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December 2019 Groundwater Remedial Action Work Plan
for the
Hoffmann-La Roche Inc. Site
Nutley, New Jersey

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Prepared For:

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	Microgram per liter
AOC	Area of Concern
ART	Accelerated Remedial Technologies
bgs.	Below Ground Surface
CAMS	Clifton-Allwood Municipal Sewer
CEA	Classification Exception Area
cis-1,2-DCE	cis-1,2-Dichloroethene
CSM	Conceptual Site Model
dioxane	1,4-Dioxane
DNAPL	Dense Non-Aqueous Phase Liquid
EISB	Enhanced In Situ Bioremediation
ERH	Electrical Resistance Heating
GWQS	Groundwater Quality Standards
HGU	Hydrogeologic unit
IA	Investigative Area
IRM	Interim Remedial Measure
ISCO	In Situ Chemical Oxidation
ISTT	In Situ Thermal Treatment
IWAS	In-Well Air Stripping
LSRP	Licensed Site Remediation Professional
LTM	Long-Term Monitoring
MeCl	Methylene Chloride
MNA	Monitored Natural Attenuation
NJDEP	New Jersey Department of Environmental Protection
PBR	Permit-by-Rule
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene

PCE+	PCE, TCE, cis-1,2-DCE, plus VC
PDI	Pre-Design Investigation
RA	Remedial Action
RAO	Response Action Outcome
RAP	Remedial Action Permit
RAR	Remedial Action Report
RAWP	Remedial Action Work Plan
RI	Remedial Investigation
RIR	Remedial Investigation Report
Roche	Hoffmann-La Roche Inc.
Route 3	New Jersey State Highway Route 3
SVE	Soil Vapor Extraction
TCE	Trichloroethene
TRC	TRC Environmental Corporation
TRSR	NJDEP's Technical Requirements for Site Remediation
UST	Underground Storage Tank
VET	Vapor Extraction Trench
VC	Vinyl chloride
VOC	Volatile Organic Compound

DECEMBER 2019 GROUNDWATER REMEDIAL ACTION WORK PLAN

HOFFMANN-LA ROCHE INC. SITE

NUTLEY, NEW JERSEY

1.0 INTRODUCTION

On behalf of Hoffmann-La Roche Inc. (Roche), TRC Environmental Corporation (TRC) has prepared this December 2019 Groundwater Remedial Action Work Plan (Groundwater RAWP) for submission to the New Jersey Department of Environmental Protection (NJDEP) for the 120-acre former Roche facility (Site), located at 340 Kingsland Street in Nutley, New Jersey (Figure 1).

1.1 Overview

Pursuant to this Groundwater RAWP, Roche will conduct final remedial actions (RAs) for seven specific plumes at the Site identified as the Investigative Area (IA)-9 Pipe Trench Area Plume, IA-2 Tank Farm Plume, IA-6 Chlorobenzene Plume, IA-10 Building 104 Plume, IA-10 Building 70 Area Plume, IA-1/4 Dioxane Plume, and the Windsor Sewer Plume (collectively, "Remedial Action Plumes").

For other plumes that are beneath and/or migrate onto the Site, a Classification Exception Area (CEA) will be established and Roche will conduct long-term monitoring utilizing the existing monitoring well network. These plumes are described as "Monitored Plumes" and they are identified in Section 2.2 below. A detailed description of the proposed remedial actions and monitoring is provided in this RAWP.

1.2 Site Information

1.2.1 *Setting*

The Site occupies approximately 120 acres in northeastern New Jersey, straddling the municipal/county boundary of the Township of Nutley in Essex County and the City of Clifton in Passaic County (Figure 1). As shown on Figure 1, the Site 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. Many of the surrounding former and current commercial/industrial areas have known soil and/or groundwater contamination due to historical operations; some of the industrial operations surrounding the Site persist to the present.

The Site is traversed by the Clifton-Allwood Municipal Sewer line, referred to as the CAMS (Figure 2), which conveys industrial and sanitary wastewater (historically and currently) from properties located north of Route 3 to a trunk line located south of the Site that leads to the Passaic Valley Sewerage Commission sewer system. The Township of Nutley abandoned a section of the CAMS on the southern portion of the Site in 1990 and replaced it with a new CAMS section located slightly to the west. This new section is still present and operational in the southern portion of the Site (Figure 2), and joins with the older section of the CAMS present in the northern portion of the

Site. Clifton has advised Roche that portions of that older section of the CAMS in the northern portion of the Site (immediately south of Route 3) have collapsed and will undergo replacement in December 2019. Roche never discharged process or sanitary wastewaters to the CAMS.

1.2.2 *History*

Roche acquired the Site from various entities and developed it in phases over time between 1929 and approximately 1970. Operations prior to Roche included agriculture, construction, milling, and manufacturing. During Roche's ownership, the eastern portion of the Site was used for research, development, and manufacturing purposes, while the western portion of the Site (west of the railroad tracks) was used for materials storage, warehousing, garage, and office space.

Roche officially ceased all business operations at the Site in December 2013 and sold the property to a developer in September 2016. Most of the on-Site buildings have been demolished, and a new property owner has been engaged in extensive redevelopment of the Site for mixed use, including a medical school.

After the 2013 cessation of Site operations, Roche planned and implemented, with NJDEP and Licensed Site Remediation Professional (LSRP) oversight, an extensive environmental investigation and an accelerated and expansive soil and groundwater cleanup.

- As summarized in Section 2 of this RAWP, Roche committed to an accelerated investigation of soil conditions in identified areas of concern (AOCs), and implemented extensive Site-wide investigations of groundwater and surface water/sediment conditions.
- Over the past 5 years, Roche removed more than 240,000 tons of impacted soil from the Site, principally soil containing historic fill material contaminants, volatile organic compounds (VOCs), and, to a lesser extent, polychlorinated biphenyls (PCBs). Virtually all soil contaminants identified at the Site present at concentrations above New Jersey's standards and screening levels (*i.e.,* Residential Direct Contact Soil Remediation Standards and Default Impact to Ground Water Soil Screening Levels) were excavated and removed, leaving only small areas of impacted soil beneath building foundations (serving as "caps") and an engineered cap over a former industrial fill area in the northwestern corner of the Site. Roche's removal of historic fill material contaminants went beyond NJDEP's presumptive "capping" remedy that allows such contaminants to remain in place. Soil Response Action Outcomes (RAOs) have been issued with NJDEP approval for all portions of the Site.
- Roche has been similarly proactive in addressing groundwater impacts beneath the Site through the implementation of ten Interim Remedial Measures (IRMs). Each IRM was preceded by a Pre-Design Investigation (PDI), which included additional source zone delineation to define the area requiring treatment and to select the optimal treatment approach. Implementation of these IRMs has greatly reduced contaminant mass at the Site and has also provided significant insight into what is and what is not achievable through remediation at the Site, which will be discussed in Section 3.0 of this RAWP.

Roche's efforts to date, undertaken on an accelerated timetable, facilitated the redevelopment and re-use of the Site, which is now home to the Hackensack University-Seton Hall Medical School and the North American Headquarters of Ralph Lauren, and will soon be the location of a major Quest Laboratories facility, among other planned buildings and businesses.

1.2.3 *Topography*

The Site is located at the southern end of an approximately 500-acre valley between two ridges aligned along north-northeast to south-southwest axes. The areas to the east, west, and north of the Site are topographically higher than the Site. This valley begins north of Allwood Road and drains surface water to the south and then to the southeast, into St. Paul's Brook, then out to the Third River, and ultimately to the Passaic River (Figure 2). Originally, streams flowed through open channels from the north through the Site; at some point, these streams were routed into buried pipelines that presently convey surface water and storm water through the Site. The principal surface water/storm water conveyance pipeline that traverses the site is referred to as the Valley Drain.

1.2.4 *Geology and Hydrogeology*

The geology and hydrogeology of the Site are discussed extensively in the 2014 Groundwater RIR and 2018 *Site-Wide Groundwater Conceptual Site Model Report* (CSM Report; TRC and B. Kueper, 2018); elements of the CSM relevant to the development of this RAWP are provided herein. In summary, the Site is underlain by up to 30 feet of overburden consisting of historic fill and glacial deposits. The overburden is underlain by bedrock of the Triassic Passaic Formation, which is a northwest-dipping, fractured and faulted, interbedded sequence of fluvial deposits consisting of conglomerate, sandstone, siltstone, and silty mudstone. The top of the bedrock is a highly fractured weathered zone that varies in thickness across the Site from less than 1 foot up to 25 feet thick.

Beneath the overburden/weathered bedrock zone, the fracture network in the competent bedrock consists of interconnected bedding-plane and high-angle fractures. The layered, fractured sedimentary bedrock beneath the Site and surrounding area was partitioned into a system of five hydrogeologic units (HGUs). HGUs are defined as portions of the bedrock aquifer containing interconnected stratigraphic bedding-plane and high-angle fractures. HGUs are typically separated by thin zones of low vertical hydraulic conductivity, which inhibit vertical groundwater flow and create significant hydraulic head gradients across HGU boundaries. Beneath most of the Site, the frequency and interconnectedness of fractures diminishes with depth, with fewer fractures observed at depths greater than 100 to 150 feet below ground surface (bgs).

Groundwater flow directions in overburden and weathered bedrock generally mimic topography and flow is primarily toward local discharge boundaries; i.e., the Valley Drain and St. Paul's Brook (Figure 2). Beneath the weathered bedrock, groundwater flows primarily through a network of transmissive bedding-plane fractures that are interconnected by numerous high-angle fractures.

In addition, due to the dip of the sedimentary rock bedding, HGUs that are present at significant depths in the northern and western portions of the Site become shallow and subcrop in the southern and eastern portions of the Site near St. Paul's Brook. This results in groundwater flowing toward St. Paul's Brook, which acts as a local discharge boundary for the more shallow portions of the flow system.

