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December 8, 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: *Investigative Area (IA)-1/4 Interim Remedial Measures (IRM) Discharge to Groundwater (DGW) Permit-by-Rule (PBR) Progress Report*
Former Hoffmann-La Roche Inc.
800 Bloomfield Ave, Suite 127, Nutley, New Jersey 07110
P.I. #009949; COD #RPC070001

Dear Ms. Gaffigan:

On behalf of Hoffmann-La Roche Inc. (Roche), TRC Environmental Corporation (TRC) has prepared the enclosed IRM DGW PBR Progress Report for the IA-1/4 groundwater IRM system operation. The remedial activities were implemented in accordance with the *IA-1/4, IA-6 and IA-12 Ozone Sparging and Sodium Persulfate Injection Discharge to Groundwater Permit-By-Rule Application* dated June 26, 2015, the *IA-1&4 Area Remediation Groundwater Treatment Piping Design Plans* dated June 26, 2015, and the *IA-1&4 Area Remediation Groundwater Treatment Piping Design Plans* dated October 9, 2015, and the New Jersey Department of Environmental Protection (NJDEP)-issued Air Pollution Control Permit (Permit Activity No. PCP150006) dated August 25, 2015.

This Progress Report provides an overview of the groundwater treatment program, including a summary of operational methods and supporting water and air quality data.

If you have any questions or need additional information, please contact John Rice at 608-826-3655 or jrice@trcsolutions.com or Rebecca Hollender at 908-988-1710 or rhollender@trcsolutions.com.

Sincerely,

TRC ENVIRONMENTAL CORPORATION

John Rice
Senior Project Manager

Rebecca Hollender, PG, LSRP
Senior Project Director

Enclosure

cc: Mr. Chandra Patel, Hoffmann-La Roche Inc.
Ms. Dawn Pompeo, TRC Environmental Corp.

Investigative Area (IA)-1/4

Interim Remedial Measure (IRM) Discharge to Groundwater (DGW) Permit-by-Rule (PBR)

Progress Report

Former 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 #009949

Prepared By:

TRC Environmental Corporation
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December 8, 2017

Investigative Area (IA)-1/4

Interim Remedial Measure (IRM) Discharge to Groundwater (DGW) Permit-by-Rule (PBR) Progress Report

Date: 12/8/17

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Investigative Area (IA)-1/4

Interim Remedial Measure (IRM) Discharge to Groundwater (DGW) Permit-by-Rule (PBR) Progress Report

Date: 12/8/17

1.0 INTRODUCTION

On behalf of Hoffmann-La Roche Inc. (Roche), TRC Environmental Corporation (TRC) has prepared this report to document groundwater remediation efforts conducted at Investigative Areas-1 and -4 (IA-1/4) of the former Roche Facility (Site) at 340 Kingsland Street, Nutley, New Jersey. The Site is situated within the Township of Nutley, Essex County and the City of Clifton, Passaic County. The IA-1/4 Interim Remedial Measure (IRM) Discharge to Groundwater (DGW) Permit-by-Rule (PBR) Progress Report (Progress Report) summarizes activities completed between July 2016 and August 2017, as well as respective groundwater, air and system monitoring results and conclusions.

The IA-1/4 groundwater remediation was initiated in early July 2016 and has been implemented in accordance with the following: *IA-1/4, IA-6 and IA-12 Ozone Sparging and Sodium Persulfate Injection Discharge to Groundwater Permit-By-Rule Application* dated June 26, 2015, the *IA-1&4 Area Remediation Groundwater Treatment Piping Design Plans* dated October 9, 2015, and the New Jersey Department of Environmental Protection (NJDEP)-issued Air Pollution Control Permit (Permit Activity No. PCP150006) dated August 25, 2015.

1.1 Background Information

The main campus of the former Roche Nutley facility was developed starting in 1928 for the manufacture of vitamins, fine chemicals, and pharmaceuticals, and for research and development. The Site consists of approximately 120 acres in what is now a predominately residential and commercial area of Nutley, New Jersey as shown in the Site location map presented as Figure 1.

