols Park, residential properties, and St. Paul's Brook; to the east by residential properties; and to the west by residential, commercial, and industrial properties. The Site is entirely developed with pavement and landscaping and previously contained multiple office, laboratory/research, production, and maintenance buildings; internal roadways; a railroad easement (Norfolk-Southern/Conrail); and other improvements. As discussed below, many of the buildings have been demolished. For reference, Figure 2 provides a NJDEP GIS Land Use/Land Cover Map, and Figure 3 provides the NJDEP GIS Landscape Project Map.

During its history beginning in 1928, the Roche Nutley operations have included vitamin and pharmaceutical manufacturing, and research and development. Roche installed multiple production wells (PW-14, PW-20, PW-32, PW-33, PW-37) from the 1930s through the 1960s to provide water for their Site operations. By the 1980s, three of these production wells (PW-20, PW-32, PW-37) were still in use and continued to be maintained into the 1990s.

Historically, Site process wastewater was diverted through subsurface pipes beneath the production buildings and discharged to a main process sewer system. The majority of the process sewer lines were located on the portion of the Site west of First Avenue, and east of the railroad track. The process sewer lines ultimately discharge to the environmental control facility (ECF) operated at the Site.

Roche officially ceased all business operations at the Nutley campus in December 2013. The Site was sold by Roche in September 2016. As documented in the previous GWPRs, Roche demolished 16 on-Site buildings (from IAs 1, 3, 4, 7, 9, 10, and 11) as part of its Site divestment and repurposing strategy. Figure 4 provides the location of all former (including those demolished prior to 2014) and existing Roche (Nutley, New Jersey) buildings.

2.2 Physical Setting

2.2.1 Topography

Figure 5 provides a map depicting the topography surrounding the Site. The regional surface drainage slopes to the south toward the Passaic River but is locally disrupted by small topographic ridges that trend northeast/southwest. The Site is located between topographic highs to the east and west that reach elevations over 200 feet above mean sea level (msl). The sloped Site is located at an elevation ranging from approximately 68 to 158 feet above msl. The highest elevation point is located in the northeastern corner of the Site. The lowest elevation point is located at the southeastern corner of the Site, near Nichols Park and St. Paul's Brook.

The surface of the majority of the Site is gently sloping to generally flat within the former central process areas. In general, the surface of the central and western portions of the Roche Site slopes from north to south toward St. Paul’s Brook.

2.2.2 Surface Water Hydrology

The Site lies within the Lower Passaic River Basin. Figure 4 provides a Site plan with the local surface water bodies. Figure 6 provides Wetlands Location Maps developed by the National Wetlands Inventory and the NJDEP. As shown on Figure 6, there are no wetlands on the Site.

There are three streams that transect, are adjacent to, and are downstream of the Site. These streams are: Springer Brook, St. Paul’s Brook, and the Valley Drain (a culverted former stream). These streams coalesce into St. Paul’s Brook and join the Third River about 1,500 feet southeast of the Site. The Third River meanders from its headwaters at the Great Notch Reservoir (Woodland Park, New Jersey) northwest of the Site, flowing southerly, and then turns north to join the Passaic River approximately 1.2 miles southeast of Roche (Figure 5).

Springer Brook is presently a buried pipe (culvert) that flows southeast along the county line, south of former Building 103 in IA-10 (on Roche property), and empties into St. Paul’s Brook. The confluence of Springer Brook and St. Paul’s Brook is located in on-Site manhole MHD-111S-1, southeast of former Buildings 103 and 104. A network of subsurface drains beneath the northwest corner of the Site collects shallow groundwater that historically discharged (periodically) to the land surface as springs in this area (in the vicinity of former Building 103); the subsurface drainage network now collects that water and discharges it to St. Paul’s Brook.

St. Paul’s Brook enters the Site at the northernmost corner of the property from drainage ditches that route surface water from areas north of and under Route 3. The brook enters a 48-inch reinforced concrete pipe (RCP) where it is conveyed east, then southeast alongside and parallel to the Norfolk-Southern Conrail railway. It emerges briefly as an open channel from a headwall south of Building 1, and is conveyed in another pipe as it exits Roche property (beneath Kingsland Street) and emerges at a headwall at Bloomfield Avenue. St. Paul's Brook is dammed in Nichols Park, creating a pond behind the dam. St. Paul's Brook parallels the railroad easement between IA-10 and the rest of the Roche Site and, after exiting the Site, flows southeast and then east toward a confluence with the Third River, approximately 1,500 feet to the southeast of the Site.

The Valley Drain receives surface water runoff from a commercial area north of Route 3 and storm water drainage from Route 3 itself, and is routed through surface ditches and City of Clifton storm sewers.[1] Once on the Site, the Valley Drain is mostly buried, flowing northeast to southwest through a 48-inch diameter pipe that runs parallel to the primary roadway (First Avenue) located in the center of the Roche property and discharges to St. Paul's Brook at the Nichols Park dam. With two exceptions, Roche's storm sewers do not discharge into the Valley Drain. There are two areas where they do connect to the Valley Drain: Surface water from Roche storm sewers in the parking lots in IA-12 (Lots 901/902) discharge into an open concrete drainage culvert to the south of IA-12 in the Jersey City Water Supply Company right-of-way before the culvert again unites with the underground Valley Drain (Figure 4). Surface water from catch basins in parking lot 903 on the western end of IA-11 discharge to the Valley Drain storm sewer very close to the Roche southern property line (Figure 4).

The NJDEP's surface water classification for St. Paul's Brook and the downstream Third River is Freshwater 2-Non-Trout\Saline Estuary 2 (FW2-NT\SE2). The limit of SE2 designation has not been identified by the NJDEP for the Third River tributaries in the vicinity of the Site.

Surface water runoff for the Site west of the railroad tracks is conveyed via a storm sewer system that discharges to St. Paul's Brook. The surface water runoff for the Site east of the railroad tracks is discharged to the Passaic Valley Sewerage Commission (PVSC) and to St. Paul's Brook during significant rain events. Based on available information, natural water springs have been observed historically at the Site (within IA-10 and IA-14). Due to past Site development, these springs were buried and their flow was diverted via sub-grade piping to the on-Site storm sewer drainage system. West of the railroad tracks, the spring water discharge is ultimately conveyed through an open culvert and storm sewer piping off Roche property via St. Paul's Brook.

2.2.3 Regional Geology

The Site is located within the Newark Basin in Essex and Passaic Counties, New Jersey. The

[1] Surface water runoff for the Site west of the railroad tracks is conveyed via a storm sewer system that discharges to St. Paul's Brook. The surface water runoff for the Site east of the railroad tracks is discharged to the PVSC.

basin is an extensional rift feature (half graben) filled with over 20,000 feet of interbedded non-marine sedimentary and igneous rocks of Triassic and Early Jurassic age. The Newark Basin forms the largest physiographic province (Piedmont province) in the northern half of New Jersey. The beds within this portion of the Newark Basin typically display a northeastern strike, tilted to the northwest at angles of 5°-15°, and may be locally faulted and folded (Olsen 1980; Schlische 1992; Herman 2001). The sedimentary formations consist of repeated sequences of sandstone, siltstone and mudstone beds, in varying proportions, which reflect climate-driven oscillation, from fluvial deposition during the Stockton Formation to the lacustrine cycles in Lockatong, Passaic and Feltville Formations.

Figure 7 depicts the regional surficial geology. As shown on Figure 7, the bedrock surface elevation contours (from 100 to 150 feet above msl) form a linear ridge along the eastern portion of the Site. Figure 8 is a map depicting the regional bedrock geology. As shown on Figure 8, two northeast-trending faults have been mapped by the New Jersey Geological Survey (NJGS) approximately 1 mile north of the Site.

2.2.4 Local Geology

The Site is underlain by overburden[2] consisting of artificial fill and glacial deposits. The artificial fill (typically 2 to 10 feet thick, depending on Site location) is the shallowest unit within the overburden and is composed of a heterogeneous mixture of sand, silt, clay, gravel and man-made materials (e.g., bricks, glass, concrete, coal/ash, wood, and metal debris). The artificial fill is underlain by glacial deposits of the Rahway Till (typically 2 to 10 feet thick, depending on Site location). The Rahway Till is composed of non-stratified, reddish-brown, poorly sorted sandy silt to sandy clayey silt, with occasional lenses of pebbles, cobbles and boulders. In a small area located in the northwestern corner of the Site (in IA-10), the artificial fill is underlain by Swamp Deposits, consisting of black-grey to brown organic silt and clay with peat.

The glacial deposits are underlain by the Passaic Formation. The Passaic Formation in the region is an interbedded sequence of reddish-brown sandstone and pebbly sandstone, pebble conglomerate, siltstone, silty shale and shale. The sandstone and pebbly sandstone are thin to thickly bedded, planar to cross-bedded with local lenses of pebble conglomerate. Under the Roche Site, the preponderant lithologies are sandstone and siltstone, with very little mudstone. A weathered bedrock zone overlies the competent bedrock interface; the weathered bedrock zone varies in thickness across the Site (10 feet to 20 feet).

Stratigraphic cross-sections depicting the local surficial and bedrock geology are presented on

[2] Each IA-specific soil RIR defines the local thickness of the overburden. On a Site-wide basis, the thickness of these overburden units is highly variable and is dependent upon the historic Site development and the courses of historic and current streams.

Figures 7 and 8.

2.2.5 Local Hydrogeology

Groundwater at the Site is found in the overburden and bedrock. Within the overburden, the depth to groundwater generally occurs between 5 to 15 feet below ground surface (bgs). In some portions of the Site, the water table is encountered in the bedrock. Historical measurements of water levels collected from wells screening the overburden and bedrock indicate that shallow groundwater flow is generally south and southeast, following the surface topography toward the Passaic River. Additionally, shallow groundwater discharges locally to culverted and open reaches of St. Paul's Brook and the utility corridor associated with the Valley Drain. Deeper groundwater flows generally from northwest to southeast, and is not influenced by surface water drainage features.

2.2.5.1 Localized Pumping Influences

There are multiple sump pumps[3] at the Site. The operation of these sump pumps can locally influence the shallow groundwater flow regime in the area of the sump operation. A list of on-Site Buildings with active sump pumps (and their respective locations) is provided below.