1.3 Investigative Area Summary

The Remediation Road Map (TRC, 2012a) divided the Site into 15 IAs that have been the focus of subsequent characterization efforts, remedial investigations (RIs), and IRMs. The process/sanitary sewer system, previously designated as IA-8, was investigated within the other individual IA investigations and is no longer considered a separate IA. A map showing the different IAs is provided as Figure 2. Groundwater plumes and associated remedies have been named according to the IA in which the plume originates, as described in Section 3.0.

2.0 REMEDIAL INVESTIGATION SUMMARY

2.1 RI Objectives

Extensive groundwater investigation has occurred at the Site as documented in the April 2014 Site-Wide Groundwater RIR, the IA-specific RIRs, several Site-Wide Groundwater Progress Reports, various PDIs, and the 2018 CSM Report. The Site-Wide Groundwater RI was conducted under work plans approved by the NJDEP, and in accordance with the NJDEP's Technical Requirements for Site Remediation (TRSR) and applicable guidance documents. The objectives of the IA-specific and the Site-Wide Groundwater RIs were as follows:

- Identify contaminant sources;
- Characterize groundwater conditions;
- Delineate the extent of groundwater contamination; and,
- Identify potential receptors.

A summary of the RI findings for groundwater plumes addressed by this RAWP is provided below, and additional details can be found in the reports referenced herein.

2.2 Identification of Groundwater Plumes

The seven Remedial Action Plumes were created by releases of VOCs and 1,4-dioxane (dioxane); they are identified below and shown on Figure 3:

- IA-9 Pipe Trench Area Plumes
- IA-2 Tank Farm Area Plume
- IA-6 Chlorobenzene Plume
- IA-10 Building 104 Area Plume
- IA-10 Building 70 Area Plume
- IA-1/4 Dioxane Plume

- Windsor Sewer Plume

Roche has implemented IRMs, described in Section 3.0, for the first six of these plumes and is proposing final remedial action for all seven plumes.

Additional VOC plumes are attributable to historical releases from breaches in the CAMS. These historical CAMS releases occurred in at least four on-Site contaminant release areas, resulting in the generation of four VOC plumes:

- CAMS IA-12 Plume
- CAMS IA-3/IA-7 North Plume
- CAMS IA-7 South Plume
- CAMS IA-11 Plume

Although Roche did not discharge wastewater to the CAMS, it proactively implemented IRMs (Section 3.0) at all four CAMS source zones to facilitate redevelopment of the Site. The vast majority of contaminant mass from the CAMS releases was removed by Roche's IRM efforts. The long-term monitoring plan proposed in Section 4.5 will collect data related to these plumes, which are included in this RAWP as Monitored Plumes.

Six additional VOC plumes that are beneath and/or migrate onto the Site have been identified as follows:

- CAMS North Plume
- Deluxe Plume
- Briad/North Plume
- Western Plume
- Sunoco Plume
- Eastern Plume

These six plumes, along with the four CAMS plumes, and the area where many plumes commingle, as shown on Figure 4, make up the Monitored Plumes.

In addition to these identified plumes, there are several isolated monitoring wells at the Site that have exceeded the New Jersey Groundwater Quality Standard (GWQS) but are not reflective of plumes. The concentrations detected in these wells are very low (usually less than 10 micrograms per liter [µg/L]) and very localized. The lateral and vertical extent of contamination around each of these singular wells has been defined. Although not reflective of a plume, the exceedances in these wells will be addressed by the groundwater monitoring program that will be submitted with the draft CEA that will accompany the Remedial Action Report (RAR) and application for a Groundwater Remedial Action Permit (RAP) after this RAWP is implemented.

2.3 Receptor Evaluation

In 2014, a Site-Wide Receptor Evaluation Update was submitted to the NJDEP (TRC 2014c), which documented the findings of a detailed evaluation of the potential for Site-related contamination to impact nearby human and ecological receptors. The results of that evaluation indicated that Site-related contaminants are not impacting human or ecological receptors. An updated Receptor Evaluation Report will be included with the final RAR.

3.0 GROUNDWATER IRMS

3.1 Introduction

Roche has proactively implemented IRMs to treat source areas for ten plumes beneath the Site – six of the Remedial Action Plumes and the four CAMs plumes. The IRMs have resulted in significant decreases in contaminant concentrations and the areal extent of the plumes. Appendix A includes figures that depict the change in plume concentration and extent over time. The maps in Appendix A show the maximum historical and current (through May 2019) extent of individual constituents that exceeded the NJDEP GWQS.

IRMs were implemented in accordance with their respective design plans and under NJDEP-issued Permits-By-Rule (PBRs), where appropriate. Progress reports for each IRM have been submitted to the NJDEP, and updated progress reports were submitted in April 2019. Each IRM is summarized below, and additional information about each IRM can be found in the report references provided herein. A matrix summarizing pertinent concentration data and remedial action information is provided below as Table 1.

Table 1: *Matrix of Plumes and Associated IRM Activities*

Plume Name	IRMs	Treatment Depth (ft. bgs)	Maximum Historical Concentration (µg/L)	Maximum Current Concentrations (µg/L)[1]	Dates of IRM Activity
IA-9 Pipe Trench Area Plumes	Excavation with amended backfill (biodegradation amendment)	15	44,700 PCE 18,100 TCE 87,700 cis-1,2-DCE 5,790 VC 19,900 toluene 842 benzene	130 PCE 6.6 TCE 3.9 VC 1.9 benzene	June 2015
IA-2 Tank Farm Area Plume	ISTT (source area) and IWAS (downgradient plume)	85 (ISTT) 60 (IWAS)	1,830,000 chloroform 113,000 benzene 339,000 MeCl	<1 chloroform 410 benzene <1 MeCl	June 2015–January 2016 (ISTT) July 2015–April 2018 (IWAS)
IA-6 Chlorobenzene Plume	IWAS/ozone with persulfate oxidation; EISB	65	12,200 chlorobenzene 1,900 PCE	370 chlorobenzene 6.8 PCE 11 TCE 49 VC 44 benzene	May 2016–December 2016 (IWAS/ozone) Restarted February - April 2018 (IWAS) May–June 2018 (EISB)
IA-10 Building 104 Area Plume	EISB	11	110 PCE 193 TCE 418 cis-1,2-DCE 31.3 VC	19 PCE 21 TCE 69 cis-1,2-DCE 18 VC	April 2015
IA-10 Building 70 Area Plume	ISCO/EISB	12	45 benzene	<1 benzene	February 2015

[1] Sampling data through May 2019. Data collected from June 2018 through May 2019 will be provided in the upcoming Annual Groundwater Progress Report.

Plume Name	IRMs	Treatment Depth (ft. bgs)	Maximum Historical Concentration (µg/L)	Maximum Current Concentrations (µg/L)[1]	Dates of IRM Activity
IA-1/4 Dioxane Plume	IWAS/ozone and persulfate oxidation	95	3,550 dioxane	230 dioxane	July 2016–November 2017 (IWAS/ozone) November 2017 (persulfate oxidation) Restarted February 2018 (IWAS/ozone) – January 2019
CAMS IA-12 Plume	ISTT (source area) and IWAS/ozone (plume) and persulfate oxidation (plume)	50	67,500 PCE 21,700 TCE 84,300 cis-1,2-DCE 24,500 VC	2,700 PCE 460 TCE 570 cis-1,2-DCE 20 VC	March 2015–July 2015 (ISTT) July 2016–December 2017 (IWAS/ozone) October/November 2017 (persulfate oxidation)
CAMS IA-3/IA-7 North Plume	IWAS/EISB with nitrogen sparge	40	275 PCE 68.3 TCE 515 cis-1,2-DCE 56.5 VC	25 PCE 4.6 TCE 11 VC	March 2017–February 2018
CAMS IA-7 South Plume	IWAS/EISB pilot test	40	1,790 PCE 500 TCE 973 cis-1,2-DCE 106 VC	1.1 PCE 1.7 TCE 9.9 VC	March 2015–September 2015
CAMS IA-11 Plume	EISB Excavation with amended backfill	120 (EISB) 27 (Excavation)	11,900 PCE 2,860 TCE 15,300 cis-1,2-DCE 10,800 VC	7.9 VC 7.7 TCE	2006–2014 (EISB) 2016 and 2017 (excavations)

Notes: PCE = tetrachloroethene; TCE = trichloroethene; cis-1,2-DCE = cis-1,2-dichloroethene; VC = vinyl chloride; MeCl = methylene chloride; ISTT = in situ thermal treatment; IWAS = in-well air stripping; EISB = enhanced in situ bioremediation; ISCO = in situ chemical oxidation

3.2 IA-9 Pipe Trench Area Plumes

The IA-9 Pipe Trench Area Plumes were almost entirely limited to the pipe trench backfill on the north and east sides of former Building 73. One of the two plumes originated from discharges associated with two Roche process sewer manholes on the north side of the building, and the other from a suspected sewer pipe leak on the east side of the building. (Figures 2 and 3). The constituents were predominantly tetrachloroethene (PCE) and its degradation products (PCE+[2]) on the north side, and toluene on the east side. IRM activities included the following:

- Removal of the two manholes, associated piping, and impacted soil from the northern trench adjacent to former Building 73 in June 2014.
- Excavation of the former Building 73 subsurface structure in June and July 2015.
- Application of Daramend® (a combined anaerobic bioremediation and abiotic reduction reagent) amendment within the backfill placed in the northern trench area to treat any PCE+ that was remaining in the groundwater.
- Application of OBC™ (a combined aerobic bioremediation and chemical oxidation reagent) amendment to the eastern trench to treat any toluene that was remaining in the groundwater.