The IRM for IA-1/4 addresses an area of approximately 140,000 square feet (sf), covering the central portion of IA-1 and extending into the western portion of IA-4. Figure 2 shows the boundaries of the IAs, locations of the former and current buildings, and the treatment system layout.

The IRM targets an area of IA-1/4 where Site operations have contributed to a dissolved-phase 1,4-dioxane (a semi-volatile organic compound [SVOC]) plume that has been delineated to a depth of approximately 90 feet below ground surface (bgs). Coincident with, or adjacent to the groundwater impacted with the 1,4-dioxane, there are also small, localized areas where groundwater is impacted with volatile organic compounds (VOCs); these VOCs include benzene, chloroform, methylene chloride, and toluene, with minor detections of hexane, 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), methyl-*tert*-butyl ether (MTBE), tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride (VC).

1.2 Hydrogeology

Groundwater beneath the Site has been monitored with a Site-wide monitoring well network to provide an understanding of the local hydrologic regime as it relates to regional groundwater flow and characteristics and water quality. The monitoring well network includes more than 1,000 wells screened in the overburden, across the bedrock/overburden interface, or in the bedrock. To aid in data management and organization during the Remedial Investigation (RI), the subsurface below the water table was subdivided based on elevation relative to mean sea level (msl) into seven vertical investigation intervals (zones):

- 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).

Zone S1 consists of mostly overburden materials and weathered bedrock. The shallow Zones S2, S3, and deep Zones D1, D2, D3, and D4 consist of fractured, competent bedrock.

All groundwater elevation and quality data have been compiled and evaluated for delineation using this groundwater elevation-based investigation zone system, as discussed in the Groundwater Remedial Investigation Report (GWRIR) and Groundwater Progress Reports (GWPRs). Roche is currently preparing a Conceptual Site Model (CSM) for the Site that builds on historic work as well as the broad and extensive knowledge gained during the Site investigations. The CSM will define the vertical hydrostratigraphic zonation of the groundwater flow system and corresponding contaminant plumes and transport patterns at the Site.

1.3 Summary of Remedial Investigation Findings

Soil RIs were conducted in IA-1 from December 2012 to August 2013, and in IA-4 from February 2013 to January 2014. These RIs included investigation of potential VOC and SVOC sources within each area, and the *Remedial Investigation Report (RIR) for Investigative Area No. 4 (IA-4) (TRC, 2014a)* included an evaluation of groundwater quality. Groundwater quality for both IAs was also evaluated as a part of the Site-Wide Groundwater RI, conducted between 2007 and 2013 and reported in the *Site-Wide Ground Water Remedial Investigation Report (TRC, 2014b).*

1,4-Dioxane was not identified as a constituent of concern (COC) during the IA-1 or IA-4 soil RIs. 1,4-Dioxane was initially identified as a groundwater COC during the IA-6 RI (December 2013) and subsequently detected in IA-1, IA-4, IA-6, IA-10, and off-Site locations.

1.4 Previous Remedial Actions

Impacted soil in both IA-1 and IA-4 was excavated and disposed in accordance with the existing PBR (NJDEP 2015). VOCs in shallow groundwater at two of the soil excavations were addressed through the addition of a chemical oxidizer (Organic BioChem™) to the backfill. Groundwater monitoring results associated with those efforts (pre- and post-excavation) are also included in this report.

1.5 Progress Report Objectives

The purpose of this Progress Report is to present data on groundwater quality and operations of the remediation system and to document the effectiveness of the remediation system for Zone S1, Zone S2, and upper Zone S3 groundwater. Specifically, the Progress Report is designed to meet the following data needs:

- Present data that document the operations and maintenance activity of the groundwater treatment system;
- Present trends in 1,4-dioxane and VOC concentrations in shallow groundwater Zones S1, S2, and S3; and,
- Present a comparison of time-concentration trends in 1,4-dioxane and dissolved oxygen (DO) concentrations (the latter is used an indicator of the presence of dissolved oxidant) to evaluate the system effectiveness and treatment extent.