- Building 52 - Sump pump located in a vault;
- Building 8 (Utility Tunnel) - Numerous sump pumps (> 50) located throughout the length of the Utility Tunnel;
- Building 39 - Sump pumps located in the basement;
- Building 76 - Sump pump located in a vault;
- Building 1 - Sump pump located in a vault;
- Building 118 - Sump pump located in a vault; and,
- Building 116 - Multiple sump pumps.

[3] Sump pumps are self-activating electrical pumps that are installed in a sump (low point) below basement or crawlspace floors to remove rising groundwater and surface runoff before it can seep into a building. Accumulated water can cause interior damage and encourage the growth of mold, mildew, and fungus. Pumps are usually maintained and equipped with all necessary components to ensure their reliability. The sump pumps operated under Roche ownership until the end of September 2016. They are assumed to remain operational under the property's new owner (September 29, 2016).

2.2.5.2 Local Investigation Zones

Extensive drilling and sampling was performed through the RI and subsequent investigative efforts to characterize groundwater elevations and delineate groundwater contamination horizontally and vertically. To aid in the visualization and interpretation of these data, seven vertical investigation zones were defined based on elevation relative to mean sea level. These are:

- **Shallow Zone S1** (greater than 80 feet above msl);
- **Shallow Zone S2** (between 80 to 50 feet above msl);
- **Shallow Zone S3** (between 50 to 0 feet above msl);
- **Deep Zone D1** (between elevation 0 to 100 feet below msl);
- **Deep Zone D2** (between 100 to 250 feet below msl);
- **Deep Zone D3** (between 250 to 400 feet below msl); and,
- **Deep Zone D4** (greater than 400 feet below msl).

These vertical investigation zones are elevation-based for project organizational/management purposes only. All groundwater elevation and quality data have been compiled and evaluated for delineation and remediation using this groundwater elevation investigation zone system, as discussed in the GWRIR and GWPRs.

Roche is currently preparing a CSM for the Site that builds on historic work as well as the broad knowledge base gained during the Site investigations. Based on detailed analysis of stratigraphic and geophysical data, the vertical zonation of the groundwater flow system and movement of impacted groundwater likely to be redefined, and the data will be reorganized accordingly.

2.3 Historic Regulatory Compliance

In October 1992, Roche entered into a voluntary Memorandum of Agreement (MOA) with the NJDEP to investigate and remediate soil and groundwater contamination found on Roche property. Since the execution of the MOA, Preliminary Assessment (PA) and Site Investigation (SI) activities have identified 192 areas of concern (AOCs). In addition to NJDEP oversight, Roche operations have been subject to the U.S. Environmental Protection Agency's (USEPA's) Resource Conservation and Recovery Act (RCRA) Corrective Action program. From the inception of the MOA, Roche has actively coordinated with the NJDEP, and more recently with the USEPA, to address and mitigate the transport of and exposure to the identified Site contaminants.

To facilitate the Site investigation of soil and groundwater conditions, Roche, with NJDEP's approval, divided the Site into specific IAs within distinct geographic confines. Over time, the boundaries of these original IAs were modified to include additional AOCs identified within an IA's proximity. On September 17, 2012, Roche submitted a Remediation Road Map to the NJDEP outlining an accelerated approach, to address all of the known, existing AOCs and complete the Site-wide RI at the Roche Site. The NJDEP approved this Remediation Road Map on October 11, 2012.

As discussed in the Remediation Road Map (2012), the boundaries of original IAs were reconfigured to establish 15 IAs (Figure 4) within the Site boundaries; these were labeled IA-1 through IA-15.[4] To assist the NJDEP case team, multiple Licensed Site Remediation Professionals (LSRPs) were retained to oversee and certify compliance with the TRSR and applicable guidance during the investigation of soil and groundwater impacts identified in specific IAs. These activities have been documented in individual IA remedial investigation (RI) reports submitted to the NJDEP. The scope of the Site-wide groundwater RI builds upon completed RI activities documented in these individual IA RI reports and past groundwater RI programs, combining groundwater information for the IAs on a Site-wide basis.

2.3.1 Historic Regulatory Deliverables

As part of the MOA (October 1992), Roche provided the NJDEP with a Baseline Groundwater Monitoring Report (September 2002) that presented a summary of quarterly groundwater sampling conducted from the initiation of groundwater monitoring at the Site in 1987 through calendar year 2000. Thereafter, quarterly groundwater monitoring results were submitted on an annual basis beginning in 2001 and continuing through 2011.

The baseline program focused on sample collection of the shallow groundwater system (wells screening Zone S1, and to a lesser extent Zones S2 and S3). Each annual report included a summary of the quarterly sampling program, an evaluation of groundwater data quality and usability, an assessment of the groundwater quality indicators, potentiometric surface maps, groundwater constituent isopleths**,** and a discussion of groundwater quality fluctuations over time.

All of these yearly groundwater assessment reports were submitted to, and approved by the NJDEP during the course of the groundwater monitoring program. In 2012, with the initiation of the Site-wide groundwater RI at the Site, the NJDEP was petitioned and agreed to the

[4] Roche's Remediation Road Map described how Roche would address the investigation within the reconfigured boundaries of the original IAs as well as the newly identified IAs (IA-1 through IA-15) to be investigated (Figure 4). IA-8 was initially identified as an investigation of all on-Site process, municipal and storm water sewers and waste lines; this is no longer considered a separate IA, and investigation of the process, municipal, and storm water and waste lines has been completed within each IA where the particular piping runs are located (see Figure 4).

discontinuation of the yearly groundwater reporting in support of implementing the Site-wide program.

Several historic groundwater investigation activities provided information that were essential to completing the Site-wide groundwater RI (as documented in the GWRIR). The most significant of these activities was documented in reports previously submitted to the NJDEP. Activities documented in these reports included:

- Installation of coreholes CH-1 through CH-10 (2002-2003);
- Completion of the MW-51 (subsequently re-designated as RW-51) pumping test (2002);
- Completion of the CH-1 pumping test and submission of the Core Hole 1 Aquifer Test Report (TRC, 2005); and,
- Additional findings and data from pre-2007 investigative work completed by TRC and others (i.e., ERM-Northeast [ERM] 1986 -1991, and Roux Associates [Roux] 1993).

These historic reports also documented the initial characterization of the geologic structure and groundwater flow conditions within the bedrock aquifer system and facilitated the development of an initial CSM.

Based on the data collected from these activities, additional RI workplans were developed and approved by NJDEP. The implementation of these workplans culminated in the submission of the Site-wide GWRIR in April 2014 and the development of supplemental workplans to further characterize the groundwater conditions at the Site. These documents and associated NJDEP correspondence are listed below (in chronological order) for reference:

- December 2007 – Phase One Remedial Investigation Workplan;

- October 2012 – Deep Bedrock Ground Water RI Workplan;

- November 2012 – Shallow Ground Water RI Workplan;

- April 2013 – Shallow Ground Water RI Workplan – Supplement 1;

- May 2013 – Deep Bedrock Ground Water RI Workplan – Supplement 1;

- June 2013 – Shallow Ground Water RI Workplan – Supplement 2;

- October 2013 – Deep Bedrock Ground Water RI Workplan – Supplement 2;

- April 2014 – Site-Wide GWRIR;
- May 2014 – NJDEP Comments on the Site-Wide GWRIR;
- June 2014 – Quarterly Passive Diffusion Bag (PDB) Ground Water Sampling Plan Rev. 3;
- July 2014 – Roche Response to NJDEP Comments on the Site-Wide GWRIR;
- September 2014 – NJDEP Supplemental Comments to Roche (addressing Roche's Response to Comments Document, dated July 2014);
- January 2015 – First Site-Wide GWPR;
- January 2015 – Roche Response to NJDEP Supplemental Comments on the Site-Wide GWRIR (addressing NJDEP Comments Document, dated September 2014);
- July 2015 – Site-Wide Groundwater Sampling Plan (GWSP) – IRM Implementation Period (Rev 1);
- August 2015 – NJDEP Comments on the Site-Wide GWSP – IRM Implementation Period (Rev 1);
- September 2015 – Revised Site-Wide GWSP – IRM Implementation Period (Rev 2) and Roche Responses to NJDEP Comments (dated August 11, 2015);
- October 2015 – NJDEP Approval (with comments) of the Revised Site-Wide GWSP – IRM Implementation Period (Rev 2);
- December 2015 – Roche Response to NJDEP Comments on Site-Wide Groundwater Sampling Plan – IRM Implementation Period (Rev 2);
- December 2015 – Second Site-Wide GWPR;
- February 2016 – NJDEP Approval of the Site-Wide GWRIR (dated April 2014);

- February 2016 – Rigid Porous Polyethylene Sampler (RPPS) Assessment Memorandum;
- February 2016 – March 2016 Quarterly GWSP – IRM Implementation Period (Rev 1);
- March 2016 – NJDEP Approval of the RPPS Assessment Memorandum;
- March 2016 – RPPS Assessment Findings Letter;
- March 2016 – NJDEP Approval (with comments) of the March 2016 Quarterly GWSP – IRM Implementation Period (Rev 1);
- March 2016 – Roche Response to NJDEP Comments on the March 2016 Quarterly GWSP – IRM Implementation Period (Rev 1);
- March 2016 – NJDEP Approval of Roche's Response to NJDEP Comments on the March 2016 Quarterly GWSP – IRM Implementation Period (Rev 1);
- May 2016 – Request for Approval-Modification of the Site-Wide GWSP – IRM Implementation Period - July 2015;
- May 2016 – NJDEP Approval of the Request for Approval Modification of the Site-Wide GWSP – IRM Implementation Period - July 2015 and Provides Comments;
- June 2016 – Roche Response to NJDEP Comments on the Request for Approval Modification of the Site-Wide GWSP – IRM Implementation Period - July 2015;
- July 2016 – Memorandum of Recommendations Regarding Monitoring Well Decommissioning;
- July 2016 – NJDEP Approval of the Memorandum of Recommendations Regarding Monitoring Well Decommissioning;
- August 2016 – Addendum to the December 2015 Site-Wide GWPR; and
- November 2016 – Modification to Site-Wide Groundwater Sampling Program.