Based on a comparison of historical to current concentrations (Table 1 above), IRM activities have successfully removed these source areas, and thereby have reduced dissolved concentrations in the plume by orders of magnitude to very low concentrations. Monitoring to assess natural attenuation of remaining constituent concentrations is ongoing. For additional information about this IRM, including performance monitoring data, see:

- March 2014 RIR—IA-9 (TRC 2014d)
- October 2014 IA-9 Northeast Area – PDI Report for Development of IRMs, Rev. 1 (TRC 2014e)
- February 2017 IA-9 Enhanced In Situ Bioremediation (EISB) via Soil Amendment with Daramend® and OBC™ Discharge to Groundwater PBR Progress Report (TRC 2017a)
- April 2019 IA-9 IRM PBR progress update letter (TRC 2019b)

3.3 IA-2 Tank Farm Area Plume

The IA-2 Tank Farm Area Plume originates from historical releases of benzene, chloroform and methylene chloride that occurred within a former tank farm located in IA-2. The tank farm that housed the aboveground storage tanks (ASTs) and underground storage tanks (USTs) in IA-2 was demolished, and the tanks, impacted soil, and impacted bedrock were excavated and

[2] PCE+ is defined as the sum of PCE, trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride (VC) in the CSM Report and this RAWP.

removed between 1990 and 1998. A supplemental soil excavation was conducted to remove remaining soil impacts in 2015. In addition, the following IRM activities were completed for groundwater:

- In situ thermal treatment (ISTT) using electrical resistance heating (ERH) in the source zone to treat bedrock to approximately 85 feet below ground surface (bgs) from June 2015 to January 2016.
- In-well air stripping (IWAS) using an Accelerated Remedial Technologies (ART) recirculating well system technology in the downgradient plume area (extending into northern IA-6) to treat groundwater to approximately 60 feet bgs from July 2015 to April 2018.

Based on a comparison of historical to current concentrations (Table 1 above), IRM activities have effectively treated this source area, and thereby have reduced dissolved concentrations in the plume by orders of magnitude to low concentrations. Monitoring to assess natural attenuation of remaining constituent concentrations is ongoing. For additional information about this IRM, including performance monitoring data, see:

- July 2013 IA-2 RIR (TRC 2013b)
- January 2015 IA-2 PDI Report for Development of IRM (TRC 2015a)
- March 2015 Full Scale ART/IWAS Design Plan (TRC 2015b)
- November 2017 IA-2 ART IWAS IRM Progress Report (TRC 2017b)
- April 2019 IA-2 IRM PBR Progress Update Letter (TRC 2019c)

3.4 IA-6 Chlorobenzene Plume

The IA-6 Chlorobenzene Plume likely originated from local releases in the vicinity of former Buildings 15, 16 and 17. Primarily chlorobenzene and PCE have been identified in groundwater in the source area. The following IRM activities have been implemented for this plume:

- A pump-and-treat system was operated from 2004 to 2015 and was subsequently abandoned so that Building 86 could be demolished.
- A soil vapor extraction (SVE) system was operated from December 2007 until April 2014 to remove VOCs from soils above the water table.
- Combined IWAS and ozone injection using ART system technology and biosparging was operated from May to December 2015, with a single persulfate injection event conducted in December 2017.
- The IWAS system was restarted in February 2018 to treat localized rebound of chlorobenzene, with ozone injection restarting in April 2018.

- EISB injections to a depth of 65 ft bgs were conducted from May to June 2018 to treat a small area with PCE exceedances.

Based on a comparison of historical to current concentrations (Table 1 above), IRM activities have significantly reduced mass in this source area, and have thereby reduced dissolved concentrations in the plume by orders of magnitude to low concentrations. Monitoring to assess natural attenuation of remaining constituent concentrations is ongoing. For additional information about the IRMs conducted to date, including performance monitoring data, see:

- September 2015 IA-6 PDI Report for Development of IRM (TRC 2015c)
- November 2017 IA-6 Discharge to Groundwater PBR—IWAS/In Situ Chemical Oxidation (ISCO) IRM Progress Report (TRC 2017c)
- April 2019 IA-6 IRM PBR Progress Report (TRC 2019d)

3.5 IA-10 Building 104 Area Plume

The source of the IA-10 Building 104 Plume has not been identified, although it may be related to incidental spills near the former building loading dock. The primary constituent of this plume is PCE and its degradation products. A groundwater IRM was implemented in April 2015, consisting of injections of ABCplus™ (anaerobic bioremediation/reductive dechlorination amendment) into shallow groundwater to a depth of 11 ft bgs within the former building footprint. The injection program and post-IRM monitoring are complete. Monitoring to assess natural attenuation of remaining constituent concentrations is ongoing. A comparison of historical to current concentrations is provided above in Table 1. For additional information about the IRM, see:

- June 2013 RIR—IA-10 (TRC 2013c)
- November 2014 IA-10 Former Building 104 Groundwater PDI for Development of IRM (TRC 2014f)
- February 2017 IA-10—Building 104 Area IRM Progress Report (TRC 2017d)
- April 2019 IA-10 Building 104 Area IRM PBR Progress Report (TRC 2019e)

3.6 IA-10 Building 70 Area Plume

The IA-10 Building 70 Area Plume originated from a release from former USTs and fuel dispensers located near the southeastern corner of Building 70 (a vehicle maintenance building; Figure 2). The USTs and dispensers were removed in November 2014, and sodium persulfate and calcium peroxide solution were injected in February 2015 to promote short-term oxidation and long-term biological degradation of benzene in shallow groundwater (depth of 12 ft bgs). A comparison of current to historical concentrations is provided above in Table 1. For additional information about the IRM, see:

- June 2013 RIR – IA-10 (TRC 2013c)
- April 2014 Site-wide Groundwater RI (TRC 2014a)

- February 2017 IA-10 Building 70 Area IRM Progress Report (TRC 2017e)
- April 2019 IA-10 Building 70 IRM PBR Progress Report (TRC 2019f)

3.7 IA-1/4 Dioxane Plume

The IA-1/4 Dioxane Plume originates near the boundary of IA-1 and IA-4, and has migrated through IA-1 and IA-6.

In developing the IRM strategy for this plume, Roche researched laboratory and field case studies for potentially viable in-situ remediation technologies for dioxane. The literature reviewed included reports by vendors (Piper Environmental Group; Regenesis), articles describing laboratory studies (Schreier, et al., 2006; Ikehata, et al., 2016), and documentation of field studies (Carroll, et al., 2018). After review of these studies, Roche selected ISCO with ozone as the optimal oxidant for in-situ treatment.

Roche implemented the following IA-1/4 IRM activities to remediate dioxane:

- IWAS with ozone using ART system technology from July 2016 to November 2017 to treat to a depth of approximately 95 feet bgs.
- One-time injection treatment with sodium persulfate in November 2017 (11 well pairs).
- IWAS with ozone using ART system technology restarted in February 2018 and operated until January 2019.

The injection scheme for IA-1/4 included 44 ozone sparge well locations, 34 IWAS wells, and nine vapor extraction trenches (VETs). Each ozone sparge well included an upper and lower (shallow and deeper) injection interval, for a total of up to 88 total sparge points in the treatment area. The treatment area contained a North System and a South System. The North System consisted of 16 shallow injection wells and 13 shallow ART IWAS wells, and five deep ozone injection wells and four deep ART IWAS wells. The South System consisted of 23 deep ozone injection wells and 17 deep ART IWAS wells.

Overall, the IRM has been successful in reducing dioxane concentrations from a maximum of 3,550 µg/L to below 230 µg/L. The average in the treatment area is now down to 91 µg/L; however, as many as seven wells in the treatment zone continue to exhibit dioxane concentrations persisting above 100 µg/L. Of the treatment area monitoring wells, 60 percent have experienced a 50 percent reduction in dioxane concentrations, and 40 percent have shown an 80 percent reduction in concentrations compared to baseline (see Table 1). This IRM appears to be one of the first full-scale in situ remedies for dioxane in bedrock in New Jersey, and it has successfully reduced dioxane concentrations in groundwater to a certain point (Table 1).

The 2019 IA-1/IA-4 IRM Progress Report provides data demonstrating that the treatment had reached a point of greatly diminished effectiveness. For the last year of operation, the average concentrations over the treatment area essentially became asymptotic despite a state-of-the-art system with closely-spaced injection wells and numerous attempts to optimize the system. This effort included injection of persulfate into several injection wells in the treatment area in November

2017; however, this did not result in a noticeable reduction of dioxane concentrations. In the second half of 2018, Roche focused all the ozone in the South System on a small area surrounding well MW-392B, and all the ozone in the North System on a small area surrounding well MW-370A; dioxane concentrations in these two monitoring wells had remained high when dioxane concentrations had been reduced in other areas. These optimization efforts were not effective in reducing dioxane concentrations in these wells with persistently high dioxane concentrations. As stated in the April 2019 IRM Progress Report:

> "The optimization trial at MW-392B showed very little improvement in dioxane removal after two months of increased ozone flow. …TRC believes the lack of successful delivery of ozone to the target area is due to a lack of connected fractures through which unreacted ozone could migrate to the well screen and the short half-life of ozone, which reduces the potency of ozone over time."

In summary, the innovative in-situ ozone oxidation IRM implemented by Roche was effective at reducing dioxane concentrations in the source area of the IA-1/4 Dioxane Plume. The IRM system was effective in reducing dioxane mass in the IA-1/4 Dioxane Plume source zone; reductions of 61, 75, and 46 percent were documented in what were labeled as the shallow, intermediate, and deep treatment zones, respectively. These zones – shallow (10 to 30 feet bgs), intermediate (30 to 50 feet bgs) and deep (50 to 100 ft bgs) are all within the upper 100 feet of the bedrock. However, it was determined through the RI and PDI that it would not be practical to remediate dioxane at greater depths in the bedrock. In fact, the remedy encountered limitations, mostly in areas of with fewer interconnected fractures, despite aggressive optimization efforts. The remedy was effective at reducing high concentrations to moderate ones, but was not able to reduce concentrations in some areas to levels below approximately 100 µg/L. The lower percentage of contaminant reduction in the "deep" (50 to 100 feet bgs) treatment zone relative to the shallow and intermediate treatment zones is indicative of the reduced effectiveness of ozone injection with depth. This reduced effectiveness is likely due to the diminishing frequency of transmissive fractures with increasing depth.