1.6 Document Overview

The following summarizes the topics presented in this report:

- Section 1.0 provides an introductory and background information, summarizes the remediation activities, and provides monitoring results through July 2017.
- Section 2.0 provides an outline of the layout and operations of the groundwater remediation system including:
  - *in-situ* chemical oxidation (ISCO) using ozone sparging;
  - in-well air stripping (IWAS); and,
  - soil vapor extraction (SVE).
- Section 3.0 provides a description and analytical results of the performance monitoring program including:
  - Groundwater monitoring;
  - Air monitoring; and,
  - System monitoring.
- Section 4.0 present conclusions and future IRM actions; and,
- Section 5.0 References.

2.0 IRM SYSTEM OPERATION

The IRM for IA-1/4 includes ISCO, IWAS, and SVE:

- ***ISCO*** is one of the few technologies proven to destroy 1,4-dioxane. Ozone sparging was selected as the chemical oxidant based on results of a pilot study completed in IA-12, because of ozone's comparatively lower cost to other oxidants, and because ozone could be generated on-Site as needed.
- ***IWAS*** was coupled with ISCO because IWAS improves the distribution and radius of influence (ROI) of the injected ozone, expedites and enhances treatment of VOCs, and controls vapor emissions within the treatment area. IWAS is accomplished within specially equipped wells designed by Accelerated Remediation Technologies, Inc. (ART).
- ***SVE*** was connected to the IWAS wells to improve stripping of VOCs (though it is not very effective for stripping 1,4-dioxane) and to trenches surrounding the treatment area to control vapor emissions and achieve the permit requirements for vapor capture.

The full-scale injection scheme for IA-1/4 includes 44 ozone sparge well locations, 34 IWAS wells (Table 1) and nine vapor extraction trenches (VETs). Each ozone sparge well includes an upper and lower (shallow and deeper) injection interval, for a total of up to 88 total sparge points in the treatment area, as follows:

- **Shallow Treatment Zone**: Includes 16 ozone injection well pairs (IW-65A/B through IW-80A/B) screened within two depth intervals ("A" wells screened from 30-40 feet bgs and "B" wells screened from 60-70 feet bgs) and 13 IWAS wells (ART-45 through ART-57) with two screened intervals in each well; typically an upper interval between 15-40 feet bgs and a second screened interval between 40-70 feet bgs.
- **Deeper Treatment Zone**: Includes 28 ozone injection well pairs (IW-60B/C through IW-64B/C and IW-81B/C through IW-103B/C) with screened intervals across two depth intervals ranging from 35-60 feet bgs ("B" wells) and 70-90 feet bgs ("C" wells) and 21 IWAS wells (ART-41 through ART-44 and ART-58 through ART-74) with dual screened intervals with the upper screen placed between 20-60 feet bgs and a lower screen placed between 60-90 feet bgs.

The treatment area is also broken into the North Area and South Area based on the remediation system requirements. The permitted amount of ozone to be injected at IA-1/4 is 44,000 kilogram (kg), at a rate of approximately 2,500 grams/hour (g/hr) for 24 months (24-hour operation), split between 44 ozone sparge well locations, each having one to two injection intervals totaling up to 88 sparge points. Figure 2 illustrates the system layout.

The permitted operating conditions for the injection and recovery components for IA-1/4 are summarized below; actual flow rates varied depending on changing Site conditions:

- **Ozone Sparge**: Ozone flow rate of 110 actual cubic feet per minute (ACFM) @ 70 pounds per square inch (psi) per ozone generator (x 2 generators);
- **IWAS Air Flow**: Air flow rate of 300 ACFM @ 45 psi per air compressor (x 2 compressors); and,

- **SVE**: Vacuum of 600 ACFM @ 10 to 14 inches of mercury (Hg) per blower (x 2 blowers).

2.1 General Equipment and Operational Description

IWAS and ozone injection wells (listed on Table 1) were constructed at locations shown on Figure 3. Each of the wellheads were completed above grade with above-grade piping and tubing that is used to connect the remediation equipment to the well heads for ozone sparging, ART IWAS, and SVE. Piping and electrical connections from the well heads lead to a centralized remediation equipment area. Piping is buried in trenches for locations where the piping crosses a fixed access road for truck traffic.