2.4 PDI, Pilot Tests, and IRM Programs

To date, IA-specific groundwater remedial actions (source removal) have been completed at IAs 2, 6, 7, 9, 11, and 12. In addition, IRMs are under implementation (or in the system-design phase) in other Site IAs to further remediate, contain, or stabilize areas of elevated groundwater contamination and prevent further spreading of contaminants in groundwater. The residual groundwater contamination will be addressed via a Site-wide Groundwater Remedial Action Workplan (RAW).

Between October 2013 and April 2015[5], PDIs, and/or pilot test programs were implemented in IA-1/IA-4, IA-2, IA-3/IA-7/Clifton-Allwood Municipal Sewer (CAMS), IA-6, IA-9, IA-10, IA-11, IA-12, and IA-15 to further characterize the vertical and areal distribution of contaminants (particularly the areas of elevated tetrachloroethene [PCE] and breakdown product concentrations), identify contaminant migration pathways within source areas, and gather sufficient biogeochemical and groundwater quality data to support the selection and design of the IRMs. Reports documenting the PDI and pilot test activities were submitted to the NJDEP in the January and December 2015 GWPRs. A schedule of active IRM programs for selected IAs is provided in Section 5.1.

[5] This time frame excludes the historic IRM programs completed in IA-11 to treat the contaminated overburden between March 2006 and November 2011.

3.0 TECHNICAL OVERVIEW

This section provides a technical overview of the supplemental groundwater characterization activities completed at the Site, specifically quarterly groundwater monitoring events (conducted between August 2015 and July 2016) and investigative programs completed in IA-11. Table 1 provides a sample collection summary (including the quality assurance [QA] and quality control [QC] samples) for this investigation period. The findings of these activities are presented in Section 4.0 and Appendix A.

3.1 Remediation Standards and Criteria

Any chemical compound detected in groundwater with a concentration that exceeds the New Jersey Groundwater Quality Standards for Class IIA Aquifers [GWQS] (N.J.A.C. 7:9C) is defined as a groundwater constituent of concern (COC, or contaminant). In November 2015, the NJDEP revised the Interim Groundwater Quality Criterion (IGWQC) for 1,4-dioxane, reduced from 10 micrograms per liter (µg/L) to 0.4 µg/L. Laboratory analysis associated with the March and June 2016 monitoring events achieved lower contaminant detection limits for 1,4-dioxane, which allowed for the detection of this compound at or below the established 0.4 µg/L IGWQC.

3.2 Supplemental Investigation and Remediation Program Objectives

Since the start of the 2013 groundwater RI, more than 1,000 monitoring wells and remedial wells/points have been installed at the Site. During this reporting period, approximately 354 additional wells were installed as part of remedial programs conducted in various Site IAs. Additional wells may be installed as part of ongoing or upcoming IRM or supplemental investigative programs. Future well installation activities will be documented in the next GWPR.

3.3 Supplemental Groundwater Remedial Programs

3.3.1 Bedrock Borehole Investigation

Between September and December 2015, borehole geophysical investigations were completed by ARM Geophysics of Hershey, Pennsylvania in the five wells listed below:

Well ID	IA	Zone	Well Type
IW-180A (DFN-2)	11	S1	Injection
PW-716†	Off-Site	N/A	Industrial
IW-146C	13	S3	Injection

Well ID	IA	Zone	Well Type
DW-67B	1	D2	Monitoring
DW-68B	1	D2	Monitoring

† Former production well at Building 716 (off-Site).

The geophysical logs for these wells are provided in Appendix B. In addition to the aforementioned borehole geophysics, additional bedrock boreholes were packer tested during the March 2015[6] – January 2016 time frame to determine zones of high yield for the construction of permanent monitoring well screens. Results for these packer tests can be found in Appendix B, Figure 1.

3.3.2 Supplemental Wells in Support of IRM Design and Implementation

Between June 2015 and May 2016, a total of 354 supplemental monitoring and remedial wells (including injection and vapor points) were installed at on- and off-Site locations as part of recent pilot studies or IRM programs. Figure 9 provides the location of these new wells. Appendix C provides the well construction documentation for the supplemental wells installed during the reporting period.

The table below lists the wells completed at the Site during the reporting period under the various supplemental groundwater characterization and IRM programs. Table 2 provides a summary of well construction details.[7] Table 3 provides a summary of the vertical investigation zones and the total number of on- and off-Site monitoring wells associated with them.

[6] Results from March 2015 to June 2015 were not previously provided in the December 2015 GWPR.

[7] Wells installed between July 2015 and January 2016 associated with some IA-specific investigation programs were included as new wells in Table 2 of the Addendum to the December 2015 GWPR, submitted August 2016. Wells installed after January 2016 are represented as new installations on Table 2 of this report.

IRM Programs = 354 Monitoring and Remedial Wells		
IA-1/4 IRM*	(14) Zone S1	IW-74A, IW-75A, IW-76A, IW-77A, IW-78A, IW-79A, IW-80A, IW-81B, RW-1, RW-2, RW-3, RW-4, RW-5, RW-6.
	(30) Zone S2	IW-73B, IW-74B, IW-75B, IW-76B, IW-77B, IW-78B, IW-79B, IW-80B, IW-82B, IW-83B, IW-84B, IW-85B, IW-86B, IW-87B, IW-88B, IW-89B, IW-90B, IW-91B, IW-92B, IW-93B, IW-94B, IW-95B, IW-96B, IW-97B, IW-98B, IW-99B, IW-100B, IW-101B, IW-102B, IW-103B.
	(25) Zone S3	IW-81C, IW-82C, IW-83C, IW-84C, IW-85C, IW-86C, IW-87C, IW-88C, IW-89C, IW-90C, IW-91C, IW-92C, IW-93C, IW-94C, IW-95C, IW-96C, IW-97C, IW-98C, IW-99C, IW-100C, IW-101C, IW-102C, IW-103C, ART-72, ART-74.
IA-4 AOC 105 RA22 IRM*	(4) Zone S1	MW-20AR, MW-183AR, MW-185AR, MW-490A.
IA-2 IWAS	(2) Zone S1	MW-155R, MW-156R.
IA-6 IRM*	(26) Zone S1	MW-447A, ART-75, ART-76, ART-78, ART-89, IA6-VP1, IA6-VP2, IA6-VP3, IA6-VP4, IA6-VP5, IA6-VP6, IA6-VP7, IA6-VP8, IA6-VP9, IA6-VP10, IA6-VP11, IW-104A, IW-105A, IW-106A, IW-107A, IW-108A, IW-109A, IW-110A, IW-111A, IW-112A, IW-113A.
	(27) Zone S2	MW-318B, MW-321B, MW-447B, ART-77, ART-79, ART-80, ART-81, ART-82, ART-83, ART-84, ART-85, ART-87, BIOS-1B, BIOS-2B, BIOS-3B, BIOS-4B, BIOS-5B, BIOS-6B, BIOS-7B, BIOS-8B, BIOS-9B, BIOS-10B, BIOS-11B, BIOS-12B, BIOS-13B, BIOS-14B, BIOS-15B.
	(3) Zone S3	MW-321C, ART-86, ART-88.
IA-2 ISTT	(3) Zone S1	MW-341A, MW-342A, MW-343A.
IA-3/IA-7/CAMS IRM*	(51) Zone S1	MW-491A, MW-492A, MW-494A, IA7-VP1, IA7-VP2, IA7-VP3, IA7-VP4, IA7-VP5, IA7-VP6, IA7-VP7, IA7-VP8, IA7-VP9, IA7-VP10, IA7-VP11, IA7-VP12, IW-115A1, IW-115A2, IW-116A1, IW-116A2, IW-117A1, IW-117A2, IW-118A1, IW-118A2, IW-119A1, IW-119A2, IW-120A1, IW-120A2, IW-121A1, IW-121A2, IW-122A1, IW-122A2, IW-123A1, IW-123A2, IW-124A1, IW-124A2, IW-125A1, IW-125A2, IW-126A1, IW-126A2, IW-127A1, IW-127A2, IW-128A1, IW-128A2, IW-129A1, IW-129A2, IW-130A1, IW-130A2, IW-131A1, IW-131A2, IW-132A1, IW-132A2.
	(29) Zone S2	MW-492B, MW-493B, MW-495B, IW-115B, IW-116B, IW-117B, IW-118B, IW-119B, IW-120B, IW-121B, IW-122B, IW-123B, IW-124B, IW-125B, IW-126B, IW-127B,

IRM Programs = 354 Monitoring and Remedial Wells		
		IW-128B, IW-130B, IW-131B, IW-132B, ART-90, ART-91, ART-92, ART-93, ART-94, ART-95, ART-96, ART-97, ART-98.
IA-9 Post-Excavation*	(10) Zone S1	MW-152R, MW-154R, MW-170R, MW-170AR, MW-466A, MW-467A, MW-468A, MW-469A, MW-470A, MW-471A.
	(3) Zone S2	MW-152BR, MW-170BR, MW-217BR.
IA-11 West IRM*	(24) Zone S1	IA11-VP5, IA11-VP6, IA11-VP7, IA11-VP8, IA11-VP9, IA11-VP10, IA11-VP11, IA11-VP12, IA11-VP13, IA11-VP14, IA11-VP15, IA11-VP16, IA11-VP17, IA11-VP18, IA11-VP19, IA11-VP22, IA11-VP23, IA11-VP24, IA11-VP25, IA11-VP26, IA11-VP27, IA11-VP28, IA11-VP29, IW-180A.
	(8) Zone S2	MW-450B, MW-451B, IW-156B, IW-157B, IW-158B, IW-161B, IW-162B, IW-168B.
	(45) Zone S3	MW-463C, MW-464C1, MW-464C2, MW-465C1, MW-465C2, MW-448B, MW-449C, MW-452C, MW-453C1, MW-453C2, MW-454C, MW-455C, MW-456C1, MW-456C2, MW-457C1, MW-457C2, MW-458C1, MW-458C2, MW-459C, MW-460C, MW-461C, MW-462C1, MW-462C2, EW-26C, IW-114C, IW-136C2, IW-151C1, IW-151C2, IW-157C1, IW-157C2, IW-158C1, IW-158C2, IW-159C1, IW-159C2, IW-160C2, IW-161C1, IW-161C2, IW-162C1, IW-162C2, IW-165C1, IW-165C2, IW-167C1, IW-167C2, IW-168C1, IW-168C2.
IA-11 B47	(4) Zone S1	MW-484A, MW-497A, MW-498A, MW-499A.
	(4) Zone S2	MW-484B, MW-497B, MW-498B, MW-499B.
IA-12 IWAS/ISCO*	(10) Zone S1	MW-225A, MW-438A, MW-439A, MW-440A, IA12-VP19, IA12-VP20, IW-45A, IW-46A, IW-48A, IW-49A.
	(14) Zone S2	MW-438B, MW-439B, IW-45B2, IW-45B3, IW-46B2, IW-46B3, IW-48B2, IW-48B3, IW-49B2, IW-49B3, ART-31, ART-32, ART-34, ART-35.
	(2) Zone S3	MW-239C, MW-60G-S3.
IA-12 Pump Test	(5) Zone S1	MW-435A, MW-436A, MW-437A, MW-443A, MW-444A.
	(5) Zone S2	MW-435B, MW-436B, MW-437B, MW-443B, MW-444B.
	(2) Zone S3	MW-294C, MW-376-S3.
IA-13 IRM*	(1) Zone S2	IW-152B.
	(3) Zone S3	IW-146C, IW-153C1, IW-153C2.