Additional information about this IRM is provided in the following reports:

- June 2015 IA-1/IA-4 Groundwater PDI Report (TRC 2015d)
- June 2015 IA-1/4, IA-6 and IA-12 Ozone Sparging and Sodium Persulfate Injection DGW PBR Application (TRC 2015e)
- December 2017 IA-1/4 IRM Discharge to Groundwater PBR Progress Report (TRC 2017f)
- April 2019 IA-1/IA-4 IRM Progress Report (TRC 2019g)

3.8 CAMS IA-12 Plume

The CAMS IA-12 Plume originated from releases of VOCs from breaches in the CAMS in the vicinity of the Route 3 guard shack along the northernmost portion of the Site (Figure 2). After an extensive PDI, Roche implemented the following IRM activities to a depth of 50 ft bgs:

- ISTT via ERH in the core of the CAMS IA-12 Plume (at and immediately around the area of dense non-aqueous phase liquid [DNAPL] and elevated PCE+ concentrations), operated from March to July 2015.
- IWAS with ozone using ART system technology for the area surrounding the ISTT area, operated from July 2016 to December 2017.
- Spot treatment with sodium persulfate around monitoring well MW-80C in October and November 2017.

The CAMS IA-12 IRM has significantly reduced contaminant mass in the source area, and has reduced plume concentrations by orders of magnitude. For a comparison of historical to current concentration data, see Table 1. For additional information about the IRM design and implementation, see:

- August 2013 RIR—IA-12 (TRC 2013d)
- January 2015 IA-12 Groundwater PDI Report for Development of IRM, Revision 1 (TRC 2015f)
- February 2017 IA-12 ISTT Condensate Drip Water Discharge to Groundwater PBR Progress Report (TRC 2017g)
- February 2017 In Situ Oxidation-Enhanced IWAS Pilot Test and Discharge to Groundwater PBR Progress Report IA-12 (TRC 2017h)
- February 2017 IA-12 Pumping and Reinjection Test and IRM Treatment Discharge to Groundwater PBR Progress Report (TRC 2017i)
- April 2019 IA-12 Operable Unit-1 IRM PBR progress update letter (TRC 2019h)
- April 2019 IA-12 Operable Unit-2 IRM PBR Progress Report (TRC 2019i)

3.9 CAMS IA-3/IA-7 North Plume

The CAMS IA-3/IA-7 North Plume originated from breaches in the CAMS at the boundary of IA-3 and IA-7 in the area southwest of former Building 115 and west of Building 123. An IRM consisting of an IWAS system with EISB with nitrogen sparge operated from March 2017 to February 2018 to address groundwater impacts in the overburden and weathered bedrock to a depth of approximately 40 feet bgs. This IRM successfully reduced PCE+ concentrations to very low concentrations, as shown in Table 1. For additional information about the IRM, see:

- February 2017 IA-3/IA-7/CAMS EISB with IWAS Pilot Test and Discharge to Groundwater PBR Progress Report (TRC 2017j)
- April 2019 CAMS IA-3/IA-7 North IRM Progress Report (TRC 2019j)

3.10 CAMS IA-7 South Plume

The CAMS IA-7 South Plume originated from a manhole along the abandoned leg of the former CAMS in the center of IA-7, south of Building 123 in the area between former Building 85 and former Building 100. An EISB application performed as a pilot test between March and September 2015 effectively treated the groundwater and reduced the PCE+ concentrations in the overburden/shallow bedrock zone in this area up to a depth of approximately 27 feet bgs to very low concentrations, as shown in Table 1. For additional information about the IRM pilot test, see:

- February 2017 IA-3/IA-7/CAMS EISB with IWAS Pilot Test and Discharge to Groundwater PBR Progress Report (TRC 2017j)
- April 2019 IA-7 South Pilot Test PBR progress update letter (TRC 2019k)

3.11 CAMS IA-11 Plume

The CAMS IA-11 Plume originated from DNAPL releases from a manhole on the abandoned leg of the former CAMS. The releases created a source zone directly below the manhole that was concentrated in the overburden and weathered bedrock, but some DNAPL penetrated into the competent bedrock beneath the weathered bedrock. The following remedial activities have been conducted to treat the CAMS IA-11 Plume:

- EISB injections to treat overburden groundwater from 2006 through 2014.
- Pilot-scale EISB injection in competent bedrock to evaluate treatment of the deeper portions of this source zone (attempts to inject amendments into the shallow weathered bedrock above the competent bedrock were unsuccessful due to the low permeability of this zone).
- Removal of former Manhole C-1 and excavation of impacted soil in 2016.
- Excavation of weathered bedrock to 27 feet bgs beneath Manhole C-1 in January 2017 and application of EHC® (an in situ chemical reduction and bioremediation product composed of controlled-release carbon, zero valent iron particles, and nutrients) and Miracle Gro (additional water-soluble bionutrients) to the backfill to serve as a treatment mechanism for any remaining contaminant mass in the vicinity of the excavation.

IRM activities in IA-11 have successfully removed the PCE+ source to a depth of 27 ft, thereby reducing dissolved concentrations in the plume by orders of magnitude to very low concentrations. For a comparison of historical to current concentration data, see Table 1. For additional information about these IRM activities, see:

- December 2004 Remedial Investigation Report MOA IA-11: Parking Lot 903 Area—AOC Nos. 10, 173, and portions of AOCs 67, 116 (TRC 2004)
- October 2013 Remedial Investigation Report—IA-11 (TRC 2013e)

- November 2013 Remediation Optimization EISB Injection Progress Report—IA-11 (Parking Lot 903) (TRC 2013f)
- January 2015: IA-11 Bedrock Groundwater Zones S1, S2 and S3 PDI Report for Development of IRMs (submitted as Appendix G of the first 2015 Site-Wide Groundwater Progress Report [TRC 2015g])
- August 2016: IA-11 West—Former CAMS Manhole Investigation Summary Report (TRC 2016a)
- November 2016: IA-11 West/CAMS Overburden Groundwater IRM Report (TRC 2016b)
- February 2017 IA-11 West/CAMS EISB Bedrock Pilot Test Report (TRC 2017k)
- December 2017 IA-11 West Excavation IRM Discharge to Groundwater PBR Report (TRC 2017l)

4.0 SITE-WIDE GROUNDWATER REMEDIAL ACTION WORK PLAN

4.1 Scope of the RAWP

Roche will conduct final RAs for the seven Remedial Action Plumes at the Site (IA-9 Pipe Trench Area Plumes, IA-6 Chlorobenzene Plume, IA-10 Building 104 Plume, IA-10 Building 70 Area Plume, IA-1/4 Dioxane Plume, and the Windsor Sewer Plume). For other plumes that are beneath and/or migrate onto the Site (the Monitored Plumes, as identified above in Section 2.2), a CEA will be established and Roche will conduct long-term monitoring utilizing the existing monitoring well network. This Section describes the proposed remedial actions for the Remedial Action Plumes and the long-term monitoring plan for the Monitored Plumes.

4.2 Remedial Objectives

The remedial objective for all Remedial Action Plumes is to meet the NJDEP GWQS for the constituents associated with each plume, as presented in Table 2.

4.3 Overview of Remedial Options

To select the most appropriate remedial technology for each Remedial Action Plume, multiple technologies were evaluated based on their performance during the numerous IRMs. All of the active remedial technologies evaluated herein have been proven to be effective at the Site. A brief description of each of the selected remediation technologies, including documentation of their effectiveness, is provided below.

4.3.1 *Excavation*

Excavation is the physical removal of impacted soil or rock. When source areas are physically removed by excavation, there is an immediate and long-term positive effect on groundwater quality because the source feeding the plume is removed. Excavation can be enhanced by the addition of amendment to the backfill; the amendment will treat both upgradient groundwater as it flows through the excavation area and contaminant mass that may have diffused into the underlying bedrock. Excavations with amendment have been successfully implemented to remediate the IA-9 Pipe Trench Plumes, the CAMS IA-11 Plume, the former IA-1 Building 55 Area Plume, and the former IA-3 Methylene Chloride Plume. In each of these cases the source was completely removed, including saturated overburden and in some cases weathered bedrock where source material was retained. These excavations of source-area soil and the underlying weathered bedrock drastically reduced groundwater concentrations, in many cases to below the applicable GWQS.

4.3.2 *Enhanced In Situ Bioremediation*

EISB is a method for treating VOCs in place by enhancing natural microbial processes. With EISB, electron donors, electron acceptors, and/or nutrients are added to the groundwater to promote the necessary conditions for aerobic biodegradation or biological reductive dechlorination.

EISB has been successfully implemented at several locations at the Site to a depth up to 40 feet bgs to enhance biological reductive dechlorination of PCE+ plumes, including the following plumes:

- IA-10 Building 104 Area Plume (injection);
- CAMS IA-3/IA-7 North Plume (with IWAS);
- CAMS IA-7 South Plume (with IWAS);
- CAMS IA-11 Plume (injection and addition of amendment to the excavation backfill);
- IA-9 Pipe Trench Plumes (addition of EISB amendment to the excavation backfill); and,
- IA-6 Chlorobenzene Plume (injection to treat PCE+).

In each case, EISB was implemented after the PDI indicated that groundwater conditions were favorable to reductive dechlorination. For the PCE+ plumes listed above, PCE daughter products (TCE, cis-1,2-DCE, and VC) were present in groundwater prior to IRM implementation, indicating that reductive dechlorination was already occurring naturally. Following implementation of the EISB IRM, reductive dechlorination occurred more rapidly as evidenced by increased proportions of daughter products relative to PCE and reduced concentrations of PCE+.

EISB was also used to remediate the IA-10 Building 70 Area Plume, by enhancing the aerobic biological degradation of benzene, and the eastern IA-9 Pipe Trench Plume, by enhancing the aerobic biological degradation of toluene.

Additional information about the Site-specific application and performance of EISB is provided in the IRM plans and progress reports for the plumes listed above.