Two sets of equipment (North System and South System) are used to service the remediation wells and SVE systems. The North System is comprised of 16 shallow injection wells and 13 shallow ART IWAS wells and 5 deep ozone injection wells and 4 deep ART IWAS wells. The South System is comprised of 23 deep ozone injection wells and 17 deep ART IWAS wells. Remediation well construction details are summarized in Table 1. The remediation equipment is housed in the centralized remediation equipment area, with headers that service their respective systems.

The ozone sparge wells are separated into shallow and deep headers for each system. Ozone sparging cycles continuously between the headers, such that the system can run with up to one half, one quarter, or one eighth of the sparge points receiving ozone at any given time. Ozone is injected mid-way through the screened intervals. Ozone is typically injected at a rate between 0.5 and 1 standard cubic feet per minute (SCFM) with 3% to 5% weight. ozone at each well head during active sparging. Ozone sparging pressures range between 45 psi and 65 psi, with a flow rate of approximately 12 to 24 ACFM per system. These actual pressures and flow rates are within the permitted limits.

The ART IWAS wells and SVE trenches are split into two groups, with approximately half located in the North System and half located in the South System. Each ART IWAS well has an air sparge point and is connected to a well vapor extraction pipe. The compressed air sparge rate for each ART IWAS well system ranges up to 185 SCFM at a discharge pressure of 45 psi. The vapor extraction portion of the ART IWAS wells is connected to the same system as the VETs. SVE for residual sparged ozone is performed by extracting from the VETs. The vapor extraction blower for each system (i.e., north and south) collects a minimum flow of 250 SCFM. The ART IWAS wells and VETs run continuously; however, valves and controls are incorporated into the design to provide flexibility in these operations. VOC emissions from the SVE blower are routed through Granular Activated Carbon (GAC) scrubbers to remove VOCs from the air stream.

The ART IWAS and SVE system began full operations in July 2016 and has since been running continuously, except for temporary shutdowns for maintenance. Ozone generation and injection began in late June 2016 but was discontinued for several months while more durable distribution panels were fabricated to minimize ozone leaks that had become excessive. Key Operation and Maintenance (O&M) actions are discussed in Section 3.4.

3.0 PERFORMANCE MONITORING PROGRAM

A performance monitoring program for the IA-1/4 IRM was presented *IA-1/4, IA-6 and IA-12 Ozone Sparging and Sodium Persulfate Injection Discharge to Groundwater Permit-By-Rule Application* dated June 26, 2015. That PBR application outlined a program and schedule to monitor groundwater and air during the IRM. Results of those efforts are summarized below.

3.1 Installation of Monitoring Wells

Twenty-three groundwater monitoring wells were installed to determine the nature and extent of groundwater impacts in the IA-1/4 areas. Fifteen of the monitoring wells were installed as part of well nests that typically included three wells, one each in Zone S1, Zone S2, and Zone S3. The wells were labeled accordingly with a single 3-digit well identifier and a suffix to designate the hydrologic zone: "A" for Zone S1, "B" for Zone S2, and "C" for Zone S3. Monitoring well locations are illustrated on Figure 3, and monitoring well construction details are summarized in Table 2.

3.2 Groundwater Monitoring Program

Water level measurements are recorded quarterly during the injection process. Additionally, groundwater geochemical parameters including pH, temperature, DO, specific conductance (SC), oxidation-reduction potential (ORP), and turbidity are monitored in the field on a quarterly basis during injection to further assess the progress of injection at surrounding monitoring wells.

Groundwater sampling was performed at the IA-1/4 treatment area as follows:

- Pre-Injection (baseline);
- Six (6) weeks post injection; and,
- Quarterly, thereafter, for the duration of the active IRM (this sampling is ongoing).

Groundwater geochemical parameters and groundwater levels were monitored quarterly at nearby monitoring wells. Geochemical parameters were collected quarterly from startup to present. Water levels were collected using an electronic water level meter (Solinst®). Groundwater quality measurements were obtained by purging water through a Horiba flow-through cell during quarterly sampling events. The groundwater monitoring plan is presented in Table 3, which identifies the monitoring points and parameters measured during the full-scale system operations.