* Note: the majority of monitoring and remedial wells listed in the above table were documented as “new” wells in Table 2 of the Addendum to the December 2015 GWPR (dated August 2016) for the following programs: IA-1/4 IRM, IA-4 AOC 105 RA22 IRM, IA-6 IRM, IA-3/IA-7/CAMS IRM, IA-9 Post Excavation, IA-11 West IRM, IA-12 IWAS/ISCO, and IA-13 IRM.

3.3.3 Well Abandonment

On July 13, 2016, on behalf of Roche, TRC submitted to the NJDEP a memorandum that proposed decommissioning 19 wells. These wells, as well as several others, experienced damage from heavy equipment at the Site during various building demolition and soil remediation activities. The 19 wells (located in Zones S1 and S3 of IAs 1, 4, 6, 7, 10, and/or off-Site areas) were identified as not being needed for ongoing IRM or long-term groundwater monitoring. Abandonment of these wells was completed in the Fall 2016. Well decommissioning records will be provided to the NJDEP in a future deliverable. Refer to Appendix D (Recommendations Regarding Monitoring Well Decommissioning Memorandum – July 2016) for the list of monitoring wells scheduled for abandonment.

On September 28, 2015, TRC discovered the location of former production well PW-716 at Building 716 located at the 800 Bloomfield Avenue in Nutley, NJ (a.k.a. the condo building). The out-of-service industrial well was found within a building addition in a 6-foot deep vault, housing a motor and storage tank associated with the inactive industrial well's pump. Because PW-716 could not be vertically accessed by drilling equipment, cranes, or trucks, Roche requested a deviation from the NJDEP Bureau of Water Allocation and Well Permitting pursuant to N.J.A.C. 7:9D, to abandon the well in a manner that deviates from established requirements. On May 24, 2016, NJDEP approved the proposal to decommission PW-716. PW-716 was abandoned by Salomone Bros., Inc. (Salomone) on June 8, 2016. A borehole geophysics investigation was completed in PW-716 prior to well decommissioning (Appendix B). Refer to Appendix D for copies of TRC's request for decommission of PW-716, Salomone's well decommissioning authorization request, and corresponding NJDEP approval letter. The NJDEP well decommissioning report is included in Appendix C.

3.4 <u>Groundwater Monitoring Programs</u>

3.4.1 Quarterly Groundwater Sampling

As per the NJDEP-approved requests for modification of the *Site-Wide Groundwater Sampling Plan – Interim Remedial Measures (IRM) Implementation Period – July 13, 2015,* submitted in February 2016 and May 2016, the low-flow sampling program was modified to employ passive diffusion bag (PDB) and/or rigid porous polyethylene sampler (RPPS) sampling techniques to facilitate sample collection from as many as 168 perimeter and selected interior monitoring wells. The proposed revisions to the quarterly groundwater sampling plan were accepted by the NJDEP in letters dated March 24, 2016 and May 26, 2016. A description of the implemented groundwater sampling methodologies and field activities is provided below.

September 2015 (3Q 2015) and December 2015 (4Q 2015) Sampling Events

Between August 18 and October 21, 2015 and November 30 and December 28, 2015, groundwater samples were collected from 168 and 167 monitoring wells, respectively, using the low-flow sampling method and analyzed for volatile organic compounds (VOCs) (SW-846 Method 8260C) and 1,4-dioxane (SW-846 Method SW846 8260C with selective ion monitoring [SIM]). All samples were analyzed by Accutest/SGS (Dayton, NJ). During well purging activities, water quality measurements (temperature, pH, oxidation-reduction potential [ORP], turbidity, specific conductivity, salinity and dissolved oxygen [DO]) were collected using a field-calibrated water quality meter. As per the NJDEP Field Sampling Procedures Manual, groundwater samples were collected subsequent to stabilization of the water quality parameters. Groundwater sampling measurements and calculations are provided on the Field Sampling Sheets in Appendix E.

March 2016 (1Q 2016) Sampling Event

Effective in November 2015, the NJDEP implemented an IGWQC of 0.4 μg/L for 1,4-dioxane[8]. During the planning of the first quarter 2016 Site-wide sampling event, NJDEP approved the transition from the low-flow sampling methodology to RPPS for select wells where detections of 1,4-dioxane exceeded 2.0 μg/L. Between February 29 and March 24, 2016, a total of 49 monitoring wells, with 1,4-dioxane levels > 2.0 μg/L, were sampled for 1,4-dioxane (via method 8260C SIM) using the RPPS devices and for VOCs (via method 8260C) using PDBs. An additional 117 monitoring wells were sampled via low-flow for VOCs (via method 8260C) and 1,4-dioxane via method 8270D SIM; which were able to achieve detection limits lower than the new IGWQC.

During well purging activities, water quality measurements (temperature, pH, ORP, turbidity, specific conductivity, salinity, and DO) were collected using a field-calibrated water quality meter. As per the NJDEP Field Sampling Procedures Manual, groundwater samples were collected subsequent to stabilization of the water quality parameters. The PDB and RPPS samplers were filled with laboratory-grade deionized water and deployed within the wells every 5 feet of saturated well screen or open borehole (for newly-installed monitoring wells) or at the 5-foot depth interval displaying the highest VOC levels (for previously sampled monitoring wells). The PDBs and RPPS were allowed to stay in the well (and equilibrate) for at least 14

8 In March 2015, the NJDEP Office of Science proposed a revision to the interim specific ground water quality criterion (ISGWQC) for 1,4-dioxane (lowered from 10 μg/L to 0.4 μg/L). The revised interim criterion went into effect on November 15, 2015.

days prior to removal and sample collection. Groundwater sampling measurements and calculations are provided on the Field Sampling Sheets in Appendix E.

June 2016 (2Q 2016) Sampling Event

Between June 20 and 24, 2016, 181 on- and off-Site monitoring wells were sampled using PDBs and RPPSs for VOCs (SW-846 Method 8260C) and 1,4-dioxane (SW-846 Method 8270D SIM). The VOC samples (excluding 1,4-dioxane) were analyzed by Accutest/SGS in Dayton, NJ. The 1,4-dioxane groundwater samples were analyzed by Accutest/SGS in Marlborough, Massachusetts. The PDB and RPPS samplers were filled with laboratory-grade deionized water and deployed within the wells every 5 feet of saturated well screen or open borehole (for newly-installed monitoring wells) or at the 5-foot depth interval displaying the highest VOC levels (for previously sampled monitoring wells). The PDBs and RPPSs were allowed to stay in the well (and equilibrate) for at least 14 days prior to removal and sample collection. Groundwater sampling measurements and calculations are provided on the Field Sampling Sheets in Appendix E.

All sampling was completed in compliance with the Roche Quality Assurance Project Plan (QAPP), the NJDEP Field Sampling Procedures Manual (August 2005), and the groundwater sampling standard operating procedures (SOPs). The groundwater sampling results for the four quarterly sampling events are discussed in Section 4.2.3. The low-flow, PDB, and RPPS sampling forms are provided in Appendix E.

3.4.1.1 Fluid-Level Measurements

September 2015 through June 2016

On September 17, 2015, December 15, 2015, March 9, 2016, and June 20, 2016, synoptic water-level measurements were collected from all on-Site and off-Site wells and established surface water gauging locations. The synoptic water-level measurements were collected from over 895 Roche-owned wells[9], 27 Deluxe Check wells, five Nova Electric wells (September 2015 only), and 11 surface water monitoring stations (September 2015 only) established along St. Paul's Brook (Tables 4-1 through 4-4).

Prior to initial water-level measurements, the integrity of each well was inspected, and a photoionization detector (PID) was used to screen the well opening for the presence of volatile

[9] By June 20, 2016, approximately 895 monitoring wells were gauged as part of the June 2016 (2Q 2016) monitoring program. This total excludes on-Site remediation wells (e.g., injection wells, recovery wells, soil vapor extraction wells, etc.) as well as off-Site monitoring wells owned by Deluxe Check and Nova.

gases. A Solinst® oil-water interface probe was used to record depth-to-water measurements from established surveyed points and to assess the potential for the presence of light/dense non-aqueous phase liquids (LNAPL/DNAPL) in each well. All pertinent observations and data were recorded on field sampling forms and in a field logbook. Results of the groundwater gauging events are provided in Section 4.1.

The water-level measurements were used to generate groundwater contour maps. NJDEP contour map reporting forms are included in Appendix F. A discussion on the Site's groundwater flow regime is provided in Section 4.1.

October 2015

On October 7, 2015, a groundwater gauging event of limited scope was conducted in portions of IA-11, IA-13, IA-15, and off-Site near Nichol's Park and B716. The objective of this program was to obtain comprehensive groundwater elevation data for Zone S1, S2, S3, and D1 wells in the B716 area (west of IA-15), given that new monitoring wells were installed in that area after the September 2015 monitoring quarter. Findings from this field investigation were presented in the Section 4.1.3.1 of the August 2016 Addendum to the 2nd GWPR.