4.3.3 *Persulfate and Ozone Oxidation*

Persulfate and ozone are oxidants that can be applied in the subsurface to chemically destroy contamination by chemical oxidization. Persulfate and ozone oxidation technologies have been employed at the Site to depths up to approximately 90 feet bgs to treat the IA-6 Chlorobenzene Plume, the IA-1/4 Dioxane Plume, and the CAMS IA-12 Plume. Persulfate and ozone have been used both separately and in combination, depending on the type of impact. In most cases, oxidants have been employed with IWAS technology, which is described below. Additional information about persulfate and ozone oxidation and its Site-specific application and performance is provided in the IRM plans and progress reports for IA-6, IA-1/4, and IA-12.

4.3.4 *In-Well Air Stripping*

IWAS is a technology that injects air into vertical wells that typically have screens in both the unsaturated and saturated zones. The aerated groundwater migrates upward under the influence of a vacuum applied to the well while VOCs are stripped from the groundwater in the well. These vapors are then captured by a vapor extraction system within the unsaturated portion of the well. The partially treated groundwater then flows out of the well through the upper screen into the unsaturated zone where it then circulates back into the saturated zone. This movement of groundwater can be used to enhance distribution of remedial additives in groundwater within a treatment zone. Roche has implemented IWAS at the Site using ART wells, which combine in situ air stripping, air sparging, and SVE within a single-well system and, where applied, EISB or oxidation. IWAS technology has successfully remediated numerous plumes at the Site in conjunction with EISB and oxidation technologies, including the following plumes:

- Southern portion of IA-2 Tank Farm Area Plume (solely IWAS);
- IA-6 Chlorobenzene Plume (with ozone and persulfate oxidation);
- IA-1/4 Dioxane Plume (with ozone and persulfate oxidation);
- CAMS IA-12 Plume (with ozone and persulfate oxidation);
- CAMS IA-3/IA-7 Plume (with EISB);
- CAMS IA-7 South Plume (with EISB).

Additional information about the Site-specific application and performance of IWAS is provided in the IRM plans and progress reports for the plumes listed above.

4.3.5 *Monitored Natural Attenuation (MNA)*

MNA is the reliance on a variety of natural attenuation processes to achieve the applicable groundwater remediation standards. Natural attenuation processes include physical, chemical, and biological processes that reduce the mass, toxicity, mobility, volume, and/or concentration of contaminants in groundwater. Per NJDEP regulation and guidance, MNA is most appropriate when used in conjunction with other remedial measures or as a follow up to active remediation. The NJDEP Monitored Natural Attenuation Technical Guidance document (MNA Guidance) outlines a lines-of-evidence approach that can be used to evaluate whether MNA is an acceptable and appropriate remedial action.

4.4 Remedy Selection

Selected remedies and remedial objectives are shown below in Table 2. The following applicable remedial requirements, as specified in N.J.A.C 7:26E-5.5, for each Remedial Action Plume are summarized on Figures 4 through 9:

- Horizontal and vertical extent of the area to be remediated;
- Volume of contamination to be removed/treated;
- Detailed description of the remedial action and technology to be used for the area of concern;
- Identification of remedial standards;
- List of all required permits; and
- The proposed completion date of the remedial action and a schedule to complete the remedial action.

Table 2: *RAWP Remedy Matrix for Remedial Action Plumes*

Plume Name	Selected Remedy	Remedial Objective (µg/L)	Maximum Current Concentrations (µg/L)[3]	Remediation Area (ft^2)	Remediation Depth (ft. bgs)	Treatment Volume[4] (ft^3)	Permits Required	Schedule
IA-9 Pipe Trench Area Plumes	MNA	1 (PCE, TCE, VC, and benzene) 70 (cis-1,2-DCE)	130 PCE 16.6 TCE 3.9 VC 1.9 benzene	950	40	28,500	None	RAP, LTM, and CEA expected 2021 once MNA demonstration is complete
IA-2 Tank Farm Area Plume	MNA	1 (benzene) 3 (MeCl) 70 (chloroform)	410 benzene <1 MeCl <1 chloroform	13,800	50	483,000	None	RAP, LTM, and CEA expected 2021 once MNA demonstration is complete
IA-6 Chlorobenzene Plume	MNA	1 (PCE, TCE, VC) 70 (cis-1,2-DCE) 50 (chlorobenzene)	6.8 PCE 6.8 TCE 49 VC 370 chlorobenzene 44 benzene	3,000 (EISB area) 25,500 (MNA area)	60 (EISB and MNA)	180,000 (EISB) 1,402,500	None	RAP, LTM, and CEA expected 2021 once MNA demonstration is complete
IA-10 Building	MNA	1 (PCE, TCE, VC)	19 PCE	2,500	10	20,000	None	RAP, LTM, and CEA expected 2021 once

[3] Sampling data through May 2019. Data collected from June 2018 through May 2019 will be provided in the upcoming Annual Groundwater Progress Report.

[4] Volume is calculated as the saturated treatment depth multiplied by the treatment area.

Plume Name	Selected Remedy	Remedial Objective (µg/L)	Maximum Current Concentrations (µg/L)[3]	Remediation Area (ft^2)	Remediation Depth (ft. bgs)	Treatment Volume[4] (ft^3)	Permits Required	Schedule
104 Area Plume		70 (cis-1,2-DCE)	21 TCE 69 cis-1,2-DCE 18 VC					MNA demonstration is complete
IA-10 Building 70 Area Plume	MNA	1 (benzene)	<1 benzene	3,000	12	21,000	None	MNA demonstration is complete; RAP, LTM, and CEA expected 2021
IA-1/4 Dioxane Plume	MNA	0.4 (dioxane)	230 dioxane	2,415,000 (MNA area – on-Site only) 2,000,000 (MNA area - Commingled)	400 (MNA area – on-Site only) 150 (MNA Area – Commingled)	900,000,000 (MNA area – on-Site only) 300,000,000 (MNA Area – Commingled)	None	RAP, LTM, and CEA expected 2021 once MNA demonstration is complete
Windsor Sewer Plume	EISB, followed by MNA	100 (TCE) (for EISB) 1 (TCE (for MNA)	8,100 TCE	3,750	30	75,000	PBR	Implement EISB in 2020; MNA demonstration in 2021-2022; RAP, LTM and CEA expected in 2023

LTM = Long Term Monitoring

4.4.1 *IA-9 Pipe Trench Plumes*

The selected remedy for the IA-9 Pipe Trench Plumes is MNA. As described in Section 3.2, Roche previously remediated these plumes via excavation and application of amendment to the backfill, resulting in significant reductions in benzene and PCE+ concentrations in groundwater. The most recent concentrations of PCE, TCE, VC, and benzene in groundwater are above the GWQS in six monitoring wells:

- 130 µg/L PCE and 16.6 µg/L TCE in MW-170BR
- 3.3 µg/L VC in MW-170AR
- 3.9 µg/L VC in MW-469A
- 1.9 µg/L benzene in MW-170R
- 1.2 µg/L VC and 1.1 µg/L benzene in MW-470A
- 1.6 µg/L benzene in MW-152R

The remedial objective is to reach the GWQS, which is 1 µg/L for PCE, TCE, VC, and benzene. The remediation area, depth, and volume are listed in Table 2 and are shown in plan view and cross-section on Figure 5. No permits are required for the MNA sampling proposed in this remedy.

Per the NJDEP MNA Guidance, MNA is an appropriate and applicable remedy for this plume because of the rationale presented below and on Figure 4:

- The remedy is protective of public health and safety and of the environment because there are no human or environmental receptors.
- Although not required by the NJDEP based on groundwater and soil vapor data collected in and around on-Site buildings, any and all new buildings throughout the Site and existing buildings anticipated to be occupied by residents, students, or commercial/industrial workers in the vicinity of this plume are required to contain vapor mitigation systems complying with NJDEP's March 2013 Vapor Intrusion Technical Guidance (as it may be amended or superseded), in accordance with a Declaration of Environmental Easements and Restrictions recorded by Roche against the real property constituting the Site.
- MNA is proposed as a follow up to an active remedial action (excavation with amendment) that has removed (and therefore controlled) the source.
- The compounds that still exceed the GWQS are likely to be effectively addressed by natural attenuation processes because:
    - PCE degrades to TCE, cis-1,2-DCE, VC, ethene and ethane via reductive dechlorination, and the presence of VC indicates that reductive dechlorination is occurring;
    - Benzene is readily biodegradable under both aerobic and anaerobic conditions; and,

- Amendments within the excavation backfill promote ongoing biodegradation of both PCE+ and benzene.

- The plume has been delineated and is not expanding.
- VOC concentrations in groundwater overall appear to be stable or decreasing based on a preliminary trend evaluation.

The proposed monitoring plan includes passive diffusion sampling for the following:

- PCE, TCE, cis-1,2-DCE, VC and benzene by EPA method 8260C

A list of wells to be monitored is included in the matrix provided as Table 3, and the locations of the monitoring wells are shown on Figure 5. The four monitoring wells within the footprint of the plume will be sampled quarterly for a period of 2 years or until each well has been sampled at least eight times, including a minimum of four consecutive quarters of monitoring, or until there are no detected GWQS exceedances in two consecutive quarterly monitoring events. Additional monitoring data will be used to update the statistical trend analysis as required by the NJDEP MNA guidance. Upgradient, side-gradient, and sentinel wells will be sampled annually to confirm that the plume is not expanding or migrating. Following additional monitoring, it is anticipated that a RAP application will be submitted for MNA that will include primary lines of evidence, including a complete evaluation of the collected data and statistical trends, to demonstrate that MNA is occurring or has met the RA objectives for this plume.

4.4.2 *IA-2 Tank Farm Plume*

The selected remedy for the IA-2 Tank Farm Plume is MNA. As described in Section 3.3, Roche previously remediated this plume via excavation, ISTT, and IWAS. Methylene chloride and chloroform exceedances have been completely remediated to concentrations below the GWQS. The most recent concentrations of benzene (as of May 2019) are above the GWQS of 1 µg/L in 11 monitoring wells (ART-MW-5BR, ART-MW-6BR, EW-3B, EW-4B, IW-191B, IW-192B, MW-186-2, MW-241B, MW-243B, MW-244B, and MW-308B) within and immediately downgradient of the former source area. The remedial objective is to meet the GWQS. The remediation area, depth, and volume are listed in Table 2 and are shown in plan view and cross-section on Figure 6. No permits are required for the MNA sampling associated with this remedy.