Groundwater samples were collected using NJDEP-approved low-flow sampling methods. Samples were collected by TRC until August 2016, and by Groundwater and Environmental Services, Inc. (GES), thereafter. Field geochemical parameter readings collected during low-flow purging include DO, ORP, SC, pH, temperature, turbidity, salinity, and total dissolved solids (TDS).

Samples were submitted to, and analyzed for 1,4-dioxane and VOCs by an NJDEP-certified laboratory (both SGS Accutest and Test America did the analyses). The 1,4-dioxane and VOC groundwater analytical results are provided in Tables 4 and 5, and are discussed in Section 3.5.1.

3.3 System Air Influent and Effluent Monitoring Program

As per NJDEP Air Permit #PCP150006, air samples were collected periodically from influent and effluent sample ports and sent to SGS Accutest Laboratories of Dayton, NJ for VOC analysis. Analytical results are presented in Tables 6A and 6B and discussed in Section 3.5.2. TRC collected influent and effluent air samples in six-liter Summa canisters using 30-minute flow regulators; samples were collected from the system starting on July 1, 2016 as follows: twice in the first week, weekly for one month, and monthly through April 2017. Semi-annual sampling was approved by NJDEP in April 2017. Semi-annual samples are currently being collected by GES in September and March.

Vapor treatment was also assessed using a hand-held photoionization detector (PID), with influent and effluent readings collected from each vessel on a monthly basis. The mid-treatment PID readings were used to assess the adsorptive capacity of the primary GAC vessel and the need for GAC change-out.

3.4 System Operation and Monitoring

As part of the system O&M, TRC conducted routine Site visits daily during the initial "shake down" and startup for approximately 2 weeks in May/June 2016. Following the full-scale startup in late July 2016, TRC shifted the system to continuous operation and visited the Site weekly for the first month of operation. After the first month of operation, TRC visited the Site regularly to confirm system operations and to collect monthly vapor phase concentration readings or as needed for system alarm issues.

The following tasks were conducted during routine Site visits:

- Collect system flow rates and operating vacuums;
- Collect influent, effluent and mid-treatment vapor concentration readings (using a hand-held PID) to assess vapor control efficiency;
- Monitor vapor probes to assess induced vacuum readings;
- Inspect ART IWAS wells and adjust the applied vacuum and flows using valves;
- Measure and record vacuum on the VET; and,
- Conduct a general inspection of the system to ensure compliance with the NJDEP air permit and proper housekeeping.

The treatment system has telemetric and data logging capabilities, for remote access to basic system controls and viewing operational data. Several electronic sensors are tied into the system control panel, which allows for remote viewing of total flow rates and blower and compressor operational status. GES monitors the sparging rate and makes adjustment to the injection scheme as needed. These adjustments include injection rates, injection pressure, ozone concentrations and injection locations.

After an initial period of system tuning, TRC was able to maintain a steady operation of the system. The flow rates from each SVE header were approximately 40 SCFM, while the flow rates for each air sparge header were between 5 and 10 SCFM. PID readings were consistently low from all headers and from the effluent of the GAC vessels. Other system readings, such as vacuum, pressure, and temperature, remained consistent throughout system operations. Sparging rates and cycle times have been modified to optimize system performance.

During the startup period and the initial operational period of the system, components that were faulty were replaced and/or fixed. The most frequent operational issue observed during the initial system operation period was leaky rotometers for the ozone distribution system. After one month of operation, the amount of ozone leaking from rotometers and fittings was determined to be excessive, and Roche shut down the ozone injection system while fabricating replacement ozone distribution panels and connections. The ozone system was restarted in late November 2016. Otherwise the system has operated as designed.

Routine maintenance is performed as per the maintenance requirements in the *IWAS/ART Operations and Maintenance Manual Investigative Area (IA)-1/4*, dated April 25, 2016. The routine maintenance includes calibration of meters, changing filters, and maintenance of compressor and pumps. Currently, GES performs the routine maintenance on the system and responds to alarm callouts, under TRC oversight.