3.5 Investigative Area (IA)-Specific Programs

3.5.1 Investigative Area 11 (IA-11) West/CAMS Groundwater Sampling Report March 2016-June 2016 Summary

The IA-11 West/CAMS groundwater sampling program was conducted by TRC to support remedial design decisions in the vicinity of the newly installed and existing monitoring wells in and around the area identified as IA-11 West. Included in this report are the results of the IA-11 West/CAMS March/April 2016 groundwater sampling of 91 wells to determine baseline VOC and Total Organic Carbon (TOC) concentrations. Also included is the May/June 2016 installation and sampling of eight monitoring wells associated with Building 47 (Lime House) to evaluate Zone S1 and upper Zone S2 groundwater quality in IA-11 near Building 47 and the Roche process sewer and to refine the characterization of chlorinated volatile organic compounds (CVOCs)[10] in groundwater for pre-design purposes.

[10] CVOCs are a large family of chemical compounds widely used in industrial and commercial products for their effective degreasing properties. CVOCs are the most prevalent groundwater contaminants at the Site, particularly tetrachloroethene (PCE), trichloroethene (TCE) and their degradation products (cis-1,2-dichloroethene [cis-1,2-DCE] and vinyl chloride [VC]). To a lesser extent 1,1,1-trichloroethane (1,1,1,-TCA), and its breakdown products 1,1-dichloroethene (1,1-DCE), and 1,1-dichloroethane (1,1-DCA) have also been detected.

March/April 2016 Groundwater Sampling Event

Groundwater samples were collected from 91 wells (for a total of 153 samples including QA/QC field and trip blanks, and duplicate samples) between March 28 and April 4, 2016. Depth to water measurements and field parameters (pH, dissolved oxygen, conductivity, turbidity, total dissolved solids, salinity, ORP, and temperature) were measured and recorded in the field book and on field forms. Groundwater samples were collected via low-flow/low purge methodology and submitted to Accutest/SGS Laboratories in Dayton, New Jersey for VOC+10 and TOC analyses.

April/May/June 2016 Well Installation and Groundwater Sampling Event

Between April 28 and May 12, 2016, eight monitoring wells were advanced to the east and south of Building 47. Monitoring wells MW-484A, MW-497A, MW498A, and MW-499A were installed in the overburden and screened approximately 5 to 15 feet bgs with a 10-foot long screen. Monitoring wells MW-484B, MW-497B, MW498B, and MW-499B were advanced to 25 feet bgs and screened from the top of weathered bedrock to the top of competent bedrock with a 5-foot long screen (approximately 20-25 feet bgs). Well logs and permits are included in the IA-11 Report provided in Appendix A.

On June 1, 2016, following a period of well equilibration, 11 groundwater samples (including QA/QC) were collected from the eight new wells via low-flow/low purge methodology and submitted to Accutest/SGS Laboratories in Dayton, New Jersey, for VOC+10 and TOC analyses. Depth to water measurements and field parameters (pH, dissolved oxygen, conductivity, turbidity, total dissolved solids, salinity, ORP, and temperature) were measured and recorded in the field book and on field forms.

3.5.2 IA-11 Process Manhole Investigation

An investigation of an abandoned Roche process manhole was initiated in July 2016, to evaluate Roche's process wastewater system as a potential source of impact. The manhole is located south of Building 47 in IA-11; see Figure 10 for location. The manhole was part of the subsurface process line that directed process waste from Building 47 (a.k.a. the Lime House) to the public sewer system (connecting to a manhole on Kingsland Street) until 1982, when Roche's ECF in IA-15 was brought online. On July 28, 2016, the manhole was located and, after removing approximately 2 inches of decorative stone and 6 inches of soil, the lid was encountered. After opening the lid it was discovered that the manhole structure was not filled in and standing water was observed. The lid was replaced until the investigation resumed on August 22, 2016. TRC reopened the manhole and visually inspected the structure to assess its integrity. No holes or cracks were observed in the structure and, utilizing a Teflon bailer, a sample was collected from the approximately 4 inches of standing water at the bottom of the manhole. The water sample was analyzed for VOCs.

To further investigate the manhole, TRC oversaw the installation of one soil boring through the bottom of the manhole into the soils and weathered bedrock below. Environmental Management Associates, Inc., (EMA), under the direction of TRC, set a casing within the manhole and backfilled around the casing with certified clean densely graded aggregate (DGA). The casing extended from grade level to the base of the manhole structure. This stabilized casing within the manhole allowed EMA to utilize a hollow stem auger to drill through the base of the manhole. Split spoons were advanced to bedrock refusal, which occurred at approximately 16.25 feet below surface grade. See Appendix G for the associated boring log. TRC field screened soils utilizing a PID. Two soil samples were collected at depths of 14-14.5 feet and 15.5-16 feet below grade. The soil samples were analyzed for VOCs.

Additionally, dark sediments were observed in the split spoon sampler at a depth just above the concrete base of the manhole. These were assumed to be sediments that had settled on the base of the manhole. A sample of the sediments was collected and also analyzed for VOCs. All samples were submitted to Accutest/SGS Laboratories.

3.6 Remediation-Derived Waste – IRM System Installation

Between September 2015 and June 2016, IRM systems installed in IA-3/7/CAMS, IA-11, and IA-12 resulted in the generation of waste material (e.g., drill cuttings, soils from trench installations, etc.). Wastes generated at the Site during the installation of IRM systems were characterized and disposed in accordance with State and Federal regulations and disposal facility permit requirements.

The waste was stored in roll-off containers and sampled for analysis of Target Compound List (TCL) VOCs, Target Analyte List (TAL) metals, TCL polychlorinated biphenyls (PCBs), pesticides, herbicides, RCRA characteristics, total petroleum hydrocarbons (TPH), full Toxicity Characteristic Leaching Procedure (TCLP), paint filter and Form U at a frequency of at least one sample for every 500 tons. In addition, samples were collected from each roll-off container for TCL VOC analysis. Based on the analytical results, waste profile applications were submitted to selected disposal facilities for approval. Following transportation, disposal, and receipt of fully executed waste disposal manifests or bills of lading, copies of manifests or bills of lading will be submitted to the NJDEP in a separate deliverable.

3.7 Data Reliability

The analytical methods used for the quarterly Site-wide groundwater sampling events are provided in the QAPP and the laboratory analytical reports. The laboratory data reports and electronic data deliverables/Electronic Data Submission (EDD/EDS) for the recent data are included on compact disc in Appendix H. Table 1 presents a summary of groundwater samples collected between August 2015 and July 2016.

Sample collection activities and laboratory analyses of groundwater samples obtained as part of the low-flow, PDB and RPPS sampling program were performed in accordance with the TRSR, the NJDEP-approved groundwater RI Workplans for shallow and deep bedrock investigations (2012 and 2013), the *Site-Wide Groundwater Sampling Plan - Interim Remedial Measures (IRM) Implementation Period Rev. 1* (July 2015) and subsequent modifications, and the revised QAPP (2013). Sample analyses were completed by Accutest/SGS Laboratories.

A quality assurance review was performed on the laboratory analytical reports for all VOC samples collected as part of the quarterly monitoring program. The method-specific calibrations and quality control performance criteria were met for the data generated during this investigation, except as indicated in the conformance/non-conformance summaries provided in the laboratory reports.

Based on a review of the laboratory reports, the majority of the data appear valid as reported and may be used for decision-making purposes. Non-detect results for 1,4-dioxane in samples MW-237A_LF25.0(A) and MW-237A_LF25.0(B) (collected in September 2015 and reported in laboratory report JC3901) are not usable for project objectives due to poor surrogate recoveries (< 10%). Overall, the groundwater sample data collected in association with this GWPR are considered to be valid and useful for the intended data quality objectives and their intended purpose with no requirements for additional sampling or re-sampling.

3.8 Factors Influencing Data

The synoptic rounds of groundwater and surface water[11] elevation measurements were completed in 1 day for each quarterly sampling period (September 17, 2015, December 15, 2015, March 9, 2016, and June 20, 2016). Overall, the data generated from these events were consistent with measurements collected prior to and after the 1-day gauging events (exceptions were indicated, where applicable). In addition, multiple building dewatering systems or building basement sumps were in operation at the Site during the entire monitoring period. It is possible

[11] Surface water measurements were only collected during the September 2015 gauging event.

that these dewatering systems could have influenced local shallow groundwater flow in the immediate vicinity of the sumps.

No significant events or seasonal variations are known to have influenced the sampling procedures or the results of the sampling programs presented in this GWPR. Due to the large number of sampled monitoring wells and associated logistical challenges, each of the comprehensive sampling events spanned multiple, consecutive weeks that extended beyond the respective monitoring month. This larger time frame for the comprehensive sampling quarters did not affect data quality.

Some of the data summary figures included with this report depict data collected using different sampling (e.g., grab, low-flow, PDB, RPPS, etc.) and analytical methods (e.g., 1,4-dioxane analysis via 8270SIM vs. 8260SIM). While the multiple data sets may have resulted in slight variations in the contaminant concentration ranges (for selected constituents), the quality of the data is not considered compromised and it supports conclusions made regarding supplemental Site characterization.

In addition, several remediation programs (soil excavations, groundwater IRMs, etc.) were implemented at the Site (i.e., IA-2, IA-1/IA-4, IA-6, IA-10, IA-11, IA-12, and IA-13); some of these could have resulted in improved groundwater quality conditions at the Site. The Remedial Action (RA) and IRM activities recently completed include:

- IA-4 excavation of heating oil-contaminated soil to the top of bedrock continued through August 2015 and concluded in September 2015; the area was backfilled with gravel.
- Drilling and packer testing of In-Well Air Stripping (IWAS) and injection wells occurred throughout the IA-1/4 and IA-6 IRM areas from August through December 2015.
- Roche completed the excavation of PCE-contaminated soil from beneath the abandoned CAMS manhole in IA-11 to the top of weathered bedrock in August 2015, backfilling with gravel.
- The IA-2 *in situ* thermal treatment (ISTT) operation continued heating bedrock (Zones S1, S2, and S3) in August 2015 and concluded in January 2016; the soil vapor extraction (SVE) system continued to operate through March 2016.
- Roche pumped groundwater continuously for 36 hours in August from MW-252C in the SE corner of IA-2 to mitigate benzene found in area wells.
- Roche (TRS) began pumping groundwater (2 – 5 gallons per minute [gpm]) from Zone S2 wells at two locations in the SE corner of IA-2 to control VOC migration beneath the ISTT electrode field in that area; pumping continued from September to December 2015.
- Wells were installed in IA-11 and IA-13 in August 2015.