Per the NJDEP MNA Guidance, MNA is an appropriate and applicable remedy for this plume for the following reasons:

- The remedy is protective of public health and safety and of the environment because there are no human or environmental receptors.
- Although not required by the NJDEP based on groundwater and soil vapor data collected in and around on-Site buildings, any and all new buildings throughout the Site and existing buildings anticipated to be occupied by residents, students, or commercial/industrial workers in the vicinity of this plume are required to contain vapor mitigation systems complying with NJDEP's March 2013 Vapor Intrusion Technical Guidance (as it may be amended or superseded), in accordance with a Declaration of Environmental Easements and Restrictions recorded by Roche against the real property constituting the Site.

- MNA is proposed as a follow up to an active remedial action (excavation, ISTT, and IWAS) that has removed and controlled the source and greatly reduced the size and concentrations of the plume.
- The compounds are likely to be effectively addressed by natural attenuation processes because benzene is readily biodegradable under aerobic and anaerobic conditions.
- The plume has been delineated and is not expanding.
- VOC concentrations in groundwater appear to be stable or decreasing based on a preliminary trend evaluation.

The proposed monitoring plan includes passive diffusion sampling for benzene by EPA method 8260C.

A list of wells to be monitored is included in the matrix provided as Table 3, and the locations of the monitoring wells are shown on Figure 6. Monitoring wells within the plume footprint will be sampled quarterly for a period of 2 years or until each well has been sampled at least eight times, including a minimum of four consecutive quarters of monitoring, or until there are no detected GWQS exceedances in two consecutive quarterly monitoring events. Additional monitoring data will be used to update the statistical trend analysis as required by the NJDEP MNA guidance. Upgradient, side-gradient, and sentinel wells will be sampled annually to confirm that the plume is not expanding or migrating. Following additional monitoring, it is anticipated that a RAP application will be submitted for MNA that will include primary lines of evidence, including a complete evaluation of the collected data and statistical trends, to demonstrate that MNA is occurring or has met the RA objectives for this plume.

4.4.3 *IA-6 Chlorobenzene Plume*

The selected remedy for the IA-6 Chlorobenzene Plume is MNA. As described in Section 3.4, Roche previously remediated chlorobenzene and PCE in this plume via a combination of pump-and-treat, SVE, IWAS, persulfate injections, and EISB. Initial post-remediation sampling demonstrated that EISB efforts have successfully reduced PCE+ concentrations to below or approaching 100 µg/L. Chlorobenzene is now below the GWQS of 50 µg/L in all but one monitoring well location within the footprint of the former plume, and recent EISB injections have significantly reduced PCE+ concentrations. PCE+ concentrations exceed the respective GWQS within the small former suspected source area. The remedial objective is to reach the GWQS, which is 50 µg/L for chlorobenzene, 1 µg/L for PCE, TCE, and VC, and 70 µg/L for cis-1,2-DCE. The remediation area, depth, and volume are listed in Table 2 and shown in plan view and cross-section on Figure 7. No permits are required for the MNA sampling associated with this remedy.

Per the NJDEP MNA Guidance, MNA is an appropriate and applicable remedy for the following reasons:

- The remedy is protective of public health and safety, and of the environment because there are no human or environmental receptors.

- Roche has made diligent and sustained efforts to remediate the contaminants in the IA-6 Chlorobenzene Plume, implementing three different remedial approaches sequentially to reduce contaminant levels to the extent feasible.
- Although not required by the NJDEP based on groundwater and soil vapor data collected in and around on-Site buildings, any and all new buildings throughout the Site and existing buildings anticipated to be occupied by residents, students, or commercial/industrial workers in the vicinity of this plume are required to contain vapor mitigation systems complying with NJDEP's March 2013 Vapor Intrusion Technical Guidance (as it may be amended or superseded), in accordance with a Declaration of Environmental Easements and Restrictions recorded by Roche against the real property constituting the Site.
- MNA is proposed as a follow up to an active remedial action (pump-and-treat, SVE, IWAS, persulfate injections, and EISB) that has removed and controlled the source.
- The compounds are likely to be effectively addressed by natural attenuation processes because PCE biologically degrades through anaerobic reductive dechlorination and the presence of breakdown products TCE, cis-1,2-DCE, VC, ethene and ethane is evidence that reductive dechlorination is occurring.
- Chlorobenzene concentrations have already decreased below the GWQS in most of IA-6.
- The plume has been delineated and is not expanding.

  The proposed monitoring plan includes passive diffusion sampling for the following:

- PCE, TCE, cis-1,2-DCE, VC, and chlorobenzene by EPA method 8260C

Due to Site redevelopment, the majority of existing monitoring wells in IA-6 have been decommissioned to accommodate construction of a parking garage. Following garage construction, several wells will be reinstalled for MNA monitoring. A list of wells to be replaced and monitored is included in the matrix provided as Table 3 and the locations of the monitoring wells are shown on Figure 7.

Replacement monitoring wells within the parking garage/plume footprint will be sampled quarterly for a period of 2 years, or until each well has been sampled at least eight times, at least four of which will be quarterly, or until there are no detected GWQS exceedances in two consecutive quarterly monitoring events. Monitoring data will be used to create a statistical trend analysis as required by the NJDEP MNA guidance. Upgradient, side-gradient, and sentinel wells will be sampled annually to confirm that the plume is not expanding or migrating. Following additional monitoring, it is anticipated that a RAP application will be submitted for MNA that will include primary lines of evidence, including a complete evaluation of all data and statistical trends, to demonstrate that MNA is occurring or has met the RA objectives for this plume.

4.4.4 *IA-10 Building 104 Area Plume*

The selected remedy for the IA-10 Building 104 Area Plume is MNA. As described in Section 3.5, Roche previously remediated this plume via EISB injections. The most recent PCE+ concentrations are above the GWQS in three monitoring wells within the former suspected source area: PCE, TCE, cis-1,2-DCE, and VC exceed the GWQS in MW-259A; and VC exceeds the GWQS in MW-283A and MW-285A. The remedial objective is to reach the GWQS, which is 1 µg/L for PCE, TCE, and VC; and 70 µg/L for cis-1,2-DCE. The remediation area, depth, and volume are listed in Table 2 and are shown in plan view and cross-section on Figure 8. No permits are required for the MNA sampling associated with this remedy.

As described in the CSM Report, the IA-10 Building 104 Area Plume is of limited extent and has been delineated horizontally and vertically by a network of tightly-spaced monitoring wells. Due to naturally reducing conditions as well as the EISB IRM, the extent of the plume has been reduced significantly over time and concentrations are continuing to decrease. An extensive monitoring record for this plume demonstrates that the plume is not expanding or migrating and that concentrations within the plume footprint are generally decreasing.

Per the NJDEP MNA Guidance, MNA is an appropriate and applicable remedy for this plume for the following reasons:

- The remedy is protective of public health and safety and of the environment because there are no human or environmental receptors.
- Although not required by the NJDEP based on groundwater and soil vapor data collected in and around on-Site buildings, any and all new buildings throughout the Site and existing buildings anticipated to be occupied by residents, students, or commercial/industrial workers in the vicinity of this plume are required to contain vapor mitigation systems complying with NJDEP's March 2013 Vapor Intrusion Technical Guidance (as it may be amended or superseded), in accordance with a Declaration of Environmental Easements and Restrictions recorded by Roche against the real property constituting the Site.
- MNA is proposed as a follow up to an active remedial action (EISB) that has controlled the source.
- PCE can be effectively addressed by natural attenuation processes because PCE biologically degrades through anaerobic reductive dechlorination, and the presence of breakdown products TCE, cis-1,2-DCE, VC, ethene, and ethane is evidence that reductive dechlorination is occurring.
- MW-259A, MW-283A, and MW-285A have each been sampled over eight times since the EISB IRM was completed, which included at least four consecutive quarters of monitoring; concentrations of PCE appear to be stable or decreasing.
- Because of new building construction, as shown on Figure 8, the following wells within the footprint of the new building have been decommissioned with NJDEP approval: MW-259A, MW-259B, MW-259C, MW-281A, MW-283A, MW-284A, and MW-285A. Most of these wells have been sampled at least ten times and evaluation of the PCE+ concentrations over time in the source area wells (MW-259A and MW-283A) indicates that the concentrations are decreasing. The last time MW-259A was sampled, the PCE+ concentrations rose to about the same concentrations detected before the IRM was

implemented. This rise in PCE+ concentrations is likely transient, and concentrations will again decline from the one-time increase. No new wells can be installed within the footprint of the new building due to access restrictions.

To re-establish the MNA monitoring network, Roche will install two additional monitoring wells to the south and east of the exterior walls of the new Quest building where Roche Building 104 was previously located. These two wells will be installed into HGU 1, deeper than overburden groundwater, to monitor potential commingling, including commingling with the Deluxe Plume. These wells will be added to the following three existing sentinel wells in the overburden that are outside of the new building and immediately downgradient of the plume:

- MW-287A – Downgradient sentinel well, sampled 10 times (2014-2016), below the GWQS for all VOCs for the last five sampling events;
- MW-286A – Downgradient sentinel well, sampled 13 times (2014-2017), currently below the GWQS for all VOCs; and,
- MW-32 – Downgradient sentinel well, sampled more than 50 times (1999-2018), currently below the GWQS for all VOCs.

All five wells will be monitored annually for two years to confirm that the plume is not expanding or migrating.[5] The list of wells to be monitored is included in the matrix provided as Table 3, and the locations of the monitoring wells are shown on Figure 7. The proposed monitoring plan includes passive diffusion sampling for PCE, TCE, cis-1,2-DCE, and VC by EPA method 8260C.