3.5 Monitoring Results

3.5.1 Groundwater Analytical Results

Groundwater samples were collected and analyzed for VOCs in accordance with the sampling plan discussed in Section 3.2. Analytical results of 1,4-dioxane are summarized in Table 4, with complete groundwater analytical data presented in Attachment 1. Figures 4A, 4B, and 4C present a comparison of DO and 1,4-dioxane concentrations by zone. Groundwater isoconcentration maps showing the extent of 1,4-dioxane before and after injections in each groundwater zone are illustrated as Figures 5A, 5B, and 5C. Maps showing exceedances recorded for each sampling event are illustrated in Figures 6A, 6B, and 6C. Laboratory reports and NJDEP Electronic Data Deliverables/Electronic Data Submissions (EDD/EDS) are included in Attachment 1.

The primary COC for this IRM is 1,4-dioxane. Therefore, the discussion that follows focuses on that constituent. However, there are also VOCs in the area that have been addressed using the IRM system. Analytical results show significant reductions in concentrations of 1,4-dioxane and VOCs within the treatment areas since inception of the IRM.

- *Shallow Groundwater Zone S1 (100 to 80 feet above msl)*: Nine S1 monitoring wells were sampled quarterly to document the progress of remedial actions in Zone S1. Baseline groundwater sampling results (those collected through April 2016) indicated that 1,4-dioxane was detected above the then-current NJDEP Interim Ground Water Quality Criterion (IGWQC) of 10 µg/L at 12 of those wells. The highest 1,4-dioxane concentrations were detected in wells located in the northeast and southeast corners of former Building 56, at reported concentrations of 1,500 µg/L at MW-393A, 1,490 µg/L at MW-370A, and 1,270 µg/L at MW-372A. 1,4-Dioxane concentrations in Zone S1 dropped off rapidly with distance from these source zone locations such that detected concentrations were less than 10 µg/L within 300 feet downgradient of MW-393A. Since the system operations began in June 2016, 1,4-dioxane concentrations have decreased in most wells, with a current maximum concentration in Zone S1 wells of 600 µg/L in well MW-393A. VOC concentrations, including benzene and VC have dropped below their respective NJDEP Ground Water Quality Standards (GWQS) in most Zone S1 wells.

- *Intermediate Bedrock Zone S2 (80 to 50 feet above msl)*: Baseline groundwater sampling results from 13 intermediate wells indicated 1,4-dioxane concentrations exceeded IGWQC in all wells within the treatment area, with 10 wells exceeding 100 µg/L, and two wells (MW-392B and MW-393B) exceeding 1,000 µg/L. Since remediation operations began, concentrations significantly decreased at most wells. 1,4-Dioxane concentrations at seven monitoring wells still exceed 100 µg/L, with a current maximum concentration in Zone S2 wells of 690 µg/L in well MW-392B. Benzene concentrations decreased to below the GWQS at eight wells that previously had exceedances. Similar decreases have occurred for chlorinated VOCs (CVOCs).
- *Deeper Bedrock Zone S3 (50 to 0 feet above msl)*: Baseline groundwater sampling results indicated 1,4-dioxane concentrations exceeded the NJDEP IGWQC at all 10 monitoring wells in Zone S3. Baseline concentrations exceeding 100 µg/L were present in seven of those wells (baseline maximum concentration within the treatment zone of 347 µg/L in MW-391-S3). Since the IRM began, concentrations decreased overall, with a current maximum concentration in Zone S3 wells of 120 µg/L in well MW-391C. Most VOCs have decreased to below their respective GWQS in Zone S3 wells.

Geochemical parameters were collected continually during system operations, including during each groundwater sampling event. Key changes in aquifer geochemistry are monitored as an indicator of the effectiveness of ozone distribution, specifically in terms of achieving a highly positive ORP (indicating the presence of an oxidizing agent) and high DO concentration (approaching saturation levels) resulting from the breakdown of ozone to diatomic oxygen. Though only an indirect indicator of the presence of ozone, dramatic increases in DO concentrations values typically correlate with a dramatic decrease in 1,4-dioxane concentration, as illustrated in Figures 4A, 4B, and 4C.