- Wells were installed in IA-10 adjacent to Windsor Place in September 2015.
- Pumping tests were conducted in IA-12 in late October-early November 2015.
- Soil excavation (from Zone S1 to bedrock) occurred in the IA-2 thermal treatment zone in October-November 2015.
- Pumping tests were conducted in IA-13 in November 2015.
- Coring (into Zone S2) occurred in IA-11 in December 2015 around the CAMS manhole area to determine CVOC concentrations in rock and groundwater.
- The IA-2 IWAS IRM system began operation in January 2016 and is ongoing.
- Additional pumping (recirculation) tests were conducted in IA-12 in February 2016.
- Additional Zone S1 monitoring wells were installed in the IA-2 ISTT area in April 2016.
- The IA-6 IWAS/*in situ* chemical oxidation (ISCO) IRM system began operation in April 2016 and is ongoing.
- Additional monitoring wells were installed around B47 in IA-11 in May 2016.
- The IA-1/4 IWAS/ISCO IRM system began operation in June 2016, but the ozone systems were taken off-line in July due to ozone leaks and not reactivated until September 2016; however, the IWAS systems continued to operate.
- The IA-12 IWAS/ISCO system began operation in late June 2016 and is ongoing.

3.9 Deviation from the Technical Requirements and Guidance

All field activities were conducted in compliance with the approved RI workplans, the *Site-Wide Groundwater Sampling Plan – Interim Remedial Measures (IRM) Implementation Period Rev. 1* (July 2015) and subsequent modifications (February 2016 and May 2016), QAPP, and the TRSR and applicable guidance documents. As such, there were no sampling methods or procedures that deviated from the approved workplan, TRSR, and applicable guidance.

It should be noted that due to the large number of monitoring wells sampled via PDBs, NJDEP's PDB Data Checklist forms (documenting field activities associated with the deployment of PDBs at each well) were not completed. Instead, relevant data (e.g., monitoring well ID, time/installation depth/depth to water during deployment and retrieval, etc.) for the collected PDB and RPPS samples are presented in a table format, which is included in Appendix E.

4.0 SUPPLEMENTAL INVESTIGATIVE FINDINGS

This section presents the findings of the supplemental groundwater characterization activities, specifically results from quarterly groundwater monitoring events (conducted between August 2015 and June 2016), and additional investigative programs completed in IA-11. The focus of this GWPR is to monitor and document groundwater quality and concentration trends over time along the Site perimeter and in select interior areas of the Site during the implementation phase of various IRM programs. The methods and procedures employed during the various field activities are presented in Section 3.0 (Technical Overview). The laboratory data packages and the EDDs associated with these investigative activities are included on compact disc(s) in Appendix H.

4.1 Groundwater Flow Regime – Synoptic Well Gauging Events

The quarterly groundwater sampling program monitors groundwater flow conditions at the Site over time to assess temporal variability in the data (e.g., seasonal fluctuations) and to continue monitoring for any potential off-Site influences on the groundwater flow system. During this reporting period, data were evaluated to assess whether the installation and/or operation of IRM systems (e.g., IWAS, amendment injections, soil/bedrock excavations, etc.) in multiple Site IAs resulted in changes to the Site's groundwater flow regime.

Figure 11 is a six-panel map that provides the most recent depiction (June 2016) of the groundwater flow regime in Zones S1 through S3 and D1 through D3. Figures I-1 through I-6 (Appendix I) compare potentiometric surface maps (four-panel maps) for quarterly events on September 17, 2015, December 15, 2015, March 9, 2016, and June 20, 2016 for Zones S1 through S3 and D1 through D3. The four-panel maps allow for the evaluation of temporal variability in the groundwater flow regime, at a specific zone, from one quarter to the next.

Please note that these potentiometric maps do not depict groundwater flow arrows.[12] Tables 4-1 through 4-4 summarize well gauging information and groundwater elevation data for September 2015, December 2015, March 2016, and June 2016.

Overall, the highest groundwater elevations are found in the northern portions of the Site (IA-12 and IA-10), and the lowest groundwater elevations are in the southern portions of the Site (IA-14 and IA-15). Four monitoring wells (DW-16C, DW-31B, DW-31C, and DW-33C) show anomalously low water levels (between 7.08 feet above msl and -219.60 feet below msl). These wells are low-yielding; i.e., monitoring wells where recovery to static groundwater head

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[12] In homogeneous, isotropic systems, groundwater flow directions meet the equipotential lines at a right angle. In contrast, for anisotropic and heterogeneous systems, such as the Roche Site, groundwater may flow in a direction oblique to the equipotential lines. Therefore, to avoid possible misrepresentation of the true groundwater flow directions beneath the Site, groundwater flow lines are not included in the potentiometric maps.

conditions has required numerous months, or has not yet occurred. The majority of these wells are located in the western portion of the Roche Site, and are generally in Zone D3. It is likely that the cause of their poor response to aquifer conditions is related to lower fracture interconnectivity in the Zone D3 bedrock at these well locations in the western portion of the Roche Site.

Data collected during the monitoring well gauging events (including depth to water, groundwater elevation measurements, presence/absence of product [LNAPL/DNAPL], PID readings, etc.) are summarized in Tables 4-1 through 4-4. As shown on Figures I-1 through I-6 (Appendix I), there is minimal seasonal variability in the horizontal groundwater gradient and hydraulic heads measured in September 2015, December 2015, March 2016, and June 2016. During the December 2015 gauging event, approximately 0.01 foot of LNAPL was recorded in Zone S1 well MW-237A[13] (product was not detected in a subsequent monitoring event [June 2016]). LNAPL has not been detected in any other on-Site or off-Site well. Similarly, DNAPL has not been detected in any monitoring well installed on- or off-Site.

Evaluation of Horizontal Hydraulic Gradients

Appendix I, Figures I-1 through I-6 present a comparison of potentiometric surface maps for Zones S1 through D3 for September 2015 through June 2016 (i.e., these maps depict the four quarterly gauging events, in a side-by-side comparison for each vertical investigation zone). It should be noted that Site stratigraphic and geophysical data are being examined for the CSM under development. Based on that evaluation, the vertical zonation of the groundwater flow system is likely to be redefined, and the water-level data will be reorganized accordingly.

Groundwater measurements recorded during the four-quarter monitoring period were consistently higher in the northeastern portion of the Site (IAs 10 and 12) and lower in the southeast (IAs 14 and 15). As shown on the table below, groundwater elevations were higher during the months of March 2016 and June 2016, with Zone S1 water-level elevations fluctuating approximately 3.5 feet over the monitoring period.

Groundwater Elevation Data - Calculated Average (feet above msl)† September 2015 through June 2016				
Zone	9/17/15	12/15/15	3/9/16	6/20/16
S1	105.02	104.07	107.31	106.26
S2	100.32	99.60	102.51	101.53

[13] Groundwater impacts detected in monitoring well MW-237A (IA-12) have been attributed to an off-Site source, located north of Route 3 (i.e., a Sunoco service station). LNAPL was first detected at this location in IA-12 during the installation of a temporary well (TW-158A) and during monitoring of permanent well, in March 2014 (0.08 foot of LNAPL), and subsequently in June 2014 (0.12 foot of LNAPL).

S3	95.55	95.42	98.46	97.55
D1	92.67	92.29	94.59	93.95
D2	92.09	91.03	93.55	92.31
D3	83.10	83.81	87.75	87.65
D4	78.40	78.07	82.22	81.41

† The calculated averages presented in this table exclude anomalous groundwater elevation data detected in Zone D2 well DW-31B and Zone D3 wells DW-16C, DW-31C and DW-33C.

As shown on Figure 11, steep horizontal groundwater gradients are observed in the northwest, northeast and southeastern portions of the Site, specifically in the shallow groundwater Zones S1, S2, and S3. In the deeper aquifer (Zones D1 through D3), a more gentle lateral gradient is noted throughout the majority of the Site, with the exception of the most downgradient, eastern-southeastern boundary. The general direction of groundwater flow in all zones appears to be from northwest to southeast. As Figure 11 shows, areas of higher potentiometric heads remain apparent during most sampling quarters in an area upgradient of Nichols Park (Zone S1) and in IA-3/IA-7 (Zones S1 and S3). In addition, a groundwater divide in the northeastern corner of the Site (IA-12) persists in Zone S2 and remains inconsistent with the potential groundwater flow established for Zones S1 and S3.

Overall, the Site's groundwater flow regime has been sufficiently characterized with over 900 on- and off-Site monitoring wells and up to 33 surface water gauging stations[14]. There is no evidence of off-Site pumping influences observed in the synoptic gauging data collected during the past 1 year of monitoring. While seasonal variability is more pronounced in the Spring, with water levels rising as much as 3 feet in the shallow aquifer, there have been no significant changes to the Site's groundwater flow conditions. Groundwater flow across the Site is not significantly affected by any of the ongoing IRM activities.

Evaluation of Vertical Hydraulic Gradients

Vertical hydraulic gradients were calculated[15] for up to 372 well clusters (screening different zones) to evaluate the vertical groundwater gradient between Zones S1 through D4. As shown in Table 5, the vertical hydraulic gradients ranged between -1.712 to +0.533 (downward and upward, respectively). Overall, the well clusters displayed downward vertical gradients, with a predominantly upward vertical gradient observed from Zone S3 to S1 in portions of IAs 11, 13, and 15.

[14] Only five surface water measurements were collected in September 2015, after which surface water measurements were discontinued as a sufficient data set has been established.

[15] Water levels measured at the well clusters (screening different zones) throughout the Site were used to calculate the vertical hydraulic gradient. The vertical gradient was derived by using the difference in hydraulic head divided by the vertical distance between the middle of the well screens in each pair of wells.

4.2 Site-Wide Groundwater Quality Assessment

In compliance with the approved *Site-Wide Groundwater Sampling Plan - Interim Remedial Measures (IRM) Implementation Period Rev. 1* (July 2015) and subsequent NJDEP-approved modifications (February 2016 and March 2016), 168 accessible on-Site and off-Site wells were sampled for VOCs using the either the Low-Flow or PDB/RPPS method in September 2015, December 2015, March 2016, and June 2016. Discussions on the quarterly sampling events are presented below.