Given the length of the monitoring record, the demonstration of decreasing concentration trends, and the Site redevelopment activities that will prevent further monitoring of the source area, Roche is proposing to demonstrate MNA with a monitoring well network that only includes sentinel wells. Based on the prior sampling results, it is expected that the sentinel well network will demonstrate that the plume is not expanding or migrating. In addition, any new buildings to be constructed in this area (and throughout the Site) are required to contain vapor mitigation systems complying with the NJDEP's March 2013 Vapor Intrusion Technical Guidance (as it may be amended or superseded), in accordance with a 2016 Declaration of Environmental Easements and Restrictions recorded by Roche against the real property. If at some point groundwater conditions change, an alternative remedial action will be evaluated.

Following additional monitoring, it is anticipated that a RAP application will be submitted for MNA that will include primary lines of evidence and a complete evaluation of all data and statistical trends to demonstrate that MNA is occurring and that the RA objective for this plume has been achieved.

[5] NJDEP had identified four HGU 1 wells in the IA-10 Building 104 Area Plume to be monitored to confirm plume stability and attenuation. However, those four wells were abandoned in 2018 following discussion with NJDEP to allow for the Quest building construction. Two HGU 1 wells are proposed to provide for the required MNA monitoring.

4.4.5 *IA-10 Building 70 Area Plume*

The selected remedy for the IA-10 Building 70 Area Plume is MNA. As described in Section 3.6, Roche previously remediated this plume via injections of sodium persulfate and calcium peroxide. Benzene exceeds the GWQS of 1 µg/L in one monitoring well location (187RI-MW2). The remediation area, depth, and volume are listed in Table 2 and are shown in plan view and cross-section on Figure 8. No permits are required for the MNA sampling associated with this remedy.

Per the NJDEP MNA Guidance, MNA is an appropriate and applicable remedy for this plume for the following reasons:

- The remedy is protective of public health and safety and of the environment because there are no human or environmental receptors.
- Although not required by the NJDEP based on groundwater and soil vapor data collected in and around on-Site buildings, any and all new buildings throughout the Site and existing buildings anticipated to be occupied by residents, students, or commercial/industrial workers in the vicinity of this plume are required to contain vapor mitigation systems complying with NJDEP's March 2013 Vapor Intrusion Technical Guidance (as it may be amended or superseded), in accordance with a Declaration of Environmental Easements and Restrictions recorded by Roche against the real property constituting the Site.
- MNA is proposed as a follow up to an active remedial action (EISB) that has controlled the source.
- Benzene can be effectively addressed by natural attenuation processes because benzene is readily degradable under aerobic and anaerobic conditions.
- 187RI-MW2 has been sampled over eight times since the EISB IRM was completed, including four consecutive quarters of monitoring, and concentrations of benzene in groundwater are decreasing based on a preliminary trend analysis (the results of a final Mann-Kendall analysis will be presented in the RAR which will be submitted along with the RAP application).

The proposed monitoring plan includes passive diffusion sampling for benzene by EPA method 8260C.

A list of wells to be monitored is included in the matrix provided as Table 3 and the locations of the monitoring wells are shown on Figure 9. The quarterly monitoring requirements to demonstrate MNA for this plume have been met. Roche will, in a separate document, provide the statistical analysis of the sampling data as a demonstration of the appropriateness of MNA as the final remedial action for this plume (including primary lines of evidence), concurrent with or followed by a groundwater RAP application. Until final RAP approval is received, the monitoring wells listed in Table 3 will be sampled annually, or until there are no detected GWQS exceedances in two consecutive monitoring events.

The NJDEP has recently advised that confirmation is required to demonstrate that MNA will address the remaining benzene despite a detected benzene concentration increase in 2017. The

Department also requested that Roche determine whether reagent-related chemicals are present in concentrations that warrant monitoring and inclusion in the Classification Exception Area. The MNA sampling proposed above was initiated in 2019. The annual sample collected from monitoring well 187RI-MW2 in 1Q19 showed no detectable benzene, indicating that MNA has already effectively addressed the remaining benzene. This well will be resampled in 1Q20 to confirm that benzene remains below the GWQS.

Regarding the presence of reagent-related chemicals, sampling data from 2016 and 2017 demonstrates that the concentrations of the injectate chemical have returned to pre-treatment baseline levels. The most indicative parameter of the chemicals injected as oxidants is sulfate, which has decreased to pre-treatment concentrations in all wells. (See Appendix B).

4.4.6 *IA-1/4 Dioxane Plume*

The proposed remedy for the IA-1/4 Dioxane Plume is MNA. The downgradient, low-concentration portion of the IA-1/4 Dioxane Plume that comingles with other dioxane-containing plumes that migrate onto, beneath and downgradient of the Site will be addressed by the long-term monitoring plan proposed below in Section 4.5. As described in Section 3.7, Roche treated the IA-1/4 Dioxane Plume source area via ISCO, using ozone-enhanced IWAS with ART system technology from July 2016 until January 2019, resulting in dioxane concentrations being reduced to an average of 91 µg/L at most monitoring well locations. The remediation area, depth, and volume are listed in Table 2 and are shown in plan view on Figure 10. No permits are required for the MNA sampling associated with this remedy.

Per the NJDEP MNA Guidance, MNA is an appropriate and applicable remedy for this plume for the following reasons:

- Roche has made an extensive IRM effort to treat the dioxane source area. Those efforts have been very successful but, as discussed in Section 3.7 above, have reached the point of greatly diminished effectiveness despite a state-of-the-art system with closely-spaced injection wells and numerous optimization efforts.
- The remedy is protective of public health and safety and of the environment because there are no human or environmental receptors.
- MNA is proposed as a follow up to an active remedial action (ART-IWAS/ISCO) that has removed most of the source.
- Numerous wells in the IA-1/4 Dioxane Plume downgradient and sidegradient of the treatment area have been sampled over the last few years, and concentrations of dioxane in groundwater are decreasing overall based on a preliminary trend analysis.

The proposed monitoring wells will be sampled for dioxane only, unless a well is also included in a monitoring well network for another plume or sampled as part of the long-term monitoring network proposed in Section 4.5 below. The wells will be sampled using passive devices and analyzed for dioxane by EPA method 8270 SIM.

The wells that will be monitored to finalize the demonstration of MNA (as required for the groundwater RAP application) are shown on Figure 10. Source area and plume monitoring wells will be sampled quarterly for a period of two years or until each well has been sampled at least eight times, including a minimum of four consecutive quarters of monitoring. Upgradient, sidegradient, and sentinel wells will be sampled annually to confirm that the plume is not expanding. Following this monitoring, it is anticipated that a RAP application will be submitted for MNA that will include primary lines of evidence, including a complete evaluation of the collected data and statistical trends, to demonstrate that MNA is occurring or has met the RA objectives for this plume, and that MNA should be approved as the final remedial action (unless RA objectives have at that time already been met).

4.4.7 *Windsor Sewer Plume*

The Windsor Sewer Plume is located in Windsor Place and extends from the Nutley municipal sewer into the eastern portion of IA-10 in HGUs 1W through 3W. It is characterized by a high proportion of TCE relative to other VOCs. In most groundwater samples, the second-most prevalent VOC is carbon tetrachloride, which has not been detected beneath most of the Site and is a characteristic tracer compound for this plume.

At the Nutley sewer in this area, the top of bedrock is close to land surface, and there is little to no saturated overburden. As such, the plume originates in HGU 1 and migrates primarily in HGUs 1W and 2W. This plume remains a primarily TCE plume as it migrates southeast through eastern IA-10. In HGUs 2W and 3W, this plume commingles with the Western Plume and the IA-6 Chlorobenzene and IA-1/4 Dioxane Plume in easternmost IA-10 and the northwest portion of Nichols Park.

The portion of the plume with TCE concentrations greater than 1,000 µg/L is restricted to an area of 60 by 60 feet and to a depth of 20 to 30 feet below ground surface (ft bgs). The maximum TCE concentrations have ranged from about 7,000 to 9,000 µg/L, which is less than 1% of the solubility of TCE (which is 1,100 mg/L). Nonetheless, the high TCE concentrations represent a source area that will continue to generate a TCE plume.

Given the target depth and constituent for remediation in this area, the observed performance of the IRMs, the remedy proposed for this plume consists of EISB in the area with TCE concentrations greater than 1,000 µg/L. The remedy will include the following:

- Bioremediation-enhancing amendments will be injected into six new wells screened from 10 to 30 ft bgs, three of which will be installed upgradient of the source, and three downgradient.
- Amendments will be injected into three wells at one time, and the other three wells will be used to extract and recirculate groundwater, thereby enhancing the distribution of amendments through the area of high TCE concentrations.
- Initially, the three upgradient wells will be used as injection wells, and after a period of time, the wells used for injection and withdrawal will be reversed.

The locations of the proposed injection wells and new and existing performance monitoring wells are shown on Figure 11. A Permit by Rule (PBR) will be required for injection of the amendments.

It is anticipated that the proposed EISB remedy will reduce TCE and daughter product concentrations in the source area to concentrations less than 100 µg/L. The remedy will then transition to MNA, as natural processes will be able to further reduce TCE and daughter product concentrations over time. The proposed remedy will require a Permit by Rule (PBR) from the NJDEP. It is anticipated that the active EISB remedy implementation with two rounds of performance monitoring will take place over the first 12 months following RAWP approval. The MNA demonstration period will consist of eight quarterly monitoring events over the following 2 years.

4.4.8 *Deep Dioxane*

Roche evaluated the potential to apply remedial techniques that were applied to the IA-1/4 Dioxane Plume (see Section 4.4.6 above) to deeper portions of the bedrock that are impacted by dioxane from one or more sources. As described in Section 3.7 above, Roche previously targeted a treatment zone in HGUs 2 and 3 (all located above approximately 100 feet bgs), and injected ozone using IWAS technology and effectively reduced dioxane concentrations from in excess of 3,000 µg/L to concentrations below 100 µg/L in most portions of the targeted treatment zone. Roche's application of this technology was selected after thorough review of the literature describing in-situ dioxane remediation efforts at other sites. The published studies, including those cited in Section 3.7, indicated that few oxidants were effective in remediating dioxane, that ozone was the most effective of these options, and that the extent of remediation was limited by the interconnectedness of porosity in the impacted geologic material. The literature Roche reviewed also indicated that there have been to date only a limited number of sites where in situ remediation of dioxane was successfully implemented, and none that were previously attempted in fractured bedrock. The system that Roche designed incorporated cutting-edge techniques (e.g., in-well sparging), more sophisticated than what was described in the literature, in what is likely the first attempt in New Jersey to maximize ozone distribution in a fractured bedrock setting, and thereby exceeding the current state of dioxane remediation at similar impacted sites.