3.5.2 Air Sampling Results

Air samples were collected periodically from influent and effluent sample ports for laboratory analysis. Analytical results from the influent samples indicate a decrease in VOC concentrations over time. The maximum total VOC concentration in the influent for the North System was observed in the first week of operations (5,281 parts per billion/volume [ppbv]), but concentrations decreased quickly in subsequent sampling events. Current influent concentrations range from 30 to 40 ppbv. The South System also reached peak concentrations in the first week, but at much lower levels (142 ppbv). Current influent concentrations are <10 ppbv for the South System. Air sampling results are summarized in Tables 6A and 6B.

VOC concentrations in the effluent samples were consistently below the concentration limits set in the air permit, which confirm that the GAC is adequately controlling emissions. Measured extraction flow rates were consistently below the air permit limit.

3.5.3 Purging Test Results

A purging test was conducted in April 2017 to determine if the distribution of ozone could be enhanced through well evacuation and recovery in areas of low permeability. Three wells with low hydraulic conductivities that appeared to be unaffected by nearby ozone injections were purged to dryness and allowed to recharge. Groundwater samples were collected before and after purging and analyzed for field parameters including DO and ORP. The testing indicated that purging allow ozonated groundwater to reach the wells. A technical memorandum that describes the test in greater detail is provided in Attachment 2.

4.0 CONCLUSIONS

The groundwater remediation system has operated within its design parameters and NJDEP permit requirements since its initial startup in June 2016. Groundwater analytical results since operations began indicate that remediation efforts have removed a significant percentage of the contaminant mass present in groundwater prior to IRM operation, with steadily decreasing COC concentrations in groundwater within the target treatment zone. No dispersion of VOCs or 1,4-dioxane beyond the treatment area has been observed that can be attributed to IRM actions.

Overall, the IRM has been successful in reducing 1,4-dioxane concentrations to below 500 µg/L, though 1,4-dioxane concentrations remain higher in three locations: MW-393A (680 µg/L) in Zone S1 and MW-392B (1,100 µg/L) and MW-393B (780 µg/L) in Zone S2. Since dissolved ozone is transported from the ozone sparge well to the target treatment area solely by water advection, the effectiveness of ozone as an oxidant for 1,4-dioxane treatment decreases as travel time increases.

For the three locations noted above where 1,4-dioxane remains above 500 µg/L, and at several other locations (with lesser 1,4-dioxane concentrations) where current operations are not effectively and continuously delivering oxidant to the target zone due to challenging aquifer characteristics (low porosity zones), further progress will most likely require the use of a different oxidant (e.g., activated sodium persulfate) that retains its potency for a much longer period (weeks to months) while migrating through bedrock fractures.

5.0 REFERENCES

TRC, 2013. Hoffmann-La Roche Inc., Nutley Site Remediation Project No. S153.29215. *Remedial Investigation Report – Investigative Area Nos. 1 (IA-1) and 5 (IA-5)*. NJDEP PI ID #s 009949. November 18, 2013.

TRC, 2014. Hoffmann-La Roche Inc., Nutley Site Remediation Project No. S153.29215. *Remedial Investigation Report (RIR) for Investigative Area No. 4 (IA-4)*. NJDEP PI ID #s 009949. March 20, 2014.

TRC, 2014. Hoffmann-La Roche Inc., Nutley Site Remediation Project No. S153.29215. *Site-Wide Groundwater Remedial Investigation Report*. NJDEP PI ID #s 009949, 614465, and 625447. April 2, 2014.

New Jersey Department of Environmental Protection Bureau of Case Management. *NJPDES Discharge to Groundwater Authorization Permit-By-Rule for IA-1 Building 55 Area for Oxygen BioChem® (OBC®).* Hoffman-La Roche Inc. 340 Kingston Street, Nutley, Passaic County, NJ 07110. SRP PI No.: 009949. March 3, 2015.

FIGURES

TABLES

ATTACHMENT 1

Accutest Laboratory Reports and
NJDEP Electronic Deliverable Submissions for Accutest Laboratory Reports
(Compact Disc provided in NJDEP hard copy only)

ATTACHMENT 2

Technical Memorandum
IA-1/4 Purging Test Event

ATTACHMENT 3

Full Digital Copy of Progress Report

(Text, Figures, Tables, and Attachments)

On CD