4.2.1 Groundwater COCs

During the 2013 RI and supplemental investigations (2014-2016), a total of 59 confirmed Site-specific groundwater COCs were identified in groundwater samples collected from monitoring wells installed at the Site. The table below summarizes the Site-specific groundwater COCs. As discussed in the GWRIR, the listed semi-volatile organic compounds (SVOCs), pesticides, and metal constituents have been attributed to historic fill and/or naturally occurring conditions, and are not a result of former Roche operations. In addition, some VOCs emanating from historic on-Site releases have been attributed to non-Roche sources (e.g., CAMS). As the RI and subsequent investigations have progressed, evidence has been collected that indicates that some of the VOCs detected in groundwater have originated off-Site and have migrated under the Roche property with groundwater flow.

VOCs[†]	SVOCs	Pesticides	Metals
1,1,1-Trichloroethane (1,1,1-TCA)	1,4-Dioxane	Dieldrin	Aluminum
1,2,4-Trichlorobenzene	2-Methylnaphthalene	Lindane	Antimony
1,1-Dichloroethane (1,1-DCA)	2-Methylphenol	Chlordane	Arsenic
1,1-Dichloroethene (1,1-DCE)	3&4-Methylphenol		Barium
1,2-Dichloroethane	bis(2-Ethylhexyl)phthalate		Beryllium
2-Butanone (MEK)	Benzo(a)anthracene (BaA)		Cadmium
Acetone	Benzo(a)pyrene		Chromium
Benzene	Benzo(b)fluoranthene		Cobalt
Bromodichloromethane	Benzo(k)fluoranthene		Iron
Carbon disulfide	Dibenzo(a,h)anthracene		Lead
Carbon tetrachloride	Hexachlorobenzene		Manganese
Chlorobenzene	Indeno(1,2,3-cd)pyrene		Nickel
Chloroethane	Pentachlorophenol		Sodium

VOCs[†]	SVOCs	Pesticides	Metals
Chloroform	TICs		Thallium
cis-1,2-dichloroethene (cis-1,2-DCE)			Zinc
Cyclohexane			
Ethylbenzene			
Methyl Tert Butyl Ether (MTBE)			
Methylcyclohexane			
Methylene chloride			
Tetrachloroethene (PCE)			
Toluene			
trans-1,2-Dichloroethene			
Trichloroethene (TCE)			
Vinyl Chloride (VC)			
Xylenes (total)			
Tentatively Identified Compounds (TICs)			

[†] The following VOC constituents have only been detected above their respective GWQS once in a limited number of monitoring wells since the 2013 monitoring period: 1,1,2,2-tetrachloroethane, 1,2-dibromoethane, 1,2-dichloropropane, 1,3-dichloropropene (total), bromomethane, chloromethane, and dibromochloromethane. These compounds are, therefore, not considered Site-specific COCs and have been removed from the above table.

4.2.2 Comprehensive Quarterly Sampling Events (September 2015 – June 2016)

Figure 9 provides a map depicting the location of all monitoring wells installed on- and off-Site (through June 2016). Table 1 provides a summary of the sample collection for each monitoring well. The list of wells sampled in the quarterly sampling events were selected to focus on areas downgradient of and in between IRM areas, areas outside of known groundwater impacts to document plume stability/absence of receptor impact (sentinel wells), and selected bedrock monitoring wells to complete eight consecutive quarters of sampling.

Comprehensive rounds of groundwater samples were collected via Low-Flow (September 2015, December 2015, March 2016) and from equilibrated PDB/RPPS (March and June 2016) retrieved from as many as 168 on- and off-Site monitoring wells (including off-Site wells located at the former Deluxe Check facility).[16] The quarterly groundwater data (September 2015 through June 2016) was supplemented with groundwater analytical results collected as part of various IRM investigative (i.e., PDI) and/or monitoring programs. All samples were analyzed for TCL VOCs by Accutest/SGS.

[16] Quarterly maps were supplemented with analytical data from grab, low-flow, or volume average purging samples collected from selected wells where recent analytical results (from the 168 wells) were not available.

As required, duplicates, field blanks and trip blanks were collected during each sampling phase/event for the same analytical parameters to assess and validate the quality of the data generated. Duplicate sample results are presented with the analytical results of the corresponding samples in Tables 6-1 through 6-4, Table 6-6, and Table 6-7. Field blank and trip blank sample results are presented in Tables 6-5, 6-6E, and 6-7C.

4.2.3 Comprehensive Quarterly Sampling Results (September 2015 – June 2016)

The groundwater quality data are provided in tables and on maps categorized by vertical investigation zone. Tables 6-1 through 6-5 provide individual summaries of the VOC analytical results for each quarter. Tables 6-6 and 6-7B summarize 1,4-dioxane analytical data collected during quarterly and supplemental sampling events. A figure included in Appendix B presents analytical results for packer test samples collected during temporary/monitoring well field screening. Figure 12 provide the groundwater VOC sampling results in plan view (by hydrostratigraphic zone) for the most recent sampling event – June 2016. Appendix I, Figures I-7 through I-13, provide a comparative four-panel view of VOC distribution across the Site for the last four quarters of monitoring (September 2015 through June 2016). The figures listed above depict isoconcentrations for the total of PCE and breakdown products at concentrations in excess of their respective GWQS (i.e., the total sum of the highest chlorinated VOC constituents; the total excludes contaminant concentrations that do not exceed their respective GWQS)[17]. Additional groundwater contaminant isoconcentration maps were prepared for 1,4-dioxane and 1,1-DCE for the June 2016 sampling event (Figures 13 and 14, respectively). Supplemental figures illustrating contaminant distribution by zone for 1,4-dioxane for each quarter (September 2015 through June 2016) are provided in Appendix I (Figures I-14 through I-20). These maps support discussions presented in sections below.

As previously discussed, TRC reviewed the data for the corresponding analytical laboratory reports and did not further qualify or reject any data points, except as noted in Section 3.7. It has been concluded that all TCL VOC (including 1,4-dioxane) data are useable for the intended purposes, with the exceptions noted in Section 3.7. Appendix H provides the laboratory reports and EDDs for the analyses performed. All groundwater sample results were compared to the NJDEP GWQS (N.J.A.C. 7:9-6).

Areas of PCE and breakdown products have been sufficiently characterized during the groundwater RI, with comprehensive discussions presented in the GWRIR (April 2014) and GWPRs (January 2015 and December 2015). These reports focused on the Site-wide characterization and distribution of VOCs across the Site as observed during eight quarters of consecutive monitoring. The Addendum to the December 2015 GWPR (dated August 2016)

[17] While the VOC figures depict contaminant isoconcentrations for the total exceeding CVOCs (PCE, TCE, cis-1,2-DCE, and VC), all VOC constituents above the established GWQS are shown in the figure data boxes.

reported findings from IA-specific investigations focused on identifying additional sources of groundwater contamination. PCE, TCE, cis-1,2-DCE, VC, 1,1-DCE and 1,4-dioxane were the only groundwater COCs encountered in concentrations above the GWQS in wells that are hydraulically downgradient from the Site, in the southern and southeastern perimeter. Therefore, the following sections discuss perimeter conditions for CVOCs and 1,4-dioxane in the south-southeastern portion of the Site and for 1,1-DCE in the southern portion of IA-10.

4.2.3.1 CVOCs Along the Site Perimeter (South & Southeastern)

As of June 2016, the most elevated CVOC concentrations were detected in the southeastern corner near IA-15, with PCE results above the 1 μg/L GWQS in Zone S1 (MW-171A =195 μg/L), Zone S2 (MW-171B = 363 μg/L), Zone S3 (MW-171C 453 = μg/L) – see Figure 12. In IA-10, the TCE contaminant levels in Zones S1, S2, and S3 have been detected at maximum concentrations of 15.9[18] μg/L (190RI-MW1), 1,060 μg/L (MW-479B), and 60.7 μg/L (MW-208C), respectively. TCE impacts in this area also extend to off-Site wells south of IA-10 near the Kingsland Street Station and St. Paul's Brook in Zone S1 in wells MW-1G (9.7 μg/L) and MW-103A (14.1 μg/L). As shown on Figure 12, the outer extent of the CVOC impacts have been sufficiently delineated laterally and vertically. Tables 6-1 through 6-4 and Table 6-7A summarize the groundwater analytical results for VOCs. A discussion on CVOC concentration trends over time is provided in Section 4.5.

4.2.3.2 1,4-Dioxane Along the Site Perimeter (South & Southeastern)

1,4-Dioxane concentrations exceeding 10 μg/L have been primarily identified in the western portion of the Site, between the Norfolk Southern Railroad tracks and First Avenue. As previously reported, the highest 1,4-dioxane concentrations (>1,000 μg/L) were found to be associated with an on-Site source located in the eastern portion of IA-1 (near former B44, B45, and B56). In March and June 2016, Roche revised its groundwater sampling and analytical methods to be able to detect 1,4-dioxane at lower concentrations (below the recently promulgated 0.4 μg/L IGWQC). Figure 13 depicts the extent of the 1,4-dioxane impacts exceeding 0.4 μg/L in Zones S1 through S3 and D1 through D4. As shown on this figure, low-level 1,4-dioxane exceedances, between 0.4 and 10 μg/L are more dispersed in Zones S3, D1, and D3, with the most downgradient impacts observed off-Site, south-southeast of the Site, in Zone S3 wells MW-214C (6.6 μg/L), MW-209C (20.5 μg/L), MW-104C (41.3 μg/L), MW-236C (0.5 μg/L), MW-171C (2.2 μg/L), MW-216C (0.9 μg/L), MW-146C (0.6 μg/L) and MW-258C (0.6 μg/L). In addition, through a lower laboratory detection limit, 1,4-dioxane (>1 μg/L) was detected in the eastern perimeter of the Site (extending from IA-12 to IA-7) in Zone D2. The outer extent of the 1,4-dioxane impacts has been sufficiently delineated laterally and vertically.

[18] Maximum concentrations in Zone S1 were encountered above 9,000 μg/L during the January Windsor Place sampling event off-Site by the Nutley Municipal Sewer as referenced in the August 2016 Addendum to the 2nd GWPR.

Tables 6-6 and 6-7B provide the groundwater analytical results for 1,4-dioxane.