However, as discussed in Section 3.7, there were a few performance monitoring wells where dioxane concentrations could not be reduced below around 300 µg/L, in large part due to the scarcity of permeable fractures in those areas. Roche made several attempts to further reduce dioxane in those limited areas. The first efforts involved a pilot test with another oxidant, sodium persulfate. This oxidant was not effective in further reducing dioxane concentrations; the oxidant was consumed by the host rock, as evidenced by transient increases in concentrations of metals that occur naturally in the bedrock. Subsequent efforts involved concentrating ozone injections in the recalcitrant areas, maximizing ozone injection rates and pressures in these discrete areas. These efforts were unable to further reduce dioxane concentrations in the recalcitrant areas (TRC 2019g).

After review of the performance of the dioxane plume IRM, Roche is requesting a Technical Impracticability (TI) Determination for active remediation of deeper dioxane. Per the Technical Impracticability Guidance for Groundwater (NJDEP, December 2013), remediation of groundwater to the applicable standards is not feasible from an engineering perspective due to limitations in currently available groundwater remediation technologies, as follows:

- Dioxane concentrations in deeper HGUs (HGU 3, HGU 4, and HGU 5) are generally between 10 and 100 µg/L beneath a large portion of the Site, with a few wells showing concentrations in the range of 100 to 300 µg/L. The experience with the IA-1/4 source area IRM is that ozone sparging was the most effective of all the technologies and succeeded in reducing high (>1,000 µg/L) concentrations, but was not effective in further reducing lower concentrations (<200 to 300 µg/L) (TRC 2019g).
- The frequency of fractures decreases in the bedrock with increasing depth. Limited fractures within the deeper rock will cause greater channeling and less distribution of ozone within the deeper bedrock and, therefore, limit its effectiveness.
- Based on past experience in the IA-1/4 source zone IRM, injection pressures exceeding 120 psi would be required to overcome the hydrostatic and fracture entry pressure to sparge at depths greater than 150 feet below the water table. Experience has shown that operating at this high pressure would create many O&M as well as safety issues. For example, injecting at such high pressures could lead to break through of ozone to the water table and to the surface. From a safety perspective, the high pressures that would be needed could create leaks in fittings and couplings. This could lead to potentially dangerous ozone concentrations in the control building and surrounding area.
- The high pressures needed to inject the ozone into the fractured rock could have unintended consequences with regard to 1,4-dioxane transport (i.e., spread of dioxane in unanticipated directions).
- The large footprint and thickness of the deep dioxane plume would require a network of densely spaced remediation wells that is impractical to install and connect to a distribution piping network, with minimal likelihood of meaningful mass reduction.
- The large footprint of the deep dioxane plume is already covered by several new buildings and a parking garage, and there are plans to develop other portions of the Site beneath which the plume extends, rendering it highly impracticable if not impossible to install the remedial wells and infrastructure that would be needed for an active remedy.
- The dioxane plume already extends off-Site. The plume is stable, and does not present a risk to human or ecological receptors. There will be no added benefit with respect to protection of downgradient receptors, because the footprint of the dioxane plume exceeding GWQS would not be reduced by minimal reductions in deep dioxane plume concentrations in the on-Site portions of the plume (TRC 2018).

4.4.9 *Eastern Plume*

The Eastern Plume is a Monitored Plume; nonetheless at DEP's request, Roche evaluated the feasibility of remediation of the portion of the Eastern Plume located in the northeast corner of the Site (eastern IA-12), where PCE concentrations are greater than 1,000 µg/L.

In eastern IA-12, the Eastern Plume occurs at a depth ranging from about 100 to 150 ft bgs, primarily in HGU 4. Roche effectively remediated shallow PCE source areas in other portions of the Site, notably four source areas along the CAMS that emanated from releases from the municipal sewer, and PCE source areas in the IA-6 and IA-9. Roche employed thermal treatment, excavation and EISB to remediate these source areas, and thereby reduced the concentrations of PCE and its breakdown products in these source areas by at least two orders of magnitude. After careful evaluation of Roche's remedial efforts designed to address PCE plumes elsewhere on the Site, and the specific hydrogeologic and contaminant distribution characteristics of this plume, Roche has determined that those remedial approaches would not be effective in treating the Eastern Plume. Per the Technical Impracticability Guidance for Groundwater (NJDEP, December 2013), remediation of groundwater to the applicable standards is not feasible from an engineering perspective due to limitations in currently available groundwater remediation technologies, as follows:

- The lack of degradation products associated with this plume indicate that conditions are not favorable in this portion of the Site for EISB.
- ISCO was applied previously at the Site and was shown to liberate metals from the bedrock.
- The depth of the plume renders excavation impracticable.
- Thermal treatment techniques have never been successfully applied in deep competent bedrock.
- The frequency of fractures decreases in the bedrock with increasing depth. Limited fractures within the deeper rock will cause greater channeling and less dispersion of remedial additives within the deeper bedrock, and limit effectiveness of in situ remedial technologies.
- The majority of the PCE mass resides within the rock matrix (primary porosity) and is not accessible to treatment.
- The large footprint and thickness of the Off-Site Eastern Plume would require a network of densely spaced remediation wells that is impractical to install and connect to a distribution piping network, with minimal likelihood of significant mass reduction
- The complexities of the fractured rock matrix create uncertainty as to where the highest PCE mass resides, and where to target injections.
- The Eastern Plume already extends off-Site. The downgradient extent of the plume is stable, and does not present a risk to human or ecological receptors (TRC 2018). There will be no added benefit to receptors, nor reduction in the footprint of the off-Site Eastern Plume greater than GWQS by reducing concentration in the portion of the plume in eastern IA-12.

4.5 Groundwater Monitoring Plan and Future CEA

The monitoring plans for the seven Remedial Action Plumes are presented on Figures 5 through 11. These monitoring plans will be implemented during the remedial action.

Roche will also implement a robust monitoring plan with approximately 275 wells in the combined MNA well network for the Remedial Action Plumes and in the long-term monitoring well network for the Monitored Plumes. This combined network covers several hundred acres and monitors hydrogeologic zones extending from ground surface to about 500 ft bgs. The wells Roche is proposing to include in the long-term monitoring network are shown on Figure 12 and listed in Table 4. Roche is proposing to sample this network of 200 wells semi-annually for the next 2 years (2020 and 2021) or until the Groundwater Remedial Action Permit (RAP) is issued, annually for 4 years afterward, from 2022 through 2025, and every 2 years for the following 4 years (2026 through 2029). The data collected during this period will be evaluated and modifications to the sampling frequency and monitoring network will be proposed, as warranted.

As required by N.J.A.C. 7:26E-5.5, following implementation of the final remedies, remedy effectiveness will be monitored according to the Groundwater Monitoring Plan provided as Table 3. All samples will be collected and analyzed pursuant to the Quality Assurance Project Plan that has been in effect for investigations at the Site since 2013 (TRC, 2012b).

Under NJDEP regulations, any exceedance of the GWQS requires the establishment of a CEA, an institutional control that stays in place until the GWQS are met. Roche will submit a draft CEA for both the Remedial Action Plumes and the Monitored Plumes, for the NJDEP's consideration with the application for a Groundwater RAP for the Site. Once the CEA is established, Roche will prepare Biennial Certification Reports, which will include presentations of the monitoring data. Roche will continue to submit annual Progress Reports until the CEA is established and the RAP is issued.

4.6 Regulatory and Mandatory Timeframes

Pursuant to N.J.A.C. 7:26E-5.8(b)2, implementation of the remedial action is required within 5 years after the earliest applicable regulatory timeframe in N.J.A.C. 7:26E-4.10 to submit a remedial investigation report (RIR).

Because the requirement to remediate was triggered prior to May 7, 1999, there was a statutory requirement for the RI to be completed on or before May 7, 2014 pursuant to the Site Remediation Reform Act (N.J.S.A. 58:10C-1 et seq.). Roche submitted the RI in April 2014. On March 20, 2019, Roche applied for a 2-year extension for completion of the remediation. Therefore, the regulatory timeframe for completion of the remedial action is May 7, 2021 (with the 2-year extension).

4.7 Reporting

After establishment of decreasing trends and other lines of evidence to support MNA as the final remedy for the seven Remedial Action Plumes, including the collection of performance monitoring data demonstrating the effectiveness of the proposed EISB remedy for the Windsor Sewer Plume, Roche will submit a RAR pursuant to N.J.A.C. 7:26E-5.7. At a minimum, the following information will be included:

- A description, by area of concern, of each remedial action implemented;
- Documentation, by area of concern, that each remedial action is effective in protecting the public health and safety and the environment by providing an overview of the data to establish the remedial action is operating as designed;
- Summary of all analytical data used to evaluate the performance of each remedy and a review of data usability pursuant to NJDEP guidance;
- A remedial action permit application(s) prepared pursuant to N.J.A.C. 7:26C-7;
- "As-built" diagrams for any permanent structures associated with the remedial action;
- A detailed description of Site restoration activities;
- A description of each permit obtained to implement the remedial action; and
- The total remediation costs through the implementation of the remedial action.

Subsequent to the NJDEP's review of the RAR and upon issuance of the RAP(s), the LSRP will issue the final RAO for the Site.

After issuance of the RAP and RAO and establishment of the CEA, Roche will prepare Biennial Certification reports through 2029, providing the results of the long-term monitoring program. The results of the long-term monitoring will be evaluated to determine if the sampling frequency and monitoring network should be modified after 2029.

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