4.2.3.3 1,1-DCE Along the Site Perimeter (IA-10)

1,1-DCE concentrations in exceedance of the 1 µg/L GWQS have been detected in selected on- and off-Site wells in Zones S1 through S3 and D1 through D3. As shown on Figure 14, there are multiple isolated areas containing 1,1-DCE in Zone S1 proximal to the CAMS, north of Route 3 and in IA-12, IA-3, IA-9 (northeast of B76), as well as the northwestern portion of the Site (IA-10 and IA-12). In Zones S2 and S3, the 1,1-DCE contamination is more dispersed (ranging from 1.3 µg/L to 61.3 µg/L) and limited to an area along the Norfolk Southern Railroad tracks and the northernmost section of the CAMS (north of Route 3 and in IA-12). As shown on Figure 14, the highest 1,1-DCE concentrations (>100 µg/L) appear to emanate from an area upgradient of IA-10 in Zones S3, D1, D2, and D3. No detection of this constituent was observed in Zone D4 wells. The 1,1-DCE impacts have been sufficient delineated, horizontally and laterally. Refer to Tables 6-1 through 6-4 and Table 6-7A for the groundwater analytical results for 1,1-DCE. A discussion on contaminant concentration trends over time for 1,1-DCE is provided in Section 4.5.

4.3 IA-11 West/CAMS Investigation Activities

4.3.1 IA-11 West/CAMS Groundwater Sampling Results - June 2016

The groundwater in IA-11 contains CVOCs at concentrations exceeding the New Jersey GWQS in both overburden and bedrock aquifers. The primary CVOCs in groundwater identified during the supplemental RI, and targeted during this IA-specific program, are PCE and breakdown products: TCE, *cis*-DCE, and VC.

Specific to the June 2016 event, the highest total CVOC concentration of approximately 8,500 µg/L (PCE, TCE, *cis*-DCE and VC) was detected in newly-installed well MW-497B, which is screened in the shallow weathered bedrock in the upper part of Zone S2, between 20 and 25 feet below grade.

This sampling event was conducted to supplement the groundwater investigation in this area in advance of the planned excavation of weathered bedrock impacted with high CVOC concentrations in western IA-11[19]. Additional groundwater monitoring will be implemented related to the weathered bedrock IRM excavation. The results from this monitoring will be used to evaluate the effects from the removal of the weathered bedrock source area on the

[19] Findings from PDI activities conducted in 2015 and 2016 in this portion of IA-11 identified residual mass of PCE (93.9 mg/kg) in samples of the weathered bedrock at 24 feet bgs. The presence of DNAPL in the weathered bedrock causes an ongoing groundwater contamination issue and warrants remediation to address the groundwater problem. Refer to the August 18, 2016 *IA-11 West Former CAMS Manhole Investigation Summary Report* for additional information.

groundwater quality of Zones S1, Zone S2, and Zone S3.

For ease of reference, Appendix A, Figures A-3 through A-5, provides a map of CVOC groundwater quality in IA-11 for Zones S1, S2, and S3. A map summarizing data collected from the newly-installed wells in IA-11 (sampled in June 2016) is provided in Appendix A, Figure A-6.

4.3.2 IA-11 B47 Roche Process Manhole Investigation Results

In July 2016, Roche conducted an investigation of an abandoned manhole located outside the southwest corner of B47 (Lime House) in IA-11. Prior to 1982, facility process and sanitary wastewater was routed from B47 to the municipal sewer located in Kingsland Street. A borehole was advanced through the manhole, the soils were screened using a PID, and two samples were collected from soil immediately above bedrock (approximately 16 feet bgs). In addition, samples from stagnant water encountered within the manhole and from sediments accumulated above the concrete base of the manhole were collected. The highest PID reading of the retrieved soil spoons was 3.4 ppm, observed at a depth of 14.5 feet bgs. As shown in Table 7-1, results from the water sample indicate no exceedances of the GWQS for VOCs. In addition, the soil and sediment samples did not result in VOC exceedances of applicable remediation standards (refer to Tables 7-2 and 7-3, respectively).

4.4 <u>Temporal Groundwater Concentration Trends</u>

Time-series plots of groundwater elevation and COC concentrations were prepared for select wells located along the Site boundary to assess for notable trends in contaminant concentrations over the monitoring period (Appendix J). In addition, this report presents statistical data tables that identify the wells where an increase in contaminant trend is evident (Appendix J). 1,4-dioxane was not evaluated due to the limited number of sampling events for this compound.

As shown in Appendix J, the trend lines for these graphs depict a stable, a decreasing, or a slight increase in contaminant levels. Twelve (DW-13-D2, DW-43A, DW-4C, MW-209C, MW-104B, MW-144A, MW-146C, MW-171B, MW-214B, MW-214C, MW-216C, and MW-258C) out of the 54 outer perimeter wells evaluated showed a slight increase (within the same order of magnitude) in contaminant concentrations over time for at least one or more COCs; these wells showing a slight increase are generally characterized by an increase in daughter products and a decrease in parent products.

5.0 SCHEDULE OF FUTURE GROUNDWATER INVESTIGATION AND REMEDIAL ACTION ACTIVITIES

The sections below present various schedules of RA field activities that are planned for completion in the near future. The schedule for project deliverables anticipated for submittal to the NJDEP within the next 12 months is also provided.

5.1 RI/RA Field Programs

The table below lists the IRM programs selected for implementation in Site IAs where contaminant mass reduction and/or control was warranted, as well as supplemental groundwater sampling programs designed to monitor groundwater quality during the IRM implementation period and/or gather supplemental data for potential natural attenuation applicability. Rows shaded gray indicate IRMs that have been completed.

RI/RA Field Programs							
IA & RI/RA Program	**Targeted COCs**	**Status**	**Treatment Zone**	**Anticipated Technology**	**NJDEP Permit**	**Anticipated Start Date**	**Duration**
Site-Wide GWSP - IRM Implementation Period	VOCs, 1,4-dioxane	Ongoing	N/A	MNA	N/A	Ongoing (began 3Q 2015)	1 year[1]
IA-1/IA-4 IRM	toluene, benzene, 1,4-dioxane	Design & installation completed; operation ongoing	Groundwater in overburden and bedrock	IWAS/ART, ISCO	Air discharge for off-gas; PBR for injections	Ongoing (began 2Q 2016)	2 - 3 years
IA-2 IRM	benzene, chloroform, methylene chloride	Design & installation completed; operation ongoing	Groundwater in overburden and bedrock	Thermal Treatment (ERH)	Air discharge for off-gas; PBR for electrode drip	Completed (1Q 2016)	6 – 8 months *Completed*
				IWAS	Air discharge for off-gas	Ongoing (began 3Q 2015)	2 - 3 years
IA-3/IA-7/ CAMS IRM	PCE and breakdown products	PDI & pilot test completed; design completed; construction ongoing	Groundwater in overburden and bedrock	IWAS, EISB	Air discharge for off-gas; PBR for injected amendment	1Q 2017	1 - 2 years

RI/RA Field Programs							
IA & RI/RA Program	**Targeted COCs**	**Status**	**Treatment Zone**	**Anticipated Technology**	**NJDEP Permit**	**Anticipated Start Date**	**Duration**
IA-6 IRM	chlorobenzene	Design & installation completed; operation ongoing	Groundwater in overburden and bedrock	IWAS/ART	Air discharge for off-gas; PBR for injections	Ongoing (began 2Q 2016)	1 – 2 years
IA-9 IRM	toluene & PCE and breakdown products	PDI and IRM completed	Unsaturated and saturated overburden	Excavation and EISB	PBR for backfilled amendment	Excavation completed. Amendment placed July 2015	1 year *Completed*
IA-10 IRM (B70)	benzene	Ongoing	Groundwater in overburden	EISB (with no recirculation)	PBR for injected amendment (submitted 8/1/2014)	Monitoring ongoing (injections completed 1Q 2015)	1 - 2 years
IA-10 IRM (B104)	PCE, TCE and breakdown products	Ongoing	Groundwater in overburden	EISB (with no recirculation)	PBR for injected amendment	Monitoring ongoing (injections completed 2Q 2015)	2 years
IA-11 IRM Bedrock	PCE and breakdown products	PDI, pumping test, & pilot test completed; excavation of source area underway	Groundwater in bedrock (Zones S1 and S2)	Excavation of source residuals in weathered bedrock; EISB (with recirculation)	PBR for injected amendment; air discharge for off-gas	Excavation in 4Q 2016; further remedies TBD	2 - 4 years
IA-12 IRM Bedrock	PCE and breakdown products	PDI, pumping test. & pilot test completed; Phase I ERH completed; IWAS/ISCO ongoing	Groundwater in bedrock	Thermal Treatment (ERH)	Air discharge for off-gas; PBR for electrode drip	Completed (as of 3Q 2015)	6 - 9 months *Completed*
				IWAS with chemical oxidation	Air discharge for off-gas; PBR for injections	2Q 2016	2 years

Notes:

1. A minimum of 1 year of monitoring was proposed in the Site-Wide GWRP – IRM Implementation Period (September 2015). This sampling plan provided flexibility to adjust the frequency, number of wells and parameters after 4 sampling quarters. A proposal to modify the plan was submitted to the NJDEP in November 2016 to change the sampling frequency to semi-annual. The NJDEP has approved this change.
2. Completed IRM programs are shown in gray.
3. ERH = Electrical Resistance Heating.
4. MNA = Monitored Natural Attenuation.
5. N/A = Not Applicable.
6. PBR = Permit-by-Rule.
7. TBD = To Be Determined.
8. IWAS = In-Well Air Stripping.
9. ART = Accelerated Remediation Technologies.
10. ISCO = *in situ* chemical oxidation.
11. EISB = Enhanced *in situ* bioremediation.

5.2 IRM Performance Monitoring

An IRM Progress Report documenting recent IRM activities and summarizing available performance monitoring data will be submitted to the NJDEP in the near future under separate cover. A schedule of the IRM monitoring programs was submitted to the NJDEP in the Addendum to the December 2015 GWPR (August 2016).

5.3 Schedule of Upcoming Groundwater Deliverables

The table lists the Site groundwater deliverables anticipated for submittal to the NJDEP within this calendar year.

Future Groundwater Deliverables	
Document Title	**Anticipated Submittal to NJDEP**
IRM Progress Reports Compilation	Winter 2016
CSM Report	Fall 2017
Modification to the Site-Wide GWSP	Spring 2017

6.0 REFERENCES

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